



Mechanical Specifications

Issued for Addendum M-02

Project Name

Toronto Western Hospital
Senior Emergency Medicine Centre (SEMC),
External Corridor & Chiller relocation
UHN Project No.: SAP#110022016

Project Number

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PART 1 - GENERAL

1.1 REFERENCES

- 1.1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and all Sections of Division 00 and 01 apply to and are part of this Section of the Specification.
- 1.1.2 The Specification is generally prepared in accordance with the format of the CSI/CSC Master Format 2004 edition.

1.2 APPLICATION

- 1.2.1 This Section specifies requirements that are common to Mechanical Divisions Work Sections and it is a supplement to each Section and is to be read accordingly. Where requirements of this Section contradict requirements of Divisions 00 or 01, conditions of Division 00 or 01 takes precedence.
- 1.2.2 Perform All Work specified herein by experienced and licensed personnel.
- 1.2.3 Be responsible for advising product vendors of requirements of this Section.

1.3 RELATED WORK

- 1.3.1 It is the intent of these specifications to furnish and install all materials and equipment as hereinafter specified and/or as shown on the drawings in such a manner as to leave each of the systems of the mechanical trades complete and in satisfactory condition.
- 1.3.2 Where used, words "Section" and "Division" shall also include other Sub-Contractors engaged on site to perform work to make building and site complete in all respects.
- 1.3.3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- 1.3.4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- 1.3.5 Where used, word "provide" shall mean supply and install as each is described above.
- 1.3.6 Where used, word "delete" or "remove" (and tenses of "delete" or "remove") shall mean 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 Consultant.
- 1.3.7 Where used, word "Authorities", shall mean any agencies, standards, rules and regulations that enforces the applicable laws, ordinances, rules, regulations or code of the place of the work.
- 1.3.8 "OSHA" and "OHSA" 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.
- 1.3.9 Where used, word "work" shall mean all equipment, permits, materials and labour to provide a complete mechanical installation as required and detailed in the Drawings and Specifications.
- 1.3.10 Where used, words "Drawings" and "Specifications" are referred to; it means the "Contract Documents".
- 1.3.11 Where used, words "Prime Mechanical Contractor" shall mean the supervisory Mechanical Contractor of all Mechanical Sub-Contractors.
- 1.3.12 The term "exposed" means, within the line of sight of any person standing or sitting in the occupied space, unless defined otherwise in the following sections.

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- 1.3.13 The term "concealed" means, not exposed, hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
- 1.3.14 The term "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.
- 1.3.15 The term "listed" means, that the materials or equipment are tested in accordance with applicable standards and are approved and listed for their intended use by a testing company approved by the Authorities having jurisdiction.
- 1.3.16 The term "approved", "approvals", etc., means, approved by Authorities having jurisdiction as conforming to the requirements of the Contract Documents.
- 1.3.17 The term "acceptable" or "acceptance", etc., means, acceptable to the Consultant as conforming to the requirements of the Contract Documents.
- 1.3.18 The term "submit for review" or "submit notice", etc., means, submit to the Consultant.
- 1.3.19 The term "subject to review" means, work or materials laid out for review by the Consultant. Obtain instruction from the Consultant before proceeding with the work. Submit further information, shop drawings, samples etc., as specified and/or as may be reasonably requested by the Consultant.
- 1.3.20 The term "accessible" used alone means, readily accessible by a person using tools as required without cutting or breaking out materials.
- 1.3.21 The term "noted" means, notes on the drawings, the detail drawings and on the Schedules.
- 1.3.22 "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.
- 1.3.23 "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.
- 1.3.24 "Consultant" – means person, firm or 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.
- 1.3.25 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.
- 1.3.26 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.
- 1.3.27 The terms "instructions" or "as instructed" or "where instructed" mean as instructed by the Consultant, including supplementary instruction notices; job site instruction notices; job site instructions by a field representative/ inspector appointed by the Consultant and including all comments made regarding submittal of shop drawings and samples for review.

1.4 DOCUMENTS

- 1.4.1 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.
- 1.4.2 Specification is arranged in accordance with CSI/CSC 50 Division Sections MasterFormat.
- 1.4.3 Drawings and Specifications are portions of Contract Documents and identify labour, products and services necessary for performance of work and form a basis for determining pricing. They are intended to be cooperative. Perform work that is shown, specified, or reasonably implied on the drawings but not mentioned in Specification, or vice-versa, as though fully covered by both.
- 1.4.4 Review Drawings and Specifications in conjunction with documents of other Divisions and, where applicable, Code Consultant's report.
- 1.4.5 Unless otherwise specifically noted in Specifications and/or on Drawings, Sections of Mechanical Divisions are not intended to delegate functions nor to delegate work and supply of materials to any specific trade, but rather to generally designate a basic unit of work, and Sections are to be read as a whole.
- 1.4.6 Drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Any information regarding accurate measurement of building is to be taken on site. Do not scale Drawings, and do not use Drawings for prefabrication work.
- 1.4.7 Drawings are intended to convey the scope of work and do not show architectural and structural details. Provide, at your cost, offsets, fittings, transformations and similar products required as a result of obstructions and other architectural and/or structural details but not shown on Drawings.
- 1.4.8 Locations of equipment and materials shown may be altered, when reviewed by Consultant, to meet requirements of equipment and/or materials, other equipment or systems being installed, and of building, all at no additional cost to Contract.
- 1.4.9 Specification does not generally indicate specific number of items or amounts of material required. Specification is intended to provide product data and installation requirements. Refer to schedules, Drawings (layouts, riser diagrams, schematics, details) and Specification to provide correct quantities. Singular may be read as plural and vice versa.
- 1.4.10 Starter/motor control centre (MCC)/variable frequency drive (VFD) schedule drawings are both mechanical and electrical, and apply to work of Mechanical Divisions and Electrical Divisions. Be responsible for reviewing starter, MCC, VFD, and motor specification requirements prior to Bid submission. Confirm and coordinate exact scope of work and responsibility of work between Mechanical Divisions and Electrical Divisions.
- 1.4.11 Drawings and Specifications have been prepared solely for use by party with whom Consultant has entered into a contract and there are no representations of any kind made by Consultant to any other party.
- 1.4.12 In the case of discrepancies between the drawings and specifications, documents will govern in order specified in "General Conditions", however, when scale and date of drawings are same, or where discrepancy exists within specification, most costly arrangement will take precedence.

1.5 METRIC AND IMPERIAL MEASUREMENTS

- 1.5.1 Generally, both metric and imperial units of measurement are given in Sections of Specification governed by this section. Measurement conversions may be generally "soft" and rounded off. Confirm exact measurements based on application. Where measurements are related to installation and onsite applications, confirm issued document measurements with applicable local code requirements, and/or as applicable, make accurate measurements onsite. Where significant discrepancies are found, immediately notify Consultant for direction.

1.6 WORK STANDARDS

- 1.6.1 Where any code, regulation, bylaw, standard, contract form, manual, printed instruction, and installation and application instruction is quoted it means, unless otherwise specifically noted, latest published edition at time of submission of Bids adopted by and enforced by local governing authorities having jurisdiction. Include for compliance with revisions, bulletins, supplementary standards or amendments issued by local governing authorities.
- 1.6.2 Where regulatory codes, standards and regulations are at variance with Drawings and Specification, more stringent requirement will apply unless otherwise directed by Consultant.
- 1.6.3 Supplementary mandatory specification and requirements to be used in conjunction with project include but are not limited to following:
- 1.6.3.1 Air-Conditioning, Heating and Refrigeration Institute (AHRI);
 - 1.6.3.2 Air Movement and Control Association (AMCA);
 - 1.6.3.3 American Iron and Steel Institute (AISI);
 - 1.6.3.4 American National Standards Institute (ANSI);
 - 1.6.3.5 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., (ASHRAE);
 - 1.6.3.6 American Society of Mechanical Engineers (ASME);
 - 1.6.3.7 American Society of Testing and Materials (ASTM);
 - 1.6.3.8 American Water Works Association (AWWA);
 - 1.6.3.9 Associated Air Balance Council (AABC);
 - 1.6.3.10 Building Industry Consulting Services, International (BICSI);
 - 1.6.3.11 Canadian Gas Association (CGA);
 - 1.6.3.12 Canadian General Standards Board (CGSB);
 - 1.6.3.13 Canadian Standards Association (CSA);
 - 1.6.3.14 Electrical and Electronic Manufacturers Association of Canada (EEMAC);
 - 1.6.3.15 Electrical Safety Authority (ESA);
 - 1.6.3.16 Electronic Industries Association (EIA);
 - 1.6.3.17 Factory Mutual Systems (FM);
 - 1.6.3.18 Illuminating Engineering Society (IES);
 - 1.6.3.19 Institute of Electrical and Electronic Engineers (IEEE);
 - 1.6.3.20 International Standards Organization (ISO);
 - 1.6.3.21 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS);
 - 1.6.3.22 National Building Code of Canada (NBC);
 - 1.6.3.23 National Electrical Manufacturers Association (NEMA);

- 1.6.3.24 National Environmental Balancing Bureau (NEBB);
- 1.6.3.25 National Fire Protection Association (NFPA);
- 1.6.3.26 National Standards of Canada;
- 1.6.3.27 NSF International;
- 1.6.3.28 Occupational Health and Safety Act (OHSA);
- 1.6.3.29 Ontario Building Code (OBC);
- 1.6.3.30 Ontario Electrical Safety Code (OESC);
- 1.6.3.31 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA);
- 1.6.3.32 Technical Standards and Safety Authority (TSSA);
- 1.6.3.33 Thermal Insulation Association of Canada (TIAC);
- 1.6.3.34 Underwriters' Laboratories of Canada (ULC);
- 1.6.3.35 Workplace Hazardous Materials Information System (WHMIS);
- 1.6.3.36 Material Safety Data Sheets by product manufacturers;
- 1.6.3.37 local utility inspection permits;
- 1.6.3.38 Codes, standards, and regulations of local governing authorities having jurisdiction;
- 1.6.3.39 additional codes and standards listed in Trade Sections;
- 1.6.3.40 Owner's standards.
- 1.6.4 Provide applicable requirements for barrier free access in accordance with latest edition of local governing building code.
- 1.6.5 Where any governing Code, Regulation, or Standard requires preparation and submission of special details or drawings for review they are to be prepared and submitted to appropriate authorities. Be responsible for costs associated with these submittals.
- 1.6.6 Unless otherwise specified, install equipment in accordance with equipment manufacturer's recommendations and instructions, and requirements of governing Codes, Standards, and Regulations. Governing Codes, Standards, and Regulations take precedence over manufacturer's instructions.
- 1.6.7 Work is to be performed by journeyperson tradesmen who perform only work that their certificates permit, or by apprentice tradesmen under direct on site supervision of experienced journeyperson tradesman. Journeyperson to apprentice ratio is not to exceed ratio determined by the Board as stated in Ontario College of Trades and Apprenticeship Act or local equivalent governing body in Place of the Work.
- 1.6.8 Journeyperson tradesmen are to have a copy of valid trade certificates available at site for review by Consultant at any time.
- 1.6.9 Experienced and qualified superintendent is to be on-site at times when work is being performed.
- 1.6.10 Coordinate work inspection reviews and approvals with governing inspection department to ensure that construction schedule is not delayed. Be responsible for prompt notification of deficiencies to Consultant and submission of reports and certificates to Consultant.
- 1.6.11 Properly protect equipment and materials on site from damage due to elements and work of trades, to satisfaction of Consultant. Equipment and materials are to be in new condition upon Substantial Performance of the Work.
- 1.6.12 Mechanical piping system work, including equipment, must comply in all respects with requirements of local technical standards authorities and CSA B51, Boiler, Pressure Vessels and Pressure Piping Code. Where required, mechanical work products must bear a CRN

number.

- 1.6.13 Electrical items associated with mechanical equipment are to be certified and bear stamp or seal of a recognized testing agency such as CSA, UL, ULC, ETL, etc., or bear a stamp to indicate special electrical utility approval.

1.7 Healthcare Facility Standards

- 1.7.1 Comply with following CAN/CSA Standards:

- 1.7.1.1 CAN/CSA Z317.13, Infection Control During Construction, Renovation, and Maintenance of Health Care Facilities: Prepare a list of areas of the work where infection control procedures are to be in force and review list and procedures with healthcare facility's Infection Control Officer or a designated healthcare facility representative prior to commencing work in aforementioned areas. As work proceeds, ensure infection control procedures are being maintained.
- 1.7.1.2 CAN/CSA Z317.1, Special Requirements for Plumbing Installations in Health Care Facilities.
- 1.7.1.3 CAN/CSA Z317.2, Special Requirements for Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Health Care Facilities.
- 1.7.1.4 CAN/CSA Z317.10, Handling of Waste Materials in Health Care Facilities and Veterinary Health Care Facilities.
- 1.7.1.5 CAN/CSA Z8000, Canadian Health Care Facilities.
- 1.7.1.6 CAN/CSA Z8001, Commissioning of Health Care Facilities.
- 1.7.1.7 CAN/CSA Z7396.1 Medical Gas Pipeline Systems - Part 1 Pipelines for Medical Gases, Medical Vacuum, Medical Support Gases, and Anaesthetic Gas Scavenging Systems: Prepare a separate set of "as-built" white prints on a day-to-day basis for medical gas piping system work.

- 1.7.2 Comply with healthcare facility's latest policies and procedures regarding infection prevention and decontamination measures during work of project. Refer to additional requirements of Division 01.

1.8 Permits, Certificates, Approvals and Fees

- 1.8.1 Contact and confirm with local authorities having jurisdiction including utility providers, requirements for approvals from such authorities. Obtain and pay for permits, certificates, and approvals required to complete Work.
- 1.8.2 Be responsible for ensuring that authorities having jurisdiction which require on-site inspection of work, have ample notification to perform inspection, with sufficient lead time to correct deficiencies in a manner that will not impede schedule of completion of Work. If any defect, deficiency or non-compliant is found in work by inspection, be responsible for costs of such inspection, including any related expenses, making good and return to site, until work is passed by governing authorities.
- 1.8.3 Submit to Consultant, approval/inspection certificates issued by governing authorities to confirm that Work as installed is in accordance with rules and regulations of local governing authorities and are acceptable.
- 1.8.4 Include in each copy of operating and maintenance instruction manuals, copies of approvals and inspection certificates issued by regulatory authorities.

1.9 Requirements for Contractor Retained Engineers

- 1.9.1 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.

- 1.9.2 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.
- 1.9.3 Unless otherwise specified in Division 00 or 01, liability insurance requirements are as follows:
 - 1.9.3.1 coverage is to be a minimum of \$1,000,000.00 CDN inclusive of any one occurrence;
 - 1.9.3.2 insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;
 - 1.9.3.3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work;
 - 1.9.3.4 retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above;
 - 1.9.3.5 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.

1.10 Interpretation of Drawings

- 1.10.1 The drawings upon which this contract is based show the arrangements, general design and extent of the piping, ductwork and other systems. These systems are suitably outlined on the drawings with regard to sizes, locations, general arrangement and installation details. The mains and connections thereto are shown more or less in diagram, except where in certain cases, the drawings may include details giving the exact locations and arrangements required. All piping and ductwork shall be concealed unless shown otherwise. The Mechanical Contract Drawings do not intend to show Architectural or Structural details.
- 1.10.2 Where any parts of the system and/or pieces of equipment are located by dimensions on the drawings, said dimensions shall be checked and verified in the field. Each Division shall make without additional charge or expense to the Owner, any necessary changes, additions or offsets to the runs to accommodate structural conditions. The Consultant shall be notified immediately, and his authority secured in writing for such revisions before proceeding with the work.
- 1.10.3 As the work progresses, and before installing fixtures and other fittings and equipment which may interfere with the work of other trades, each Contractor shall consult with the Consultant and obtain detail drawings or instructions for the exact location of such equipment.

1.11 Existing Services

- 1.11.1 Where work involves breaking into or connecting existing services, carry out work at times directed by governing authorities, with minimum of disturbance to the premises and its operation.
- 1.11.2 Before commencing work, establish location and extent of service lines in area of work and notify Consultant of finding.
- 1.11.3 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- 1.11.4 Remove abandoned service lines. Cap or otherwise seal lines at cut-off points, in manner approved by authorities having jurisdiction over service.
- 1.11.5 Record locations of maintained, re-routed and abandoned service lines. The sub-contractors concerned shall provide this Division with all necessary dimensions required to accurately locate those services.
- 1.11.6 Where the location of any of these utilities has been shown on the plans, such information is not guaranteed. It is the responsibility of this Division to verify locations, elevations, etc.,

immediately after they move on the site. If for any reason the information obtained necessitates changes in procedures or design, they must advise the Consultant at once. If this verification of existing conditions is not done at the outset and any problems arise, the responsibility for same is entirely this Division's.

- 1.11.7 Where it is necessary to temporarily shut down equipment or services serving essential areas, this Division shall include premium costs to ensure the work force is scheduled for "round the clock" operation in order to minimize disruption and equipment downtime.

1.12 Discrepancies & Omissions

- 1.12.1 The specifications are to be considered as an integral part of the plans which accompany them; neither the plans nor the specifications shall be used alone. Any item or subject omitted from one, but which is mentioned or reasonably implied in the other, shall be considered as properly and sufficiently specified, and must therefore, be provided. Notify the Consultant in writing of any discrepancy between the drawings and the Specifications, or omissions from Documents, or having doubt as to their meaning or intent. Misinterpretations of either the plans or the specifications shall not relieve this Division of responsibility.
- 1.12.2 Carefully examine Documents and visit the site of the building to determine and review existing site conditions that will or may affect work and become thoroughly familiar with all the conditions to be met in carrying out the work covered by these specifications. Include for such conditions in Bid Price. No extras will be allowed for failure to properly evaluate conditions which affect the scope of the work included in Divisions 21, 22, 23 and 25.
- 1.12.3 Report to Consultant, prior to Bid Submittal, any existing site condition that will or may affect performance of work as per Documents. Failure to do so will not be grounds for additional costs.

1.13 Workplace Safety

- 1.13.1 Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage and disposal of hazardous materials. Submit WHMIS MSDS (Material Safety Data Sheets) for products where required, and maintain one copy at site in a visible and accessible location available to personnel.
- 1.13.2 Comply with requirements of Occupational Health and Safety Act and other regulations pertaining to health and safety, including worker's compensation/insurance board and fall protection regulations. When working in confined spaces, comply with requirements of Occupational Health and Safety Act - Ontario Regulation 632, "Confined Spaces" and any other applicable Ministry of Labour requirements.
- 1.13.3 If at any time during course of existing building work, hazardous materials other than those identified in Documents and pertaining to Project Scope of Work, are encountered or suspected that were not identified as being present and which specific instructions in handling of such materials were not given, cease work in area in question and immediately notify Consultant. Comply with local governing regulations with regards to working in areas suspected of containing hazardous materials. Do not resume work in affected area without approval from Consultant.

1.14 Planning and Layout of Work

- 1.14.1 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings.
- 1.14.2 Plan, coordinate, and establish exact locations and routing of services with affected trades prior to installation such that services clear each other as well as other obstructions. Generally, order of right of way for services to be as follows:
- 1.14.2.1 piping requiring uniform pitch;
 - 1.14.2.2 piping 100 mm (4") dia. and larger;
 - 1.14.2.3 large ducts (main runs);

- 1.14.2.4 cable tray and bus duct;
- 1.14.2.5 conduit 100 mm (4") dia. and larger;
- 1.14.2.6 piping less than 100 mm (4") dia.;
- 1.14.2.7 smaller branch ductwork;
- 1.14.2.8 conduit less than 100 mm (4") dia..
- 1.14.3 Unless otherwise shown or specified, conceal work in finished areas, and conceal work in partially finished and/or unfinished areas to extent made possible by the area construction. Install services as high as possible to conserve headroom and/or ceiling space. Notify Consultant where headroom or ceiling space appears to be inadequate prior to installation of work.
- 1.14.4 Do not use Contract Drawing measurements for prefabrication and layout of piping, sheet metal work and such other work. Locations and routing are to generally be in accordance with Contract Drawings, however, prepare layout drawings for such work. Use established bench marks for both horizontal and vertical measurements. Confirm inverts, coordinate with and make allowances for work of other trades. Accurately layout work, and be entirely responsible for work installed in accordance with layout drawings. Where any invert, grade, or size is at variance with Contract Drawings, notify Consultant prior to proceeding with work.
- 1.14.5 Prepare plan and interference drawings (at a minimum drawing scale of 1:50 or 1/4"=1' 0") of work for coordination with each trade Contractor. Arrange for preparation of detailed section drawings of ceiling spaces of corridors and any other congested areas. Sections are to be cross referenced with plan drawings so that trades may make use of section drawings. Section drawings to indicate lateral and elevation dimensions of major services within ceiling space. Lateral dimensions are to be from grid lines and elevations from top of floor slab. Obtain from Consultant, engineering drawings for this use. Contractors' interference drawings are to be distributed among other Trade Contractors. Submit drawings to Consultant for review. Failure of General Contractor to prepare and coordinate overall interface drawings of trades does not relieve respective Division Contractor of responsibility to ensure that work is properly planned and coordinated.
- 1.14.6 Carry out alterations in arrangement of work that has been installed without proper coordination, study, and review, even if in accordance with Contract Documents, in order to conceal work behind finishes, or to allow installation of other work, without additional cost. In addition, make necessary alterations in other work required by such alterations, without additional cost.
- 1.14.7 Shut-off valves, balancing devices, air vents, equipment and similar products, particularly such products located above suspended ceilings must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.
- 1.14.8 Be responsible for making necessary changes, at no additional cost, to accommodate structural and building conditions that were missed due to lack of coordination.

1.15 Coordination of Work

- 1.15.1 Review Contract Documents and coordinate work with work of each trade. Coordination requirements are to include but not be limited to following:
 - 1.15.1.1 requirements for openings, sleeves, inserts and other hardware necessary for installation of work;
 - 1.15.1.2 concrete work such as housekeeping pads, sumps, bases, etc., required for work, and including required dimensions, operating weight of equipment, location, etc.;
 - 1.15.1.3 depth and routing of excavation required for work, and requirements for bedding and backfill;
 - 1.15.1.4 wiring work required for equipment and systems but not specified to be done as part of mechanical work, including termination points, wiring type and size, and any other requirements.

- 1.15.2 Ensure materials and equipment are delivered to site at proper time and in such assemblies and sizes so as to enter into building and be moved into spaces where they are to be located without difficulty.
- 1.15.3 Wherever possible, coordinate equipment deliveries with manufacturers and/or suppliers so equipment is delivered to site when it is required, or so it can be stored within building, subject to available space as confirmed with Owner, and protected from elements.
- 1.15.4 Ensure proper access and service clearances are maintained around equipment, and, where applicable, access space for future equipment removal or replacement is not impeded. Comply with code requirements with regards to access space provision around equipment. Remove and replace any equipment which does not meet this requirement.
- 1.15.5 Where work is to be integrated or is to be installed in close proximity with work of other trades, coordinate work prior to and during installation.

1.16 Openings

- 1.16.1 Supply opening sizes and locations to Consultant to allow verification of their effect on design, and for inclusion on structural drawings where appropriate.
- 1.16.2 No openings are permitted through completed structure without written approval of Consultant. Show required openings on a copy of structural drawings. Identify exact locations, elevations, and size of proposed openings and submit to Consultant for review, well in advance of doing work.
- 1.16.3 Prior to leaving site at end of each day, walk through areas of work and check for any openings, penetrations, holes, and/or voids created under scope of work of project, and ensure that any openings created under scope of work have been closed off, fire-stopped and smoke-sealed. Unless directed by Owner and coordinated with Consultant, do not leave any openings unprotected and unfinished overnight.

1.17 Equipment Loads

- 1.17.1 Supply equipment loads (self-weight, operating weight, housekeeping pad, inertia pads, etc.) to Consultant, via shop drawing submissions, prior to construction.
- 1.17.2 Where given choice of specific equipment, actual weight, location and method of support of equipment may differ from those assumed by Consultant for base design. Back-check equipment loads, location, and supports, and include necessary accommodations.
- 1.17.3 Where supporting structure consists of structural steel framing, it is imperative that equipment loads, location, and method of support be confirmed prior to fabrication of structural steel. Be responsible for confirming locations of equipment with Consultant prior to construction.

1.18 Products

- 1.18.1 Be responsible for ordering of products (equipment and materials) in a timely manner in order to meet project-scheduling timelines. Failure to order products to allow manufacturers sufficient production/delivery time to meet project-scheduling timelines is an unacceptable reason to request for other suppliers or substitutions.
- 1.18.2 Provide Canadian manufactured products wherever possible or required and when quality and performance is obtainable at a competitive price. Products are to be supplied from manufacturer's authorized Canadian representative, unless otherwise noted. Unless otherwise specified, products are to be new and are to comply with applicable respective Canadian standards. References to UL listings of products to include requirements that products are to be also Underwriters Laboratories of Canada (ULC) listed for use in Canada. Products are to meet or exceed latest ANSI/ASHRAE/IES 90.1 standards, as applicable. Do not supply any products containing asbestos materials or PCB materials.
- 1.18.3 Systems and equipment of this Project are to be "State of the Art" and be most recent and up to date series/version of product that is available at time of shop drawing review process. Products that have been stored or "on shelf" for an extended period of time will not be accepted. Software

is to be of latest version available and be provided with updates available at time of shop drawing review process. Systems are to be designed such that its software is backwards compatible. Future upgrades are not to require any hardware replacements or additions to utilize latest software.

- 1.18.4 Products scheduled and/or specified have been selected to establish a performance and quality standard, and, in some instances, a dimensional standard. In most cases, base specified manufacturers are stated for any product specified by manufacturer's name and model number. Where acceptable manufacturers are listed, first name listed is base specified company. Bid Price may be based on products supplied by any of manufacturers' base specified or named as acceptable for particular product. If acceptable manufacturers are not stated for a particular product, base Bid Price on product supplied by base specified manufacturer.
- 1.18.5 Documents have been prepared based on product available at time of Bidding. If, after award of Contract, and if successful manufacturer can no longer supply a product that meets base specifications, notify Consultant immediately. Be responsible for obtaining other manufacturers product that complies with base specified performance and criteria and meets project timelines. Proposed products are subject to review and consideration by Consultant and are considered as substitutions subject to a credit to Contract. In addition, if such products require modifications to room spaces, mechanical systems, electrical systems, etc., include required changes. Such changes are to be submitted in detail to Consultant for review and consideration for acceptance. There will be no increase in Contract Price for revisions. Above conditions supplement and are not to supersede any specification conditions with regards to substitutions or failure to supply product as per issued documents.
- 1.18.6 Listing of a product as "acceptable" does not imply automatic acceptance by Consultant and/or Owner. It is responsibility of Contractor to ensure that any price quotations received and submittals made are for products that meet or exceed specifications included herein.
- 1.18.7 If products supplied by a manufacturer named as acceptable are used in lieu of base specified manufacturer, be responsible for ensuring that they are equivalent in performance and operating characteristics (including energy consumption if applicable) to base specified products. It is understood that any additional costs (i.e. for larger starters, larger feeders, additional spaces, etc.), and changes to associated or adjacent work resulting from provision of product supplied by a manufacturer other than base specified manufacturer, is included in Bid Price. In addition, in equipment spaces where equipment named as acceptable is used in lieu of base specified equipment and dimensions of such equipment differs from base specified equipment, prepare and submit for review accurately dimensioned layouts of rooms affected, identifying architectural and structural elements, systems and equipment to prove that equipment in room will fit properly meeting design intent. There will be no increase in Contract Price for revisions.
- 1.18.8 In addition to manufacturer's products base specified or named as acceptable, other manufacturers of products may be proposed as substitutions to Consultant for review and consideration for acceptance, listing in each case a corresponding credit for each substitution proposed. However, base Bid Price on products base specified or named as acceptable. Certify in writing to Consultant that proposed substitution meets space, power, design, energy consumption, and other requirements of base specified or acceptable product. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally or architecturally, required by acceptance of proposed substitution. Consultant has sole discretion in accepting any such proposed substitution of product. Indicate any proposed substitutions in areas provided on Bid Form. Do not order such products until they are accepted in writing by Consultant.
- 1.18.9 Where products are listed as "or approved equal", certify in writing that product to be used in lieu of base specified product, at least meets space, power, design, energy consumption, and other requirements of base specified product and is equivalent or better than base specified product. When requested by Consultant, provide full design detail drawings and specifications of proposed products. Acceptance of these "or approved equal" products is at sole discretion of Consultant. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally or architecturally, required by acceptance of approved equal product. There must be no increase in Contract price

due to Consultant's rejection of proposed equivalent product.

- 1.18.10 Whenever use of product other than base specified product is being supplied, ensure corresponding certifications and product information (detailed catalogue and engineering data, fabrication information and performance characteristics) are submitted to Consultant for review. Failure of submission of these documents to Consultant in a timely manner to allow for review will result in base specified product to be supplied at Consultant's discretion, at no additional cost to Contract.
- 1.18.11 Products supplied by a manufacturer/supplier other than a manufacturer listed as acceptable may be considered for acceptance by Consultant if requested in writing with full product documentation submitted, a minimum of 10 working days prior to Bid closing date.
- 1.18.12 Any proposed changes initiated by Contractor after award of Contract may be considered by Consultant at Consultant's discretion, with any additional costs for such changes if approved by Consultant, and costs for review, to be borne by Contractor.
- 1.18.13 Whenever use of product other than based specified products or named as acceptable is being supplied, time for process of submission of other products and Consultant's review of products will not alter contract time or delay work schedule.

1.19 Material Substitution

- 1.19.1 The following requirements are aimed to establish a certain quality of materials to be used.
- 1.19.2 Besides, the objective is not to eliminate the loyal competition in the tender process applied to materials and substitute products.
- 1.19.3 Equivalences can be submitted on a list separated from the tender form, but attached to the basic submission. A global amount for several equivalences is not acceptable. If no list is annexed to its basic submission, the Contractor accepts and agrees to do the works such as written in the specification for the aforementioned project with the specified materials.
- 1.19.4 No request of replacement will be studied during the submission period and if it is received after the opening of the submissions, except when the material or the concerned product became unavailable. Only the equivalence proposition in appendix of the basic submission will be studied.
- 1.19.5 The equivalences will be accepted only on the following conditions:
 - 1.19.5.1 Equivalence must be submitted before the contract;
 - 1.19.5.2 Proofs of equivalences will be required and this at the Supplier's fees;
 - 1.19.5.3 Samples of the proposed material or equipment and the specified material or equipment may be required;
 - 1.19.5.4 The main points of comparison are: construction, efficiency, capacity, dimensions, weight, service access, minimal standard, availability and delivery of spare parts, maintenance, delivery deadlines, origin of the product, etc.
- 1.19.6 Any equivalence requiring an increase of the installation time or a surplus of auxiliary materials or any modification which would ensue from it, will not justify an additional payment for the Contractor. The basic price has to include all these changes.
- 1.19.7 Documents having been prepared with the dimensions and the characteristics of devices specified in the specification, the Contractor is solely responsible to make sure that the equivalence he proposes can settle down without change in the plans, not so as to modify the conditions of the original design and the spirit of the contract, and has to verify that all dimensions of the equivalences are suitable to the project. He has to inform the Engineer, in writing, that the equipment which he suggests as equivalence meets these requirements and to ask for its approval.
- 1.19.8 The Consultant reserves the right to accept or to refuse one or several equivalences (materials considered equivalent by the Contractor); his decision is final. The basic price of the submission will be adjusted more or less, according to the acceptance of the Engineer.

1.20 Access Panels & Doors

1.20.1 For Non-Fire-Rated Separation (Drywall Ceilings & Walls):

- 1.20.1.1 Supply for finished drywall ceilings and walls, APS (Bauco-Plus II) recessed access door of a suitable size to provide access to plumbing cleanouts and for servicing dampers, valves and equipment which will be concealed.
- 1.20.1.2 Access door to be designed for flush installation in drywall surfaces. Access door is recessed 1" to receive drywall. The flange of the door is a textured galvanized steel taping bend with pre-punched holes. Drywall compound is applied over the beading at the same time as the drywall joints are finished
- 1.20.1.3 Door to be 16 gauge prime-coated steel with 14 gauge steel frame and screwdriver operated can latch.
- 1.20.1.4 Prime Mechanical Contractor shall include for the installation of all access doors supplied by Division 21, 22, 23 and 25. Engage and pay the respective General Trade on site to install same.

1.20.2 For Non-Fire-Rated Separation (Not Drywall Ceilings & Walls):

- 1.20.2.1 Supply for finished ceiling or wall surfaces that are not of drywall construction, Smillie, McAdams Summerlin Limited, Le Hage (Ancon Industries Incorporated) access doors of a suitable size to provide access to plumbing cleanouts and for servicing dampers, valves and equipment which will be concealed. Minimum size for reach-in access to be 12" x 12" (300 mm x 300 mm) and 18" x 18" (450 mm x 450 mm) for man access.
- 1.20.2.2 Door and frame to be 16 gauge prime-coated steel with concealed hinges and positive locking and self-opening screwdriver lock.
- 1.20.2.3 Prime Mechanical Contractor shall include for the installation of all access doors supplied by Divisions 21, 22, 23, 25. Engage and pay the respective General Trade on site to install same.

1.20.3 Fire-Rated Separations:

- 1.20.3.1 Supply access doors in fire-rated ceiling assemblies, walls and shafts. Access doors shall be Smillie, McAdams Summerlin Limited, Le Hage (Ancon Industries Incorporated), ULC listed, manufactured and installed in accordance with NFPA-80.
- 1.20.3.2 Door to be complete with 16 gauge steel frame with concealed continuous hinge and key-operated lock and self closer, double wall 20 gauge prime-coated steel door with 2" (50 mm) thick insulation.
- 1.20.3.3 ULC rating 1-1/2 hours, temperature rise maximum 250°F (120°C) in thirty (30) minutes.
- 1.20.3.4 Prime Mechanical Contractor shall include for the installation of all access doors supplied by Divisions 21, 22, 23, 25. Engage and pay the respective General Trade on site to install same.

1.20.4 For access doors located in the Operating Room ceiling and in the soffit beneath the Operating Room addition, refer to architectural for final locations and details.

1.20.5 Size access panel doors to provide adequate access and correspond with the type of structural and architectural finish.

1.20.6 Ensure proper fire resistance rating of doors/panels in fire separations.

1.20.7 Provide the following:

- 1.20.7.1 Type RW recessed for "SG" board in wet areas.
- 1.20.7.2 Type TM flush mount for tile and masonry.
- 1.20.7.3 Type WB flush for wall board.

1.20.8 Materials & Finish:

1.20.8.1 Galvanized bonderized steel, phosphate-dipped with baked-on rust inhibitive grey prime finish.

1.20.8.2 Stainless steel with No. 4 finish in Shower, Wet Washrooms and Drying Areas.

1.20.9 Acceptable Products:

1.20.9.1 Le Hage

1.20.9.2 Milcor

1.20.9.3 Acudor

1.20.9.4 Nystrom

1.20.9.5 Access Panel Solutions Inc. (Bauco - Plus II) for Drywall

1.21 Concrete Work & Supports

1.21.1 Installation of concrete bases for all mechanical equipment shall be by this Division.

1.21.2 Prime Mechanical Contractor shall construct the bases. Provide accurate templates for the concrete trade to pour the bases.

1.21.3 For equipment suspended from the building structure, provide all structural members, platforms, brace and hanger rods as required. Method of attachment to be reviewed with the Structural Consultant before proceeding with the installation.

1.21.4 For pre-cast slabs, Prime Mechanical Contractor shall co-ordinate all openings for pipes and ducts with the Precast Concrete Erector. The Precast Concrete Erector shall be responsible for drilling or cutting all holes through precast slabs. Holes through the structural slabs shall be sleeved as specified herein.

1.22 Flashing

1.22.1 The Prime Mechanical Contractor shall provide flashings for the work of this Division. If not specified, a description is to be supplied for approval.

1.22.2 Generally, all pipes and small ducts or stacks passing through the roof shall be flashed with an 18 gauge steel sleeve soldered watertight and fastened to the roof deck before the roofing is applied with a minimum of 8" (200 mm) overlap along the roof deck and extending 8" (200 mm) up the pipe or duct, sealed with a weather skirt.

1.22.3 Vent stacks may be flashed with patented flashing cones provided with the equipment.

1.22.4 Where large ducts pass through roof, curbs and flashing shall be by this Division where shown on the roofing plan. If not shown, all curbs, flashings and counter flashing are by this Division.

1.23 Painting

1.23.1 Mechanical equipment, grilles, fans, shall be shop prime coated unless noted to be finish coated. Where the prime coat or finish coat has been marred, touch up the surface.

1.23.2 Equipment exposed to the exterior weather conditions are to be shop finished with rust-resistant paint or as specified in equipment specification.

1.23.3 Leave all work in a clean, paintable condition.

1.23.4 All exposed structural members required for supporting piping, ductwork and equipment shall be galvanized. Where threaded rods are used, they shall be cadmium plated including washers and nuts.

1.23.5 Paint pipe sleeves one (1) coat primer.

1.23.6 Paint all relief and drain pipes serving Mechanical equipment, flat black.

1.24 Cutting & Patching

- 1.24.1 It is the responsibility of the Prime Mechanical Contractor to install sleeves for piping and ducts, and provide frames for opening for grilles, louvres, fans and similar equipment to be built into the existing building. All structural components must have the location, size and proposed method of cutting approved before proceeding.
- 1.24.2 Should damage occur to the work of other trades and Divisions, remedial work will be done by the trade who originally installed the work, at the expense of the sub-contractor who caused the damage.
- 1.24.3 Where pipes and ducts pass through walls in the existing building, the cutting and patching is by the Prime Mechanical Contractor.
- 1.24.4 Co-ordinate work with Division 01 for Firestopping and Smoke Seals.

1.25 Sleeves

- 1.25.1 Provide pipe sleeves at points where pipes (plumbing, heating, sprinkler, gas, etc.) pass through masonry of minimum 22 gauge thickness galvanized sheet steel with lock seam joints. Where ducts pass through masonry provide suitable 18 gauge galvanized steel sleeves. Size sleeves on insulated piping or ducts to permit insulation to continue through. Where piping or ducts pass through concrete or frame construction, provide 1/8" (3 mm) thick galvanized iron sleeves. On copper pipe provide copper pipe sleeves.
- 1.25.2 Use cast iron or steel pipe sleeves with annular fin continuously welded at midpoint, through foundation walls and where sleeve extends above finished floor.
- 1.25.3 Provide 1/8" (3 mm) clearance all around, between sleeve and pipes or between sleeve and insulation and where piping passes below footings, provide minimum clearance of 2" (50 mm) between sleeve and pipe. Backfill up to underside of footing with concrete of same strength as footing.
- 1.25.4 Terminate sleeves flush with surface of concrete and masonry and 2" (50 mm) above floors. Not applicable to concrete floors on grade.
- 1.25.5 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction; caulk between sleeve recess and pipe; fasten roof flashing to clamp device; make watertight durable joint.
- 1.25.6 Fill voids around pipes.
 - 1.25.6.1 Where sleeves pass through walls or floors, caulk space between insulation and sleeve or between pipe and sleeve with waterproof, fire-retardant, non-hardening mastic. Seal space at each end of sleeve with waterproof, fire-retardant, non-hardening mastic.
 - 1.25.6.2 Ensure no contact between copper pipe and ferrous sleeve.
- 1.25.7 Co-ordinate work with Division 01 for Firestopping and Smoke Seals.

1.26 Escutcheons & Plates

- 1.26.1 Provide on exposed pipes passing through finished walls, partitions, floor and ceilings.
- 1.26.2 Use chrome or nickel-plated brass, solid type with set screws for ceiling or wall mounting.
- 1.26.3 Inside diameter shall fit around finished pipe. Outside diameter shall cover sleeve.
- 1.26.4 Where sleeve extends above finished floor, escutcheons or plates shall clear sleeve extension.
- 1.26.5 Secure to pipe or finished surface.

1.27 Dielectric Couplings

- 1.27.1 Provide wherever pipes of dissimilar metals are joined.

1.27.2 Provide insulating unions for pipe sizes 2"Ø (50 mm) and smaller, and flanges for pipe sizes 2-1/2" (65 mm) and larger. Brass adaptors and bronze valves will not be accepted.

1.27.3 Provide an isolating separation wherever piping may touch dissimilar metal studs, joists, concrete, etc.

1.28 Fire Stopping

1.28.1 The Prime Mechanical Contractor is responsible for all fire stopping related to the work of Division 21, 22, 23 and 25 including, but not limited to, the ductwork, piping and control wiring.

1.29 Impeller, Sheave & Belt Changes

1.29.1 The Prime Mechanical Contractor to carry the costs for pump impeller, fan sheave and belt changes. See Section 20 05 50 - Testing, Adjusting and Balancing.

1.30 Non-Ferrous Materials

1.30.1 Materials within designated imaging rooms to be of non-ferrous construction as coordinated with Consultant. Devices, system components, etc., utilized to be approved for use in designated imaging room type applications. Methods of construction to take into consideration use of non-ferrous materials. Ultimate approval of any materials, devices or components, or methods of construction to be at imaging system manufacturer's discretion. Coordinate and confirm final requirements with successful imaging system supplier.

1.31 Scaffolding, Hoisting and Rigging

1.31.1 Unless otherwise specified or directed, supply, erect and operate scaffolding, rigging, hoisting equipment and associated hardware required for work, and subject to review by and coordination with Consultant. Include for the cost of dismantling and reassembling equipment, where required, to the manufacturer's approval.

1.31.2 Direct this work by qualified people normally engaged in rigging, hoisting and handling of equipment.

1.31.3 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.

1.31.4 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Consultant.

1.32 Protection

1.32.1 Protect work from damage. Securely plug or cap open ends of conduits, pipes, ducts or equipment to prevent entry of dirt, dust, debris, water, snow or ice. Cover all items cast into concrete floors/walls such as floor drains, cleanouts, etc., prior to pour, with heavy plastic tape or duct tape. Clean all piping, ducting, conduits and equipment inside and outside before testing.

1.32.2 Material stored on site shall be protected from weather and kept dry and clean at all times. Take care to avoid corrosion of metal parts. Protect all bearings and motors from damage due to moisture and dust. Equipment not yet in operation shall be turned over at least at monthly intervals to prevent bearing deterioration.

1.33 Rights Reserved

1.33.1 Rights are reserved to furnish any additional detail drawings which, in the judgement of the Consultant, may be necessary to clarify the Work and such drawings shall form a part of the Contract.

1.34 Superintendence

1.34.1 Maintain at this job site, at all times, qualified personnel and supporting staff with proven

experience in erecting, supervising, testing and adjusting projects of comparable nature and complexity.

1.35 Co-Ordination

- 1.35.1 The Prime Mechanical Contractor is responsible for co-ordinating the mechanical work herein to suit Project Phasing Schedule.
- 1.35.2 Co-ordinate all Mechanical Work with the work of any other Divisions to avoid conflicts. Be responsible for modifying the work of this Division to accommodate space conflicts.
- 1.35.3 Failure to co-ordinate will result in installed work being removed and new work put in place without cost to the Owner.

1.36 Maintenance

- 1.36.1 Furnish spare parts in accordance with Division 01 requirement and as follows:
 - 1.36.1.1 One set of packing for each pump.
 - 1.36.1.2 One casing joint gasket for each size pump.
 - 1.36.1.3 One filter cartridge or set of filter media for each filter or filter bank in addition to final operation set.
 - 1.36.1.4 One glass for each gauge glass.
- 1.36.2 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Division 01 requirement.
- 1.36.3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.37 Delivery, Storage & Handling

- 1.37.1 Transport, store and handle the materials in conformance with the manufacturer's instructions.
- 1.37.2 Delivery and receipt:
 - 1.37.2.1 Deliver the materials to the job site in their original packaging. The name and the address of the manufacturer marked must be labelled on the packaging.
- 1.37.3 Storage and protection:
 - 1.37.3.1 Store the materials in a dry environment.
 - 1.37.3.2 Store the materials in the temperature and humidity conditions recommended by the manufacturer, and protect them from exposure to extreme weather conditions.
- 1.37.4 Packaging waste management: recover the packaging waste so that it may be re-used or recycled or reclaimed by the manufacturer. This includes pallets, lockers, packing and other packing material.

1.38 Tendering Instructions

- 1.38.1 Refer to the General Conditions for the Instructions to Bidders.
- 1.38.2 The Prime Mechanical Contractor agrees to employ those subcontractors proposed in the Mechanical Form(s) of Tender and accepted by the Owner at the signing of the Contract.
- 1.38.3 The Owner may, for reasonable cause, object to the use of a proposed subcontractor and consequently, may require the Prime Mechanical Contractor to employ one of the other subcontractor bidders.
- 1.38.4 In the event that the Owner requires a change from a proposed subcontractor, originally proposed by the Prime Mechanical Contractor, the Contract Price shall be adjusted by the difference in cost.

- 1.38.5 The Prime Mechanical Contractor shall not be required to employ as a subcontractor, a firm to whom he may reasonably object.
- 1.38.6 Work of subcontractors named at the time of Tender or substitutions authorized by the Owner will be recognized as being in accordance with the Contract Documents and any payments will be approved by the Owner, only to such subcontractors.

1.39 Changes in the Work

- 1.39.1 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 approval, a quotation being proposed cost for executing change or revision.
- 1.39.2 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.
- 1.39.3 If overhead and profit percentages are not specified in Division 00 or 01, but allowable under Contract as confirmed with Consultant prior to contract signing, then allowable maximum percentages for overhead and profit are to be 7% and 5% respectively.
- 1.39.4 Unless otherwise specified in Divisions 00 or 01, following additional requirements apply to all quotations submitted:
 - 1.39.4.1 when change or revision involves deleted work as well as additional work, cost of deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from cost of additional work before overhead and profit percentages are applied to additional work;
 - 1.39.4.2 material costs are not to exceed those published in local estimating price guides;
 - 1.39.4.3 mechanical material labour unit costs are to be in accordance with Mechanical Contractors Association of America Labor Estimating Manual, less 25%;
 - 1.39.4.4 electrical material labour unit costs are to be in accordance with National Electrical Contractors Association Manual of Labor Units at difficult level, less 25%;
 - 1.39.4.5 costs for journeyperson and apprentice labour must not exceed prevailing rates at time of execution of Contract and must reflect actual personnel performing work;
 - 1.39.4.6 cost for site superintendent must not exceed 10% of total hours of labour estimated for change or revision, and change or revision must be such that site superintendent's involvement is necessary;
 - 1.39.4.7 costs for rental tools and/or equipment are not to exceed local rental costs;
 - 1.39.4.8 overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals;
 - 1.39.4.9 quotations, including those for deleted work, to include a figure for any required change to Contract time.
- 1.39.5 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable Consultant to expeditiously process quotation and issue a Change Order will not be grounds for any additional change to Contract time.
- 1.39.6 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- 1.39.7 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.40 Progress Payment Breakdown

- 1.40.1 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.

- 1.40.2 Payment breakdown is subject to Consultant's approval and 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.

- 1.40.3 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.

1.41 Notice for Required Field Reviews

- 1.41.1 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.

- 1.41.2 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.

- 1.41.3 Do not conceal work until Consultant advises that it may be concealed.

- 1.41.4 When Consultant is requested to perform a field review and work is not ready to be reviewed, reimburse Consultant for time and travel expenses.

1.42 Submittals

- 1.42.1 Submittals: in accordance with Division 01.

- 1.42.2 Shop drawings to show:

1.42.2.1 Mounting arrangements.

1.42.2.2 Operating and maintenance clearances.

- 1.42.3 Shop drawings and product data accompanied by:

1.42.3.1 Detailed drawings of bases, supports, and anchor bolts.

1.42.3.2 Acoustical sound power data, where applicable.

1.42.3.3 Points of operation on performance curves.

1.42.3.4 Manufacturer to certify current model production.

1.42.3.5 Certification of compliance to applicable codes.

- 1.42.4 In addition to transmittal letter referred to in Division 01: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.

- 1.42.5 Closeout Submittals:

1.42.5.1 Provide operation and maintenance data for incorporation into manual specified in Division 01.

1.42.5.2 Operation and maintenance manual approved by, and final copies deposited with, Consultant before final inspection.

1.42.5.3 Operation data to include:

1.42.5.3.1 Control schematics for systems including environmental controls.

1.42.5.3.2 Description of systems and their controls.

1.42.5.3.3 Description of operation of systems at various loads together with reset schedules and seasonal variances.

- 1.42.5.3.4 Operation instruction for systems and component.
- 1.42.5.3.5 Description of actions to be taken in event of equipment failure.
- 1.42.5.3.6 Valves schedule and flow diagram.
- 1.42.5.3.7 Colour coding chart.
- 1.42.5.4 Maintenance data to include:
 - 1.42.5.4.1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - 1.42.5.4.2 Data to include schedules of tasks, frequency, tools required and task time.
- 1.42.5.5 Performance data to include:
 - 1.42.5.5.1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - 1.42.5.5.2 Equipment performance verification test results.
 - 1.42.5.5.3 Special performance data as specified.
 - 1.42.5.5.4 Testing, adjusting and balancing reports as specified in Section 20 05 50 - Testing, Adjusting and Balancing.
- 1.42.5.6 Approvals:
 - 1.42.5.6.1 Submit two (2) copies of draft Operation and Maintenance Manual to Consultant for review. Submission of individual data will not be accepted unless directed by Consultant.
 - 1.42.5.6.2 Make changes as required and re-submit as directed by Consultant.
- 1.42.5.7 Additional data:
 - 1.42.5.7.1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- 1.42.5.8 As-built drawings:
 - 1.42.5.8.1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.
 - 1.42.5.8.2 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).
 - 1.42.5.8.3 Submit to Consultant for review and make corrections as directed.
 - 1.42.5.8.4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
 - 1.42.5.8.5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- 1.42.5.9 Submit copies of as-built drawings for inclusion in final TAB report.
- 1.42.5.10 Site records:
 - 1.42.5.10.1 Engineer will provide one set of mechanical drawings. Mark changes as work progresses and as changes occur.
 - 1.42.5.10.2 Transfer information to reproducible, revising reproducible to show work as actually installed.

1.42.5.10.3 Use different colour waterproof ink for each service.

1.42.5.10.4 Make available for reference purposes and inspection.

1.43 Record Drawings

- 1.43.1 The Consultant will provide an extra set of whiteprints to be marked up by this Division as the job progresses, showing all changes and deviations from the plans, so that on completion of the job, the Consultant will have a record of the exact location of all piping, ductwork and equipment. These drawings shall be available during construction at all times and will be reviewed monthly by the Consultant.
- 1.43.2 Record drawings shall locate all concealed shut-off valves, dampers, control valves and concealed air vents.
- 1.43.3 The Consultant will provide to the Prime Mechanical Contractor the AutoCAD disk for a fee. The Prime Mechanical Contractor will be required to sign "Transfer of Files on Electronic Media" Form and pay the fee in order to receive the files. A sample of this form is attached to the section. Return completed disks to the Consultant with Maintenance Manuals.

1.44 Interference Drawings

- 1.44.1 Before shop fabrication begins or undertaking installation work inside the building, prepare an integrated set of mechanical interference sketches, where indicated on the drawings.
- 1.44.2 These sketches shall be prepared by the Prime Mechanical Contractor with the co-operation of other trades and shall show the location or space allocated for the work of each trade.
- 1.44.3 Submit two (2) copies of detailed interference sketches, showing structural members, electrical conduits, devices and all Mechanical elements to the Consultant for review and general approval before proceeding with the work.
- 1.44.4 Copies of these reviewed interference drawings shall be submitted to all trades, the General Contractor, the Architect, and the Consultant, and general approval shall be obtained before the space allotment and installation.
- 1.44.5 As a minimum, interference drawings shall be made for all areas of mechanical equipment rooms, duct shafts and corridor ceiling spaces.
- 1.44.6 Work that has been installed before review of interference drawings, and has been determined that it is in conflict with the building, shall be removed from the site at no extra cost to the Owner. The work, approved by the Consultant, shall be installed at no extra cost to the Owner.

1.45 Materials & Equipment - Acceptable Products, Base Bid, Alternate Products, Unsolicited Alternates

- 1.45.1 Provide materials and equipment in accordance with Division 01.
- 1.45.2 Equipment and material to be CSA certified and manufactured to standards specified herein.
- 1.45.3 Factory assemble control panels and component assemblies.
- 1.45.4 The Specification indicates Acceptable Product manufacturers (or Acceptable Manufacturers) for various products, materials and systems which make up the mechanical work. The Tender Price shall be based on any of the "Acceptable Products".
- 1.45.5 The Specifications may also indicate Base Bid and Approved Alternate (or Alternate Products) manufacturers for various products, materials and systems. For such cases, the Tender Price MUST be based on the "Base Bid" manufacturer/system. The net dollar addition or deduction to/from the Tender Price for each "Approved Alternate" shall be indicated on the Bid Form 00 41 00 or letter attached to the Bid Form for consideration by the Consultant.
- 1.45.6 The net dollar deduction from the Tender Price if the alternate is accepted. This value shall reflect all costs associated with the incorporation of the alternate into the work, including any required changes in Architectural, Structural, Electrical and other Mechanical Sections and the

Consultants costs of revising the design to suit.

- 1.45.7 The Owner reserves the right to accept or reject any or all "Approved Alternates".

1.46 Manufacturers, Shop Drawings & Submittals

- 1.46.1 Before fabrication of any materials and/or equipment, submit shop drawings and data sheets covering all items of equipment listed as requiring shop drawings. Shop drawings to be submitted are listed in each section under SUBMITTALS. These will be reviewed and returned to the Contractor. Materials shall not be ordered until "accepted" review has been given.
- 1.46.2 The Prime Mechanical Contractor is to consult with the Consultant on the manner in which drawings will be handled. Supply metric information for metric projects.
- 1.46.3 Equipment requiring electrical wiring by Division 26 will have the electrical wiring diagrams submitted with the shop drawings. Shop drawings will not be reviewed unless wiring diagrams accompany the equipment drawings.
- 1.46.4 For whiteprint-type shop drawings, eight (8) copies as required. For 8-1/2" x 11" fixture cuts, submit eight (8) copies of booklets as required.
- 1.46.5 The Prime Mechanical Contractor is to keep track of the shop drawings and the subsequent equipment delivery using a Review Summary Form similar to the form shown below. This form is to be updated and presented at each job meeting until all the equipment is on the job.
- 1.46.6 The shop drawings must apply to the equipment under consideration. Advertising literature and comprehensive data sheets are not acceptable.
- 1.46.7 The shop drawings must contain the following information: job name, equipment tag, actual dimensions of unit and dimensioned location and size of all field connections, model, performance curves, capacity, HP, voltage and all accessories listed in the specifications and/or being provided, and the operating points of the proposed equipment. Room schedules are to be provided for multiple units.
- 1.46.8 The shop drawings submitted for review must first be carefully checked by the Prime Mechanical Contractor and bear the Contractor's identification review stamp or signature. Drawings will not be considered otherwise.
- 1.46.9 Shop drawing review is for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Any action shown is subject to the requirements of the contract documents. Contractor is responsible for the dimensions which shall be confirmed and correlated at the job site; fabrication processes and techniques of construction; coordination of his or her work with that of all other trades; and the satisfactory performance of his or her work.
- 1.46.10 Shop drawings will be returned "No Exception Taken", "Revise & Resubmit", "Make Corrections Noted, Resubmission Not Required" or "Rejected, Submit Compliant Product/System".
- 1.46.10.1 "No Exception Taken" Drawings shall be considered as conforming with the design concept.
- 1.46.10.2 "Make Corrections Noted, Resubmission Not Required" Drawings shall be considered as conforming with the design concept once corrections have been made as noted on the drawings. This notation shall not hold up manufacture. These drawings shall be corrected for final submission with project Maintenance/Operation manuals.
- 1.46.10.3 "Revise & Resubmit" Drawings shall be considered as conforming with the design concept once corrections have been made as noted on the drawings. These drawings shall be corrected and resubmitted for final review but such resubmission shall not hold up manufacture.
- 1.46.10.4 "Rejected, Submit Compliant Product/System" These drawings are rejected and work shall not proceed on the manufacture of this equipment. The drawings shall be re-drawn or corrected, and resubmitted with corrections as noted on the drawings or a

letter attached thereto.

1.46.11 All shop drawings must be submitted promptly.

[illegible]

STATUS LEGEND

'A' - No Exception Taken
'C' - Make Corrections Noted, Resubmission Not Required

'B' - Revise & Resubmit
'D' - Rejected, Submit Compliant Product/System

1.47 Operation & Maintenance Manuals

- 1.47.1 During the one (1) year guarantee period, commencing after Substantial Completion Letter has been issued by the Consultant's Office, maintain all equipment installed as part of this Division. This is to include lubrication of bearings, cleaning of strainers, etc., except the replacement of air filters and water treatment. This agreement shall be part of the written guarantee. This work shall be carried out in the presence of the owner's representative, and a letter shall be sent to the Consultant stating that this work was carried out. Three (3) maintenance inspections must be carried out by the Prime Mechanical Contractor during this one (1) year period, evenly spaced over the time frame. (after Substantial Completion Letter issued by the Architect). Submit written report to Owner and Consultant after each inspection.
- 1.47.2 This maintenance shall continue up to the date of instruction of the Owner's designated representatives, at which time each piece of equipment is to be lubricated and checked in the presence of the Owner's representative(s).
- 1.47.3 Not later than three (3) weeks prior to application for inspection by Consultant for Substantial Performance, submit records and maintenance manuals to Consultant.
- 1.47.4 Prepare two (2) sets of "letters" sized, hard-cover, three-ring, black, maintenance manuals, containing dimensioned certified prints of each piece of mechanical equipment and Manufacturer's recommended maintenance instructions, air balancing reports, and wiring diagrams. Tabulated at the front of this binder is to be a maintenance schedule for each piece of equipment, and lubricant to be used, and a tabulation of things to be checked at each piece of equipment.
- 1.47.5 Maintenance Manuals will be requested by the Consultant shortly after the final submission of all shop drawings. Maintenance manuals must be submitted and reviewed before training of the Owner's personnel and before a final inspection will be carried out.
- 1.47.6 In addition to the three (3) maintenance inspections called for in Item .1, the Prime Mechanical Contractor shall organize and attend bi-weekly site meetings with the Owner's Representative to review mechanical system deficiencies. The meetings will commence after substantial completion of the project has been granted and extend for four (4) months for a total of nine (9) meetings. The Prime Mechanical Contractor will take minutes of each meeting indicating status of all mechanical deficiencies. The Prime Mechanical Contractor shall issue copies of the minutes to the Owner and Mechanical Consultant after each meeting.

1.48 Temporary or Trial Usage

- 1.48.1 Do not use any permanent Mechanical Systems during construction unless specific written approval is obtained from the Consultant.
- 1.48.2 Temporary or trial usage of any mechanical device, machinery, apparatus, equipment or materials shall not be construed as evidence of acceptance of same and no claim for damage shall be made for injury to or breaking of any part of such work which may so be used.
- 1.48.3 Where the Owner permits the use of a system the Prime Mechanical Contractor shall be in charge of and maintain all equipment in accordance with manufacturers instruction at all times the systems are in operation.
- 1.48.4 The use of permanent systems shall not invalidate the guarantee or warranty.
- 1.48.5 Prior to final acceptance, return all equipment to as new condition and provide supplier certification of same.

1.49 Time for Completion

- 1.49.1 Review the general contract requirement for completion dates. Identify at the time of tender any items which may affect the time for completion.
 - 1.49.1.1 Advise the Consultant if materials and equipment involves longer delivery times than indicated in the schedule.
 - 1.49.1.2 Monitor and expedite delivery of equipment and materials. If necessary, inspect at source of manufacture.

1.49.2 Be responsible for failure of, or delay in, the delivery of specified equipment.

1.50 Preliminary Testing

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

1.51 Testing & Adjusting

- 1.51.1 Test all piping systems for leaks providing gauges, materials and labour as required. Equipment furnished as part of the permanent installation shall not be used for testing purposes. Before testing, remove all equipment which is not designed to withstand the test pressures. All piping is to be tested before covering is applied, and before backfilling or concealing.
- 1.51.2 **Hydrostatic Tests:** All pressure pipe is to be tested as described in each Section. Test pressure shall be maintained for the times noted, during which time the pressure test shall remain constant without pumping.
- 1.51.3 **Gravity Piping:** All gravity drainage piping shall be given a ball test and a water test, which must be supervised and inspected by the local Plumbing Inspector.
- 1.51.4 All testing shall be done to the satisfaction and approval of the Consultant and the Division shall notify the Consultant forty-eight (48) hours prior to testing.
- 1.51.5 Before final payment, test the operation of each system and all equipment installed, make all necessary adjustments and replacements, and demonstrate to the satisfaction of the Consultant that all equipment is operating as intended and without undue noise and vibration.
- 1.51.6 All tests must be witnessed by the Owner's Authorized Representative. Failure to do so will result in a re-test.
- 1.51.7 If system pumps are used during the system flushing, Prime Mechanical Contractor shall supply and install replacement pump seals in each pump, once flushing is complete and tests results accepted.

1.52 Start-Up & Instruction

- 1.52.1 The Prime Mechanical Contractor shall start-up equipment and operate for a minimum of five (5) days. During this time, adjust controls, clean strainers, replace faulty gauges and thermometers, fasten loose equipment and reduce noise.
- 1.52.2 The start-up procedure shall include the completion of the enclosed Equipment Start-Up and Acceptance Check List, which shall be signed by the Mechanical foreman, the Sheet Metal foreman, and Controls foreman where applicable and Electrical foreman certifying they have verified the equipment is ready for acceptance by the Consultant and Owner. When all of the Check Lists have been signed off, the Mechanical foreman and his Sub-Contractors shall demonstrate the operation of the equipment to the Consultant and Owner for sign off acceptance. There shall be an individual Check List sheet for each individual piece of equipment.

- 1.52.3 When the sign off procedure is complete, the Prime Mechanical Contractor shall instruct the Owner's designated representative in the operation and maintenance of all equipment. The Consultant and the Board's Commissioning agent shall be present during the operation instruction.

1.53 Operate & Adjust Systems

- 1.53.1 Operate all systems to full capacity and verify proper, safe, efficient operation of all parts and each complete system. Oil motors and grease bearings before operating equipment.
- 1.53.2 When work is complete and systems are in operation, adjust valves, belt drives, controls and thermostats so that there is an even distribution of cooling and heating throughout. Turn over to Owner necessary keys, handles and operating devices for each system.
- 1.53.3 Test for both heating and cooling days. Refer to Section 23 08 01 - Performance Verification Mechanical Piping Systems

1.54 Completion

- 1.54.1 Keep the premises in a clean and orderly condition during construction. All waste and unusable materials shall be promptly removed from the site.
- 1.54.2 Upon completion of this work, go over the entire installation, clean and polish all fixtures and equipment, and remove all surplus materials and rubbish of every description incidental to this work, leaving the installation neat and orderly.
- 1.54.3 Before final payment is made, the following items must be completed:
- 1.54.3.1 Present to the Consultant "Maintenance Manuals" complete with air and water balancing reports, wiring diagrams and certified equipment prints.
 - 1.54.3.2 Present to the Consultant an as-built record set of drawings and CAD disk.
 - 1.54.3.3 Instruction of Owner's personnel in the maintenance and operation of all new equipment.
 - 1.54.3.4 Present to the Consultant completed Equipment Start-up and Acceptance Checklist.
 - 1.54.3.5 Present to the Consultant Test Certificates and results.
 - 1.54.3.6 Present to the Consultant Valve Tag Charts.
 - 1.54.3.7 Spare filters and frames, labelled and located where directed by the Owner.
 - 1.54.3.8 Present to the Consultant start-up report for fan coil units.
 - 1.54.3.9 Present to the Consultant start-up report for air handling unit.
 - 1.54.3.10 Present to the Consultant Medical Gas Certification
 - 1.54.3.11 Present to the Consultant complete controls commissioning report.
 - 1.54.3.12 Present to the Consultant as-built drawings on CAD diskette.
 - 1.54.3.13 Maintain a set of approved drawings on site available for review by authorities.
 - 1.54.3.14 Perform the above work in a timely manner so as not to interfere with the progress of the project.
- 1.54.4 A value of 1% of the total contract price shall be withheld until points .3.1 to .3.14 are completed to the satisfaction of the Consultant.

1.55 Liability

- 1.55.1 Each Section and Trade shall:
- 1.55.1.1 Assume full responsibility for laying out his work and for any damage caused to other Sections or Owner by improper location or carrying out of same.
 - 1.55.1.2 Be responsible for prompt installation of work in advance of concrete pouring, ceiling

installation or similar work.

1.55.1.3 Protect finished and unfinished work of this Division and work of other Sections from damage due to work of this Division.

1.55.1.4 Be responsible for condition of material and equipment supplied. Be responsible for protection and maintenance of work completed until termination and acceptance.

2 PRODUCTS

2.47 Materials

2.47.1 Not used

3 EXECUTION

3.47 Painting Repairs & Restoration

3.47.1 Prime and touch up marred finished paintwork to match original.

3.47.2 Restore to new condition, finishes which have been damaged.

3.48 Cleaning

3.48.1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.49 Demonstration

3.49.1 Consultant will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.

3.49.2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.

3.49.3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.

3.49.4 Instruction duration time requirements as specified in appropriate sections.

3.50 Protection

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



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Transfer of Files on Electronic Media

Consultant of Record ("Consultant"): EXP Services Inc.

Contractor ("Contractor"): _____ []

Re: Project Name, Project Address, ("Owner"): _____ []

The Contractor hereby acknowledges requesting from the Consultant, electronic data containing graphic (electronic) representation of Engineering Drawings as per attached list of drawings, subject to the condition that the said drawings are to be used only for information and reference in connections with the Owner's use and occupancy of the Project. The Contractor shall be responsible for checking and verifying all dimensions and details, or quantities of materials and for the co-ordination of architectural, structural, mechanical and electrical elements as required to facilitate complete and accurate fabrication and installation. Any omissions and discrepancies shall be reported to the Consultant. The Contractor hereby warrants to the Consultant that the drawings will only be used for development of shop drawings/record drawings. The drawings shall not be used for any other project **or purpose** either by the Contractor or others. The Contractor further warrants not to alter the electronic data or the information contained therein, in any way except for the above noted purposes, and acknowledges that such unauthorized use or alteration of the original work is protected in accordance with the Copyright Act and subject to penalties prescribed therein.

The Contractor hereby acknowledges that the said electronic data contain information which may be updated or altered at any time by the Consultant, and that it is the responsibility of the Contractor to make themselves aware of these changes, in a timely manner. In the event of a conflict between the drawings issued to the Contractor and the sealed Contract Drawings, the sealed Contract Drawings shall govern.

The Contractor agrees to pay the Consultant **\$1.00, plus Applicable Taxes** for these electronic data. The fees noted are to cover the costs of preparation of the electronic data, and disbursements related to the preparation and shipment/forwarding of the electronic data only. By paying the fees quoted, the Contractor has in no way purchased the drawings or any rights to the drawings or the information contained therein, and the Contractor may only alter the drawings for the purposes noted above.

The electronic files will be provided in AutoCAD format (Version 2000 or more recent). The Consultant makes no representation as to the compatibility of these files with the Contractors hardware or software beyond the specified release of the referenced software.

The Contractor shall, to the fullest extent permitted by law, indemnify, defend and hold harmless the Consultant, and its sub-consultants from all claims, damages, losses, expenses, penalties and liabilities for any kind, including attorney's fees, arising out of, or resulting from the use of the electronic data by the Contractor, or by third party recipients of the electronic data from the Contractor.

The Consultant believes that no licensing or copyright fees are due to others on account of the transfer of the electronic media, but to the extent any are, the Contractor will pay the appropriate fees and hold the Consultant harmless from such claims.

Any purchase order number provided by the Contractor is for Contractor's accounting purposes only. Purchase order terms and conditions are void and are not part of this agreement.

The laws of the Province of Ontario shall govern this agreement.

The conditions and undertakings expressed wherein apply to partners, employees, agents, successors, assigns and legal or other representatives of the Contractor.

Dated at _____ this _____ day of _____, 20 ____.

**Authorized Acceptance
by Consultant**

Signature

Print Name and Title _____

Date _____

By Contractor

Signature

Print Name and Title _____

Date _____

Common Work Results for Mechanical

EQUIPMENT START-UP AND ACCEPTANCE CHECK LIST														
UNIT: LOCATION: MANUFACTURER: MOTOR MANUFACTURER: MOTOR NAMEPLATE: MODEL NO./TYPE: HORSEPOWER/kW: OVERLOAD HEATER/FUSES:	UNIT # SERIAL # SERIAL #													
<div style="display: flex; justify-content: space-between;"> <div> PRE START-UP INSPECTION APPLICABLE) </div> <div> NOTES: (N/A, NOT </div> </div> POWER WIRING COMPLETE CONTROL WIRING COMPLETE INSTRUMENTATION INSTALLATION COMPLETE CHEMICAL TREATMENT ADDED BELT DRIVE TENSION ADJUSTED VERIFY LUBRICATION IS COMPLETE VERIFY VIBRATION ISOLATION IS COMPLETE VERIFY PROPER OVERLOAD HEATER/FUSE SIZES VERIFY ALIGNMENT MOTORS & DRIVES VERIFY PROPER DIRECTION OF ROTATION VERIFY LOCAL SAFETY & OPERATING CONTROL CHECK ABNORMAL/EXCESSIVE VIBRATION CHECK LEAKING PACKING GLANDS TEMPORARY STICKERS, TAGS, ETC. REMOVED														
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ACCEPTED BY	OWNER'S REP	DATE												
ACCEPTED BY	CONSULTANT	DATE												

END OF SECTION

PART 1 - GENERAL

1.1 APPLICATION

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

1.2 SUBMITTALS

- 1.2.1 Submit the following for review:

- 1.2.1.1 shop drawings/product data sheets: submit for:

1.2.1.1.1 pressure gauges and thermometers;

1.2.1.1.2 electric motors (submit with equipment they are associated with).

- 1.2.1.2 access door locations: submit white prints of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations in walls and ceilings in finished areas;

- 1.2.1.3 samples: submit a sample of each proposed type of access door, and samples of materials and any other items as specified in mechanical work Sections of the Specification;

- 1.2.1.4 list of equipment nameplates: submit a list of equipment identification nameplates indicating proposed wording and sizes;

- 1.2.1.5 pipe & duct identification: submit a list of pipe and duct identification colour coding and wording;

- 1.2.1.6 valve tag chart: submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording;

- 1.2.1.7 waste management and reduction plan: submit a waste management and reduction plan prior to commencing work and as per requirements specified in this Section;

- 1.2.1.8 drive belts: as specified in Part 2 of this Section, submit a spare belt set, tagged and identified, for each belt driven piece of equipment;

- 1.2.1.9 additional submittals: submit any other submittals specified in this Section or other mechanical work Sections of the Specification;

PART 2 - PRODUCTS

2.1 PIPE SLEEVES

2..1.1 Galvanized Steel Pipe – Waterproof: Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at the sleeve midpoint.

2..1.2 Galvanized Steel or Cast-Iron Pipe: Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.2 FIRE STOPPING AND SMOKE SEAL MATERIALS

2.2.1 Design firestopping and smoke seals to maintain fire rating required in fire-rated walls and partitions; in all cavity wall construction at each floor level; in expansion joints where fire rating and/or fire separation is required; and elsewhere indicated.

2.2.2 Provide firestopping system in all joints, cut-outs around penetrations in the walls and floors and elsewhere required to ensure complete integrity of the fire rating prior to start of construction.

2.2.3 Provide seals to form draft tight barriers to retard the passage of flame, smoke, gas and firefighter's hose stream.

2.2.4 The installed seal shall provide and maintain a fire-resistance rating equivalent to the rating of the adjacent floor, wall or other fire separation assembly to the requirements and approval of authorities having jurisdiction.

2.2.5 Firestopping and smoke seals shall be ULC or Intertek Testing Services listed Products and systems in accordance with ULC-S115 suitable to actual application and installation conditions.

2.2.6 Firestop sealant: single component, low modulus, silicone rubber, moisture curing, ULC labelled to CAN/CGSB 19.13-M and ULC-S115.

2.2.7 Firestop insulation: to CAN/ULC-S702, Type 2; mineral fibre manufactured from rock or slag, suitable for manual application.

2.2.8 Density: 81 kg/m³ when tested to ASTM C303.

2.2.9 Combustibility: Non-combustible to CAN/ULC S114.

2.2.10 Melt temperature: >1175 degrees C.

2.2.11 Surface burning characteristics: to CAN/ULC S102, maximum flame spread of 0, smoke developed of 0.

2.2.12 Moisture Absorption: 0.04 percent when tested to ASTM C1104.

2.2.13 Smoulder Resistance: 0.01 percent when tested to CAN/ULC S129.

2.2.14 Damming, back-up, supports, and anchorage: In accordance with manufacturer's fire rated systems and to acceptance of authorities having jurisdiction.

2.2.15 Primer: As recommended by firestop sealant manufacturer.

2.2.16 Firestopping and smoke seals shall be ULC or Intertek Testing Services listed Products and systems in accordance with ULC-S115 suitable to actual application and installation conditions. All fire and smoke seals shall be 'L' rating.

2.2.17 Acceptable fire stop and smoke seal material manufacturers are 3M Canada Inc., Specified Technologies Inc. and A/D Fire Protection Systems and Hilti Canada.

2.3 WATERPROOFING SEAL MATERIALS

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

2.3.1.1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;

2.3.1.2 The Metraflex Co. "MetraSeal" type ES.

2.4 PIPE ESCUTCHEON PLATES

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

2.5 PIPING HANGERS AND SUPPORTS

2.5.1 General: Pipe hanger and support materials, including accessories, are to be, unless otherwise specified, in accordance with the Manufacturers Standardization Society (MSS) Standard Practice Manual SP-58, Pipe hangers and Supports-Materials, Design and Manufacture, and where possible, MSS designations are indicated with each product specified below. Conform to the following requirements:

2.5.1.1 unless otherwise specified, all ferrous hanger and support products are to be electro-galvanized;

2.5.1.2 hangers and supports for insulated piping are to be sized to fit around the insulation and the insulation jacket.

2.5.2 Horizontal Suspended Piping: Hangers and supports are to be:

2.5.2.1 adjustable steel clevis hanger – Anvil Fig. 260 – MSS Type 1;

2.5.2.2 adjustable swivel ring band type hanger – Anvil Fig. 69 – MSS Type 10;

2.5.3 Horizontal Pipe On Vertical Surfaces: Epoxy coated steel pipe stays are not permitted. Supports are to be:

- 2.5.3.1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
- 2.5.3.2 heavy-duty steel pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26;
- 2.5.3.3 single steel pipe hook - Myatt Fig. 156;
 - 2.5.3.3.1 Floor Supports For Vertical Risers: Supports are to be:
 - 2.5.3.3.1.1 copper tubing riser clamp – Anvil Fig. CT-121, Anvil Fig. CT-121C (plastic coated), or Myatt Fig. 150CT – MSS Type 8;
 - 2.5.3.3.1.2 heavy-duty steel riser clamp – Anvil Fig. 261, or Myatt Fig's. 182, 183, 190 and 191 – MSS Type 8.
 - 2.5.3.3.2 Vertical Piping on Vertical Surfaces: Epoxy coated steel pipe stays are not permitted. Supports are to be:
 - 2.5.3.3.2.1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
 - 2.5.3.3.2.2 heavy-duty steel pipe bracket or soil pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26;
 - 2.5.3.3.2.3 extension split pipe clamp – Anvil Fig's. 138R or Myatt Fig. 129 – MSS Type 12;
 - 2.5.3.3.3 Base of Vertical Risers: Support for vertical risers in excess of 20' (6 m) high extending out from base mounted equipment is to consist of a base elbow support with flange equal to Empire Tool & Mfg. Co. Fig. 830.
 - 2.5.3.3.4 Horizontal Pipe On Racks: Unistrut or equal galvanized steel pipe racks with pipe securing hardware as follows:
 - 2.5.3.3.4.1 standard galvanized steel U-bolts/clamps supplied by the rack manufacturer;
 - 2.5.3.3.4.2 adjustable roller chair - Anvil Fig. 175 with Fig. 160-165 steel protection saddle.
 - 2.5.3.3.5 Special Hangers and Supports: Special hangers and supports for various applications are as follows:
 - 2.5.3.3.5.1 vibration isolated riser supports – black steel riser clamps as specified above, complete with neoprene–steel–neoprene sandwich type vibration isolation pads between the clamp and the floor;
 - 2.5.3.3.5.2 for groups of pipes having the same slope – Anvil Fig. 195 welded steel brackets, Anvil Fig. 46 universal trapeze assemblies, or Unistrut or equal support assemblies, all with U-bolts, clamps, etc., to secure pipes in place;

- 2.5.3.3.5.3 for sections of piping connected to vibration isolated equipment – hangers and supports as specified above but complete with MSS Type 48 spring cushions;
- 2.5.3.3.5.4 for piping on an existing roof – Portable Pipe Hangers (Canada) Inc. "PP" Series prefabricated portable pipe support system components to suit the pipe, complete with all required accessories including bases, galvanized structural steel frames, and galvanized steel pipe hangers and/or supports conforming to MSS SP-58;
- 2.5.3.3.5.5 for fire protection piping – generally as above but ULC listed and/or FM approved, and in accordance with Chapter requirements of the NFPA Standard applicable to the piping system;
- 2.5.3.3.5.6 for bare horizontal copper piping – generally as above but factory vinyl coated to prevent direct copper/steel contact;
- 2.5.3.3.5.7 for bare copper vertical piping – corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate the pipe from the clamp;
- 2.5.3.3.5.8 insulation protection shields to & including 1½" dia. – equal to Anvil "Rib-Lok" Fig. 168 galvanized steel shields with ribs to keep the shield centred on the hanger.
- 2.5.3.3.6 Hanger Rods: Electro-galvanized carbon steel (unless otherwise specified), round, threaded, to ASTM A36, complete with captive machine nuts with washers at hangers, sized to suit the loading in accordance with Table 3 in MSS SP-58, but in any case, minimum 3/8" diameter.
- 2.5.3.3.7 Acceptable Manufacturers: Acceptable hanger and support material manufacturers are:
 - 2.5.3.3.7.1 E. Myatt & Co. Inc.;
 - 2.5.3.3.7.2 Anvil International Inc.;
 - 2.5.3.3.7.3 Empire Tool & Mfg. Co. Inc.;
 - 2.5.3.3.7.4 Hunt Manufacturing Ltd.;
 - 2.5.3.3.7.5 Unistrut Canada Ltd.;
 - 2.5.3.3.7.6 Nibco Inc. "Tolco";
 - 2.5.3.3.7.7 Taylor Pipe Supports.

2.6 Pressure Gauges and Thermometers

2.6.1 **Pressure Gauges:** Adjustable, glycerine filled, 4" or 4½" diameter, each accurate to within 1% of scale range and complete with a type 304 stainless steel case with relief valve and polished stainless steel bayonet, stainless steel rotary movement with stainless steel bushings and socket, a clear acrylic window, a dual scale white dial with a scale range such that the working pressure of the system is at the approximate mid-point of the scale, and black pointer. Acceptable products are:

2.6.1.1 H. O. Trerice Co. Model 700 LFSS-40;

2.6.1.2 Weiss Instruments Model LF4S-2;

2.6.1.3 Ashcroft #35-1009 SWL-26.

2.6.2 **Pressure Gauge Accessories & Additional Requirements:** Accessories and additional requirements are as follows:

2.6.2.1 a bronze ball type shut-off valve is to be provided in the piping to each pressure gauge;

2.6.2.2 each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber.

2.6.2.3 each pressure gauge for steam piping or steam equipment is to be equipped with a steel coil syphon.

2.6.2.4 pressure gauges in fire protection piping must be ULC listed and labelled.

2.6.2.5 pressure gauges in medical gas piping systems are to conform to CSA Z7396.1 and are to be identified with the name of the service it is provided for as well as "USE NO OIL".

2.6.3 **Thermometers:** Round, 5" diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale and complete with a hermetically sealed stainless steel case with stainless steel ring, dampened bimetal coil, calibration adjustment screw, white aluminum dual scale dial with black and blue markings and a range such that the working temperature of the system is the approximate mid-point of the scale, black aluminum pointer, double strength glass window, ½" NPT connection with ¼" diameter stainless steel stem, and a suitable thermowell. Acceptable products are:

2.6.3.1 H.O. Trerice Co. B85600 Series;

2.6.3.2 Weiss Instruments Model 5VBM25;

2.6.3.3 Ashcroft #50EI60E-040-0/250.

2.7 **EQUIPMENT BELT DRIVES**

2.7.1 ANSI/RMA Standard V-belt type rated at minimum 1.5 times the motor nameplate rating, and in accordance with the following requirements:

2.7.1.1 belts are to be reinforced cord and rubber, and multiple belts are to be matched sets;

2.7.1.2 sheaves are to be cast iron or steel, secured to shafts with removable keys unless otherwise specified, standard adjustable pitch ($\pm 10\%$ range) for motors under 10 HP, fixed pitch type with split tapered bushing and keyway for motors 10 HP and larger, and, if required, replaced as part of the mechanical work to suit system air/water quantity testing and balancing work;

2.7.1.3 motor slide rail adjustment plates are to allow for centre line adjustment.

2.7.2 Supply a spare belt set (tagged and identified) for each belt drive and hand to the Owner upon Substantial Performance of the work.

2.8 EQUIPMENT DRIVE GUARDS AND ACCESSORIES

2.8.1 **For V-belt drives** - removable, four sided, fully enclosed, galvanized sheet steel guards to OSHA standards, cleaned, factory primed and painted with yellow equipment enamel, complete with a 2-piece full length hinged front panel to permit belt maintenance or replacement without removing the guard, and 1½" diameter tachometer openings at each shaft location.

2.8.2 **For flexible couplings** - removable "U" shaped galvanized steel guards to OSHA Standards with a 3/32" thick frame and expanded mesh face.

2.8.3 **For unprotected fan inlets & outlets** - unless otherwise specified, removable ¾" galvanized steel wire mesh with galvanized steel frames, all to OSHA Standards.

2.9 ELECTRIC MOTORS

2.9.1 Unless otherwise specified, motors are to conform to EEMAC Standard MG1, applicable IEEE Standards, and applicable CSA C22.2 Standards, and are to meet NEMA standards for maximum sound level ratings under full load. Confirm motor voltages prior to ordering.

2.9.2 Vertically mounted and submersible motors are to be purposely designed for mounting in this attitude.

2.9.3 Motor Efficiency: The efficiency of single phase motors to 1 HP is to be in accordance with CAN/CSA C747. The efficiency of all three phase motors 1 HP and larger is to be in accordance with CAN/CSA C390 or IEEE 112B.

2.9.4 Single Phase Motors: Unless otherwise specified, motors smaller than ½ HP are to be 115 volt, continuous duty capacitor start type with an EEMAC 48 or 56 frame size, solid base, heavy-gauge steel shell with solid die-cast end shields, dynamically balanced die-cast rotor, integral automatic reset thermal overload protection, Class "B" insulation, and a 1.15 service factor at 40°C (105°F) ambient temperature.

2.9.5 Three Phase Motors: Unless otherwise specified, motors ½ HP and larger are to be totally enclosed, fan cooled, 3 phase, T-frame, squirrel cage continuous duty induction motors suitable for voltages indicated on the Drawings, EEMAC Design "B" for normal starting torque or Design "C" for high starting torque as required by the application, each complete with Class "B" insulation, a 1.5 service factor at 40°C ambient temperature, grease lubricated open ball bearings with grease fittings to permit re-lubrication without dismantling the motor, a cast iron frame with cast iron feet where required, cast iron end bracket and precision machined bearing fit, and balanced carbon steel shaft assembly with die-cast aluminium rotor windings.

2.9.6 Motors for VFD's: Motors for equipment with variable frequency drives are to be generally as specified above but inverter duty type to NEMA Standard MG-1 Part 31, quantified by CSA for operation from a variable frequency drive of the type specified, and complete with Class "H" insulation. Motors are to be equipped with AEGIS, or approved equal, shaft grounding ring system to protect bearings from damage by diverting harmful shaft voltages and bearing currents to ground.

2.9.7 Acceptable Manufacturers: Acceptable motor manufacturers are:

2.9.7.1 Westinghouse Canada Inc.;

2.9.7.2 Canadian General Electric;

2.9.7.3 Baldor Electric Co.;

2.9.7.4 U.S. Electrical Motors;

2.9.7.5 Weg Electric Corp.;

2.9.7.6 Marathon Electric;

2.9.7.7 Magna-Tech Canada;

2.9.7.8 Toshiba Corp.;

2.9.7.9 Leeson Canada.

2.10 **MOTOR STARTERS AND ACCESSORIES**

2.10.1 General: All motor starters must be capable of starting the associated motors under the imposed loads. Confirm that starter voltage matches the motor prior to ordering.

2.10.1.1 Starters For Single Phase Motors: Unless otherwise specified, starters for single 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 "hand-off-automatic" switch in an enclosure to match the starter enclosure.

2.10.1.2 Starters For Three Phase Motors Less Than 50 HP: Unless otherwise specified, starters for three 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 "hand-off-automatic" switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per the motor starter schedule.

2.10.1.3 Motor Starter Enclosures: Unless otherwise specified, motor starter enclosures are to be in accordance with the following NEMA/EEMAC ratings:

2.10.1.3.1 all enclosures located in sprinklered areas – Type 2;

- 2.10.1.3.2 all enclosures exposed to the elements – Type 3R, constructed of stainless steel;
- 2.10.1.3.3 all enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;
- 2.10.1.3.4 all enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;
- 2.10.1.3.5 all enclosures except as noted above – Type 1;
- 2.10.1.3.6 all enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.
- 2.10.1.4 Motor Control Centres: Multi-unit, 9' high, EEMAC Class 1, type "B", factory assembled, dead front, floor mounted, free-standing motor control centre with tin plated copper bus and an EEMAC 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 all required facilities for line and load side power wiring connections.
- 2.10.1.5 Disconnect Switches For Motor Control Centres: Heavy-duty, CSA certified, front operated switches as per the motor starter schedule, each complete with a handle suitable for padlocking in the "off" position and arranged so that the door cannot be opened with the handle in the "on" position and an EEMAC enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.
- 2.10.1.6 Fuses: Unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.
- 2.10.1.7 Acceptable Manufacturers: Acceptable manufacturers are:
 - 2.10.1.7.1 Rockwell Automation Inc. - Allen-Bradley;
 - 2.10.1.7.2 Eaton Corp. – Cutler-Hammer;
 - 2.10.1.7.3 Eaton Corp. – Moeller Electric;
 - 2.10.1.7.4 Siemens Canada;
 - 2.10.1.7.5 Schneider Electric.

2.11 **MECHANICAL WORK IDENTIFICATION MATERIALS**

- 2.11.1 Equipment Nameplates: Minimum 1/16" thick 2-ply laminated coloured plastic plates, minimum ½" x 2" for smaller items such as damper motors and control valves, minimum 1" x 2½" for equipment, and minimum 2" x 4" for control panels and similar items. Additional requirements are as follows:

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- 2.11.1.1 unless otherwise specified or required, each nameplate is to be white, complete with bevelled edges and black engraved wording to completely identify the equipment and its use with no abbreviations;
 - 2.11.1.2 wording is generally to be as per the drawings or UHN equipment naming convention, i.e. Fan 5-P-104, and is to include equipment service and building area/zone served, but must be reviewed prior to engraving;
 - 2.11.1.3 supply stainless steel screws for securing nameplates in place;
 - 2.11.1.4 nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.
 - 2.11.2 Valve Tags: Coloured, 1½" square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match the piping identification colour, each complete with a 1/8" diameter by 4" long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:
 - 2.11.2.1 Valve V12
 - 2.11.2.2 8"
 - 2.11.2.3 Chill. Water
 - 2.11.2.4 Normally Open
 - 2.11.3 Standard Pipe Identification: Standard pipe identification is to be in accordance with latest ANSI/ASME A13.1 "Scheme for the Identification of Piping Systems", equal to Smillie McAdams Summerlin Ltd. or Brady vinyl plastic with indoor/outdoor type vinyl ink lettering and directional arrows, as follows:
 - 2.11.3.1 for pipe to and including 6" diameter, coiled type snap-on markers of a length to wrap completely around the pipe or pipe insulation;
 - 2.11.3.2 for pipe larger than 6" diameter, saddle type strap-on markers with 2 opposite identification locations and complete with nylon cable ties.
 - 2.11.4 Standard Pipe Identification Wording and Colours: Identification wording and colours for pipe identification materials shall match existing on site.
 - 2.11.5 Medical Gas Pipe Identification: Medical gas piping identification materials and requirements are specified in the mechanical Section entitled Medical Gas Piping Systems.
 - 2.11.6 Duct Identification: Custom made Mylar stencils with 2" high lettering to accurately describe the duct service, i.e. "AHU-1 SUPPLY", complete with a directional arrow, and coloured ink with ink pads and roller applicators. Ink colour is generally to be black but must contrast with the lettering background.
 - 2.12 **Flexible Connectors**
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2.12.1 Double wall stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by the manufacturer to suit the application. Shop drawings or product data sheets must indicate construction and performance requirements that suit the application. Acceptable manufacturers are:

2.12.1.1 Hyspan Precision Products Inc.;

2.12.1.2 Senior Flexonics Ltd.;

2.12.1.3 The Metraflex Co.

PART 3 - EXECUTION

3.1 General Piping and Ductwork Installation Requirements

- 3.1.1 Unless otherwise specified, locate and arrange horizontal pipes and ducts above or at the ceiling on floors on which they are shown, arranged so that under consideration of all other work in the area, the maximum ceiling height and/or usable space is maintained. If required to maintain ceiling heights, reroute and/or resize ductwork, with Consultant's approval.
- 3.1.1.1 Unless otherwise specified, install all work concealed in finished spaces, and concealed to the degree possible in partially finished and unfinished spaces. Refer to and examine the Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Note that walls which are painted are considered finished.
 - 3.1.1.2 Install all pipes and ducts parallel to building lines and to each other.
 - 3.1.1.3 Neatly group and arrange all exposed work.
 - 3.1.1.4 Service and Maintenance Access: Locate all work to permit easy access for service or maintenance as required and/or applicable. Locate all valves, dampers and any other equipment which will or may need maintenance or repairs and which are installed in accessible construction so as to be easily accessible from access doors. Where valves, dampers and similar piping or ductwork accessories occur in vertical services in shafts, pipe spaces or partitions, locate the accessories at the floor level.
 - 3.1.1.5 Dissimilar Metal Pipe Connections: Make all connections between pipes of different materials using proper approved adapters. Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe.
 - 3.1.1.6 Manufacturer's Instructions: Ensure that equipment and material manufacturer's installation instructions are followed unless otherwise specified herein or on the drawings, and unless such instructions contradict governing codes and regulations.
 - 3.1.1.7 Cleaning: Carefully clean all ducts, pipe and fittings prior to installation. Temporarily cap or plug ends of pipe, ducts and equipment which are open and exposed during construction.
 - 3.1.1.8 Surfaces To Receive Your Work: Inspect surfaces and structure prepared by other trades before performing your work. Verify that surfaces or the structure to receive your work have no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of your work will constitute acceptance of such surfaces as being satisfactory.
 - 3.1.1.9 Piping Rust and Dirt: Any ferrous piping that exhibits in excess of 5% surface rust, either inside or outside or both is to be wire brush cleaned to bare metal and coated with suitable primer. Steel pipe, fittings and accessories are to be

free of corrosion and dirt when work is complete or prior to being concealed from view. Where dirt is evident, clean the piping prior to being concealed.

- 3.1.1.10 Drain Pans: Provide continuous galvanized sheet metal drip pan under where indicated on the drawings and under all drain, water and water solution piping extending through all rooms with electrical equipment such as electrical, elevator equipment and transformer rooms, and all other spaces provided primarily for the installation of electrical equipment. Drip pans are to be complete with a drain pipe connection and drain piping is to be extended to the closest drain.
- 3.1.1.11 Repair of Finished Surfaces: For factory applied finishes, repaint or refinish all surfaces damaged during shipment and installation. The quality of the repair work is to match the original finish. This requirement also applies to galvanized finishes.
- 3.1.1.12 Unions and Flanges: Whether shown or specified on the drawings or not, provide screwed unions or flanges in all piping connections to equipment, and in regular intervals in long (in excess of 12 m/40') piping runs to permit removal of sections of piping.
- 3.1.1.13 Elbows and Eccentric Reducers: Unless otherwise specified and except where space limitations do not permit, all piping elbows are to be long radius. Eccentric reducers are to be installed with the straight side at the top of the piping.

3.2 Pipe Joint Requirements

3.2.1 Do not make pipe joints in walls or slabs.

- 3.2.1.1 Ream all piping ends prior to making joints.
- 3.2.1.2 Screwed Steel Piping: Properly cut threads in screwed steel piping and coat male threads only with Teflon tape or paste, or an equivalent thread lubricant. After the pipe has been screwed into the fitting, valve, union, or piping accessory, not more than two pipe threads are to remain exposed.
- 3.2.1.3 Welded Steel Piping: Site bevel steel pipe to be welded or supply mill bevelled pipe. Remove all scale and oxide from the bevels and leave smooth and clean. Use factory made welding tees or welding outlet fittings for piping branches off mains. Do not use shop or site fabricated fittings unless written approval has been obtained.
- 3.2.1.4 Welding Requirements: Welded joints are to be made by CWB certified, licensed journeyman welders qualified in accordance with CSA B51, Boiler Pressure Vessel and Pressure Piping Code, and who are in possession of a proper certificate of qualification for each procedure to be performed. Each weld is to be identified with the welder's identification symbol, and welds are not to be concealed until they have been inspected and approved. Electrodes are to be in accordance with CSA W48 Series, Electrodes, and requirements of CAN/CSA W117.2, Safety in Welding, Cutting and Allied

Processes are to be followed.

- 3.2.1.5 Flanged Joints: Unless otherwise specified, make all flanged joints with Cranite Ltd. or equivalent gasket materials to suit the application, and bolts and nuts. Bolts are not to be longer than the length necessary to screw the nut up flush to the end of the bolt. Bolts used for flanged connections in all piping with a working pressure of 100 psi and greater are to be ASTM A-193, Grade B-7, with heavy hexagon nuts to ASTM A-194, CL-2H. Provide suitable washers between each bolt head and the flange and between each nut and the flange.
- 3.2.1.6 Examination of Flanged Joints: A random check of bolted flanged connections will be made to verify that flanged connections are properly mated with no shear force acting on bolts. Supply all labour to disconnect and reconnect the selected flanged joints. If improperly mated joints are found, remove and reinstall the affected piping so that the flanges mate properly. If improperly mated joints are found, additional joints will be checked, and you will be responsible for the repair of any other improper joints discovered.
- 3.2.1.7 Soldered Joints: Unless otherwise specified make all soldered joints in copper piping using flux suitable for and compatible with the type of solder being used. Clean the outside of the pipe end and the inside of the fitting, valve, or similar accessory prior to soldering.
- 3.2.1.8 Medical Gas Piping Joints: Joints in medical gas system piping are to be silver brazed in accordance with requirements of CAN/CSA-Z7396.1.
- 3.2.1.9 Mechanical Joints: Install mechanical joint fittings and couplings in accordance with the manufacturer's instructions.
- 3.2.1.10 Grooved Pipe & Coupling Joints: Grooves are to be rolled. Make arrangements with the coupling and fitting manufacturer for shop and/or site instructions and demonstrations as required, and adhere to the manufacturer's instructions with respect to pipe grooving, support, type of gasket required, anchoring and guiding the grooved piping system.

3.2 Installation of Pipe Sleeves

- .1 Where pipes pass through concrete and/or masonry surfaces provide pipe sleeves as follows:
 - .1 in poured concrete slabs: unless otherwise specified - minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves;
 - .1 in concrete or masonry walls: Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.
 - 1. Waterproof Sleeves: Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with a waterstop plate in accordance with the drawing detail. Provide waterproof sleeves in the following locations:

- .1 in mechanical room floor slabs, except where on grade;
- .2 in slabs over mechanical, fan, electrical and telephone equipment rooms or closets;
- .3 in all floors equipped with waterproof membranes;
- .4 in the roof slab;
- .5 in waterproof walls.
 - 2. Size sleeves, unless otherwise specified, to leave ½" clearance around the pipes, or where the pipe is insulated, a ½" clearance around the pipe insulation.
 - 3. Pack and seal the void between the pipe sleeves and the pipe or pipe insulation in non-fire rated construction for the length of the sleeves as follows:
 - .1 interior construction: pack sleeves in interior construction with mineral wool and seal both ends of the sleeves with non-hardening silicone base caulking compound;
 - .2 exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - 4. Where sleeves are required in masonry work, accurately locate and mark the sleeve location, and hand the sleeves to the mason for installation.
 - 5. Terminate piping for sleeves that will be exposed so that the sleeve is flush at both ends with the building surface concerned so that the sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 4" above the finished floor.
 - 6. "Gang" type sleeving will not be permitted.
 - 7. Where sleeves are provided in non-fire rated construction for future piping, or where piping has been removed from existing sleeves, cap and seal both ends of the sleeved opening.

3.3 Installation of Waterproof Mechanical Seals

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

3.4 Installation of Pipe Escutcheon Plates

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

3.5 Installation of Fastening and Securing Hardware

- .1 Provide all fastening and securing hardware required for mechanical work to maintain installations attached to the structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding the dead loads, live loads, superimposed dead loads, and any vibration of the installed products.
- .2 Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.
- .3 Where the floor, wall or ceiling construction is not suitable to support the loads, provide additional framing or special fasteners to ensure proper securement to the structure that is to support the products. Provide reinforcing or connecting supports where required to distribute the loading to the structural components.
- .4 Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CSA Standards CAN3-Z166.1 and CAN3-Z166.2.

3.6 Installation of Pipe Hangers and Supports

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

- .4 copper and steel pipe: hang or support at spacing in accordance with the following schedule:

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
to 1"	2.4 (8')	1.8 (6')
1½"	2.7 (9')	2.4 (8')
2"	3.0 (10')	2.7 (9')
2½"	3.6 (12')	3.0 (10')
3"	3.6 (12')	3.0 (10')
4"	4.2 (14')	3.6 (12')

- .5 flexible grooved pipe/coupling joint piping: as above but with not less than one hanger or support between joints;
- .6 changes in direction: where pipes change direction, either horizontally or vertically, provide a hanger or support on the horizontal pipe not more than 12" from the elbow, and where pipes drop from tee branches, support the tees in both directions not more than 2" on each side of the tee;
- .7 grouped piping: when pipes with the same slope are grouped and a common hanger or support is used, space the hanger or support to suit the spacing requirement of the smallest pipe in the group and secure pipes in place on the common hanger or support;
- .8 roller hangers & supports: provide roller hangers or supports for all heat transfer piping 8" diameter and larger and conveying a material 75°C (170°F) or greater to facilitate pipe movement due to expansion and contraction, and at each hanger or support tack weld a steel protection saddle to the pipe to protect the piping insulation.
- .5 Vertical Piping: Unless otherwise shown or specified, support vertical piping by means of supports specified in Part 2 of this Section, spaced in accordance with the following:
- .1 support vertical pipes at maximum 3 m intervals or at every floor, whichever is lesser;
- .2 for sections of vertical piping with a length less than 10', support the pipe at least once;
- .3 for all vertical cast iron plain end pipe (mechanical joint type), secure the riser or pipe clamp around the pipe under a flange integral with the pipe for vertical support purposes, or provide a length of hub and spigot pipe to facilitate proper support;
- .4 for all vertical steel pipe risers in excess of 10', weld shear lugs to the pipe to carry the load

- .5 for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between the riser clamps and the floor.
- .6 Piping On The Roof: Support piping on the roof as follows:
 - .1 on existing roof - provide support members as specified in Part 2 of this Section spaced as per the schedule above and of a type to suit the application, and, for each support, carefully scrape away the roofing gravel, bed the support in a heavy covering of roofing mastic, then scrape the gravel back up around the support - secure pipes to supports;
- .7 Isolation for Bare Copper Tubing: Each hanger, support or securement for horizontal bare copper tubing is to be plastic coated to prevent direct contact between the pipe and the ferrous hanger. Each wall or floor clamp for vertical bare copper piping is to be isolated from the pipe by means of strips of flexible rubber inserts. The use of painted ferrous hangers and supports, including those painted with copper coloured paint, is not acceptable. Site application of tape or other types of isolation is not acceptable.
- .8 Insulation Protection Shields: For insulated horizontal piping to and including 1½" diameter, provide galvanized steel insulation protection shields between the insulation and the hanger or support. Install shields immediately after the pipe is insulated.
- .9 Pipe Support from Steel Deck: Do not support piping from steel deck without written consent from the Consultant.

3.7 Supply of Access Doors

- .1 Supply access doors to give access to all mechanical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on the drawings.
- .2 Locate access doors as inconspicuously as possible in walls and partitions and arrange mechanical work such that it is clearly within view and accessible for inspection and servicing, and to suit access door locations shown on the reviewed and approved white prints of reflected ceiling plan and elevation drawings submitted as per Part 1 of this Section.
- .3 Group piping and ductwork to ensure the minimum number of access doors is required. Access doors will be installed by the trades responsible for the particular type of construction in which the doors are required.
- .4 Submit a sample of each proposed access door for review prior to ordering.
- .5 Identify access doors supplied for concealed medical gas system shut-off valves or equipment with a permanent label in accordance with requirements of CAN/CSA Standard Z7396.1.

3.8 Installation of Valves

- .1 Generally, valve locations are indicated or specified on drawings or specified in Sections of the Specification where the valves are specified, however, regardless of locations shown or specified, the following requirements apply:

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

3.9 Installation of Pressure Gauges and Thermometers

- .1 Pressure Gauges: Provide pressure gauges in the following locations:
 - .1 in valved tubing across the suction, suction strainer (if applicable), and discharge piping of each circulating pump;
 - .2 in the supply and return piping connections to equipment such as heat exchangers, main coils, etc.;
 - .3 in expansion tank(s);
 - .4 in piping at each side of a pressure reducing valve;
 - .5 wherever else shown and/or specified on the contract documents or in the Specification.
- .2 Thermometers: Provide thermometers in the following locations:
 - .1 in supply and return piping connections to equipment such as heat exchangers, main coils, etc., unless temperature indication is supplied with the equipment;
 - .2 wherever else shown and/or specified herein or on the drawings.
- .3 Installation Requirements: Conform to the following installation requirements:
 - .1 for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in the piping well;
 - .2 for pressure gauges in piping at equipment locations, install the pressure gauge between the equipment and the first pipe fitting;
 - .3 locate, mount and adjust all instruments so they are easily readable;

- .4 where pressure gauges and/or thermometers are located at high level or in an area where they cannot be easily seen, provide remote reading instruments.

3.10 Installation of Equipment Drive Guards and Accessories

- .1 Provide OSHA guards for all exposed accessible rotating parts such as belt drives, couplings, fan wheels, and shaft ends on all mechanical equipment.
- .2 Install belt guards to allow movement of motors for adjusting belt tension.
- .3 Provide a means to permit lubrication and use of test instruments with guards in place.
- .4 Secure guards to the equipment or equipment base but do not bridge sound or vibration isolation.
- .5 Where equipment oil level gauges, oil reservoirs, grease cups, or grease gun fittings are integral with the equipment but are not easily accessible for service, extend to an accessible location using aluminium or copper tubing.

3.11 Mechanical Work Identification

- .1 Exposed Piping & Ductwork: Identify new exposed piping and ductwork as per Part 2 of this Section in locations as follows:
 - .1 at every end of every piping or duct run;
 - .2 adjacent to each valve, strainer, damper and similar accessory;
 - .3 at each piece of connecting equipment;
 - .4 on both sides of every pipe and duct passing through a floor, wall or partition, unless otherwise specified;
 - .5 at 20' (6 m) intervals on pipe and duct runs exceeding 6 m in length;
 - .6 at least once in each room, and at least once on pipe and duct runs less than 20' (6 m) in length.
- .2 Concealed Piping & Ductwork: Unless otherwise specified identify new concealed piping and ductwork as per Part 2 of this Section in locations as follows:
 - .1 at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;
 - .2 at maximum 20' intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room;
 - .3 at each access door location;
 - .4 at each piece of connected equipment, automatic valve, etc..
- .3 Equipment: Provide an identification nameplate for each new piece of equipment, including items such as control valves, motorized dampers, instruments, and similar products. Secure nameplates in place, approximately at eye level if possible, with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces. Locate all nameplates in the most conspicuous and

readable location.

- .4 Motor Starters and Disconnect Switches: Provide an identification nameplate for each new motor starter or disconnect switch located in a motor control centre or on a motor starter panel, and on each individually mounted starter which you supply, and on each disconnect switch provided as part of the electrical work for motorized equipment which you provide.
- .5 Valve Tagging & Chart: Tag valves and prepare a valve tag chart in accordance with the following requirements:
 - .1 attach a valve tag to each new valve, except for valves located immediately at the equipment they control;
 - .2 prepare a computer printed valve tag chart to list all tagged valves, with, for each valve, the tag number, location, valve size, piping service, and valve attitude (normally open or normally closed);
 - .3 if an existing valve tag chart is available at the site, valve tag numbering is to be an extension of existing numbering and the new valve tag chart is to incorporate the existing chart;
 - .4 frame and glaze one copy of the chart and, unless otherwise directed, affix to a wall in each main Mechanical and/or Equipment Room;
 - .5 include a copy of the valve tag chart in each copy of the operating and maintenance instruction manuals;
 - .6 hand an identified and packaged (jewel case) compact disc of the valve tag chart to the Owner at the time the O & M Manuals are submitted.
- .6 Ceiling Tacks or Stickers: Where new shut-off valves, control dampers, sensors, and similar items which will or may need maintenance and/or repair are located above accessible suspended ceilings, provide round coloured ceiling tacks in the ceiling panel material, or stickers equal to Brady "Quick Dot" on the ceiling grid material to indicate locations of the items. Unless otherwise specified, ceiling tack or sticker colours are to be as follows:
 - .1 HVAC piping valves and equipment: yellow
 - .2 fire protection valves and equipment: red
 - .3 plumbing valves and equipment: green
 - .4 HVAC ductwork dampers and equipment: blue
 - .5 control system hardware and equipment: orange

3.12 Finish Painting of Mechanical Work

- .1 Touch-up paint all damaged factory applied finishes on mechanical work products.

3.13 Pipe Leakage Testing

- .1 Before new piping has been insulated or concealed, and before equipment, fixtures and

fittings have been connected, test all piping for leakage.

- .2 Tests are to be witnessed by the Consultant and/or Owner's representative, and, where required, representatives of governing authorities. Give ample notice of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.
- .3 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.
- .4 Gravity Drainage & Vent Piping: Securely close all openings and pipe ends and fill piping with water up to the highest level and ensure that the water stands at the same level for a minimum of two hours. After the fixtures and fittings are set and the pipes connected to the building drain or drains, turn on water into all pipe, fixtures, fittings and traps in order to detect any imperfect material or workmanship. Make a smoke test if required by the Municipality. At your option, drain and vent piping may be pressure tested with cold water at 50 psi (345 kpa) for two hours with zero leakage.
- .5 Domestic Water Piping: Test piping with cold water at a pressure of 1½ times normal working pressure and maintain the pressure for a minimum of two hours.
- .6 Sprinkler System Piping: Test all system piping in accordance with requirements of NFPA No. 13, "INSTALLATION OF SPRINKLER SYSTEMS", and in accordance with any additional requirements of governing authorities.
- .7 Standpipe System Piping: Test all system piping in accordance with requirements of NFPA No. 14, "STANDPIPE AND HOSE SYSTEMS", and in accordance with any additional requirements of governing authorities.
- .8 Heat Transfer (HVAC) System Piping: Test piping with cold water at a pressure of 150 psi (1035 kPa) for a minimum of two hours.
- .9 Steam & Condensate Piping: Test piping with cold water for a minimum of two hours at the following pressures:
 - .1 0 psi to 15 psi low pressure piping - 100 psi;
 - .2 16 psi to 99 psi medium pressure piping - 150 psi;
 - .3 greater than 99 psi high pressure piping - 200 psi.
- .10 Medical Gas System Piping: Perform leakage and flow tests for all piping using oil-free compressed air or oil-free dry nitrogen in accordance with requirements of CAN/CSA Standard Z7396.1.
- .11 General Re: All Testing: The following requirements apply to all testing:
 - .1 ensure that all piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing;
 - .2 temporarily remove or valve off all piping system specialties or equipment which may be damaged by test pressures prior to pressure testing the systems, and flush piping to remove foreign matter;
 - .3 when testing is carried out below the highest level of the particular system,

- increase the test pressure by the hygrostatic head of 1 psi for every 24" below the high point;
- .4 include for temporary piping connections required to properly complete the tests;
- .5 piping under test pressure is to have zero pressure drop for the length of the test period;
- .6 make tight leaks found during tests while the piping is under pressure, and if this is impossible, remove and refit the piping and reapply the test until satisfactory results are obtained;
- .7 where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions;
- .8 tests are to be done in reasonably sized sections so as to minimize the number of tests required;
- .9 in addition to the leakage tests specified above, demonstrate proper flow throughout the systems including mains, connections and equipment, as well as proper venting and drainage, and Include for any necessary system adjustments to achieve the proper conditions.

3.14 Supply of Motor Starters and Accessories

- .1 Unless otherwise shown or specified, supply a starter for each item of motorized equipment you provide. Refer to the drawing Motor Starter Schedule.
- .2 Three Phase Motor Starters In Motor Control Centres: Where three phase starters are indicated in motor control centres, supply the motor control centres with starters and bolt to a concrete housekeeping pad where shown.
- .3 Disconnect Switches In Motor Control Centres: Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with the equipment is fed from a motor control centre, provide a disconnect switch in the motor control centre in lieu of a motor starter.
- .4 Single Phase Motor Starters: Unless otherwise specified or shown on the drawings, single phase motor starters will be mounted adjacent to the equipment they serve and connected complete as part of the electrical work. Hand the starters to the electrical trade at the site at the proper time.

3.15 Electrical Wiring Work for Mechanical Work

- .1 Unless otherwise specified or indicated, the following electrical wiring work for mechanical equipment will be done as part of the electrical work:
 - .1 "line" side power wiring to motor starters or disconnect switches in motor control centres and starters or disconnects on motor starter panels, and "load" side wiring from the starters or disconnects to the equipment;
 - .2 "line" side power wiring to individual wall mounted starters, and "load" side wiring from the starters to the equipment;

- .3 "line" side power wiring to pre-wired power and control panels and variable frequency drives, and "load" side power wiring from the panels and VFD's to the equipment;
- .4 provision of receptacles for plug-in equipment;
- .5 provision of disconnect switches for all motors that are in excess of 30' from the starter location, or that cannot be seen from the starter location, and all associated power wiring;
- .6 all motor starter interlocking in excess of 24 volts;
- .7 wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts;
- .8 provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work;
- .9 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers;
- .10 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units;
- .11 120 volt wiring connections to duplex receptacles integral with air handling unit control panels.
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work is to be installed in conduit and is to be done as part of the mechanical work in accordance with wiring requirements specified for the electrical work.

3.16 Interruption to and Shut-Down Of Mechanical Services and Systems

- .1 Co-ordinate all shut-down and interruption to existing mechanical systems with the Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight Friday until 6:00 a.m. Monday morning.
- .2 Upon award of a Contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner and Consultant in writing 15 days in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut-down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .1 In general, where demolition will cause shutdown of services to areas which are to remain functional, it is expected that new work is to be roughed-in up to the

point of final connections in order to minimize shutdowns. In many cases, this will require the need to run new services parallel to the existing services which are to be removed.

- .5 Pipe Freezing: Pipe freezing may be used to connect new piping to existing piping without draining the existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. (1-800-661-9983).
 - .1 Note that due to the age of some of the services within the existing buildings, shut-off valves may be seized or will not hold. Where connecting to existing hydronic piping, it is to be assumed that pipe freezing will be required.

3.17 Cutting, Drilling, and Patching for Mechanical Work

- .1 Do all cutting, drilling and patching of the existing building for the installation of your work. Perform all cutting and drilling with proper tools and equipment. Confirm the exact location of cutting and drilling with the Consultant prior to commencing the cutting and/or drilling work.
 - .1 This includes for all required mechanical work, inclusive of areas outside of the defined renovation and scope of work areas indicated on the architectural drawings.
- .1 Patch surfaces, where required, to exactly match existing finishes using tradesmen skilled in the particular trade or application worked on.
- .2 Where new pipes pass through existing construction, core drill an opening. Size openings to leave ½" clearance around the pipes or pipe insulation.
- .3 You will be responsible for the repair of any damage to existing services, exposed or concealed, caused as a result of your cutting or drilling work.
- .4 Where drilling is required in waterproof slabs, size the opening to permit snug and tight installation of a pipe sleeve which is sized to leave ½" clearance around the pipe or pipe insulation. Provide a pipe sleeve in the opening. Pipe sleeves are to be Schedule 40 galvanized steel pipe with a flange at one end and a length to extend 4" above the slab. Secure the flange to the underside of the slab and caulk the void between the sleeve and slab opening with proper non-hardening silicone base caulking compound to produce a water-tight installation.

3.18 Packing and Sealing Core Drilled Pipe Openings

- .1 Pack and seal the void between the pipe opening and the pipe or pipe insulation for the length of the opening as follows:
 - .1 non-fire rated interior construction: pack openings in non-fire rated interior construction with mineral wool and seal both ends of the opening with non-hardening silicone base caulking compound to produce a water-tight seal;
 - .2 exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have

been specified;

- .3 exterior walls below grade: seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified below.

3.19 Instructions to Owner

- .1 Instruct the Owner's designated representatives in all aspects of the operation and maintenance of mechanical systems and equipment.
- .2 Arrange and pay for the services at the site, for the length of time required, of qualified technicians and other manufacturer's representatives to instruct on specialized portions of the installation.
- .3 Submit, prior to Substantial Performance, a complete list of systems for which instructions were given, stating for each system:
 - .1 date instructions were given to the Owner's staff;
 - .1 duration of instruction;
 - .2 names of persons instructed;
 - .3 other parties present (manufacturer's representatives, etc.);
- .4 Obtain the signatures of the Owner's staff to verify they properly understood the system installation, operation and maintenance requirements and have received operating and maintenance manuals and record drawings.

3.20 Cleaning Mechanical Work

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

3.21 Maintaining Equipment Prior to Acceptance

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

3.22 Connections to Other Equipment

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

connections.

3.23 Installation of Flexible Connectors

- .1 Provide flexible connectors in piping connections to all seismically restrained equipment, and wherever else shown.
- .1 Provide flexible connectors in all piping connections to vibration isolated equipment.

3.24 Fan Noise Levels

- .1 Submit sound power levels with fan shop drawings/product data, with levels measured to AMCA 300 and calculated to AMCA 301.

3.25 Fire Stopping

- .1 Ensure that fire ratings of floors and walls are maintained.
- .2 Fill spaces between openings, pipes and ducts passing through fire separations and install firestopping systems in accordance with the appropriate ULC system number for the products and type of penetration.
- .3 Install firestopping systems using personnel trained or instructed by the product manufacturer.

END OF SECTION

PART 1 - GENERAL

1.1 APPLICATION

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

1.2 SUBMITTALS

- 1.2.1 Product Data: Submit shop drawings for all devices specified herein and as indicated and scheduled on the drawings. Submittals shall indicate full compliance with the device specification in Part 2. Any deviation shall be specifically noted and subject to engineer approval. Submittals shall include device dimensions, placement, attachments and anchorage requirements. Shop Drawings shall include the following:

- 1.2.1.1 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment, if needed or required. Include auxiliary motor slides and rails, base weights, equipment static loads.
- 1.2.1.2 Vibration Restraint Details: Detailed submittal drawings of vibration restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors. Include ratings for loads.

1.3 MANUFACTURER'S CERTIFICATION LETTER

- 1.3.1 Submit a letter from the vibration isolation manufacturer to certify correct installation of his products, as specified in Part 3 of this Section.

1.4 SEISMIC RESTRAINT REQUIREMENTS

- 1.4.1 Refer to the mechanical work Section entitled Seismic Control and Restraint for requirements for use of a Seismic Consultant, and seismic restraint requirements applicable to vibration isolated materials and equipment.

PART 2 - PRODUCTS

2.1 GENERAL

- 2.1.1 Vibration isolation products are to be in accordance with the drawing schedule and details, and as specified below.
- 2.1.2 Springs: All springs are to be stable, colour coded, selected to operate at no greater than $\frac{2}{3}$ solid load, designed in accordance with the Society of Automotive Engineers Handbook Supplement 9 entitled Manual on Design and Application of Helical and Spiral Springs, and with spring diameters in accordance with the manufacturer's recommendations to suit the static deflection and maximum equipment load.

- 2.1.3 Finishes: All steel components of isolation products not exposed to the weather or moisture are to be zinc plated. All steel components of isolation products exposed to the weather or in a damp, moist environment are to be factory painted with rust inhibiting primer and two coats of neoprene.
- 2.1.4 Where the weight of isolated equipment may change significantly due to draining or filling with a liquid, vibration isolators are to be equipped with limit stops to limit spring extensions.
- 2.1.5 Flexible Piping Connections: Flexible piping connections to vibration isolated equipment are specified in the appropriate piping sections of the Specification.

2.2 ISOLATION PADS

- 2.2.1 Sandwich type pads, 20 mm ($\frac{3}{4}$ ") nominal thickness, selected for 3.2 mm ($\frac{1}{8}$ ") static deflection unless otherwise specified, consisting of two waffle type or ribbed 50 durometer neoprene pads permanently bonded to a minimum #10 gauge steel plate, and complete with rubber bushed bolt holes and equipment anchor bolts with neoprene isolation grommets. Acceptable products are:

- 2.2.1.1 Kinetics Noise Control Vibron Products Group Type NGS/NGD;
- 2.2.1.2 Vibro-Acoustics Ltd. Type NSN;
- 2.2.1.3 Mason Industries Inc. Type SW/S/SW with HG Bolt Insertion Washers;

2.3 SPRING HANGERS

- 2.3.1 Welded steel plate housing with top and bottom rod mounting holes and spring retainer, neoprene double deflection isolation element, stable colour coded spring, and heavy-duty rubber washers. Acceptable products are:

- 2.3.1.1 Kinetics Noise Control Vibron Products Group. Type SRH;
- 2.3.1.2 Vibro-Acoustics Ltd. Type SHR-SN;
- 2.3.1.3 Mason Industries Inc. Type 30N.

PART 3 - EXECUTION

3.1 INSTALLATION OF VIBRATION ISOLATION MATERIALS

- 3.1.1 Provide vibration isolation products for mechanical work in accordance and requirements specified herein and/or on the drawings.
- 3.1.2 At a minimum, vibration isolation shall be provide for mechanical equipment as recommended in "Table 47. Selection Guide for Vibration Isolation" in Chapter 48 of the ASHRAE Handbook.
- 3.1.3 Supply to the vibration isolation product manufacturer or supplier a copy of a "reviewed" shop drawing or product data sheet for each piece of equipment to be isolated and dimensioned pipe layouts of associated piping to be isolated.
- 3.1.4 Unless otherwise specified, all vibration isolation products are to be the product of one manufacturer.

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- 3.1.5 Ensure that the 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.
- 3.1.6 Isolation For Base Mounted Equipment: 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:
- 3.1.6.1 block and shim all bases level so that all ductwork and piping connections can be made to a rigid system at the proper operating level, before isolated adjustment is made, and ensure that there is no physical contact between isolated equipment and the building structure;
 - 3.1.6.2 all steel bases are to clear the sub-base by 25 mm (1");
 - 3.1.6.3 all concrete bases are to clear the sub-base by 50 mm (2").
- 3.1.7 Isolation of Piping: Isolate all 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 the following:
- 3.1.7.1 for pipe to and including 100 mm (4") dia. – first three points of support;
 - 3.1.7.2 for pipe 125 mm (5") to 200 mm (8") dia. – first four points of support;
 - 3.1.7.3 for pipe 250 mm (10") dia. and larger – first six points of support;
 - 3.1.7.4 the 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");
 - 3.1.7.5 secure the top of the spring hanger frame rigidly to the structure, and do not install spring hangers in concealed locations;
 - 3.1.7.6 where it is impossible to use at least two spring hangers, provide Senior Flexonics Ltd. Style 102 (or 102-U as required) or equal, twin sphere, moulded rubber flexible connection assemblies, selected by the manufacturer and suitable in all respects for intended application, and complete with required nipples and connections to provide proper vibration isolation.
- 3.1.8 Control Wiring Connections: For all control wiring connections to vibration isolated equipment ensure that 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 the conduit will remain intact if the equipment moves 300 mm (12") laterally from its installed position, and flexible enough to transmit less vibration to the structure than is transmitted through the vibration isolation. Coordinate these requirements with the mechanical trades involved. If electrical power connections are not made in a similar manner as part of the electrical work, report this fact to the Consultant.

- 3.1.9 Manufacturer's Inspection & Certification: Arrange and pay for the vibration isolation product manufacturer to visit the site to inspect installation of his equipment. Do any revision work required as a result of improper installation. When the vibration isolation equipment manufacturer is satisfied with the installation, obtain and submit a letter stating that he has inspected the installation and that his equipment is properly installed.

END OF SECTION

PART 1 - GENERAL

1.1 Application

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

1.2 Submittals

- .1 **Insulation System Samples:** At least four weeks prior to insulation work commencing, submit a sample of each type of insulation (and insulation accessories and finish), in applied form, for approval. Mount the samples on a plywood board. Identify each product with the manufacturer's name and insulation type, and the proposed use of the insulation. When the sample board has been approved, all mechanical insulation work is to conform to the approved sample board.
- .2 **Product Data Sheets:** Submit a product data sheet for each insulation system product.
- .3 **Removable/Reusable Insulation Covers:** Submit a fabrication drawing for each custom made cover to indicate material and fabrication details, and a 300 mm (12") square sample of the proposed cover material.
- .4 **Fire Rated Duct Wrap Certification Letter:** As per Part 3 of this Section, submit a letter from the fire rated duct wrap supplier to certify that the duct wrap has been properly installed.
- .5 **Lagging Adhesive Colour Samples:** Submit a colour chart for coloured lagging adhesive for canvas jacketed insulation.

1.3 Quality Assurance

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

1.4 Definitions

- .1 For the work of this Section:

- .1 "concealed" means mechanical services and equipment above suspended ceilings, in non-accessible chases, in accessible pipe spaces, and furred-in spaces;
- .2 "exposed" means exposed to normal view during normal conditions and operations;
- .3 "mineral fibre" includes glass fibre, rock wool, and slag wool;
- .4 "domestic water" or "potable water" means all piping extended from the building Municipal supply main.

PART 2 - PRODUCTS

2.1 Fire Hazard Ratings

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

2.2 Thermal Performance

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

2.3 Pipe Insulation Materials

- .1 **Horizontal Pipe Insulation at Hangers & Supports:** Equal to Belform Insulation Ltd. "Koolphen K-Block" insulated pipe support inserts consisting of minimum 150 mm (6") long, premoulded, rigid, sectional phenolic foam insulation (of same thickness as adjoining insulation) with a reinforced foil and kraft paper vapour barrier jacket and a captive galvanized steel saddle.
- .2 **Flexible Foam Elastomeric:** Closed cell, sleeve type, longitudinally split self-seal, foamed plastic pipe insulation with a water vapour transmission rating of 0.10 in accordance with ASTM E96-90, Procedure B, and all required installation accessories. Acceptable products are:
 - .1 Armacell AP/Armaflex SS;
 - .2 IK Insulation Group K-Flex "LS" Self-Seal Pipe Insulation.
- .3 **Premoulded Mineral Wool:** Rigid, sectional, sleeve type, non-combustible, longitudinally split mineral wool or basalt pipe insulation with a reinforced vapour barrier jacket. Acceptable products are:
 - .1 ProRox PS 960;
 - .2 IIG (Johns Manville Inc.) MinWool-1200.

- .4 **Fire Rated Premoulded Mineral Wool:** Non-combustible, fire-rated, rigid, sectional, longitudinally split mineral wool or basalt pipe insulation with a reinforced vapour barrier jacket and compatible with CAN4-S115 and CAN/ULC-S01 firestopping. Acceptable products are:
 - .1 ProRox PS 960;
 - .2 IIG (Johns Manville Inc.) MinWool-1200.
- .5 **Premoulded Mineral Fibre:** Rigid, sectional, sleeve type insulation to ASTM Standard C 547-00, with a factory applied vapour barrier jacket. Acceptable products are:
 - .1 Johns Manville Inc. "Micro-Lok AP-T Plus";
 - .2 Knauf Fiber Glass "Pipe Insulation" with "ASJ-SSL" jacket;
 - .3 Manson Insulation Inc. "ALLEY K APT";
 - .4 Owens Corning Fiberglas Pipe Insulation.
- .6 **Blanket Mineral Fibre:** Blanket type roll insulation to CGSB 51-GP-11M, 12 kg/m³ (3/4 lb./ft.³) density to achieve R-4.2, with a factory applied vapour barrier facing. Acceptable products are:
 - .1 Johns Manville Inc. Microlite FSK Duct Wrap Type 75;
 - .2 Knauf Fiber Glass Blanket Insulation FSK Duct Wrap;
 - .3 Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap;
 - .4 Certainteed Corporation Softtouch FSK Duct Wrap Type 75.
- .7 **Premoulded Weatherproof Jacketed Mineral Fibre:** Knauf Insulation "Redi-Klad 1000" sectional, sleeve type pipe insulation with a self-sealing weather-proof jacket and a 100 mm (4") butt joint sealing strip with each section.

2.4 Barrier-Free Lavatory Piping Insulation Kits

- .1 Removable, flexible, reusable, white moulded plastic insulation kits for barrier-free lavatory drain piping and potable water supplies exposed under the lavatory. Acceptable products are:
 - .1 Truebo "Lav-Guard 2" E-Z Series;
 - .2 Zeston "SNAP-TRAP";
 - .3 McGuire Manufacturing Co. Inc. "ProWrap".

2.5 Equipment Insulation Materials

- .1 **Blanket Mineral Fibre:** Blanket type roll form insulation to ASTM Standard C553-00, 12 kg/m³ (3/4 lb./ft.³) density to achieve R-4.2, with a factory applied vapour barrier facing. Acceptable products are:
 - .1 Johns Manville Inc. Microlite FSK Duct Wrap Type 75;
 - .2 Knauf Fiber Glass Blanket Insulation FSK Duct Wrap ;

- .3 Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap;
- .4 Certainteed Corporation Softtouch FSK Duct Wrap Type 75.
- .2 **Semi-Rigid Mineral Fibre Board:** Roll form, moulded insulation to ASTM Standard C1393-00a, with a factory applied vapour barrier facing consisting of laminated aluminum foil and kraft paper. Acceptable products are:
 - .1 Knauf Fiber Glass Pipe and Tank Insulation;
 - .2 Manson Insulation Inc. "AK FLEX";
 - .3 Johns Manville Inc. Pipe and Tank Insulation "Micro-Flex";
 - .4 Multi-Glass Insulation Ltd. "MULTI-FLEX MF";
 - .5 Owens Corning Pipe and Tank Insulation;
 - .6 Glass-Cell Fabricators Ltd. "R-Flex".
- .3 **Semi-Rigid Mineral Wool Blanket:** Equal to Roxul "Enerwrap80" flexible, black fibrous scrim faced mineral wool blanket insulation to ASTM C 553.
- .4 **Closed Cell Foamed Glass:** Pittsburgh Corning "FOAMGLAS" expanded, rigid board and block type insulation with a liquid or vapour permeability rating (as per ASTM C240) of 0.00.

2.6 Removable/Reusable Insulation Covers

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

2.7 Ductwork System Insulation Materials

- .1 **Rigid Mineral Fibre Board:** Preformed board type insulation to ASTM C612-00a, 48 kg/m³ (3.0 lb./ft.³) density to achieve R-4.2, with a factory applied reinforced aluminum foil and kraft paper facing. Acceptable products are:

- .1 Knauf Fiber Glass Insulation Board with FSK facing;
 - .2 Manson Insulation Inc. "AK BOARD FSK";
 - .3 Johns Manville Inc. Type 814 "Spin-Glas";
 - .4 Owens Corning 703.
- .2 **Semi-Rigid Mineral Fibre Board:** Roll form insulation to ASTM Standard C1393 00a, consisting of cut strips of rigid mineral board insulation glued to an aluminium foil and kraft paper facing. Acceptable products are:
- .1 Multi-Glass Insulation Ltd. "Multi-Flex MKF";
 - .2 Glass-Cell Fabricators Ltd. "R-FLEX";
 - .3 Owens Corning Pipe and Tank Insulation;
 - .4 Johns Manville Inc. Pipe and Tank Insulation.
- .3 **Blanket Mineral Fibre:** Blanket type roll form insulation to ASTM Standard C553-00, 12 kg/m³ (3/4 lb./ft.³) density to achieve R-4.2, with a factory applied vapour barrier facing. Acceptable products are:
- .1 Johns Manville Inc. Microlite FSK Duct Wrap Type 75;
 - .2 Knauf Fiber Glass Blanket Insulation FSK Duct Wrap;
 - .3 Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap;
 - .4 Certainteed Corporation Softtouch FSK Duct Wrap Type 75.
- .4 **Flexible Foam Elastomeric Sheet:** Sheet form, CFC free, closed cell, self-adhering elastomeric nitrile rubber insulation with a water vapour permeability rating of 0.08 in accordance with ASTM E96 Procedure A. Acceptable products are:
- .1 Armacell "AP/Armaflex SA";
 - .2 IK Insulation Group "K-Flex Duct Wrap", S2S.

2.8 Fire Rated Duct Wrap

- .1 Flexible, non-combustible, blanket type mineral fibre duct wrap completely encapsulated in reinforced foil, 40 mm (1½") thick, suitable for installation with zero clearance to combustibles, and ULC tested and listed (ULC Designs FRD-3 & 5 for ventilation ducts, ULC Design FRD-4 for kitchen exhaust duct) to facilitate a 1 or 2 hour fire resistance rating to kitchen grease exhaust duct in accordance with requirements of NFPA-96, and/or a 1 or 2 hour fire resistance rating to ventilation or pressurization ductwork in accordance with requirements of ISO 6944.
- .2 Acceptable manufacturers are:
 - .1 3M Fire Barrier Duct Wrap 615+;
 - .2 CL4 Inc. "CL4Fire";
 - .3 Unifrax Corp. "FyreWrap Elite 1.5";
 - .4 Morgan Thermal Ceramics "FireMaster FastWrap XL".

2.9 Insulating Coatings

- .1 Equal to Robson Thermal Manufacturing Ltd. insulating coatings as follows:
 - .1 anti-condensation coating, "No Sweat-FX";
 - .2 thermal insulating coating, "ThermaLite".

2.10 Insulation Fastenings

- .1 **Wire:** Minimum #15 gauge galvanized annealed wire.
- .2 **Wire Mesh:** Minimum #15 gauge galvanized annealed wire factory woven into 25 mm (1") hexagonal mesh.
- .3 **Aluminium Banding:** Equal to ITW Insulation Systems Canada "FABSTRAPS" minimum 12 mm (½") wide, 0.6 mm (1/16") thick aluminium strapping.
- .4 **Stainless Steel Banding:** Equal to ITW Insulation Systems Canada "FABSTAPS" 0.6 mm (1/16") thick, minimum 12 mm (½") wide type 304 stainless steel strapping.
- .5 **Duct Insulation Fasteners:** Weld-on 2 mm (3/32") diameter zinc coated steel spindles of suitable length, complete with minimum 40 mm (1½") square plastic or zinc plated steel self-locking washers.
- .6 **Tape Sealant:** Equal to MACtac Canada Ltd. self-adhesive insulation tapes, types PAF, FSK, ASJ, or SWV as required to match the surface being sealed.
- .7 **Adhesive - Mineral Fibre Insulation:** Clear, pressure sensitive, brush consistency adhesive, suitable for a temperature range of -20°C to 82°C (-4°F to 180°F), compatible with the type of material to be secured, and WHMIS classified as non-hazardous.
- .8 **Adhesive – Flexible Elastomeric Insulation:** Armacell "Armaflex" #520 air-drying contact adhesive.
- .9 **Lagging Adhesive:** White, brush consistency, ULC listed and labelled, 25/50 fire/smoke rated lagging adhesive for canvas jacket fabric, suitable for colour tinting, complete with fungicide and washable when dry.
- .10 **Sheet Metal Screws:** No. 10 stainless steel sheet metal screws.

2.11 Insulation Jackets and Finishes

- .1 **Canvas:** ULC listed and labelled, 25/50 rated, roll form, minimum 170 g (6 oz.) canvas jacket material.
- .2 **White PVC:** Roll form sheet and fitting covers, minimum 15 mil thick white PVC, 25/50 rated, complete with installation and sealing accessories. Acceptable products are:
 - .1 Proto Corp. "LoSMOKE";
 - .2 The Sure-Fit System "SMOKE-LESS 25/50";
 - .3 Johns Manville Inc. "Zeston" 300.

- .3 **Rigid Aluminium:** Equal to ITW Insulation Systems Canada "Lock-on" 0.406 mm (0.016") thick embossed aluminum jacket material to ASTM B209, factory cut to size and complete with polysurlyn moisture barrier and continuous modified Pittsburgh Z-Lock, and "Fabstraps" and butt straps with weatherproof the end to end joints. Fittings are to be two-piece epoxy coated pressed aluminum with weather locking edges.
- .4 **Stainless Steel:** Equal to ITW Insulation Systems Canada "Lock-on" 0.254 mm (0.010") thick type 304 embossed stainless steel to ASTM A240, factory cut to size and complete with moisture barrier and continuous modified Pittsburgh Z-Lock, and butt straps with "Fabstraps" to cover end to end joints. Fittings are to be two piece pressed stainless steel with weather locking edges.
- .5 **Adhesive Backed Flexible Aluminium:** MFM Building Products Corp. "Flex-Clad 400" roll form sheet material with an aggressive rubberized asphalt adhesive backing, high density polyethylene reinforcement, and an embossed aluminum facing.
- .6 **Protective Coating - Flexible Foam Elastomeric Insulation:** Equal to Armacell "WB Armaflex" weatherproof, water-based latex enamel finish.

PART 3 - EXECUTION

3.1 General Insulation Application Requirements

- .1 Unless otherwise specified, do not insulate the following:
 - .1 factory insulated equipment and piping;
 - .2 heating piping within radiation unit enclosures, including blank filler sections of enclosures;
 - .3 heating piping in soffits and/or overhang spaces and connected to bare element radiation in the spaces;
 - .4 branch potable water piping located under counters to serve counter mounted plumbing fixtures and fittings, except barrier-free lavatories;
 - .5 exposed chrome plated potable water angle supplies from concealed piping to plumbing fixtures and fittings, except barrier-free lavatories;
 - .6 heated liquid system pump casings, valves, strainers and similar accessories;
 - .7 heating system expansion tanks;
 - .8 fire protection pump casings;
 - .9 manufactured expansion joints and flexible connections;
 - .10 acoustically lined ductwork and/or equipment;
 - .11 flexible branch ductwork from sheet metal ducts to grilles or diffusers;
 - .12 fire protection system water storage tanks;
 - .13 piping unions, except for unions in "cold" category piping.
- .2 Install insulation directly over pipes and ducts and not over hangers and supports.
- .3 Install piping insulation and jacket continuous through pipe openings and sleeves.

- .4 Install duct insulation continuous through walls, partitions, and similar surfaces except at fire dampers.
- .5 When insulating "cold" piping and equipment, extend insulation up valve bodies and other such projections as far as possible, and protect the insulation jacketing from the action of condensation at its junction with the metal.
- .6 Insulate, vapour seal, and finish all seismic restraints, braces, anchors, hanger rods, and similar hardware directly connected to "cold" piping and/or equipment, for a distance of 300 mm (12") clear of the adjacent pipe or equipment finish, to match the piping and/or equipment insulation.
- .7 When insulating vertical piping risers 75 mm diameter and larger, use insulation support rings welded directly above the lowest pipe fitting, and thereafter at 4.5 m centres and at each valve and flange. Insulate as per Thermal Insulation Association of Canada National Insulation Standards, Figure No. 9.
- .8 Where piping and/or equipment is traced with electric heating cable, ensure that the cable has been tested and accepted prior to the application of insulation, and ensure that the cable is not damaged or displaced during the application of insulation.
- .9 Where existing insulation work is damaged as a result of a new mechanical work, repair the damaged insulation work to new work standards.
- .10 Where mineral fibre rigid sleeve type insulation is terminated at valves, equipment, unions, etc., neatly cover the exposed end of the insulation with a purpose made PVC cover on "cold" piping, and with canvas jacket material on "hot" piping.
- .11 Carefully and neatly gouge out insulation for proper fit where there is interference between weld bead, mechanical joints, etc., and insulation. Bevel away from studs and nuts to permit their removal without damage to insulation, and closely and neatly trim around extending parts of pipe saddles.
- .12 Where thermometers, gauges, and similar instruments occur in insulated piping, and where access to heat transfer piping balancing valve ports and similar items are required, create a neat, properly sized hole in the insulation and provide a suitable grommet in the opening.

3.2 Insulation for Horizontal Pipe at Hangers and Supports

- .1 At each hanger and support location for piping 50 mm (2") diameter and larger and scheduled to be insulated, except where roller hangers and/or supports are required, and unless otherwise specified, supply a factory fabricated section of phenolic foam pipe insulation with integral vapour barrier jacket and captive galvanized steel shield. Supply the insulation sections to the piping installers for installation as the pipe is erected.
- .2 For 100 mm (4") diameter and larger heating system piping where roller type hangers and supports are provided, a steel saddle will be tack welded to the pipe at each roller hanger or support location. Pack saddle voids with loose mineral wool insulation.

3.3 Pipe Insulation Requirements - Mineral Fibre

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- .1 Insulate the following pipe inside the building and above ground with mineral fibre insulation of the thickness indicated:
- .1 domestic cold water piping to and including 100 mm (4") dia. – 25 mm (1") thick;
 - .2 domestic cold water piping larger than 100 mm (4") dia. – 40 mm (1½") thick;
 - .3 domestic hot water piping, to and including 40 mm (1½") dia. – 25 mm (1") thick;
 - .4 domestic hot water piping, larger than 40 mm (1½") dia. – 40 mm (1½") thick;
 - .5 tempered domestic water piping, supply and return, to and including 40 mm (1½") dia. – 25 mm (1") thick;
 - .6 tempered domestic water piping, supply and return, larger than 40 mm (1½") dia. – 50 mm (2") thick;
 - .7 storm drainage piping from roof drains to the point where main vertical risers extend straight down, without offsets, and connect to horizontal underground mains - 25 mm (1") thick;
 - .8 condensate drainage piping from fan coil unit or any other air conditioning system/unit drain pans to main vertical drain risers or to indirect drainage point – 25 mm (1") thick;
 - .9 drainage piping from refrigerated drinking fountains to nearest 75 mm (3") dia. or larger drain pipe – 25 mm (1") thick;
 - .10 chilled water piping, supply and return, to and including 100 mm (4") dia – 25 mm (1") thick;
 - .11 chilled water piping, supply and return, larger than 100 mm (4") dia. – 40 mm (1½") thick;
 - .12 chilled glycol solution piping, supply and return, to and including 100 mm (4") dia. – 25 mm (1") thick;
 - .13 chilled glycol solution piping, supply and return, larger than 100 mm (4") dia. – 40 mm (1½") thick;
 - .14 hot water heating piping, supply and return, to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .15 hot water heating piping, supply and return, 40 mm (1½") dia. and larger – 40 mm (1½") thick [50 mm (2") thick if higher temperature application with non-condensing boiler];
 - .16 glycol solution heating or heat reclaim piping, supply and return, to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .17 glycol solution heating or heat reclaim piping, supply and return, 40 mm (1½") dia. and larger – 40 mm (1½") thick; [50 mm (2") thick if higher temperature application with non-condensing boiler];
 - .18 low pressure (to 140 kPa-20 psi) steam piping to 40 mm (1½") dia. – 100 mm (4") thick;

- .19 low pressure (to 140 kPa-20 psi) steam piping, 40 mm (1½") dia. and larger – 112 mm (4½") thick;
 - .20 medium pressure (140 - 415 kPa-20 – 60 psi) steam piping to 40 mm (1½") dia. – 100 mm (4") thick;
 - .21 medium pressure (140 - 415 kPa-20 – 60 psi) steam piping, 40 mm (1½") dia. and larger – 112 mm (4½") thick;
 - .22 low pressure condensate piping to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .23 low pressure condensate piping, 40 mm (1½") dia. and larger – 50 mm (2");
 - .24 medium pressure condensate piping to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .25 medium pressure condensate piping, 40 mm (1½") dia. and larger – 50 mm (2");
 - .26 boiler feedwater piping complete – 25 mm (1") thick;
 - .27 boiler blowdown piping complete – 40 mm (1½") thick;
 - .28 chilled domestic cold water piping from remote water cooler(s) to drinking fountain(s) – 40 mm (1½") thick;
 - .29 all piping as above located inside building in unheated areas and indicated to be traced with electric heating cable – minimum 50 mm (2") thick;
 - .30 drum drip(s) in dry zone standpipe and/or sprinkler system piping – 50 mm (2") thick;
 - .31 refrigerant suction piping (between compressor and evaporator coil) inside building – 25 mm (1") thick;
 - .32 refrigerant hot gas piping (between compressor and condenser) inside building – 25 mm (1") thick;
 - .33 refrigerant hot gas by-pass piping (between compressor discharge and evaporator coil) inside building – 25 mm (1") thick;
 - .34 air compressor set fresh air intake piping – 25 mm (1") thick;
 - .35 heat pump equipment earthloop piping – 25 mm (1") thick.
- .2 **Piping:** Ensure that the overlap flap of the sectional insulation jacket is secured tightly in place. Cover section to section butt joints with tape sealant.
- .3 **Fittings:** Insulate fittings with sectional pipe insulation mitred to fit tightly, and cover butt joints with tape sealant, or, alternatively, wrap fittings with blanket mineral fibre insulation to a thickness and insulating value equal to the sectional insulation, secure in place with adhesive and/or wire, and cover with PVC fitting covers.
- .4 **"Cold" Piping Unions, Valves, Strainers, Etc.:** Unless otherwise specified, insulate unions, valves, strainers, and similar piping system accessories in "cold" piping such as domestic water or chilled water piping with cut and tightly fitted segments of sectional pipe insulation with all joints covered with tape sealant, or, alternatively, wrap the piping union, valve, strainer, etc., with blanket mineral fibre and cover with PVC covers as for "Fittings" above.

- .5 **Flanges and Mechanical Couplings:** Terminate sectional insulation approximately 50 mm (2") from the flange or coupling on each side of the flange or coupling. Cover the flange or coupling with a minimum 50 mm (2") thickness of blanket mineral fibre insulation wide enough to butt tightly to the ends of the adjacent sectional insulation. Secure the blanket insulation in place and cover with a purpose made purpose made PVC coupling cover.
- .6 **Fire Protection Piping Drum Drips:** Drum drips in dry zone sprinkler and/or standpipe system piping will be traced with electric heating cable as part of the electrical work and are generally not shown on the drawing(s). Confirm the number and size of the drum drips required with the trade providing the piping and include for the insulation to suit. Note that wherever possible drum drips will be located in heated areas.
- .7 **Concealed Rough-In Piping at Plumbing Fixtures:** Take special care at concealed water rough-in piping at plumbing fixtures to ensure that the piping is properly insulated. If necessary due to space limitations, use 12 mm (½") thick sectional pipe insulation in lieu of 25 mm (1") thick insulation.
- .8 **Seismic Restraint Hardware:** Insulate all seismic restraint hardware such as hanger rods, braces, anchors, etc., directly connected to "cold" category piping and equipment for a distance of 300 mm (12") from the piping or equipment with insulation and finish to match the pipe or equipment insulation. Coat all seismic restraint hardware for a distance of 300 mm (12") from the termination of the insulation with Robson Thermal "NO-SWEAT-FX" water based anti-condensation coating.

3.4 Pipe Insulation Requirements – Mineral Wool

- .1 Insulate the following pipe inside the building and above ground with high temperature mineral wool insulation of the thickness indicated:
 - .1 high pressure (above 415 kPa-60 psi) steam piping to 40 mm (1½") dia. – 100 mm (4") thick;
 - .2 high pressure (above 415 kPa-60 psi) steam piping, 40 mm (1½") dia. and larger – 112 mm (4½") thick;
 - .3 high pressure condensate piping – 50 mm (2") thick;
 - .4 engine-generator set exhaust system piping – 75 mm (3") thick;
- .2 **Piping:** Generally, install as specified above for mineral fibre insulation.
- .3 **Fittings, Valve, Etc.:** Generally, install as specified above for mineral fibre insulation but cover with canvas, not PVC fitting covers.

3.5 Pipe Insulation Requirements – Flexible Foam Elastomeric (closed cell)

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

3.6 Pipe Insulation Requirements – Closed Cell Foamed Glass

- .1 Install closed cell foamed glass insulation in strict accordance with the manufacturer's published instructions to suit the application, and using adhesive, joint sealants, and jacketing to produce a 100% water-tight installation. Insulate the following pipe with closed cell foamed glass of the thickness indicated:
 - .1 Steam piping outside the building - 113mm (4.5");
 - .2 Chilled water outside the building - 25 mm (1")

3.7 Pipe Insulation Requirements – Fire Rated Insulation

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

3.8 Installation Of Weather-Proof Jacketed Insulation

- .1 Install sectional weather-proof jacketed pipe insulation in strict accordance with the manufacturer's instructions to produce a water-tight weatherproof installation. Insulate fittings with blanket type glass fibre insulation of a thickness and insulating value equal to the sectional insulation and secured in place with adhesive and wire. Jacket fittings with manufactured aluminium fitting covers sealed water-tight. Insulate the following pipe with weather-proof jacketed insulation:
 - .1 Steam piping outside the building;
 - .2 Chilled water outside the building
 - .3 Refrigerant suction and hot gas piping outside the building.

3.9 Installation Of Barrier Free Lavatory Insulation Kits

- .1 Provide manufactured insulation kits to cover exposed drainage and water piping under new barrier free lavatories.

3.10 Equipment Insulation Requirements - Blanket Type Mineral Fibre

- .1 Insulate the following equipment with mineral fibre blanket type insulation of the thickness indicated:
 - .1 chilled water and/or domestic cold water pump casings – 40 mm (1½") thick;
 - .2 roof drain sumps where inside the building – 25 mm (1") thick;
 - .3 water meter(s) – 40 mm (1½") thick;
 - .4 the top of radiant ceiling panels – 50 mm (2") thick.
- .2 Unless otherwise noted, wrap the equipment to a thickness and insulating value equal to an equivalent thickness of rigid sectional pipe insulation. Laminate the insulation in place with a full coverage of adhesive and secure with wire. Apply a jacket of the insulation vapour barrier material secured in place with adhesive or sealant tape.

- .3 Cover roof drain sumps with purpose made PVC fitting covers.
- .4 Lay the fibreglass blanket on radiant ceiling panels after testing is complete.

3.11 Equipment Insulation Requirements - Semi-Rigid Mineral Fibre

- .1 Insulate the following equipment with semi-rigid mineral fibre board insulation of the thickness indicated:
 - .1 refrigeration machine water chiller(s) and suction elbow(s) – 50 mm (2") thick;
 - .2 uninsulated domestic hot water storage tank(s) – 40 mm (1½") thick;
 - .3 shell and tube type heat exchangers – 40 mm (1½") thick;
 - .4 condensate receiver(s) – 40 mm (1½") thick;
 - .5 flash tanks – 40 mm (1½") thick;
 - .6 hot well tank – 40 mm (1½") thick;
 - .7 deaerating feedwater heater – 40 mm (1½") thick;
 - .8 blow-down tank – 40 mm (1½") thick;
 - .9 chilled water or chilled glycol solution storage tank – 50 mm (2") thick;
 - .10 heating main air separator – 40 mm (1½") thick;
 - .11 chilled water expansion tank – 40 mm (1½") thick.
- .2 Install the insulation as required to fit the shape and contour of the equipment. Secure the insulation in place with adhesive, and with aluminium straps on 450 mm (18") centres. Apply a 6 mm (¼") thick skim coat of insulating cement, then, when the insulating cement has dried, apply a 6 mm (¼") thick coat of cement trowelled smooth.
- .3 For "cold" equipment, prime the insulation with suitable sealer and apply a jacket of glass thread reinforced foil and kraft paper vapour barrier jacket material laminated in place with a full coverage of adhesive.
- .4 Provide removable and replaceable insulated metal covers for all equipment with removable heads to permit the heads to be removed and replaced without damaging the adjacent insulation work.

3.12 Equipment Insulation Requirements – Semi-Rigid Mineral Wool

- .1 Insulate the following equipment with mineral wool blanket insulation of the thickness indicated:
 - .1 engine-generator set exhaust system silencer(s) – 75 mm (3") thick;
 - .2 uninsulated boiler breeching where inside the building – 75 mm (3") thick.
- .2 Cut or mitre the insulation (or use factory scored type insulation) to fit the shape and contour of the equipment and secure the insulation in place with aluminium straps on 450 mm (18") centres. Point all joints, mitres, scores and gaps with insulating cement. Apply a 12 mm (½") thick coat of insulating cement and trowel smooth.

3.13 Equipment Insulation Requirements – Removable/Reusable Type

- .1 Provide custom designed and manufactured removable and reusable insulation covers for the following:
 - .1 plate type heat exchanger(s);
 - .2 150 mm (6") dia. and larger piping strainers, backflow preventers, etc.;
 - .3 diesel engine exhaust manifolds;
 - .4 150 mm (6") dia. and larger steam traps and similar equipment.
- .2 Provide "wrap type" removable and reusable insulation covers for "cold" circuit balancing valves, backflow preventers, and similar items, and for steam traps and similar items requiring service in piping less than 150 mm (6") dia.

3.14 Ductwork Insulation Requirements - Mineral Fibre

- .1 Insulate the following ductwork systems inside the building and above ground with mineral fibre insulation of the thickness indicated:
 - .1 all outside air intake ductwork, casings and plenums from fresh air intakes to and including mixing plenums or sections, or, if mixing plenums or sections are not provided, to the first heating coil, or if both mixing plenums or sections and heating coil sections are not provided, and the fresh air is not tempered, then the fresh air ductwork system complete – minimum 40 mm (1½") thick as required;
 - .2 mixed supply air or preheated supply air casings, plenums and sections to and including the fan section where not factory insulated – minimum 25 mm (1") thick rigid board or minimum 40 mm (1½") thick flexible blanket as required;
 - .3 supply air ductwork outward from fans, except for supply ductwork exposed in the area it serves – minimum 25 mm (1") thick rigid board or minimum 40 mm (1½") thick flexible blanket as required;
 - .4 exhaust discharge ductwork for a distance of 3 m (10') downstream (back) from exhaust openings to atmosphere, including any exhaust plenums within the 3 m (10') distance – minimum 25 mm (1") thick rigid board or minimum 40 mm (1½") thick flexible blanket as required;
 - .5 any other ductwork, casings, plenums or sections specified or detailed on the drawings to be insulated – thickness as specified.
- .2 Insulation for casings, plenums, and exposed rectangular ductwork is to be rigid board type. Insulation for round ductwork and concealed rectangular ductwork is to be blanket type. Insulation shall be minimum 75mm (3") thick fiberglass rigid board 3.0 lbs density in 2 layers to achieve R-12 as required.
- .3 **Exposed Rectangular Ducts and/or Casings:** Liberally apply adhesive to all surfaces of the duct and/or casing. Accurately and neatly press the insulation into the adhesive with tightly fitted butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom and side surfaces. Secure and seal all joints with 75 mm (3") wide tape sealant. Additional installation requirements are as follows:

- .1 at trapeze hanger locations install insulation between the duct and the hanger;
- .2 provide drywall type metal corner beads on edges of ductwork, casings and plenums in equipment rooms, service corridors, and any other area where the insulation is subject to accidental damage, and secure in place with tape sealant.
- .4 **Concealed Rectangular or Oval Ductwork:** Liberally apply adhesive to all surfaces of the duct and wrap the insulation around the duct with a top butt joint and tight section to section butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom surfaces. Secure and seal all joints with 75 mm (3") tape sealant. Additional installation requirements are as follows:
 - .1 at each trapeze type duct hanger provide a 100 mm (4") wide full length piece of rigid mineral fibre board insulation between the duct and the hanger.
- .5 **Exposed & Concealed Round or Oval Ductwork:** Accurately cut sections of insulation to fit tightly and completely around the duct. Liberally apply adhesive to all surfaces of the duct and wrap the insulation around the duct with a top butt joint and tight section to section butt joints. Seal all joints with tape sealant. At duct hanger locations install the insulation between the duct and hanger. At each hanger location for concealed ductwork where flexible blanket insulation is used, provide a 100 mm (4") wide full circumference strip of semi-rigid board type duct insulation between the duct and the hanger.
- .6 **Common Duct Insulation Requirements:** Insulation application requirements common to all types of rigid ductwork are as follows:
 - .1 at duct connection flanges insulate the flanges with neatly cut strips of the rigid insulation material secured with adhesive to side surfaces of the flange with a top strip to cover the exposed edges of the side strips, then butt the flat surface duct insulation up tight to the flange insulation, or, alternatively, increase the insulation thickness to the depth of the flange and cover the top of the flanges with tape sealant;
 - .2 the installation of fastener pins and washers is to be concurrent with the duct insulation application;
 - .3 cut insulation fastener pins almost flush to the washer and cover with neatly cut pieces of tape sealant;
 - .4 accurately and neatly cut and fit insulation at duct accessories such as damper operators (with standoff mounting) and pitot tube access covers;
 - .5 prior to concealment of insulation by either construction finishes or canvas jacket material, patch all vapour barrier damage by means of tape sealant.

3.15 Ductwork Insulation Requirements - Flexible Elastomeric

- .1 Insulate all exposed exterior ductwork (except fresh air intake ductwork) and associated plenums and/or casings outside the building with minimum 40 mm (1½") thick flexible elastomeric sheet insulation as required, applied in two minimum 20 mm (¾") thick layers with staggered tightly butted joints.

- .2 Install with adhesive in strict accordance with the manufacturer's published instructions to produce a weather-proof installation. Ensure that sheet metal work joints are sealed watertight prior to applying insulation.

3.16 Duct Wrap Requirements – Fire Rated Material

- .1 Provide blanket type fire rated duct wrap system material for the following ductwork to produce the fire rating indicated:
 - .1 fume hood exhaust ductwork; on level S of new building
 - .2 stairwell pressurization ductwork;
 - .3 Dryer exhaust ductwork on level S of building H;xz
 - .4 Supply/Return ductwork on level 4 of new building;
 - .5 New generators engine exhaust.
 - .6 And other ductwork with fire wrap indicated on mechanical drawings.
- .2 Install the duct wrap material in accordance with ULC design requirements and the wrap supplier's instructions.
- .3 Coordinate installation of duct wrap with the installation of the ductwork.
- .4 Arrange and pay for the duct wrap supplier to examine the completed duct wrap system at the site. Submit a letter from the supplier to certify that the duct wrap system has been properly installed.

3.17 Application of Insulating Coatings

- .1 Apply, in accordance with the manufacturer's instruction, insulating coatings to the following bare metal surfaces:
 - .1 paint all bare metal surfaces clear of "cold" piping and/or equipment insulation for a distance of from 300 mm (12") to 600 mm (24") clear of the pipe or equipment insulation, with "No Sweat-FX" anti-condensation coating;
 - .2 paint all bare metal surfaces associated with mechanical systems with an operating temperature 60°C (140°F) with "ThermaLite" insulating coating.
- .2 Apply coatings with a brush. Remove any splatter or excess coating from adjacent surfaces.

3.18 Insulation Finish Requirements

- .1 **Canvas:** Unless otherwise shown and/or specified, jacket all exposed mineral fibre insulation, and calcium silicate duct insulation work inside the building with canvas secured in place with a full 100% covering coat of lagging adhesive. Accurately cut canvas with scissors or a knife. Do not rip or tear canvas to size. Remove lagging adhesive splatter from adjacent uninsulated surfaces.

- .2 **White PVC:** Jacket exposed pipe insulation work inside the building with white sheet PVC and fitting covers. Install sheet PVC and fitting covers tightly in place with overlapped circumferential and longitudinal joints arranged to shed water. Seal all joints to produce a neat water-tight installation. Provide slip-type expansion joints where required by manufacturer's instructions.
- .3 **Rigid Aluminum:** Install aluminum jacket material tightly in place with overlapped circumferential joints positioned to shed water and covered with butt straps supplied with the jacket. Provide aluminum jacket for the following insulation:
 - .1 Steam piping outside the building;
 - .2 Chilled water outside the building
 - .3 Refrigerant suction and hot gas piping outside the building;
- .4 **Protective Coating - Foamed Glass Insulation:** Apply two heavy coats of "PITTCOTE 404" coating with 24 hr. between coats to all foamed glass insulation exposed above grade.
- .5 **Protective Coating – Flexible Elastomeric Insulation:** Apply 2 coats (with 24 hr. between coats) of the specified coating to all insulation outside the building.

END OF SECTION

PART 1- GENERAL

1.1 DESCRIPTION

- 1.1.1 This specification further describes the electrical, mechanical, environmental, agency, and reliability requirements for three-phase, Variable Frequency Drives (VFD) to meet the project's objectives.

1.2 QUALITY ASSURANCE

- 1.2.1 VFDs are to comply with following codes, regulations and standards (as applicable):

- 1.2.1.1 applicable local codes and regulations;
- 1.2.1.2 IEEE-519-1992
- 1.2.1.3 NEMA MG-1 Motors and Generators
- 1.2.1.4 Canadian Electrical Code (CSA 22.1-12)
- 1.2.1.5 EN50082-1/2
- 1.2.1.6 IEC 61800-3

1.3 SUBMITTALS

- 1.3.1 The manufacturer shall submit all shop drawings for review prior to approval, including outline dimensions, conduit entry locations, weight, customer connection and power wiring diagrams.
- 1.4.1.1 The contractor shall submit a complete technical product description including a complete list of options provided. Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.
 - 1.4.1.2 Certification Letter: Submit a start-up and installation certification letter from supplier of VFDs as specified in Part 3 of this Section;
 - 1.4.1.3 Parameters: Prepare list of parameters for uploading for Owner's future use as specified in Part 3 of this Section. Load on USB type flash drive and submit to Consultant.
 - 1.4.1.4 Extended Warranty: Where extended warranty is specified to be included, include a copy of VFD extended warranty in each Operating and Maintenance Manual. Prior to Substantial Performance of Work, submit a copy of warranty to Owner.
 - 1.4.1.5 Additionally, coordinate with Prime Contractor and Electrical Contractor to ensure that shop drawings clearly identify that proposed VFDs and connected motors are 100% compatible and Mechanical Contractor to sign off on selected VFDs.

1.4 COORDINATION WITH ELECTRICAL DIVISIONS

- 1.4.1 This Section specifies VFD requirements for motors. Ensure that VFDs packaged with various system equipment, complies with specifications of this Section.
- 1.4.1.1 VFDs are each to be approved by respective manufacturers of VFDs and connected motors, as suitable for installation on scheduled motors. VFD output current rating to match or exceed connected motor nameplate full load current rating.
 - 1.4.1.2 Coordinate and review with Electrical Divisions, responsibility requirements for supply of VFDs, harmonic filters and requirements for control and power conductors and connections.
 - 1.4.1.3 Check that motors are equipped with AEGIS or approved equal, shaft grounding ring system to protect bearings from damage in motors by diverting harmful shaft voltages and bearing currents to ground.
 - 1.4.1.4 Additionally, review and confirm responsibilities with Consultant and Prime Contractor.

PART 2 - MATERIALS AND PRODUCTS

2.2 MANUFACTURERS

- 2.2.1 VFD Manufacturers may include the following:

- 2.1.1.1 Danfoss;
- 2.1.1.2 ABB;
- 2.1.1.3 Schneider Electric (Square D);
- 2.1.1.4 Rockwell Automation;
- 2.1.1.5 Eaton Cutler Hammer;
- 2.1.1.6 Siemens Electric.

Note that naming specific vendors does not imply acceptance of their standard products nor relieve them from meeting the specifications described herein.

.1 The VFD shall be listed by Underwriters Laboratories (UL) and properly labelled by the manufacturer. Assembled drive packages shall be manufactured by a manufacturer of UL Listed Industrial Control Panels and shall include the manufacturer's UL label. If a modification is required to the manufacturer's standard product to meet the requirements of this specification, only the VFD manufacturer is allowed to make that modification. Distributor and/or System Integrator changes to a manufacturer's standard product are specifically not allowed.

2.2 OPERATIONAL REQUIREMENTS

2.2.1 Incoming Power: Three phase, 575 Vac (+10% to -10%) and 60 Hz (+/-5 Hz) power is converted to a fixed potential DC bus level. Maximum input voltage imbalance shall be 0.5% as defined in NEMA MG 1 section 14.35.2

2.2.1.1 Frequency stability of +/-0.05% for 24 hours with voltage regulation of +/-1% of maximum rated output voltage.

2.2.1.2 Speed regulation of +/- 0.5% of base speed.

2.2.1.3 Insensitive to input line rotation.

2.2.1.4 Humidity: 0 to 95% (non-condensing and non-corrosive).

2.2.1.5 Altitude: 0 to 3,300 feet (1000 meters) above sea level.

2.2.1.6 Ambient Temperature: 0 to 50 °C.

2.2.1.7 Storage Temperature: -40 to 60 °C.

2.3 POWER REQUIREMENTS

2.3.1 The Variable Frequency Drive (VFD) shall be of the fixed dc bus type. The VFD shall convert three phase, 50 or 60 Hz input power to three phase adjustable voltage, adjustable frequency output power using Pulse Width Modulation (PWM) switching techniques and Insulated Gate Bi-Polar Transistors (IGBTs).

2.3.1.1 The VFD shall include a 6 pulse diode bridge rectifier and a dc link reactor. All input rectifier section components including the input ac line reactor and the phase shifting transformer shall be factory mounted and wired within the confines of the VFD enclosure.

2.3.1.2 Drive output voltage shall vary with frequency to maintain a constant volt per hertz ratio up to motor base speed (typically 60 Hz).

2.3.1.3 The VFD shall be horsepower rated and have a continuous output current rating equal to or greater than the Full Load Current rating of the motor including service factor.

2.3.1.4 Normal Overload Capacity (Variable Torque) rated drives shall have a 1 minute overload rating equal to 120% of their continuous output current rating.

2.3.1.5 The VFD shall have an efficiency at full load and speed no less than 98%. The efficiency shall exceed 90% at 50% speed and load.

2.3.1.6 The VFD shall maintain the line side displacement power factor at no less than 0.96, regardless of speed and load.

2.4 ENCLOSURE

2.4.1 VFDs shall be provided in the following enclosures

2.4.1.1 in climate controlled areas – NEMA 12;

2.4.1.2 in non-climate controlled areas – NEMA 3R.

2.4.2 The VFD enclosure shall be constructed of sheet steel with powder coat paint. Plastic enclosures will not be acceptable. This type of metal enclosure will reduce Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI) and will provide rugged and durable protection for all internally mounted components.

2.4.3 All user serviceable parts shall be accessible from the front such that no rear access will be required.

2.5 ELECTRONICS

2.5.1 The VFD must pass the following standards for noise immunity and voltage transient protection:

2.5.1.1 IEEE C62.41-1991 Category B (Voltage Transients up to 6000V)

2.5.1.2 IEC EN50082-1/2 (Generic Immunity Standard)

2.5.1.3 VFDs that have not been tested to these standards are not acceptable.

2.5.2 The VFD shall have a built-in EMI/RFI noise filters. The onboard filters shall allow the VFD assembly to be CE Marked and meet product standard IEC 61800-3 Category 2 with up to 100 ft of motor cable.

2.5.3 All VFD circuit boards shall be conformal coated for maximum protection in harsh environments.

2.5.4 All VFD operating parameters shall be stored in non-volatile memory (EEPROM). Potentiometers and/or jumpers (links) will not be allowed for any adjustments.

2.5.5 For long term preventive maintenance, the VFD shall have a feature to measure its total DC bus capacitance without any disassembly of the VFD.

2.6 DISCONNECT AND BYPASS

2.7.1 A complete three-contactor bypass shall be provided to allow the motor to be safely transferred from VFD output to the AC line or from the AC line to the VFD, while the motor is at zero speed. The contactor bypass shall be electrically interlocked. The bypass shall consist of "VFD", "OFF", "BYPASS", and "TEST" modes. Contactors shall be IEC rated and have the following functionality:

2.6.1.1 Drive input contactor shall open and close input to the VFD.

2.6.1.2 Drive output contactor shall open and close the connection between the VFD and motor.

2.6.1.3 Bypass contactor shall open and close the connection to line start the motor.

- 2.6.1.4 The bypass shall be provided to allow the ac motor to be operated off the VFD (normal operating mode) or directly off the ac power line (bypass mode), even in the event of drive failure.
- 2.6.1.5 Door mounted bypass operator device shall include a "Power On" indicating light, a "VFD Mode" indicating light, a "Bypass Mode" indicating light, a "Test Switch" indicating light, and a "VFD-Off-Bypass-Test" mode selector switch.
- 2.6.1.6 The VFD shall include a door interlocked input ac line, the enclosure door shall only be operable with the disconnect in the "Off" position, except by trained personnel.
- 2.6.1.7 Fuses: Class J input line fuses shall be provided to ensure that the VFD maintains bypass operation capability in the event of a VFD failure. The fuses should thus be located to provide protection for the input rectification circuit. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 AIC.
- 2.6.1.8 VFD Input and Output Contactors shall be one size larger than standard design. Both VFD and Bypass to be short circuit rated at 100KAIC or as required by the facility.
- 2.6.1.9 Bypass motor overload protection shall be provided by bimetallic Class 20 overload relay
- 2.6.1.10 Bypass: Through the operator interface the user shall be able to select manual or automatic transfer to bypass for the following faults: over current, over voltage, under voltage, loss of analog input
- 2.6.1.11 Bypass voltage range: The bypass shall maintain positive contactor control through the voltage tolerance window of nominal voltage +30%, -35%, to avoid contactor coil failure during brown out/ low line conditions and allow for input single phase operation when in VFD mode.
- 2.6.1.12 Motor protection from single phase power conditions: the bypass system must be able to detect single phase power condition and in a controlled manner, disengage the motor.
- 2.6.1.13 The system must then give a single phase input power indication.

2.7 HARMONICS

- 2.7.1 All VFDs greater than 20HP shall meet all the requirements of IEEE-519-1992 for total harmonic distortion and for each individual harmonic as detailed in the specification. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the VFD input terminals.
 - 2.7.1.1 VFDs are to be provided with harmonic filters to limit harmonics distortion produced by each drive to following maximum levels as measured to input side of drive:
 - 2.7.1.1.1 Total harmonic distortion (voltage) – 3%;
 - 2.7.1.1.2 Total harmonic distortion (amperage) – 5%.
- 2.7.2 Harmonic filter to include features as follows:

- 2.7.2.1 Manufactured and tested in accordance with latest applicable standards of ULC, CSA and NEMA;
- 2.7.2.2 Treat characteristic low frequency harmonics generated by a 3-phase diode bridge rectifier load (5th, 7th, 11th, 13th etc.);
- 2.7.2.3 Passive inductor/capacitor network;
- 2.7.2.4 Low capacitive resistance that ensures compatibility with engine generator sets without need to switch out capacitors;
- 2.7.2.5 Full load efficiency harmonic mitigation equipment/VFD combination to be greater than 96%;
- 2.7.2.6 Copper wiring;
- 2.7.2.7 Manufactured and tested in accordance with latest applicable standards of ULC, CSA and NEMA;
- 2.7.2.8 220 °C system insulation class and temperature rise of 130 °C;
- 2.7.2.9 Anti-vibration pads between reactor or transformer core and enclosure;
- 2.7.2.10 Ventilated sprinkler proof enclosure as specified above.
- 2.7.2.11 Filter bypass and capacitor contactor.

2.8 Control Features

- 2.8.1 Motor Compatibility: The VFD shall be capable of operating any standard squirrel cage induction motor with a full load current rating equal to or less than the full load current rating of the VFD. At any time in the future it shall be possible to install a new or rewound standard squirrel cage induction motor with a full load current rating equal to or less than the full load current rating of the VFD without making any modification to the VFD.
 - 2.8.1.1 VFD Speed Control: The VFD speed reference shall be selectable from any of the following: drive keypad, analog signal input (voltage or current signal), speed increase / decrease pushbuttons (contact inputs), or via digital communications

- 2.8.1.2 PID: The VFD shall include a high performance set-point controller. The set-point controller shall include gain adjustments for Proportional, Integral, and Differential functions (PID Control).
 - 2.8.1.2.1 The VFD's PID regulator shall allow a pressure or flow signal to be connected for closed loop control.
- 2.8.1.3 The PID set point shall be adjustable from the terminal, by analog input or through communication network.
- 2.8.1.4 Ramp: The VFD shall have separately adjustable rates of acceleration and deceleration control. The acceleration and deceleration ramps shall be adjustable from 0.1 to 3200 seconds and it shall be possible to select either a linear ramp or an s-curve shaped ramp.
- 2.8.1.5 Flying start: The VFD shall be capable of determining the speed and direction of a spinning motor. The VFD must be able to catch a motor spinning in either direction and bring the motor to the desired operating speed in the proper direction without stopping the motor or tripping the drive.
- 2.8.1.6 Trip/Restart: The VFD shall have the ability to be programmed to automatically restart after a power failure/outage. The VFD shall also have the ability to automatically restart after a non-critical fault. In the event of a critical fault such as a Ground Fault, Short circuit or overload, the VFD should trip lock and alarm to the BAS. Trip lock alarms require manual reset by an operator.
- 2.8.1.7 Skip frequencies/bands: The VFD shall have at minimum 3 programmable set points that lock out continuous operation at frequencies (mechanical resonance). The set points shall have adjustable bandwidth.
- 2.8.1.8 Password: The VFD shall include password protection to prevent parameter changes by unauthorized personnel.
- 2.8.1.9 Drive shall be capable of providing control for hardwired interlocks.
- 2.8.1.10 Run Permissive: A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.
- 2.8.1.11 Smoke Control Override Mode: VFD to be complete with a Smoke Evacuation Mode setting utilizing the preset speed function to operate at a set speed when given a command from the buildings fire controls.
- 2.8.1.12 Firefighters Override mode: VFD shall include standard programmable firefighters override mode to allow a digital input to control the VFD and override all other local or remote commands. The selection of operation and speed shall be available for preset. The VFD shall display "Firemode" when activated.

2.9 VFD PROTECTIVE FEATURES

- 2.9.1 The VFD shall provide protection against a variety of conditions typical of HVAC in hospital settings. This includes but is not limited to high temperature, high load current, high voltage, short circuit, surge/sag, transients, phase imbalance, single phase input. RFI and harmonics are discussed elsewhere in this specification,
- 2.9.1.1 There shall be an adjustable motor current sensing circuit for the VFD modes to provide proof of flow (broken belt) indication. The condition shall be indicated on the interface and transmitted over the BAS. The broken belt indication shall be programmed to be a system (drive and bypass) indication. The broken belt condition sensing algorithm shall be programmable to cause a warning or system shutdown.
 - 2.9.1.2 The VFD main PCB shall include isolated control circuitry.
 - 2.9.1.3 Operation at frequencies more than 10% above motor base speed shall be prevented unless the user specifically programs the VFD to allow for high speed motor operation.
 - 2.9.1.4 The VFD shall not require any additional external impedance (dc bus reactor or ac line reactor) to protect itself.
 - 2.9.1.5 The VFD shall protect itself from the following through a normal shut down with no component damage or blown fuses.
 - 2.8.1.2.1 Output circuit phase-to-phase and/or phase-to-ground faults. VFDs that require an isolation transformer to provide ground fault or short circuit protection are not acceptable.
 - 2.8.1.2.1 Damage due to a single phase condition on the input ac power line and/or the complete loss of input power
 - 2.8.1.2.1 Damage due to any unintended disconnection or reconnection of the output load. The VFD shall not trip off line due to the instantaneous removal of motor load
 - 2.9.1.6 The VFD shall protect itself from over/under voltage. The VFD shall go through an orderly shutdown when the incoming ac line voltage falls outside the acceptable voltage limits as defined in the previous section of this specification.
 - 2.9.1.7 The VFD shall be insensitive to phase rotation. Incorrect phase sequence during installation or inadvertent phase reversal after installation shall not cause damage to the drive or prevent it from operating.
 - 2.9.1.8 The VFD shall include heat sink thermal protection to protect itself against excessively high ambient temperature conditions.
 - 2.9.1.9 An Instantaneous Over Current (IOC) trip circuit shall continuously monitor the peak output current. It shall provide instantaneous shutdown without component failure whenever its trip point is surpassed. The IOC trip point must be greater than or equal to 250% of the VFD's rated full load output current.

- 2.9.1.10 The VFD shall be provided with Metal Oxide Varistors (MOVs) for transient voltage suppression on all three phases of the incoming power line. The MOVs shall have a rating of not less than 80 joules. An additional MOV to ground shall be provided on grounded ac power systems.
- 2.9.1.11 The VFD shall protect against damage due to any interruption or run away of its incoming speed reference signal. If the speed reference signal is a 4 to 20 ma current reference, it shall be possible to program the VFD to either shut down, go to minimum speed, or continue operation at its last known speed reference point whenever a loss of reference signal is detected.
- 2.9.1.12 The VFD shall be capable of protecting the motor against damage during stall conditions.
- 2.9.1.13 The VFD shall include electronic thermal motor overload protection

2.10 VFD OPERATOR INTERFACE

- 2.10.1 All VFDs for this project (regardless of their horsepower rating) shall utilize identical operator interfaces, control boards and employ exactly the same programming methods.
 - 2.10.1.1 The Operator Interface shall include a backlit LCD display in complete English words for programming and fault diagnostics. All VFD faults shall be displayed in English words.
 - 2.10.1.2 The VFD shall include a bright LED to indicate that voltage is present on the DC Bus.
 - 2.10.1.3 The VFD main PCB shall have LED indicators to indicate: Drive in Current Limit and Microprocessor Active.
 - 2.10.1.4 The Operator Interface Keypad shall:
 - 2.10.1.4.1 Allow frequently accessed VFD programmable parameters to be adjusted from the digital operator keypad located on the front of the VFD.
 - 2.10.1.4.2 Use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not acceptable, and particularly those that use alphanumeric code and tables.
 - 2.10.1.4.3 Include adjustable contrast with large characters easily visible in normal ambient light.
 - 2.10.1.4.4 Include the ability to start and stop the drive, reset VFD faults, and manually adjust the VFD's speed reference.
 - 2.10.1.5 The Operator Interface shall include Hand / Off / Automatic Selection. It shall allow the operator to select where the VFD Start / Stop commands and Speed Reference signal will come from on the VFD. In "Hand" Mode the VFD is operated using a local Speed Reference and local Start and Stop commands. In "Auto" Mode the VFD follows a remote speed reference signal (typically 4 to 20 ma) and responds to remote Run / Stop commands.

- 2.10.1.6 The Operator Interface shall be removable and remote mountable.
- 2.10.1.7 The display shall include the following status indicators (or equivalent) at a minimum:
 - 2.10.1.7.1 Run,
 - 2.10.1.7.2 Forward,
 - 2.10.1.7.3 Reverse,
 - 2.10.1.7.4 Stop,
 - 2.10.1.7.5 Ready,
 - 2.10.1.7.6 Alarm,
 - 2.10.1.7.7 Fault,
 - 2.10.1.7.8 Local,
 - 2.10.1.7.9 Panel,
 - 2.10.1.7.10 Remote,
 - 2.10.1.7.11 Hand,
 - 2.10.1.7.12 Auto,
 - 2.10.1.7.13 Test
 - 2.10.1.7.14 Bypass
 - 2.10.1.7.15 Off
- 2.10.1.8 The operator shall be able to scroll through the keypad menu to choose between the following (or equivalent):
 - 2.10.1.8.1 Monitor
 - 2.10.1.8.2 Operate
 - 2.10.1.8.3 Parameter setup
 - 2.10.1.8.4 Actual parameter values
 - 2.10.1.8.5 Active faults
 - 2.10.1.8.6 Fault history
 - 2.10.1.8.7 LCD contrast adjustment

- 2.10.1.9 The following setups and adjustments, at a minimum, are to be available through the interface:
 - 2.10.1.9.1 Start command from keypad, remote or communications port
 - 2.10.1.9.2 Speed command from keypad, remote or communications port
 - 2.10.1.9.3 Motor direction selection
 - 2.10.1.9.4 Maximum and minimum speed limits
 - 2.10.1.9.5 Acceleration and deceleration times, two settable ranges
 - 2.10.1.9.6 Critical frequency avoidance (minimum 3 with bandwidth control)
 - 2.10.1.9.7 Torque limit
 - 2.10.1.9.8 Multiple attempt restart function
 - 2.10.1.9.9 Multiple preset speeds adjustment
 - 2.10.1.9.10 Catch a spinning motor start or normal start selection
 - 2.10.1.9.11 Programmable analog output
 - 2.10.1.9.12 DC brake current magnitude and time
 - 2.10.1.9.13 Proportional/Integral/Differential (PID) process controller
- 2.10.1.10 The VFD interface display shall be programmable through the keypad to display any parameter, input, or output, with a minimum of five parameters displayed. The default parameters are:
 - 2.10.1.10.1 Output Speed (%)
 - 2.10.1.10.2 Motor RPM
 - 2.10.1.10.3 Motor Power (kW)
 - 2.10.1.10.4 Motor Current
- 2.10.1.11 The VFD interface shall be capable is displaying any monitored parameters.

2.11 MONITORING & ALARMS

- 2.11.1 The VFD keypad shall be capable of monitoring the following parameters at a minimum, with the capability to being assigned to a digital or analog output to the BAS:
 - 2.11.1.1 Output frequency
 - 2.11.1.2 Output speed (%)

- 2.11.1.3 Motor current
- 2.11.1.4 Motor torque
- 2.11.1.5 Motor power (kW)
- 2.11.1.6 Motor voltage (Output voltage)
- 2.11.1.7 Motor RPM
- 2.11.1.8 DC-link voltage
- 2.11.1.9 Heatsink temperature
- 2.11.1.10 Total operating days counter
- 2.11.1.11 Total operating hours
- 2.11.1.12 Operating hours (with reset function)
- 2.11.1.13 Total megawatt hours
- 2.11.1.14 Megawatt hours (with reset function)
- 2.11.2 Cost of electricity consumed by the drive for a given period (based on internal calculations and with reset function)
 - 2.11.2.1 Voltage level of analog input
 - 2.11.2.2 Current level of analog input
 - 2.11.2.3 Digital inputs status
 - 2.11.2.4 Digital and relay outputs status
 - 2.11.2.5 Motor temperature rise, percentage of allowable.
 - 2.11.2.6 Information to indicate the standard software and optional features software loaded.
- 2.11.3 The VFD shall transmit alarms to the BAS.
- 2.11.4 The VFD shall have two built in reset-able timers to provide alarms for critical maintenance tasks such as changing filters and lubricating bearings.
- 2.11.5 The VFD shall be capable of providing a log of the last 10 alarm condition that occur. The information should include but not limited to:
 - 2.11.5.1 Time of alarm
 - 2.11.5.2 Alarm Code

- 2.11.5.3 Amperage at alarm
- 2.11.5.4 Frequency at alarm
- 2.11.5.5 DC Bus Voltage at alarm

2.12 COMMUNICATIONS

- 2.12.1 The VFD shall be capable of communicating with the existing Building Automation System.
 - 2.12.1.1 VFD shall be capable of digital communications through RS-232/422/485, USB,
 - 2.12.1.2 The following protocols shall be embedded in the VFD and selectable via a parameter without any field programming to download software prior to operation:
 - 2.12.1.2.1 BacNet.
 - 2.12.1.2.2 ModBus RTU
 - 2.12.1.2.3 Metasys N2
 - 2.12.1.2.4 Optional adapters shall be available for Ethernet/IP, LonWorks, etc
 - 2.12.1.3 Standard advanced programming and trouble-shooting functions shall be available by using a personal computer's RS-232, USB, or Ethernet port, with a Windows™ based software. The software shall permit control, setup, monitoring, and reviewing diagnostic or trend information.
 - 2.12.1.4 Digital Inputs
 - 2.12.1.4.1 The VFD shall be capable of accepting up to six (6) digital inputs. One input shall be a dedicated "drive enable" input and the other digital inputs shall be user programmable. It shall be possible to direct these digital inputs to any settable bit parameter within the drive.
 - 2.12.1.4.2 It shall be possible to individually invert the sense of any input. Digital Inputs will typically be used to start and stop the drive, reset a fault, change machine direction, or select an alternate reference source. They may also be used to select preset speeds, alternative acceleration and deceleration rates and various different operational modes.
 - 2.12.1.5 Analog Inputs
 - 2.12.1.5.1 The VFD shall be capable of accepting up to two (2) analog input signals configured as one or more of the following signal types: 0 to 10VDC, 0 to -10VDC, -10 to +10VDC, 0 to 20 mA, 4 to 20mA, 20 to 0 mA, or 20 to 4 mA. These analog inputs shall be user programmable.

- 2.12.1.5.2 It shall be possible to individually scale each input, invert it, offset it, and then direct it to any settable parameter within the drive. Typically, these inputs will be used as (speed or current) reference signals, but they may also be used as feedback signals (PID Control), or they may be used to set limits or control thresholds within the drive. An option card shall be available for applications requiring more than two analog inputs.

2.12.1.6 Digital Outputs

- 2.12.1.6.1 The VFD shall have two (2) digital outputs. Each digital output must be a voltage free "form C" contact rated 120VAC at 5 amps or higher.
- 2.12.1.6.2 Digital outputs shall be user programmable to mirror the state of any bit parameter within the VFD such as drive fault, drive run, at target speed, in current limit, or at zero speed. It shall also be possible to control these outputs based on the result of a logical operation (AND, OR, NOR) on any two bit parameters within the VFD. Each digital output must include an optional time delay function. For applications requiring more outputs, an option card shall be available to provide up to five (5) additional relay outputs.

2.12.1.7 Analog Outputs

- 2.12.1.7.1 The VFD shall have two (2) analog output signals.
- 2.12.1.7.2 Each analog output shall be user programmable and scalable. The analog outputs shall be 0 to 10 VDC signals user programmable to mirror any parameter in the VFD such as output frequency, motor speed, motor current, motor voltage, or kW. An option card shall be available for applications requiring more than two analog outputs.

2.12.1.8 Defined Parameters

- 2.12.1.8.1 The VFD shall be able to generate up to two (2) customer defined parameters by adding, subtracting, multiplying, dividing, ramping, limiting, and/or filtering existing parameters within the drive.
- 2.12.1.8.2 Defined parameters can be displayed, routed to an analog output, or re-routed and used as an input parameter to control another function within the drive.

- 2.12.1.9 Provide communication cards and output signal conditioner card(s) as required to meet VFD communication requirements with the existing BAS system.

- 2.12.1.10 Communications card(s) to be provided as required to allow the VFD to communicate with Computers, PLCs, BAS, and microprocessor based data collection systems. Available protocols include Modbus RTU, Metasys N2 and many others.

PART 3 - EXECUTION

3.1 SETUP

- 3.1.1 The VFD manufacturer shall provide the services of a factory authorized start-up engineer. The start-up engineer shall also instruct the owner's operators in the proper use of the VFD.

3.2 TRAINING

- 3.2.1 The VFD manufacturer shall be available for 3 hours of training for this project.

3.3 DOCUMENTATION & WARRANTY

- 3.3.1 The VFD manufacturer shall provide one (or more) copies of the VFD Operation and Maintenance Manual as part of the final documentation package.
- 3.3.1.1 The VFD manufacturer shall provide one (or more) copies of its list of recommended spare parts as part of the final documentation package.
- 3.3.2 The VFD manufacturer shall provide digital and physical copies of the start up reports for each unit.
- 3.3.3 The VFD manufacturer shall warrant the VFD for a period of not less than 5 years. Warranty shall be on site parts and labour type, factory warranty not acceptable.

END OF SECTION

PART 1 - General

1.1 APPLICATION

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

1.2 SUBMITTALS

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

PART 2 - Products

2.1 NOT APPLICABLE

PART 3 - Execution

3.1 Disconnection and Removal of Existing Mechanical Work

- 3.1.1 Where indicated on the contract documents, disconnect and remove existing mechanical work, including hangers, supports, insulation, etc. Disconnect at the point of supply, remove obsolete connecting services and make the system safe. Cut back obsolete piping behind finishes and cap water-tight unless otherwise specified.
- 3.1.2 The scope and extent of the demolition or revision work is only generally indicated on the contract documents. Estimate the scope, extent and cost of the work at the site during the bidding period site visit(s). Claims for extra costs for demolition work not shown or specified but clearly visible or ascertainable at the site during bidding period site visits will not be allowed.
- 3.1.3 If any re-design is required due to discrepancies between the mechanical contract documents and site conditions, notify the Consultant who will issue a Site Instruction. If, in the opinion of the Consultant, discrepancies between the mechanical contract documents and actual site conditions are of a minor nature, the required modifications are to be done at no additional cost.
- 3.1.4 Where existing mechanical services extend through, or are in an area to serve items which are to remain, maintain the services in operation. Include for rerouting existing services concealed behind existing finishes and which become exposed during the renovation work, so as to be concealed behind new or existing finishes.
- 3.1.5 Unless otherwise specified, remove from the site and dispose of all existing materials which have been removed and are not to be relocated or reused. Refer to waste management and disposal requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods.
- 3.1.6 Unless otherwise specified, remove from the site and dispose of all existing materials which have been removed and are not to be relocated or reused, except for the following which are to be handed over to the Owner at the site:

3.1.6.1 Plumbing fixtures and fittings in good condition.

3.2 Hazardous Waste

3.2.1 Be advised that items such as drainage sumps, catch basins, interceptors, and the like may contain unidentified hazardous waste and caution is to be taken when disconnecting and removing these items.

3.2.2 If hazardous waste not listed in the Specification is found, notify the Owner and Consultant immediately and await directions.

3.3 Interruption to and Shut-Down of Mechanical Services And Systems

3.3.1 Co-ordinate all shut-down and interruption to existing mechanical systems with the Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight Friday until 6:00 a.m. Monday morning.

3.3.2 Upon award of contract, submit a list of anticipated shut-down times and their maximum duration.

3.3.3 Prior to each shut-down or interruption, inform the Owner in writing seventy-two hours in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut-down or interrupt any system or service without such written approval.

3.3.4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.

3.3.5 Pipe Freezing: Pipe freezing may be used to connect new piping to existing piping without draining the existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. or Rigid Tool Co. RIGID "SuperFreeze".

End of Section

PART 1 - GENERAL

1.1 APPLICATION

- 1.1.1 This Section specifies mechanical system testing, adjusting, and balancing requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.2 SUBMITTALS

- 1.2.1 Name and Qualifications of Testing and Balancing Agency: Within thirty days of work commencing at the site, submit the name and qualifications of the proposed testing and balancing agency in accordance with requirements of the article entitled Quality Assurance below.
- 1.2.2 Sample Test Forms: Submit sample test forms, if other than those standard forms prepared by the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) are proposed for use.
- 1.2.3 Drawing Evaluation Report: Submit a report by the Agency to indicate the Agency's evaluation of the mechanical drawings with respect to service routing and location or lack of balancing devices. Include the set of drawings used and marked-up by the Agency to prepare the report.
- 1.2.4 Site Visit Reports: Submit a report by the Agency after each site visit made by the Agency during the construction phase of this Project.
- 1.2.5 Draft Report: Submit a draft report, as specified in Part 3 of this Section.
- 1.2.6 Final Report: Submit a final report, as specified in Part 3 of this Section.
- 1.2.7 Warranty: Submit a testing and balancing warranty as specified in Part 3 of this Section.
- 1.2.8 Post Construction Site Visit Reports: Submit reports listing observations and results of post construction site visits as specified in Part 3 of this Section.

1.3 DEFINITIONS

- 1.3.1 The following are definitions of words used in this Section:
- 1.3.1.1 "TAB" – means testing, adjusting and balancing to determine and confirm quantitative performance of equipment and systems and to regulate the specified fluid flow rate and air patterns at the terminal equipment, e.g., reduce fan speed, throttling, etc.;
- 1.3.1.2 "hydronic systems" – includes heating water, chilled water, glycol-water solution, condenser water, and any similar system;
- 1.3.1.3 "air systems" – includes all outside air, supply air, return air, exhaust air, and relief air systems;
- 1.3.1.4 "flow rate tolerance" – means the allowable percentage variation, minus to plus, of actual flow rate values in the Contract Documents;

- 1.3.1.5 “report forms” – means test data sheets arranged for collecting test data in logical order for submission and review, and these forms, when reviewed and accepted, should also form the permanent record to be used as the basis for required future testing, adjusting and balancing;
- 1.3.1.6 “terminal” – means the point where the controlled fluid enters or leaves the distribution system, and these are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods;
- 1.3.1.7 “main” – means the duct or pipe containing the system’s major or entire fluid flow;
- 1.3.1.8 “submain” – means the duct or pipe containing part of the systems’ capacity and serving two or more branch mains;
- 1.3.1.9 “branch main” – means duct or pipe servicing two or more terminals;
- 1.3.1.10 “branch” – means duct or pipe serving a single terminal.

1.4 QUALITY ASSURANCE

- 1.4.1 Testing and Balancing Agency: Employ the services of an independent testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems to produce the design objectives. The testing, adjusting and balancing agency is to have successfully completed testing, adjusting and balancing of mechanical systems for a minimum of five projects similar to this Project within the past three years, and is to be certified as an independent agency in all required categories by one of the following:
 - 1.4.1.1 AABC - Associated Air Balance Council;
 - 1.4.1.2 NEBB - National Environmental Balancing Bureau;
- 1.4.2 Standards: Testing, adjusting and balancing of the complete mechanical systems is to be performed over the entire operating range of each system in accordance with one of the following publications:
 - 1.4.2.1 National Standards For A Total System Balance published by the Associated Air Balance Council;
 - 1.4.2.2 Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems published by the National Environmental Balancing Bureau;
 - 1.4.2.3 Chapter 37, Testing, Adjusting, and Balancing of ASHRAE Handbook HVAC Applications.

1.5 ACCEPTABLE LIST OF TAB FIRMS:

- 1.5.1 EnviroBalance.

PART 2 - Products

2.1 NOT APPLICABLE

PART 3 - Execution

3.1 SCOPE OF WORK

3.1.1 Perform total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications and comfort conditions, and recording and reporting the results.

3.1.2 Mechanical systems to be tested, adjusted and balanced include:

3.1.2.1 Domestic Water Systems: TAB of domestic water systems (all piping extended from the Municipal main) is to include:

3.1.2.1.1 domestic hot water recirculation piping;

3.1.2.1.2 tempered water piping flows.

3.1.2.2 Medical Gas Systems: TAB of medical gas systems is not part of the TAB work and is specified in the mechanical work Section entitled Medical Gas Piping Systems.

3.1.2.3 Heating Systems: TAB of heating systems is to include all piping and equipment fluid temperatures, pressure, flows and control, and if TAB is not done during the heating season, a follow-up site visit during the heating season will be required to confirm proper flows and temperatures, and any required system "fine tuning".

3.1.2.4 Cooling Systems: TAB of cooling systems is also to include all piping and equipment fluid temperatures, flows and control, and if TAB is not done during the cooling season, a follow-up site visit during the cooling season will be required to confirm proper flows and temperatures, and any required system "fine tuning".

3.1.2.5 Air Handling Systems: TAB of air handling systems is to include all equipment and ductwork air temperatures, capacities and flows. System shall be tested for all scenarios as per the schedule.

3.1.2.5.1 the balancer is to provide AHU static pressure profiles on minimum OA, and full OA. The balance must use proportional balancing methodology for air and water. The balancer must understand the sequence of operation for all systems and provide the controls contractor with Box k factors, flow confirmation values for volume sensors with corresponding VFD speeds and system setup information

3.1.2.6 Existing Systems: All of the existing systems revised as part of the mechanical work, are to be tested, adjusted and balanced as for new systems.

3.2 TESTING, ADJUSTING AND BALANCING

3.2.1 General Requirements: Conform to the following requirements:

- 3.2.1.1 as soon as possible after award of Contract, the Agency is to carefully examine a white print set of mechanical drawings with respect to routing of services and location of balancing devices, and is to issue a report listing the results of the evaluation;
- 3.2.1.2 the set of drawings examined by the Agency is to be returned with the evaluation report, with red line mark-ups to indicate locations for duct system test plugs, and required revision work such as relocation of balancing devices and locations for additional devices;
- 3.2.1.3 after review of the mechanical work drawings and specification, the Agency is to visit the site at frequent, regular intervals during construction of the mechanical systems, to observe routing of services, locations of testing and balancing devices, workmanship, and anything else that will affect testing, adjusting and balancing;
- 3.2.1.4 after each site visit, the Agency is to report results of the site visit indicating the date and time of the visit, and detailed recommendations for any corrective work required to ensure proper adjusting and balancing;
- 3.2.1.5 testing, adjusting and balancing is not to begin until:
 - 3.2.1.5.1 building construction work is substantially complete and doors have been installed;
 - 3.2.1.5.2 mechanical systems are complete in all respects, and have been checked, started, adjusted, and then successfully performance tested.
- 3.2.1.6 all mechanical systems to be tested, adjusted and balanced are to be maintained in full, normal operation during each day of testing, adjusting and balancing;
- 3.2.1.7 obtain copies of reviewed shop drawings of all applicable mechanical plant equipment and terminals, and temperature control diagrams and sequences;
- 3.2.1.8 the Agency is to walk each system from the system "head end" equipment to terminal units to determine variations of installation from design, and the system installation trades will accompany the Agency;
- 3.2.1.9 the Agency is to check all valves and dampers for correct and locked position, and temperature control systems for completeness of installation before starting equipment;
- 3.2.1.10 wherever possible, the Agency is to lock all balancing devices in place at the proper setting, and permanently mark settings on all devices;
- 3.2.1.11 for belt-driven equipment, the Agency is to report to the Commissioning Agent who in turn is to inform the Contractor and Consultant of any situation where sheaves have to be replaced to suit testing and balancing, and replacements are to be done by the Contractor at no cost;

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- 3.2.1.12 the Agency is to leak test all ductwork as specified in Section 23 31 05 in accordance with requirements of SMACNA "HVAC Air Duct Leak Test Manual", coordinate work with the work of Section 23 31 05, provide detailed sketch(es) to Sheet Metal Contractor and Consultant identifying ductwork not in accordance with acceptable leakage values specified in Section 23 31 05 and 23 31 06, and retest corrected ductwork;
 - 3.2.1.13 noise: the Agency is to balance all systems with due regard to objectionable noise which is to be a factor when adjusting fan speeds and performing terminal work such as adjusting air quantities, and should objectionable noise occur at the design conditions, the Agency is to immediately report the problem and submit data, including sound readings, to permit an accurate assessment of the noise problem to be made;
 - 3.2.1.14 stratification: the Agency is to check all supply air handling system mixing plenums for stratification, and where the variation of mixed air temperature across coils is found to be in excess of plus or minus 5 percent of design requirements, the Agency is to report the problem and issue a detail sketch of plenum baffle(s) required to eliminate the stratification;
 - 3.2.1.15 tolerances: the Agency is to perform testing, adjusting and balancing to within plus or minus 5% of design values, and make and record measurements using instruments with minimum accuracy which are within plus or minus 2% of required values;
 - 3.2.1.16 filters for all air handling systems equipped with air filters, test and balance the systems with simulated 50% loaded (dirty) filters by providing a false pressure drop;
 - 3.2.1.17 seasonal requirements: test, adjust and balance air conditioning systems during the summer season and heating systems during winter season, including at least a period of operation at outside conditions within 2.8°C (5°F) wet bulb temperature of maximum summer design condition, and within 5.5°C (10°C) dry bulb temperature of minimum winter design condition, and take final temperature readings during seasonal operation.
- 3.2.2 Preparation of Reports: Prepare reports as indicated below.
- 3.2.2.1 Draft Reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on AABC or NEBB forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit two complete sets of draft reports. Only one complete set of draft reports will be returned.
 - 3.2.2.2 Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports. Use units of measurement (SI or Imperial) as used on the Project Documents.
 - 3.2.2.3 Report Format: Report forms are to be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the divisions listed below, separated by divider tabs:

- 3.2.2.3.1 General Information and Summary;
- 3.2.2.3.2 Air Systems;
- 3.2.2.3.3 Hydronic Systems;
- 3.2.2.3.4 Temperature Control Systems;
- 3.2.2.4 Report Contents: The Agency is to provide the following minimum information, forms and data:
 - 3.2.2.4.1 inside cover sheet to identify the Agency, the Contractor, and Project, including addresses, and contact names and telephone numbers and a listing of the instrumentation used for the procedures along with the proof of calibration;
 - 3.2.2.4.2 the remainder of the report is to contain the appropriate forms containing as a minimum, the information indicated on the standard AABC or NEBB report forms prepared for each respective item and system;
 - 3.2.2.4.3 the Agency is to include for each system to be tested, adjusted and balanced, a neatly drawn, identified (system designation, plant equipment location, and area served) schematic "as-built" diagram indicating and identifying all equipment, terminals, and accessories;
 - 3.2.2.4.4 the Agency is to include report sheets indicating building comfort test readings for all rooms.
- 3.2.3 Verification of Reports: After the final testing and balancing report has been submitted, the Agency is to visit the site with the Contractor and Consultant to spot check results indicated on the balancing report. The Agency is to supply all labour, ladders, and instruments to complete spot checks. Note that if results of spot checks do not, on a consistent basis, agree with the final report, the spot check procedures will stop and the Agency is to then rebalance the systems involved, resubmit the final report, and again perform spot checks with the Contractor and Consultant.
- 3.2.4 Certification and Warranty: When the final report has been accepted, the Contractor is to submit to the Owner, in the name of the Owner, a certificate equal to the AABC National Guaranty Certification or a NEBB Quality Assurance Program Bond, and in addition, the Contractor is to submit a written extended warranty from the Agency covering one full heating season and one full cooling season, during which time any balancing problems which occur, with the exception of minor revision work done during scheduled site visits, will, at no cost, be investigated by the Agency and reported on to the Owner, and if it is determined that the problems are a result of improper testing, adjusting and balancing, they are to be immediately corrected without additional cost to the Owner.
- 3.2.5 Post Balancing Site Visits: After acceptance of the final report, the Agency is to perform post testing and balancing site visits in accordance with the following requirements:
 - 3.2.5.1 post testing and balancing site visits are to be made:
 - 3.2.5.1.1 once during the first month of building operation;

- 3.2.5.1.2 once during the third month of building operation;
- 3.2.5.1.3 once between the fourth and tenth months in a season opposite to the first and third month visit.
- 3.2.5.2 during each return visit and accompanied by the Owner's representative, the Agency is to spot rebalance terminal units as required to suit building occupants and eliminate complaints;
- 3.2.5.3 the Agency is to schedule each visit with the Contractor and the Owner, and inform the Consultant;
- 3.2.5.4 after each follow-up site visit, the Agency is to issue to the Contractor and Consultant a report indicating any corrective work performed during the visit, all abnormal conditions and complaints encountered, and recommended corrective action.

End of Section

PART 1 - General

1.1 SUBMITTALS

1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets to the regulatory authority for review and approval prior to submitting to the Consultant. Conform to the following requirements:

- 1.1.1.1 submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings;
- 1.1.1.2 submit complete CAD white print layout drawings indicating source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, and risers, all signed and sealed by a qualified professional mechanical engineer as specified below;
- 1.1.1.3 submit copies of all calculations signed by the same engineer who signs the layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing;
- 1.1.1.4 in addition to submitting shop drawings to the regulatory authority as specified above, shop drawings must be approved by the Owner's insurer prior to being submitted to the Consultant for review.

1.2 QUALITY ASSURANCE

1.2.1 Codes and Standards: Fire protection standpipe system work is to be in accordance with the following Codes and Standards:

- 1.2.1.1 NFPA 14, Standard for the Installation of Standpipes and Hose Systems;
- 1.2.1.2 CSA B137.2, PVC Injection-Molded Gasketed Fittings for Cold-Water Pressure Services;
- 1.2.1.3 CSA B137.3, Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications;
- 1.2.1.4 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;
- 1.2.1.5 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;
- 1.2.1.6 ASTM A536, Standard Specification for Ductile Castings.
- 1.2.1.7 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);
- 1.2.1.8 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.

- 1.2.2 Site Personnel: All site personnel are to be sprinkler fitters licensed in the jurisdiction of the work and under the continuous supervision of a foreman who is an experienced fire protection system installer and a journeyman pipe fitter licensed in the jurisdiction of the work.
- 1.2.3 Dimensions and Coordination: Check and verify all dimensions and conditions at the site and ensure that the work can be performed as indicated. Co-ordinate work with all trades at the site and accept responsibility for and the cost of making adjustments to piping and/or spacing to avoid interference with other building components.
- 1.2.4 Existing System: Verify the working condition of all existing standpipe system equipment which has direct interface with the new work and is to remain. Replace with new equipment where necessary.
- 1.2.5 System components must be UL and/or ULC listed and labelled.
- 1.2.6 All grooved couplings, and fittings, valves and specialties shall be the products of a single manufacturer.
- 1.2.7 All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.3 DESIGN REQUIREMENTS

- 1.3.1 Design Criteria: Fire protection standpipe work is to be designed in accordance with NFPA 14 and Provincial Standards, and, where required, local building and fire department requirements and the standards of the Owner's Insurer. If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at the nearest fire hydrant to obtain criteria to be used in system design. Include hydrant location and flow and pressure test data with system design calculations.
- 1.3.2 System Designer: Fire protection standpipe work is to be designed by a fully qualified mechanical professional engineer registered and licensed in the jurisdiction of the Project. Refer to the mechanical work Section entitled Mechanical Work General Requirements for requirements governing the employment of the Engineer.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- 2.1.1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:
 - 2.1.1.1 Schedule 40 Steel – Grooved Coupling Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with fittings and couplings equal to Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints. Strap-on fittings such as Victaulic "Snap-Let" strap type fittings are not acceptable.

- 2.1.1.2 Schedule 40 Steel – Screwed and Welded Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping is to be complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping is to be complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible.

2.2 SHUT-OFF VALVES

- 2.2.1 Equal to Victaulic Style 705, minimum 300 psi rated full port brass or bronze body screwed ball valves and lug body or grooved end type butterfly valves.
- 2.2.2 Butterfly valves shall include a pressure responsive seat, and the stem shall be offset from the disc centreline to provide complete 360-degree circumferential seating.

2.3 FIRE HOSE CABINETS

- 2.3.1 National Fire Equipment Ltd. fire hose cabinet assemblies as indicated on the Drawings and as specified below.
- 2.3.2 Cabinet Construction: Unless otherwise specified, cold rolled steel with a 304 stainless steel for Hospital projects, #18 gauge with universal knockouts for tubs, #14 gauge for doors and trim, with all metal edges ground and rounded. Doors are to be complete with:
 - 2.3.2.1 hollow channel reinforcement;
 - 2.3.2.2 full length semi-concealed piano hinge with paint stop feature and designed to permit 180° door opening;
 - 2.3.2.3 a full removable panel of "Duo-Lite" ¼" thick clear safety glass with adhesive centre;
 - 2.3.2.4 a Model SMSS flush stainless steel door latch.
- 2.3.3 Cabinet Sizes and Mounting: Cabinet mounting and sizes are to be as follows:
 - 2.3.3.1 recessed cabinets – Model "Knight 200-2", 760 mm x 760 mm x 200 mm (30" x 30" x 8") with 12 mm (½") turnback frame and 50 mm (2") frame adjustment;
- 2.3.4 Fire Hose Valve: Model A156S, 1½", forged brass, satin finish, adjustable pressure restricting angle hose valve where standpipe pressure is less than 150 psi, complete with integral automatic drain vent, factory set to suit standpipe system pressure.
- 2.3.5 Fire Department Hose Valve: Model A56, 2½", forged brass, satin finish, Fire Department angle hose valve with cap and chain.
- 2.3.6 Hose Rack, Hose and Nozzle: Model S-4 stationary hose rack with independently swivelling pins, a Model S-5 automatic water stop, and 100' of "Poly-Flex" 100% synthetic 1½" diameter hose with Model A70BO forged brass couplings and a Model A7B forged brass nozzle with rubber bumper and adjustment for fog, straight stream and shutoff.
- 2.3.7 Spanner Wrench: Model C-21 "Trinal" spanner wrench.

- 2.3.8 Fire Extinguisher: Stored pressure, multi-purpose, 5 lb, 3A10B:C rated dry chemical extinguisher.
- 2.3.9 Chrome Plating: All brass components in recessed cabinets in finished areas are to be chrome plated.
- 2.3.10 Cabinets of stainless steel construction are to be as specified above but constructed of Type 304 stainless steel with a #4 satin finish applied to door and frame after fabrication and removal of weld spots.
- 2.3.11 Acceptable Manufacturers: Acceptable manufacturers are:
 - 2.3.11.1 National Fire Equipment Ltd.;
 - 2.3.11.2 Wilson & Cousins;
 - 2.3.11.3 Potter-Roemer Inc.

PART 3 - EXECUTION

3.1 DEMOLITION

- 3.1.1 Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide all required standpipe system piping. Unless otherwise specified, piping is to be as follows:
 - 3.2.1.1 for piping inside building and above ground, Schedule 40 grooved end black steel with Victaulic or equal fittings and coupling joints, or, for piping to and including 2" diameter, screwed fittings and joints or piping 2½" diameter and larger, welding fittings and welded joints.
- 3.2.2 Do all piping work in accordance with requirements of NFPA No. 14, governing regulations, and "reviewed" shop drawings.
- 3.2.3 All pipe sizes, pipe routing, and layout of work shown on the drawings are to assist you during the tendering period. Do not reduce the size of the standpipe main or re-route the main unless approved.
- 3.2.4 All pipe, fittings, couplings, flanges, and similar components are to be clean after erection is complete. Any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibits rust is to be wire brush cleaned and carefully coated with suitably coloured primer.

- 3.2.5 Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer and shall be verified as suitable for the intended service. A factory-trained field representative of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products.
- 3.2.6 Slope all horizontal piping so that it may be completely drained. Provide capped drain points.
- 3.2.7 Provide a pressure gauge at the highest outlet in each standpipe riser. Locate gauges so that they can be read easily. Where possible, locate gauges in fire hose cabinets. See the mechanical work Section entitled Basic Mechanical Materials and Methods for pressure gauge requirements.

3.3 INSTALLATION OF SHUT-OFF VALVES

- 3.3.1 Provide shut-off valves in piping where shown and wherever else required.
- 3.3.2 Locate all valves for easy operation and maintenance.
- 3.3.3 Confirm exact locations prior to roughing-in.

3.4 INSTALLATION OF FIRE HOSE CABINETS

- 3.4.1 Provide fire hose cabinets.
- 3.4.2 Confirm exact cabinet locations prior to roughing-in.

End of Section

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets to the regulatory authority for review and approval prior to submitting to the Consultant. Conform to the following requirements:
- 1.1.1.1 submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings;
 - 1.1.1.1.1 Sprinklers shall be referred to on drawings and product submittals and be specifically identified by the manufacturer's listed model or series designation. Trade names and other abbreviated listings are not allowed.
 - 1.1.1.2 submit complete white print CAD layout drawings indicating the source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, sprinkler heads layout and zones, all signed and sealed by a qualified professional mechanical engineer as specified below;
 - 1.1.1.3 submit copies of all calculations, including hydraulic calculations, stamped and signed by the same engineer who signs the layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing, including occupancy-hazard design requirements;
 - 1.1.1.4 in addition to submitting shop drawings to the regulatory authority as specified above, shop drawings must be approved by the Owner's insurer prior to being submitted to the Consultant for review.
- 1.1.2 Test Certificate: Submit a complete sprinkler system test certificate as specified in Part 3 of this Section.

1.2 QUALITY ASSURANCE

- 1.2.1 Codes and Standards: Fire protection standpipe system work is to be in accordance with the following Codes and Standards:
- 1.2.1.1 NFPA 13, Standard for the Installation of Sprinkler Systems;
 - 1.2.1.2 NFPA 25 Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems)
 - 1.2.1.3 NFPA 70 National Electrical Code.
 - 1.2.1.4 NFPA 72 National Fire Alarm Code.
 - 1.2.1.5 National Building Code.
 - 1.2.1.6 National Fire Code

- 1.2.1.7 CAN/ULC-S524 (Standard for the Installation of Fire Alarm Systems)
- 1.2.1.8 CAN/ULC-S537 (Standard for the Verification of Fire Alarm Systems)
- 1.2.1.9 Requirements of authority having jurisdiction (AHJ).
- 1.2.1.10 CSA B137.2, PVC Injection-Molded Gasketed Fittings for Cold-Water Pressure Services;
- 1.2.1.11 CSA B137.3, Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications;
- 1.2.1.12 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;
- 1.2.1.13 ASTM A135, Standard Specification for Electric-Resistance-Welded Steel Pipe;
- 1.2.1.14 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;
- 1.2.1.15 ASTM A536, Standard Specification for Ductile Castings;
- 1.2.1.16 ASTM A795, Standard Specification for Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use;
- 1.2.1.17 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);
- 1.2.1.18 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.
- 1.2.2 Subcontractor and Site Personnel: Fire protection sprinkler work is to be performed by Siemens. All site personnel are to be sprinkler fitters licensed in the jurisdiction of the work and under the continuous supervision of a foreman who is an experienced fire protection system installer and a journeyman pipe fitter.
- 1.2.3 Dimensions and Coordination: Check and verify all dimensions and conditions at the site and ensure that the work can be performed as indicated. Co-ordinate fire protection sprinkler work with all trades at the site and accept responsibility for and the cost of making adjustments to piping and/or spacing to avoid interference with other building components.
- 1.2.4 Existing Sprinkler Work: Verify the working condition of all existing fire protection sprinkler system equipment which has direct interface with the new work and is to remain. Replace with new equipment where necessary.
- 1.2.5 All system components must be UL and/or ULC listed and labelled.
- 1.2.6 All grooved couplings, and fittings, valves and specialties shall be the products of a single manufacturer.
- 1.2.7 All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.
- 1.3 DESIGN REQUIREMENTS**

- 1.3.1 Design Criteria: Fire protection sprinkler work is to be designed in accordance with NFPA 13 and Provincial Standards, and, where required, local building and fire department requirements and the standards of the Owner's Insurer. If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at the nearest fire hydrant to obtain criteria to be used in sprinkler system design. Include hydrant location and flow and pressure test data with system design calculations.
- 1.3.2 System Designer: Fire protection sprinkler work is to be designed by a fully qualified mechanical professional engineer registered and licensed in the jurisdiction of the work. Refer to the mechanical work Section entitled Mechanical Work General Requirements for requirements governing employment of the Engineer.
- 1.3.3 Sprinkler /System Occupancy – Hazard Design requirements: As per NFPA 13 occupancy-hazard density requirements, unless otherwise specified.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- 2.1.1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:
- 2.1.1.1 Schedule 40 Steel – Grooved Coupling Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and mechanical fittings and couplings equal to Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints. Strap type outlet fittings such as Victaulic "Snap-Let" are not acceptable.
- 2.1.1.2 Schedule 40 Steel – Screwed and Welded Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping is to be complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping is to be complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible.

2.2 SHUT-OFF VALVES

- 2.2.1 Equal to Victaulic Style 705, minimum 300 psi rated full port brass or bronze body screwed ball valves and lug body or grooved end type butterfly valves.
- 2.2.2 Butterfly valves shall include a pressure responsive seat, and the stem shall be offset from the disc centreline to provide complete 360-degree circumferential seating.

2.3 SPRINKLER HEADS

- 2.3.1 Sprinkler heads, unless otherwise specified, are to be as scheduled in Part 3 of this Section.
- 2.3.2 Sprinkler body shall be die-cast, with a hex-shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer that directly engages the wrench boss.
- 2.3.3 Concealed sprinkler head ceiling plates are to match the ceiling colour.

- 2.3.4 Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 165°F heads. All other heads, unless otherwise specified or required, are to be 135°F rated.
- 2.3.5 Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.
- 2.3.6 Concealed type of sprinkler heads shall be used for finished spaces for healthcare application.
- 2.3.7 Acceptable sprinkler head manufactures are:
 - 2.3.7.1 Tyco Fire Suppression & Building Products;
 - 2.3.7.2 Victaulic Co.;
 - 2.3.7.3 The Viking Corporation;
 - 2.3.7.4 The Reliable Automatic Sprinkler Co.

2.4 SPARE SPRINKLER HEAD CABINET

- 2.4.1 Surface wall mounting, red enamelled steel, identified cabinet with hinged door, shelves with holes for mounting sprinkler heads, a wrench or wrenches suitable for each type of sprinkler head, and a full complement of spare sprinkler heads.
- 2.4.2 The cabinet is to be sized to accommodate a minimum of four spare heads for each type of head used on the project, however, each cabinet is to be full of spare heads.

PART 3 - EXECUTION

3.1 DEMOLITION

- 3.1.1 Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide all required sprinkler system piping.
- 3.2.2 Do all piping work in accordance with requirements of NFPA 13, governing regulations, and "reviewed" shop drawings.
- 3.2.3 Piping, unless otherwise specified, is as follows:
 - 3.2.3.1 for piping inside the building and above ground except as noted below – Schedule 40 grooved end black steel with Victaulic or equal fittings and coupling joints, or, for piping to and including 2" diameter, screwed fittings and joints, or, for piping 2½" diameter and larger, welding fittings and welded joints;

- 3.2.4 All pipe sizes, pipe routing, sprinkler head quantities and locations, and layout of work shown on the drawings are to assist you during the tendering period. Ensure adequate head coverage, head quantities and pipe sizing as specified in Part 1 of this Section. Do not reduce the size of the sprinkler main or re-route the main unless approved.
- 3.2.5 All pipe, fittings, couplings, flanges and similar components are to be clean after erection is complete. Any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibits rust is to be wire brush cleaned and carefully coated with suitably coloured primer.
- 3.2.6 Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer and shall be verified as suitable for the intended service. A factory-trained field representative of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products.
- 3.2.7 When sprinkler work is complete, test system components and the overall system(s) and submit completed test certificate and other documentation in accordance with Chapter 8 of NFPA 13.

3.3 INSTALLATION OF SHUT-OFF VALVES

- 3.3.1 Provide shut-off valves in piping where shown, and wherever else required.
- 3.3.2 Locate all valves for easy operation and maintenance.
- 3.3.3 Confirm exact locations prior to roughing-in.

3.4 INSTALLATION OF SPRINKLER HEADS

- 3.4.1 Provide all required sprinkler heads. Sprinkler head types are to be in accordance with the following schedule, unless otherwise specified. Sprinkler head manufacturers indicated on the schedule are for type indication purposes. Acceptable manufacturers are listed in Part 2 of this Section.
- 3.4.2 Unless otherwise specified, sprinkler heads are to be in accordance with the following schedule:

APPLICATION	SPRINKLER HEAD TYPE
Healthcare Facility Type I rooms/areas as per CAN/CSA-Z317.1, Table 1, HVAC Design Criteria, first two columns	Reliable Model G4 "The Concealer" concealed sprinkler head with a dust type gasketed seal.
Healthcare Facility Type II rooms/area as per CAN/CSA-Z317.1, Table 1, HVAC Design Criteria, first two columns	Tyco Series RFII "Royal Flush II" concealed pendent
Healthcare Facility Type III rooms/areas as per CAN/CSA-Z317.1, Table 1, HVAC Design Criteria, first two columns	Tyco Series RFII "Royal Flush II" concealed pendent
Rooms/areas with a suspended ceiling	Tyco Series RFII "Royal Flush II" concealed pendent
Rooms/areas without a suspended ceiling	Tyco Series TY-RFB pendent

- 3.4.3 Sprinkler head locations must be carefully coordinated with all drawings, including architectural reflected ceiling plan drawings, and, where applicable, electrical drawings. Coordinate sprinkler head locations in areas with suspended ceilings with the location of lighting, grilles, diffusers, and similar items recessed in or surface mounted on the ceiling as per the reflected ceiling plans. In areas with lay-in tile, centre the sprinkler head both ways in the lay-in tile wherever possible. Confirm locations prior to roughing-in.
- 3.4.4 Maintain maximum headroom in areas with no ceilings.
- 3.4.5 Provide guards for heads where they are subject to damage.
- 3.4.6 Provide high temperature heads in equipment rooms and similar areas over heat producing or generating equipment.
- 3.5 Installation of Spare Sprinkler Head Cabinet
- 3.5.1 Supply a full complement (to fill cabinet) of spare sprinkler heads of the types used (minimum four of each type) and place in a wall mounting storage cabinet located adjacent to the sprinkler system "head end" equipment where later directed.

End of Section

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in Part 2 of this Section except for pipe and fittings, and chlorine.

1.2 QUALITY ASSURANCE

- 1.2.1 Domestic water piping and valves are to comply with following codes, regulations and standards (as applicable):
- 1.2.1.1 applicable local codes and regulations;
 - 1.2.1.2 CAN/CSA B125.1, Plumbing Supply Fittings;
 - 1.2.1.3 CAN/CSA B125.3, Plumbing Fittings;
 - 1.2.1.4 CAN/CSA B137 Series, Thermoplastic Pressure Piping Compendium;
 - 1.2.1.5 NSF/ANSI 14, Plastics Piping System Components and Related Materials;
 - 1.2.1.6 NSF/ANSI 61, Drinking Water System Components – Health Effects;
 - 1.2.1.7 NSF/ANSI 372, Drinking Water System Components – Lead Content.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- 2.1.1 Hard Copper - Solder Joint: Type "L" hard drawn seamless copper to ASTM B88, complete with copper solder type fittings to ASME/ANSI B16.18 and soldered joints using The Canada Metal Co. Ltd. "SILVABRITE 100" or equal lead-free solder for cold water pipe, and 95% tin/5% Antimony or "SILVABRITE 100" solder for other services.

2.2 SHUT-OFF VALVES

- 2.2.1 Ball Valves: Class 600, 600 psi WOG rated full port ball type valves, each complete with a forged brass body with solder ends, forged brass cap, and blowout-proof stem, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat, and a removable lever handle. Valves in insulated piping are to be complete with stem extensions. Acceptable products are:
- 2.2.1.1 Toyo Valve Co. Fig. 5049A;
 - 2.2.1.2 Milwaukee Valve Co. #BA-155;
 - 2.2.1.3 Kitz Corporation Code 59;
 - 2.2.1.4 Apollo Valves # 77-200;

2.2.1.5 Watts Industries (Canada) Inc. #FBVS-3.

2.2.2 Butterfly Valves - Flanged Joint: Non-corrosive, ANSI Class 125 minimum 175 psi cold water pressure rated, resilient seated butterfly valves, each complete with a coated cast ductile iron lug type body, stainless steel shaft, bronze disc, and EPDM seat, and each suitable for domestic water bubble-tight dead-end service with the valve in position and either side of the connecting piping removed. Butterfly valves to and including 4" dia. are to be equipped with lever handles. Butterfly valves larger than 4" dia. are to be equipped with worm gear operators. Acceptable products are:

2.2.2.1 DeZurik #632L Series;

2.2.2.2 Kitz Corporation Code #6122EL/EG;

2.2.2.3 Toyo Valve Co. #918BESL/EG;

2.2.2.4 Bray Valve and Controls Canada Series 31, 31H, 40/41, 42/43, 44/45;

2.2.2.5 Apollo Valves # 143 Series;

2.2.2.6 Watts Industries (Canada) Inc. #BF-03.

2.3 CHECK VALVES

2.3.1 Horizontal: Class 125, bronze 200 psi WOG rated horizontal swing type check valves with solder ends. Acceptable products are:

2.3.1.1 Toyo Valve Co. Fig. 237;

2.3.1.2 Milwaukee Valve Co. #1510;

2.3.1.3 Kitz Corporation Code 23;

2.3.1.4 Apollo Valves # 61-600.

2.3.2 Vertical: Equal to Kitz Corp. Code 26, bronze, 250 psi WOG rated vertical lift check valve with soldering ends.

2.4 DRAIN VALVES

2.4.1 Minimum 300 psi water rated, 3/4" dia., straight pattern full port bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 3/4" dia. garden hose, and a cap and chain. Acceptable products are:

2.4.1.1 Toyo Valve Co. Fig. 5046;

2.4.1.2 Dahl Brothers Canada Ltd. Fig. No. 50. 430;

2.4.1.3 Kitz Corporation Code 58CC;

2.4.1.4 Apollo Valves # 78-104-01;

2.4.1.5 Watts Industries (Canada) Inc. #B6000-CC.

2.5 DOMESTIC HOT WATER PIPING MANUAL BALANCING VALVES

2.5.1 Solder or flanged end type as required, globe style, non-ferrous circuit balancing valves designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off, complete with capped and valved drain connection, and valved ports for connection to a differential pressure meter.

2.5.2 Acceptable products are:

2.5.2.1 Tour and Andersson Model Series 790, 786H or 787H;

2.5.2.2 Armstrong Fluid Technology Model CBV Series;

2.5.2.3 Watts Industries (Canada) Inc. Model CSM Series.

2.6 DOMESTIC HOT WATER PRESSURE INDEPENDENT PIPING BALANCING VALVES

2.6.1 Equal to Tour & Andersson TCP Pressure Independent Balancing & Control Valve, rated for 230 psi, NPT threaded ends, non-ferrous Ametal® DZR brass copper alloy body, PPS (polyphenylsulfide) plug, EPDM o-ring seat and spindle seal, stainless steel return spring, Nedox® coated Ametal® spindle, HNBR membrane, and 10-position setting dial.

2.6.2 Valve shall be designed for modulating control of hot water re-circulation systems suitable for control, pre-setting (of flow), differential pressure control, measuring, shut-off, and flushing.

2.6.3 Suitable for working temperatures to +250°F (+120°C). Body material shall be ISO 6509 compliant.

2.7 PRESSURE REDUCING VALVES

2.7.1 For piping less than or equal to 50 mm (2") diameter, non-corrosive, non-ferrous direct spring acting pressure reducing valves to CAN/CSA B356, each factory set at 345 kPa (50 psi) unless otherwise specified or required, each field adjustable from 175 kPa (25 psi) to 520 kPa (75 psi) and each complete with an integral inlet strainer. Acceptable products are:

2.7.1.1 Conbraco 36C Series;

2.7.1.2 Zurn/Wilkins 600 Series;

2.7.1.3 Watts Industries (Canada) Inc. #25AUB Series;

2.7.1.4 Cash-Acme EB-240 Series;

2.7.1.5 Victaulic Co. (Bermad) Series 386.

2.7.2 For piping 65 mm (2-1/2") diameter and larger, non-corrosive pilot operated pressure reducing valve to CAN/CSA B356, factory set at the required pressure, field adjustable, and complete with a bronze body and trim, screwed or flanged connections, and brass body pilot valve with stainless steel seat. Acceptable products are:

- 2.7.2.1 Singer Valve Model 106 PR;
- 2.7.2.2 Zurn/Wilkins Model ZW109;
- 2.7.2.3 Watts Industries (Canada) Inc. Series N223;
- 2.7.2.4 Victaulic Co. (Bermad) Series 386.

2.8 CHLORINE

- 2.8.1 Sodium hypochlorite to AWWA B-300-75.

PART 3 - EXECUTION

3.1 DEMOLITION

- 3.1.1 Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide all required domestic water piping.
- 3.2.2 Piping, unless otherwise specified, is to be as follows:
 - 3.2.2.1 for pipe inside building and aboveground in sizes to 100 mm (4") dia. – Type "L" hard copper with solder joints or Type "L" hard copper with pressure coupled mechanical joints.
- 3.2.3 Slope all piping so that it can be completely drained.
- 3.2.4 Provide proper dielectric unions in all connections between copper pipe and ferrous pipe or equipment. Dielectric unions are to conform to ASTM F1545-97 and are to be complete with a thermoplastic liner.

3.3 INSTALLATION OF SHUT-OFF AND CHECK VALVES

- 3.3.1 Refer to Part 3 of the mechanical work Section entitled Basic Mechanical Materials and Methods.
- 3.3.2 Provide balancing valves in domestic hot water recirculation piping where shown or required. Balancing valves to be provided as follows:
 - 3.3.2.1 Piping up to and including 1": Pressure Independent Balancing Valves
 - 3.3.2.2 Piping greater than 1": Manual Balancing Valves
- 3.3.3 Locate each valve such that it is easily accessible.

3.4 INSTALLATION OF PRESSURE REDUCING VALVES

- 3.4.1 Provide domestic water pressure reducing valves in piping where shown and/or required. Install so that each valve is readily accessible. Whenever possible, provide pressure reducing valves factory preset to required pressures.
- 3.4.2 Check and test operation and adjust as required.

3.5 FLUSHING AND DISINFECTING PIPING

- 3.5.1 Flush and disinfect all new and/or reworked domestic water piping after leakage testing is complete.
- 3.5.2 Isolate new piping from existing piping prior to flushing and disinfecting procedures.
- 3.5.3 Flush piping until all foreign materials have been removed and the flushed water is clear. Provide connections and pumps as required. Open and close valves, faucets, hose outlets, and service connections to ensure thorough flushing.
- 3.5.4 When flushing is complete, disinfect the piping with a solution of chlorine in accordance with AWWA C601.
- 3.5.5 When disinfecting is complete, submit water samples to a certified laboratory for purity testing and, when testing indicates pure water in accordance with governing standards, submit a copy of the test results and fill the systems.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in Part 2 of this Section.
- 1.1.2 Prior Substantial Performance of the Work, submit a minimum of 3 identified keys for key operated hydrants.

PART 2 - PRODUCTS

2.1 INTERIOR HOSE BIBBS

2.1.1 Flush-Concealed

- 2.1.1.1 Recessed, 92 mm (3-5/8") deep, recessed, encased wall hydrant with lockable bronze or stainless steel box with hinged cover identified "WATER", bronze interior parts, a screwdriver operated stop in the supply, key operated control valve, 20 mm (3/4") dia. hose connection, and a vacuum breaker.

2.1.1.2 Acceptable products are:

- 2.1.1.2.1 Jay R. Smith #5509QT-CL-SAP;
- 2.1.1.2.2 Zurn #Z1350;
- 2.1.1.2.3 Mifab #MHY-55;
- 2.1.1.2.4 Watts Industries (Canada) Inc. #HY-330.

2.1.2 Semi-Recessed - Finished Areas

- 2.1.2.1 Anti-siphon type, 100 mm (4") deep hose bibb with stainless steel face with operating key, bronze interior parts, 20 mm (3/4") dia. solder inlet, 20 mm (3/4") dia. hose connection, and integral vacuum breaker.

2.1.2.2 Acceptable products are:

- 2.1.2.2.1 Jay R. Smith #5619-SAP-98;
- 2.1.2.2.2 Zurn #Z1333 "ECOLOTROL";
- 2.1.2.2.3 Mifab #MHY-30;
- 2.1.2.2.4 Watts Industries (Canada) Inc. #HY-430.

2.1.3 Surface – Exposed – Cold Water – Unfinished Areas

- 2.1.3.1 Brass or bronze hose bibb with hose end vacuum breaker.

2.1.3.2 Acceptable products are:

- 2.1.3.2.1 Watts Industries (Canada) Inc. #SC8-1;
- 2.1.3.2.2 Zurn/Wilkins # Z1341 with hose end vacuum breaker;
- 2.1.3.2.3 Chicago Faucets #293-E27CP;
- 2.1.3.2.4 Jay R. Smith #5609QT-SAP.

2.1.4 Exposed – Unfinished Areas – Hot and Cold Water

2.1.4.1 Mixing faucet for surface mounting.

2.1.4.2 Acceptable products are:

- 2.1.4.2.1 Delta Commercial #28T8083;
- 2.1.4.2.2 Zurn #Z841L1-RC;
- 2.1.4.2.3 Jay R. Smith #5560QT-LB-SAP;
- 2.1.4.2.4 Watts Industries (Canada) Inc. #HY-300-2-VB.

2.2 FLOOR DRAIN TRAP SEAL PRIMERS

- 2.2.1 Primer Valve Type: Precision Plumbing Products Inc. Model P2-500 trap primer valve, constructed of brass, adjustable to high or low water pressures and complete with "O" ring seals, ½" threaded inlet and outlet connections, and, for priming two traps from the same primer, a DU-2 dual outlet distribution unit.

2.3 WATER HAMMER ARRESTORS

- 2.3.1 Piston type, sealed, all stainless steel construction, pressurized water hammer arrestors suitable for either vertical or horizontal installation, each complete with a pressurized compression chamber, welded nesting-type expansion bellows surrounded by non-toxic mineral oil, and a male treaded nipple connection.

2.3.2 Acceptable products are:

- 2.3.2.1 Jay R. Smith 5000 Series;
- 2.3.2.2 Precision Plumbing Products "SS" Series.

2.4 BACKFLOW PREVENTERS

- 2.4.1 Reduced Pressure Zone Assembly

- 2.4.1.1 Lead-free reduced pressure zone assembly backflow preventer in accordance with CAN/CSA B64 (including supplements), each of bronze or epoxy coated cast iron bronze fitted construction depending on size, and complete with inlet strainer, inlet and outlet shut-off valves, an intermediate relief valve, ball valve type test cocks, and a proper air gap fitting.
- 2.4.1.2 Acceptable products are:
 - 2.4.1.2.1 Watts Industries #LF009QT-S for 12 mm (½") size, #LF909QT-S for 20 mm to 50 mm (¾" to 2") size, and #LF909-NRS-S for 65 mm (2-½") and larger size;
 - 2.4.1.2.2 Zurn/Wilkins 975XL2 and 375 Series;
 - 2.4.1.2.3 "Apollo" Valves manufactured by Conbraco Industries Inc. Series 4ALF;
 - 2.4.1.2.4 Danfoss Flomatic Corp. Series RPZ.

PART 3 - Execution

3.1 INSTALLATION OF HOSE BIBBS

- 3.1.1 Provide hose bibbs where shown and/or specified on the contract documents.
- 3.1.2 Unless otherwise shown, specified, or required, mount hose bibbs approximately 3' above the floor. Confirm exact locations prior to roughing-in.

3.2 INSTALLATION OF TRAP SEAL PRIMERS

- 3.2.1 Provide all required accessible trap seal primers to automatically maintain a water seal in floor drain traps, whether shown on the contract documents or not.
- 3.2.2 Water Closet Flush Valves: Water closet flush valves may be used for priming washroom floor drain traps if the flush tube is properly tapped and primer tubing exposed in the washroom is chrome plated.

3.3 INSTALLATION OF WATER HAMMER ARRESTORS

- 3.3.1 Provide accessible water hammer arrestors in domestic water piping in locations as follows:
 - 3.3.1.1 in headers at groups of plumbing fixtures;
 - 3.3.1.2 at the top of risers;
 - 3.3.1.3 at ends of long horizontal runs of piping;
 - 3.3.1.4 in piping connecting solenoid valves or equipment with integral solenoid valves;
 - 3.3.1.5 wherever else required by Code.

- 3.3.2 Install each unit in a piping tee either horizontally or vertically in the path of potential water shock in accordance with the manufacturer's published instructions and details.

3.4 INSTALLATION OF BACKFLOW PREVENTERS

- 3.4.1 Provide a reduced pressure zone assembly backflow preventer on incoming DCW service and in each direct domestic water connection to equipment other than plumbing fixtures and fittings.
- 3.4.2 Locate each backflow preventer on floor or wall between 765 mm and maximum 1.5 m (30" and 60") above floor such that it is easily accessible for maintenance and testing. Equip each backflow preventer with an air gap fitting and pipe the reduced pressure zone water outlet to drain.
- 3.4.3 Test operation of each backflow preventer in accordance with requirements of CAN/CSA B64 by personnel certified for such testing by governing authorities, and submit signed test results and a properly and clearly identified and marked inspection and test record card for each backflow preventer.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings.
- 1.1.2 Plumbing Inspection Certificate: Submit a copy of the plumbing inspection certificate prior to application for Substantial Performance.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- 2.1.1 Copper- Solder Joint: Type DWV hard temper to ASTM B306, with forged copper solder type drainage fittings and 50% silver - 50% tin solder joints.
- 2.1.2 Cast Iron: Class 4000 cast iron pipe, fittings, and mechanical coupling joints to CAN/CSA B70.
- 2.1.3 Glass Piping: O-I/Schott Process Systems Inc., "KIMAX" tempered and concealed Borosilicate glass pipe and fittings with "KIMAX" one (1) bolt compression type stainless steel couplings.
 - 2.1.3.1 Acceptable manufacturers are Owens-Illinois and Industrial Specialties Ltd., "PEGASUS".

PART 3 - EXECUTION

3.1 DEMOLITION

- 3.1.1 Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 DRAIN AND VENT PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide all required drainage and vent piping. Pipe, unless otherwise specified, is to be as follows:
 - 3.2.1.1 for acid-proof drainage piping and acid proof vent piping to the extent indicated on the drawings – "KIMAX" glass pipe;
 - 3.2.1.2 for all other pipe inside building and aboveground in sizes less than or equal to 65 mm (2-1/2") dia. – type DWV copper;
 - 3.2.1.3 for all other pipe inside building and aboveground in sizes greater than or equal to 75 mm (3") dia. – Class 4000 cast iron;

- 3.2.2 Unless otherwise specified, slope horizontal drainage piping aboveground in sizes to and including 75 mm (3") dia. 25 mm (1") in 1.2 m (4'), and pipe 100 mm (4") dia. and larger 25 mm (1") in 2.4 m (8').
- 3.2.3 Unless otherwise specified, slope horizontal branches of vent piping down to fixture or pipe to which they connect with a minimum pitch of 25 mm (1") in 1.2 m (4').
- 3.2.4 Extend vent stacks up through roof generally where shown but with exact locations to suit site conditions and in any case a minimum of 3 m (10') from fresh air intakes. Terminate vent stacks a minimum of 330 mm (13") above roof (including roof parapets) in vent stack covers. Where not shown on drawings, route vent piping from source to building exterior as required in order to satisfy local governing codes and authority. Coordinate vent routing with other building services and ensure there is no architectural impact.

- 3.2.5 Provide cast brass dielectric unions at connections between copper pipe and ferrous pipe or equipment.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section.
- 1.1.2 Certification Letters: Submit letters from product manufacturer's/supplier's to certify correct installation of products as specified in Part 3 of this Section.

PART 2 - PRODUCTS

2.1 VENT STACK COVERS

- 2.1.1 Equal to Lexcor Model VSC-S "Flash-Tite" seamless, spun aluminum, insulated 13" high vent stack covers with caps and a factory applied asphalt primer coating on the top and bottom of the flange.
- 2.1.2 Each vent stack cover is to be complete with a vandal-proof cap.

2.2 CLEANOUTS

- 2.2.1 Horizontal Piping: TY pipe fitting with an extra heavy brass plug screwed into the fitting.
- 2.2.2 Vertical Piping: Bronze or copper cleanout tees in copper piping, each complete with a bronze ferrule, and, for cast iron piping, "BARRETT" type cast iron cleanout tees, each gas and water-tight and complete with a bolted cover.

2.3 FLOOR CLEANOUT TERMINATIONS

- 2.3.1 Factory finished cast iron terminations, each adjustable and complete with a cast iron body with neoprene sleeve, solid, gasketed, polished nickel-bronze scoriated top access cover to suit the floor finish, a seal plug, and captive, vandal-proof, stainless steel securing hardware. Acceptable products are:
 - 2.3.1.1 Watts Industries (Canada) Ltd.;
 - 2.3.1.2 Jay R. Smith Manufacturing Co.;
 - 2.3.1.3 Zurn Industries Ltd.;
 - 2.3.1.4 Mifab Inc.
- 2.3.2 All cleanout terminations in areas with a tile or sheet vinyl floor finish are to be as above but with a square top in lieu of a round top.

2.4 FLOOR DRAINS, FUNNEL FLOOR DRAINS AND HUB DRAINS

- 2.4.1 Unless otherwise specified or scheduled, floor drains and funnel floor drains are to be vandal-proof drains in accordance with the drawing schedule, each complete with a cast iron body and a trap seal primer connection. All cast iron components are to be factory finished with latex based paint coating.
- 2.4.2 All floor drains in areas with a tile or sheet vinyl floor finish are to be as above but with a square grate in lieu of a round grate.
- 2.4.3 Acceptable manufacturers are:
- 2.4.3.1 Watts Industries (Canada) Ltd.;
 - 2.4.3.2 Jay R. Smith Manufacturing Co.;
 - 2.4.3.3 Zurn Industries Ltd.;
 - 2.4.3.4 Mifab Inc.

2.5 ROOF DRAINS

- 2.5.1 Unless otherwise specified or scheduled, roof drains are to be cast iron body drains with aluminium domes, in accordance with the drawing schedule. All cast iron components are to be factory finished with a latex based paint coating.
- 2.5.2 Acceptable manufacturers are:
- 2.5.2.1 Watts Industries (Canada) Ltd.;
 - 2.5.2.2 Jay R. Smith Manufacturing Co.;
 - 2.5.2.3 Zurn Industries Ltd.;
 - 2.5.2.4 Mifab Inc.

PART 3 - EXECUTION

3.1 INSTALLATION OF CLEANOUTS

- 3.1.1 Provide cleanouts in drainage piping in locations as follows:
- 3.1.1.1 in the building drain or drains as close as possible to the inner face of the outside wall, and, if a building trap is installed, locate the cleanout on the downstream side of the building trap;
 - 3.1.1.2 at or as close as practicable to the foot of each drainage stack;
 - 3.1.1.3 at maximum 50' intervals in horizontal pipe 4" dia. and smaller;
 - 3.1.1.4 at maximum 100' intervals in horizontal pipe larger than 4" dia.;
 - 3.1.1.5 wherever else shown on drawings.

3.1.2 Cleanouts are to be same diameter as pipe in piping to 100 mm (4") dia., and not less than 100 mm (4") dia. in piping larger than 100 mm (4") dia.

3.1.3 Where cleanouts in vertical piping are concealed behind walls or partitions, install cleanouts near floor and so cover is within 25 mm (1") of the finished face of the wall or partition.

3.2 INSTALLATION OF FLOOR CLEANOUT TERMINATIONS

3.2.1 Where cleanouts occur in horizontal inaccessible underground piping, extend the cleanout TY fitting up to the floor, and provide a cleanout termination set flush with the finished floor.

3.2.2 In waterproof floors, ensure that each cleanout termination is equipped with a flashing clamp device. Cleanout terminations are to suit the floor finish.

3.2.3 Where cleanout terminations occur in finished areas, confirm locations prior to rough-in and arrange piping to suit.

3.2.4 Ensure that cleanout termination covers in tiled floor are square in lieu of round.

3.2.5 Cleanout terminations for cleanouts for horizontal inaccessible, acid-proof piping shall be cast iron epoxy coated cleanout terminations to suit the floor finish.

3.3 INSTALLATION OF FLOOR DRAINS, FUNNEL FLOOR DRAINS AND HUB DRAINS

3.3.1 Provide floor drains, funnel floor drains and hub drains.

3.3.2 Coordinate location of floor drains, funnel floor drains and hub drains with equipment provided by Mechanical Division and Owner's supplied equipment. Install in accordance with manufacturer's instructions.

3.3.3 Equip each drain with a trap.

3.3.4 In equipment rooms and similar areas, exactly locate floor drains to suit the location of mechanical equipment and equipment indirect drainage piping. In washrooms, exactly locate floor drains to avoid interference with toilet partitions.

3.3.5 Confirm the exact location of drains prior to roughing in. Where floor drains occur in washrooms coordinate locations with toilet partition installations.

3.3.6 Temporarily plug and cover floor drains during construction procedures. Remove plugs and covers during final cleanup work and when requested, demonstrate free and clear operation of each drain. Replace any damaged grates, and refinish any areas of the drain where the cast iron finish has been damaged or removed, including rusted areas.

3.4 INSTALLATION OF ROOF DRAINS

3.4.1 Supply roof drains and place roof drain bodies in position for flashing into roof construction as part of the roofing work. Connect with piping and provide accessories.

- 3.4.2 Protect roof drains from damage and entrance of debris until roofing work is complete, and refinish any areas where the cast iron factory finish has been damaged or removed, including rusted areas.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Product Data: Submit product data sheets (fixture cuts) for all plumbing fixtures and fittings, including accessories. All product data sheets must confirm that the proposed fixtures and fittings meet all requirements of this Section of the Specification.
- 1.1.2 Colour Charts: Submit fixture manufacturer's standard colour charts for all fixtures where colours are available but a particular colour is not specified.

PART 2 - PRODUCTS

2.1 GENERAL RE: PLUMBING FIXTURES AND FITTINGS

- 2.1.1 Fixtures and fittings, where applicable, are to be in accordance with requirements of CAN/CSA-B45 Series, General Requirements for Plumbing Fixtures, including supplements, ASME A112.1.18.1/CSA B125.1, Plumbing Supply Fittings, and CAN/CSA-B125.3, Plumbing Fittings, and Healthcare Facility Standards as referenced in Section 20 05 05.
- 2.1.2 All barrier-free fixtures and fittings are to be in accordance with governing Code requirements.
- 2.1.3 Unless otherwise specified, all vitreous china, porcelain enamelled, and acrylic finished fixtures are to be white.
- 2.1.4 Unless otherwise specified, all toilet seats are to be constructed with an anti-microbial compound to inhibit the growth of bacteria on the seat surface.
- 2.1.5 Unless otherwise specified, all fittings and piping exposed to view are to be brass, chrome plated and polished.
- 2.1.6 All fittings located in areas other than private washrooms are to be vandal-resistant.
- 2.1.7 All fixture carriers are to be suitable in all respects for the fixture they support and the construction in which they are located.
- 2.1.8 Floor flanges for floor mounted water closets are to be cast iron or brass, secured to the floor to prevent movement and complete with a wax seal and brass or stainless steel bolts, nuts, and washers. Plastic floor flanges will not be acceptable.
- 2.1.9 Proper seal to mate with the fixture carrier flange and produce a water-tight installation.
- 2.1.10 Exposed traps for fixtures not equipped with integral traps, such as lavatories, are to be adjustable chrome plated cast brass "P" traps with cleanouts, minimum #17 gauge chrome plated tubular extensions, and chrome plated escutcheons, all to suit the fixture type and drain connection.
- 2.1.11 Concealed traps for fixtures not equipped with integral traps, such as counter sinks, are to adjustable cast brass with cleanout plugs, all to suit the fixture type and drain connection.

- 2.1.12 Exposed supplies for fixtures which do not have supply trim/fittings with integral stops, i.e. lavatories, are to be solid chrome plated brass angle vales with screwdriver stops for public areas, wheel handle stops for private areas, flexible stainless steel risers, and stainless steel or chrome plated steel escutcheons, all arranged and sized to suit the fixture.
- 2.1.13 Water piping as specified, complete with ball type shut-off valves as specified with the water piping or Dahl Bros. Canada Ltd. ¼ turn Mini Ball Valves.

2.2 PLUMBING FIXTURES AND FITTINGS

- 2.2.1 Plumbing fixtures and fittings are to be in accordance with the following schedule:

2.2.1.1 Toilet - Wall Hung (WC-1)

- 2.2.1.1.1 **American Standard 3351101.020 Toilet - AFWALL® MILLENNIUM™ FloWise®**, Toilet, Wall-hung with wall outlet, Toilet operates in the range of 4.2 to 6.0 LPF (1.1 - 1.6 GPF), White finish Vitreous china, EverClean® antimicrobial surface, Elongated bowl, Concealed trapway design, Direct-fed siphon jet flush action, 38 mm (1-1/2") top spud, Flush valve by others, 254 x 305 mm (10" x 12") water surface area, Fully-glazed 54 mm (2-1/8") trapway, Static load rating of 454 kg (1000 lb), this product is not recommended for bariatric use, Condensation channel, Toilet seat not included, 356 mm (14") wide, 660 mm (26") from finished wall, Compliances: ASME A112.19.2 compliant, CSA B45.1 compliant.
- 2.2.1.1.2 **Seat - Centoco AM500STSCSSFE-001 FAST-N-LOCK**, For elongated bowl, Open front, Heavy duty, For commercial applications, Polypropylene, Toilet seat, With less seat cover, Self-sustaining plastic commercial check hinges, and stainless steel hinge pin, Specified in White finish, and Antimicrobial additive inhibits the growth of stain and odor causing bacteria, FAST-N-LOCK mounting system takes the guess work out when tightening the hardware. The specially designed fasteners in click" when the appropriate torque is reached. The bolt and nut material shall be stainless steel, Dimensions: 25 mm (1") high, 470 mm (18-1/2") long, 362 mm (14-1/4") wide.
- 2.2.1.1.3 **Flush Valve – Sloan ROYAL 111-YG-1.28-SG - ROYAL®** Manual Exposed Water closet flushometer, High Efficiency 4.8 LPF (1.28 GPF), 38 mm (1-1/2") spud coupling For top spud toilet, constructed from Semi-red brass, Polished chrome finish, Chloramine resistant PERMEX® synthetic rubber diaphragm, Saniguard® coated metal oscillating handle, Flush tube for 292 mm (11-1/2") rough-in, Adjustable tailpiece, 25 mm (1") I.P.S. screwdriver Bak-Chek® angle control stop with free spinning vandal-resistant stop cap, Dual-filtered fixed bypass, Sweat solder adapter kit with cover tube, High back pressure vacuum breaker, Inlet located right of valve, 25 mm (1") supply pipe, Cast wall flange with set screw, Non-hold-open, no external volume adjustment, fixed volume accuracy is controlled by CID™ technology, Extended angle back check stop seat bumper for seats with lids, 103 - 552 kPa (15 - 80 PSI) operating water pressure, Compliances: Requires less than 5 pounds of force to activate (push button), cUPC compliant.

- 2.2.1.1.4 **Carrier - Watts ISCA-101-L/R** - Industry Standard single Horizontal adjustable Closet Carrier, patented compression seal faceplate assembly, epoxy coated cast iron, epoxy coated cast iron, with incremental measurements embossed onto legs to easily adjust height of carrier to most commonly used fixture requirements, epoxy coated cast iron, Plated hardware, neoprene bowl gasket, Adjustable ABS nipple, integral test cap, 51 mm (2") no hub vent connections, 102 mm (4") no hub waste, Adjustable for standard and wheelchair height, chrome cap nuts, Carrier complies with requirements of ASME A112.6.1M up to a 500 lb (227 kg) static load, required minimum space is 292 mm (11-1/2")
- 2.2.1.2 **Toilet - Wall Hung (WC-2) – Barrier Free Type**
- 2.2.1.2.1 **American Standard 3351101.020 Toilet** - AFWALL® MILLENNIUM™ FloWise®, Toilet, Wall-hung with wall outlet, Toilet operates in the range of 4.2 to 6.0 LPF (1.1 - 1.6 GPF), White finish Vitreous china, EverClean® antimicrobial surface, Elongated bowl, Concealed trapway design, Direct-fed siphon jet flush action, 38 mm (1-1/2") top spud, Flush valve by others, 254 x 305 mm (10" x 12") water surface area, Fully-glazed 54 mm (2-1/8") trapway, Static load rating of 454 kg (1000 lb), this product is not recommended for bariatric use, Condensation channel, Toilet seat not included, 356 mm (14") wide, 660 mm (26") from finished wall, Compliances: ASME A112.19.2 compliant, CSA B45.1 compliant.
- 2.2.1.2.2 **Seat - Centoco AM820STSSFE-001 FAST-N-LOCK**, For elongated bowl, Open front, Heavy duty, For commercial applications, Polypropylene, Toilet seat, With seat cover, Self-sustaining plastic commercial check hinges, and Metal hinge pin, Specified in White finish, and Antimicrobial additive inhibits the growth of stain and odor causing bacteria, FAST-N-LOCK mounting system takes the guess work out when tightening the hardware. The specially designed fasteners in click" when the appropriate torque is reached. The bolt and nut material shall be stainless steel, Dimensions: 25 mm (1") high, 470 mm (18-1/2") long, 362 mm (14-1/4") wide.
- 2.2.1.2.3 **Flush Valve – Sloan ROYAL 111-YG-1.28-SG** - ROYAL® Manual Exposed Water closet flushometer, High Efficiency 4.8 LPF (1.28 GPF), 38 mm (1-1/2") spud coupling For top spud toilet, constructed from Semi-red brass, Polished chrome finish, Chloramine resistant PERMEX® synthetic rubber diaphragm, Saniguard® coated metal oscillating handle, Flush tube for 292 mm (11-1/2") rough-in, Adjustable tailpiece, 25 mm (1") I.P.S. screwdriver Bak-Chek® angle control stop with free spinning vandal-resistant stop cap, Dual-filtered fixed bypass, Sweat solder adapter kit with cover tube, High back pressure vacuum breaker, Inlet located right of valve, 25 mm (1") supply pipe, Cast wall flange with set screw, Non-hold-open, no external volume adjustment, fixed volume accuracy is controlled by CID™ technology, Extended angle back check stop seat bumper for seats with lids, 103 - 552 kPa (15 - 80 PSI) operating water pressure, Compliances: Requires less than 5 pounds of force to activate (push button), cUPC compliant.
- 2.2.1.2.4 **Backrest – CM-16104-WM**. wall mounting, back rest, solid core plastic laminate panel back, Antique white, 305 mm (12") wide, 102 mm (4") high, 137 mm (5-3/8"), 18 gauge stainless steel bar with #4 gloss with flanges and covers, concealed snap flanges and mounting hardware included, Provide adequate backing in wall for support and comply to local codes for barrier free requirements.

2.2.1.2.5 **Carrier - Watts ISCA-101-L/R** - Industry Standard single Horizontal adjustable Closet Carrier, patented compression seal faceplate assembly, epoxy coated cast iron, epoxy coated cast iron, with incremental measurements embossed onto legs to easily adjust height of carrier to most commonly used fixture requirements, epoxy coated cast iron, Plated hardware, neoprene bowl gasket, Adjustable ABS nipple, integral test cap, 51 mm (2") no hub vent connections, 102 mm (4") no hub waste, Adjustable for standard and wheelchair height, chrome cap nuts, Carrier complies with requirements of ASME A112.6.1M up to a 500 lb (227 kg) static load, required minimum space is 292 mm (11-1/2")

2.2.1.3 **Toilet – Floor mounted (WC-3) Non Plumbed**

2.2.1.3.1 **Zurn Z5561-LH** Two piece vitreous china water closet, for disabled persons, elongated bowl of 432 mm (17 in) in height, ultra-performing. Eco Flush siphon jet action, 54 mm (2 1/8 in) completely glazed trap way; chrome finish metal handle, bolt caps, 4.2 L (1.1 US gal) per flush, with vandal lock tank.

2.2.1.3.2 **Seat cover Zurn Z5957SS-EL** Heavy duty solid plastic elongated seat, open front, with cover, molded bumper guard, stainless steel check hinges. (White).

2.2.1.4 **Basin - Wall Hung (LAV-2) – Barrier Free**

2.2.1.4.1 **American Standard 0958908ec.020 0062000.020 Basin - MURRO**, Wall-hung Lavatory, Vitreous china, EverClean® antimicrobial surface, White finish, 203 mm (8") centerset, Less overflow, Faucet ledge with recessed self-draining deck, For concealed arm or wall support, Acrylic shroud, conceals control box and thermostatic mixing valve (0097000), Soap dispenser, When installed with a below deck electronics faucet which has the control box, the accessories will not fit under the shroud and will need to be installed outside the shroud, Overall Dimensions: 545 mm (21-7/16") long, 540 mm (21-1/4") wide, 152 mm (6") high, Bowl Dimensions: 394 mm (15-1/2") long, 540 mm (21-1/4") wide, 127 mm (5") deep

2.2.1.4.2 **Faucet - Chicago Faucets 895-GN8FCABCP** - Counter mounted, Manual, Two handles, Sink/lavatory faucet, Polished chrome finish, 203 mm (8") centerset, Lead Free ANSI/NSF 61 compliant, ECAST® brass construction, Less supply, 1/4 turn compression cartridge, 3.8 LPM (1 GPM) maximum flowrate, Plain end outlet with laminar flow control insert in spout inlet, Rigid Gooseneck spout, 203 mm (8") spout reach, 33 mm (13-1/8") high, 102 mm (4") wrist blade handle with indexed buttons, Less drain, 13 mm (1/2") NPSM supply inlet for 10 mm (3/8") or 13 mm (1/2") flexible riser.

- 2.2.1.4.3 **Mixing Valve - Lawler 570-86820** - Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, internal checks, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, ±20% pressure variation, 40-80 °F, 10 °F, 180 °F max, ±5 °F, Protects against scalding and chilling, 7 GPM flowrate @ 45 PSI
- 2.2.1.4.4 **Fixture Drain - McGuire PRODRAIN** - Patented grid drain, Straight drain, Lavatories without overflows, Heavy cast brass, Chrome-plated finish, Less overflow, 17 gauge 32 mm (1-1/4") Ø tailpiece diameter, 17 gauge 152 mm (6") long tailpiece, Brass locknut, Heavy rubber basin washer Fiber friction washer, CSA compliant
- 2.2.1.4.5 **McGuire LFCK170LK Supply** - Lead Free, Sweat to compression, Integral check supply kit w/5" sweat extension, Chrome-plated finish, 1/2" Sweat w/5" Sweat extension x 3/8" O.D, 305 mm (12") chrome-plated risers, Loose key, Faucet, Deep bell wall flange
- 2.2.1.4.6 **P-Trap - McGuire 8902CBSAN** - Cast brass body material, Chrome-plated finish, 1-1/4x1-1/2 p-trap, 304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend
- 2.2.1.4.7 **Carrier - Watts CA-411-CA-481** - Floor mounted concealed arm lavatory carrier, Wall mounted steel support plate with plated hardware, Leveling screws and basin locking device, upper tie rod, and plated hardware., required minimum space is 89 mm (3-1/2")
- 2.2.1.5 **Basin - Wall Hung (L-1) – General Use**
- 2.2.1.5.1 **American Standard 0355915.020 Basin** - Wall-hung Lavatory, Vitreous china, White finish, 203 mm (8") centerset, Less overflow, With faucet ledge, 102 mm (4") high backsplash, For wall hanger (included) or concealed arms (by others), Overall Dimensions: Bowl Dimensions: 254 mm (10") long, 381 mm (15") wide, 165 mm (6-1/2") deep
- 2.2.1.5.2 **Faucet - Chicago Faucets 895-GN8FCABCP** - Counter mounted, Manual, Two handles, Sink/lavatory faucet, Polished chrome finish, 203 mm (8") centerset, Lead Free ANSI/NSF 61 compliant, ECAST® brass construction, Less supply, 1/4 turn compression cartridge, 3.8 LPM (1 GPM) maximum flowrate, Plain end outlet with laminar flow control insert in spout inlet, Rigid Gooseneck spout, 203 mm (8") spout reach, 33 mm (13-1/8") high, 102 mm (4") wrist blade handle with indexed buttons, Less drain, 13 mm (1/2") NPSM supply inlet for 10 mm (3/8") or 13 mm (1/2") flexible riser.

- 2.2.1.5.3 **Mixing Valve - Lawler 570-86820** - Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, internal checks, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, ±20% pressure variation, 40-80 °F, 10 °F, 180 °F max, ±5 °F, Protects against scalding and chilling, 7 GPM flowrate @ 45 PSI
- 2.2.1.5.4 **Fixture Drain - McGuire PRODRAIN** - Patented grid drain, Straight drain, Lavatories without overflows, Heavy cast brass, Chrome-plated finish, Less overflow, 17 gauge 32 mm (1-1/4") Ø tailpiece diameter, 17 gauge 152 mm (6") long tailpiece, Brass locknut, Heavy rubber basin washer Fiber friction washer, CSA compliant
- 2.2.1.5.5 **McGuire LFCK170LK Supply** - Lead Free, Sweat to compression, Integral check supply kit w/5" sweat extension, Chrome-plated finish, 1/2" Sweat w/5" Sweat extension x 3/8" O.D, 305 mm (12") chrome-plated risers, Loose key, Faucet, Deep bell wall flange
- 2.2.1.5.6 **P-Trap - McGuire 8902CBSAN** - Cast brass body material, Chrome-plated finish, 1-1/4x1-1/2 p-trap, 304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend
- 2.2.1.5.7 **Carrier - Watts CA-411** - Floor mounted concealed arm lavatory carrier, Leveling screws and basin locking device, upper tie rod, and plated hardware., required minimum space is 89 mm (3-1/2").
- 2.2.1.6 **Sink (S-1) – Counter Mounted, Single Compartment**
- 2.2.1.6.1 **Franke Commercial LBS6808-316P-1-3 Sink** - Single compartment sink, 203 mm (8") centerset, Commercial sinks, with overall dimension 508 mm (20") long, 521 mm (20-1/2") wide, 203 mm (8") high, constructed from 18 gauge Type 316 Stainless steel, Bowl dimensions are 457 mm (18") long, 406 mm (16") wide, 203 mm (8") deep, Polished to #4 satin finish, Factory installed EZ TORQUE™ fasteners, Factory applied rim seal, Center back waste location, 38 mm (1-1/2") (DN38) type 316 stainless steel tailpiece, 89 mm (3-1/2") type 316 stainless steel crumb cup strainer, Undercoated to reduce condensation and resonance, Codes and Compliances: ASME A112.19.3 compliant, CSA B45.4 compliant.

- 2.2.1.6.2 **Faucets - Chicago Faucets 786-GN8FCABCP** - Counter mounted, Manual, Two handles, Sink faucet, Chrome-plated finish, 203 mm (8") centerset, Lead Free ANSI/NSF 61 and ANSI/NSF 372 compliant, ECAST® brass construction, Less supply, -377-XTAB quatern compression cartridge, 5.7 LPM (1.5 GPM) maximum flowrate, -FC 5.7 LPM (1.5 GPM) laminar flow control insert in spout inlet, plain end outlet, Rigid Gooseneck spout, 203 mm (8") spout reach, -317-PR vandal-resistant 102 mm (4") metal wrist blade handles with red & blue index, Grid drain included, 13 mm (1/2") NPSM supply inlet for 10 mm (3/8") or 13 mm (1/2") flexible riser.
- 2.2.1.6.3 **Mixing Valve - Lawler 570-86820** - Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, internal checks, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, ±20% pressure variation, 40-80 °F, 10 °F, 180 °F max, ±5 °F, Protects against scalding and chilling, 7 GPM flowrate @ 45 PSI
- 2.2.1.6.4 **McGuire LFCK165LK Supply** - Lead Free, Pipe to compression, Integral check supply kit, Chrome-plated finish, 3/8" I.P.S x 3/8" O.D, 305 mm (12") chrome-plated risers, Loose key, Faucet, Shallow wall flange
- 2.2.1.6.5 **P-Trap - McGuire 8912CBSAN** - Cast brass body material, Chrome-plated finish, 1-1/2x1-1/2 p-trap, 304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend.
- 2.2.1.7 **Sink (HHS-1) – Hand Hygiene Sink**
- 2.2.1.7.1 **American Standard 9118111.02** - Wall-hung Infection control sink, Vitreous china, EverClean® antimicrobial surface, White finish, Single hole centerset, Sealed overflow, With faucet ledge, Includes offset grid drain with Saniguard® coating, For floor-mounted carrier (by others), Removable acrylic shroud (with mounting hardware) provided, Overall Dimensions: 508 mm (20") long, 432 mm (17") wide, 663 mm (26-3/32") high Bowl Dimensions: 260 mm (10-1/4") long, 419 mm (16-1/2") wide, 235 mm (9-1/4") deep.
- 2.2.1.7.2 **Faucets - Chicago Faucets 626-FCABCP**, Counter mounted, Remote faucet, Polished chrome finish, Singlehole centerset, Lead Free ANSI/NSF 61 and ANSI/NSF 372 compliant, Brass construction, 5.7 LPM (1.5 GPM) maximum flowrate, Laminar flow outlet, Rigid/swing Gooseneck spout, 133 mm (5-1/4") projection, 273 mm (10-3/4") high, Remotely operated, 13 mm (1/2") NPSM supply inlet for 10 mm (3/8") or 13 mm (1/2") flexible riser.

- 2.2.1.7.3 **Remote Valve – Chicago faucet** - Foot operation, ECAST brass construction with less than 0.25% lead content weighted, Polished chrome finish, 13 mm (1/2") NPT female thread inlet, 10 mm (3/8") NPT female thread outlet, 138 - 862 kPa (20 - 125 PSI) operating pressure range, 40°F - 140°F (4°C - 60°C) operating temperature range
- 2.2.1.7.4 **Mixing Valve - Lawler 570-86820** - Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, internal checks, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, ±20% pressure variation, 40-80 °F, 10 °F, 180 °F max, ±5 °F, Protects against scalding and chilling, 7 GPM flowrate @ 45 PSI
- 2.2.1.7.5 **P-Trap - McGuire 8912CBSAN** - Cast brass body material, Chrome-plated finish, 1-1/2x1-1/2 p-trap, 304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend
- 2.2.1.7.6 **Carrier - CA-421 Single**, Wall Plate, Integral welded feet, Universal steel hangar support plate, Heavy gauge steel offset uprights, Plated hardware
- 2.2.1.8 **Sink (HHS-2) – Hand Hygiene Sink (Barrier Free)**
- 2.2.1.8.1 **Whitehall basin 4151-9-H1-TE Wall-hung Infection prevention sink**, Corterra™ solid surface polymer resin, SteriTouch® antimicrobial protection, -9-H1 Single hole centerset, With faucet ledge, Angled internal slope to defuse outlet water and minimize splash, 32 mm (1-1/4") NPS grid strainer with close elbow, 32 mm (1-1/4") O.D. tailpiece, Offset drain provided to prevent water discharge directly into drain, For Wall Plate Carrier, Trap enclosure made of Corterra® non-porous solid surface polymer, Overall Dimensions: 562 mm (22-1/8") long, 540 mm (21-1/4") wide, 692 mm (27-1/4") high
- 2.2.1.8.2 **Chicago Faucet 116.429.AB.1 Counter mounted, Automatic no-touch**, Hardwired, Lavatory faucet, Polished chrome finish, Single hole centerset, Lead Free ANSI/NSF 61 compliant, ECAST® brass construction, Dual supply for hot and cold water service, stainless steel hoses included, 5.7 LPM (1.5 GPM) maximum flowrate, Plain end outlet with laminar flow control insert in spout inlet, Rigid/swing Gooseneck spout, 133 mm (5-1/4") spout reach, Dual infrared sensor, User-adjustable temperature control mixer, 12 volt AC transformer required (to be ordered separately). 243.260.00.1/242.340.00.1 Hardwired AC transformer, Transformer and wire

- 2.2.1.8.3 **McGuire risers, LFCK165LK ICV DEFENDER** Faucet Supply kit, consisting of (2) stop valves, (2) flanges (standard), Lead Free Chrome-plated finish Brass body, 138 -862kPa (20 - 125 PSI) operating pressure, 4 to 60 °C (40 to 140 °F) operating temperature, Loose key handle, Full turn, Angle stop, Spring actuated integral check valve, C.P. wrought steel shallow wall flange (standard), 305 mm (12") C.P. lavatory flexible copper riser tubes (standard), 10 mm (3/8") I.P.S. inlet x 10 mm(3/8") O.D. outlet, 82 °C (180 °F) maximum during high-temperature system flush, Compliances and certifications: AB 100 compliant, ASME A112.18.3, ASMEA112.18.2-2 (risers), CSA B125.2 compliant (risers), Certified to NSF/ANSI 372,Certified to NSF/ANSI 61, UPC compliant.
- 2.2.1.8.4 **P-Trap 8902CBSAN** Cast brass body material, Chrome-plated finish, 1-1/4" x 1-1/2" P-Trap,304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend.
- 2.2.1.8.5 **Carrier CA-421-M60 Single**, Wall Plate, Integral welded feet, Universal steel hangar support plate, Heavy gauge steel offset uprights, Plated hardware, Valve support plate.
- 2.2.1.9 **Casting Sink (CS-1)**
- 2.2.1.9.1 **Franke SL2424-316-1-2-1140F-316 203 mm (8") centerset**, Without faucet ledge,16 gauge Type 316 Stainless steel Polished to #4 satin finish, With backsplash, Radius coved corners on front and back only, Stainless steel tubular legs with adjustable feet for leveling, Center waste location, 38 mm x 76 mm (1-1/2" x 3") Type 316 stainless steel tailpiece, 1140F-316 89 mm (3 1/2") Type 316 stainless pull up crumb cup strainer, Codes and Compliances: ASME A112.19.3 compliant, CSA B45.4 compliant, Bowl Dimension: 610 mm (24") long, 610 mm (24") wide, 356 mm (14") deep, Overall Dimension: 691 mm (27-3/16") long, 691 mm (27-3/16") wide, 1119 mm (44-1/16") high.
- 2.2.1.9.2 **Chicago Faucet 631-GN8FCABCP** Wall-hung, Manual, Two handles, Sink faucet, Polished chrome finish, 203 mm (8") centerset, Lead Free ANSI/NSF 61 compliant, ECAST® brass construction, 10 mm (3/8") offset inlet supply arms, Quatern™ compression cartridge (90° turn), 5.7 LPM (1.5 GPM) maximum flowrate, Plain end outlet with laminar flow control insert in spout inlet, Rigid/swing Gooseneck spout, 203 mm (8") spout reach, 295 mm (11-5/8") high, Vandal-resistant 102 mm (4") wrist blade handles with indexed buttons, 13 mm (1/2") NPT female thread inlet.
- 2.2.1.9.3 **Mixing Valve Lawler 570-86820** Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, The temperature is adjusted with the help of Spindle.
- 2.2.1.9.4 Plaster Trap Gelco trap HV kit 5 gallons. Patterson 344-4221
- 2.2.1.10 **Shower - (SH-1)**

- 2.2.1.10.1 **Chicago Faucets SH-TP6-00-023 Polished chrome finish**, Thermostatic/pressure balancing tub and shower system with hand spray and valve trim options, Less showerhead, With hand shower, 9.5 LPM (2.5 GPM) flowrate, Two 864 mm (34") stainless steel hoses with integrated automatic hose drain, Hand spray with pause control, Wall elbow, In-line vacuum breaker, Embossed and colour-coded temperature index, Cold to hot cycle, Wall mounted, Square trim, 178 x 178 mm (7" x 7") trim size, Lever handle, Thermostatic/pressure balancing valve with automatic drain, Integrated check valves and service stops, 610 mm (24") long ADA grab bar, Wall mounted grab bar, Thermostatic/pressure balancing cartridge, 13 mm (1/2") NPT male thread or 13 mm (1/2") nominal copper sweat, 13 mm (1/2") NPT male thread or 13 mm (1/2") nominal copper sweat, ADA
- 2.2.1.10.2 **Hand Shower** – Chicago Faucets 624-CP - Hand spray with Pause control, 1.5 GPM (5.5 LPM) flowrate, 13 mm (1/2") Ø NPT female thread inlet
- 2.2.1.10.3 **Drain:** Watts WSD-SQNB Epoxy coated cast iron, Floor drain, Square No-hub outlet, 102 mm (4") nickel bronze strainer, Serrated flange.
- 2.2.1.10.4 **Mixing Valve Lawler Point of Use and Master controlled fixtures**, Thermostatic master water mixing control valve, The temperature is adjusted with the help of Spindle.
- 2.2.1.11 **Bathtub – (BT-1) Non-Plumbed**
 - 2.2.1.11.1 Zara II, kirted bathtub, white glossy acrylic 59 3/4" x 31 3/4" x 20"
- 2.2.1.12 **Bottle Filler Station (BFS-1)**
 - 2.2.1.12.1 **Elkay Model no LZWSM8K** – Elkay ezH2O in wall bottle filling station with mounting frame filtered registered stainless. Chilling capacity of 8.0 GPM of 50°F drinking water, based on 80°F inlet water and 90°F ambient, per ASHRAE 18 testing. It shall include Antimicrobial, Filtered, Green Ticker™, Hand Free, Laminar Flow, real drain, Visual Filter monitor. Product shall be wall mount (in wall frame/plate), indoor use and certified to UL399 and CAN/CSA C22.2 No. 120. Power connection 115V/60Hz
- 2.2.1.13 **Mop Service Sink (MS-1) - Floor Mounted**
 - 2.2.1.13.1 **Stern Williams SBC-1700** - Single compartment corner sink, Mop service sinks, with overall dimension 610 mm (24") long, 610 mm (24") wide, 305 mm (12") high, constructed from Precast terrazzo, Bowl dimensions are 546 mm (21-1/2") long, 546 mm (21-1/2") wide, 254 mm (10") deep, Pearl grey marble chips and white portland cement, 76 mm (3") pipe size, cast integrally and provides for a caulked lead connection not less than 25 mm (1") deep to a 76 mm (3") pipe, flat stainless steel strainer, Two side tiling flanges, With stainless steel cap, Hose and wall hook, Mop hanger, Splash catcher.
 - 2.2.1.13.2 **Faucets - Chicago Faucets 897-317-XKCP** - Wall-hung, Manual, Two 4" wing blade handles, Mop sink faucet, Rough chrome plated finish, 194 - 213 mm (7-5/8" to 8-3/8") adjustable centerset, Round wall escutcheons, Brass construction, Less supply, Adjustable supply arms, 1/4 turn ceramic cartridge, No flow restrictor, Threaded hose end, Spout with pail hook, 203 mm (8") spout reach, 273 mm (10-3/4") high, Top brace, 102 mm (4") lever handle with indexed buttons, Less drain, Atmospheric vacuum breaker is not intended for continuous pressure applications.

- 2.2.1.13.3 Mixing Valve Lawler Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, The temperature is adjusted with the help of Spindle
- 2.2.1.14 **Eye Wash – (EW-1)**
 - 2.2.1.14.1 Bradely S19294HBT Barrier-free design, Flush mounted, fully accessible to people with physical disabilities. Stainless steel cabinet and door conceal eyewash. Integral strainer. Eyewash activates by pulling the cabinet door down. gas spring softens the action of opening the unit allowing the door to descend in a smooth and controlled manner. Water collected by the door assembly and directed back into the wall for drainage. Safe, steady water flow under varying water supply conditions from 30-90 PSI is assured by integral flow control. vandal resistant ceramic valve.
 - 2.2.1.14.2 Eyewash Sprayhead Assembly high performance rinsing platform. integral 5.1 gpm flow control. integral flow control in the sprayhead assembly.
 - 2.2.1.14.3 Cabinet Corrosion resistant stainless steel cabinet and doors. Top section of the door conceals the eye/face wash unit which is activated with a plastic molded wide grip handle. Bottom of cabinet conceals tailpiece and fittings, and is provided with a locking device to prevent tampering with the unit. Open back and side panels in the bottom section of cabinet to accommodate multiple waste options.
 - 2.2.1.14.4 Valve ceramic ½" NPT stay-open valve. The ceramic discs provide a precise 20° activation and deactivation angle, minimizing excessive splashing when the unit is activated. Pipe and Fittings Chrome-plated brass.
 - 2.2.1.14.5 Mixing Valve S19-2000 Navigator EFX8 - Emergency Thermostatic Mixing Valve
- 2.2.1.15 **Flusher Disinfecter Faucet only (WS-1)**
 - 2.2.1.15.1 Flusher Disinfecter Topline 10A (Provided by client)
 - 2.2.1.15.2 Chicago Faucet 540-LDE35-317ABCP Handles include color-coded index 8" body, adjustable arms 7-1/4" - 8-3/4" centers 6" S-type swing spout Pressure compensating Softflo aerator 1.5 GPM Vandal Proof 4" wristblade handle Quatum™ compression operating cartridge, right-hand Quatum™ compression operating cartridge, left-hand 3/8" offset inlet supply arm ECAST® design provides durable cast brass construction with total lead content equal to or less than 0.25% by weighted average
 - 2.2.1.15.3 Mixing Valve Lawler Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, The temperature is adjusted with the help of Spindle

2.3 ACCEPTABLE MANUFACTURERS

Subject to compliance with requirements, manufacturers that may be incorporated into the Work include, but are not limited to, the following:

- 2.3.1 Flush Valves:
 - 2.3.1.1 Sloan;
 - 2.3.1.2 Delta Commercial;
 - 2.3.1.3 Zurn Industries.
- 2.3.2 Plumbing Brass:
 - 2.3.2.1 Sloan;
 - 2.3.2.2 Acorn Engineering;
 - 2.3.2.3 American Standard;
 - 2.3.2.4 Delta Commercial;
 - 2.3.2.5 Chicago Faucet.
- 2.3.3 Emergency Eye Wash and Emergency Showers:
 - 2.3.3.1 Haws;
 - 2.3.3.2 Speakman;
 - 2.3.3.3 Bradley.
- 2.3.4 Drain Fittings, Angle Supplies, and Traps:
 - 2.3.4.1 McGuire;
 - 2.3.4.2 American Standard;
 - 2.3.4.3 Delta Commercial;
 - 2.3.4.4 Zurn Industries.
- 2.3.5 Fixture Carriers:
 - 2.3.5.1 Watts Industries;
 - 2.3.5.2 Jay R. Smith;
 - 2.3.5.3 Zurn Industries.

2.3.6 Water Closets, Lavatories, and Urinal:

2.3.6.1 American Standard;

2.3.6.2 Whitehall Manufacturing Co.

2.3.6.3 **Zurn.**

2.3.7 Thermostatic Mixing Valves:

2.3.7.1 Lawler;

2.3.7.2 Delta Commercial;

2.3.7.3 Leonard.

2.3.8 Toilet Seats:

2.3.8.1 Olsonite;

2.3.8.2 Centoco;

2.3.8.3 Bemis Commercial.

2.3.9 Electronic "No Touch" Flush Valves:

2.3.9.1 Sloan;

2.3.9.2 Delta Commercial;

2.3.9.3 Zurn Industries.

2.3.10 Electronic "No Touch" Faucets:

2.3.10.1 Sloan;

2.3.10.2 Delta Commercial;

2.3.10.3 Zurn Industries.

2.4 CAULKING

2.4.1 General Electric Series SCS-1200 Silicone Construction Sealant or Dow Corning 780 silicone rubber sealant with primers as recommended by the sealant manufacturer. Caulking colour(s) for coloured fixtures other than white, if any, will be selected by the Consultant from the sealant manufacturer's standard colour range.

PART 3 - EXECUTION

3.1 DEMOLITION

- 3.1.1 Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 INSTALLATION OF PLUMBING FIXTURES AND FITTINGS

- 3.2.1 Provide all required plumbing fixtures and fittings.
- 3.2.2 Where new fixtures and fittings are to be connected to existing piping, include for all required piping revisions.
- 3.2.3 Connect plumbing fixtures and fittings with piping of minimum size in accordance with the following schedule. Refer to manufacturer's published connection (rough-in) requirements. Where manufacturer requires piping connection larger than shown below, provide piping accordingly:

FIXTURE AND/OR FITTING	DRAIN SIZE MM (IN.)	VENT SIZE MM (IN.)	DHW SIZE MM (IN.)	DCW SIZE MM (IN.)	TEMP WATER SIZE MM (IN.)
Water Closets Flush Valve Type	100 (4)	38 (1½)	-----	25 (1)	-----
Lavatories	32 (1¼)	32 (1¼)	12 (½)	12 (½)	-----
Lavatories (Electronic Faucet)	32 (1¼)	32 (1¼)	12 (½)	12 (½)	12 (½)
Emergency Eye Wash	-----	-----	-----	-----	12 (½)

- 3.2.4 Confirm the exact location of all plumbing fixtures and trim prior to roughing-in. Refer to architectural plan and elevation drawings.
- 3.2.5 When installation is complete, check and test the operation of each fixture and fitting. Adjust or repair as required.
- 3.2.6 Barrier-Free Fixtures: Comply with mounting height and other requirements of governing Code(s).

- 3.2.7 Electronic Lavatory Faucets: Locate control panels for electronic faucets under the lavatories or counter sink and recessed into the wall. Coordinate panel installations with the electrical trade who will provide 115 volt power wiring to the panels. Install flexible conduit (supplied with box) and extend cord from faucet through the flexible conduit to the control box. Connect hot and cold water piping to the mixing valve in each box, and tempered water piping from each mixing valve to the faucet. Set mixing valve maximum temperature limit stops to 110°F after domestic water systems (hot and cold) are complete. Ensure that each programmable controller is properly programmed, and that water off after deactivation is set for three seconds.
- 3.2.8 Emergency Eye Wash Fixtures: Install eye wash fixtures in accordance with the manufacturer's printed instructions. Ensure that exposed piping is painted.
- 3.2.9 Mixing Valves For Emergency Fixtures: Wall mount mixing valves for emergency fixtures approximately 1.5m (5') above the floor in fully recessed SS cabinet and secure in place. Check and confirm valve operation and the temperature of the tempered water supply. Identify each cabinet and hand three identified cabinet keys to the Consultant prior to Substantial Performance.

3.3 CAULKING AT PLUMBING FIXTURES AND FITTINGS

- 3.3.1 Caulk around plumbing fixtures and fittings where they contact walls, floors, and any other building surface.
- 3.3.2 Clean areas/surfaces to be caulked and prime in accordance with the sealant manufacturer's instructions. Where damage to a building surface may occur, mask the surface to prevent damage and ensure a clean exact edge to the caulking bead.
- 3.3.3 Apply caulking using a gun with the proper size and shape of nozzle and force the sealant into joints to ensure good surface contact and a smooth and even finished bead of sealant.
- 3.3.4 If joints have been masked the sealant may be tooled in a continuous stroke to obtain complete void filling. Remove masking tape immediately after tooling and before the sealant begins to skin.

END OF SECTION

PART 1 - GENERALS

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings. The appropriate CRN assigned to each component is to be clearly indicated on the component shop drawing/product data sheet. Shop drawings and product data sheets must confirm that products proposed meet all requirements of this Section.
- 1.1.2 Additional Data: Submit product data sheets for all motors, and certified wiring diagrams for all equipment requiring power, control and/or alarm wiring connections.
- 1.1.3 Pipe Joint Brazing Procedures: Submit, prior to work commencing on site, a detailed account of your proposed pipe joint brazing procedures including pre and post nitrogen purging.
- 1.1.4 Certification Reports: Submit written certification by equipment manufacturers/ suppliers confirming that the equipment is properly installed, has been tested, and is in proper operating condition, all as specified in Part 3 of this Section.
- 1.1.5 Start-Up Reports: Submit manufacturer's start-up reports as specified in Part 3 of this Section.
- 1.1.6 Cabinet/Panel Keys: Submit three identified keys for all cabinet/panel lockable doors prior to Substantial Performance.

1.2 DESIGN PRESSURE AND TEMPERATURE REQUIREMENTS

- 1.2.1 System design pressures are as follows:
 - 1.2.1.1 oxygen, medical air:
 - 1.2.1.1.1 maximum system pressure, 380 kPa (55 psi);
 - 1.2.1.1.2 maximum pressure at terminal unit, 345 kPa (50 psi).
 - 1.2.1.2 vacuum:
 - 1.2.1.2.1 maximum system vacuum, 54 kPa (15.94 "Hg);
 - 1.2.1.2.2 maximum vacuum at terminal unit, 68 kPa (20.08 "Hg).

- 1.2.2 Design temperature for all services will be ambient temperature.

1.3 QUALITY ASSURANCE

- 1.3.1 All products and work must comply in all respects with requirements of CAN/CSA-Z7396.1 and related Standards, and, where applicable, requirements of local governing authorities.

- 1.3.2 Medical gas systems work must be performed by journeyman plumber/pipefitter / steamfitter tradesmen completely familiar with the requirements of CAN/CSA-Z7396.1, and who are qualified and certified (with jurisdictional authority issued Certificate) for silver brazing with nitrogen backing without using flux in accordance with Clause 4.5 in Part 1 of CSA-B51. The jurisdictional authority is the authority designated by the province of the work to perform oversight functions cited in Clause 4.5 in Part 1 of CSA-B51.
- 1.3.3 The Consultant reserves the right to ask for and review the Certificate of any tradesman, and only tradesmen with valid Certificates may work on the systems.

PART 2 - PRODUCTS

2.1 GENERAL RE: PIPING SYSTEM MATERIALS AND COMPONENTS

- 2.1.1 All pipe, fittings, and piping system components are to be factory washed and degreased. Pipe is to be capped. Fittings and components are to be packaged.
- 2.1.2 All piping system components to be site connected with piping are to be complete with factory installed, washed, degreased and capped Type "K" hard copper piping stubs with joints silver brazed while the component and piping is full of nitrogen.
- 2.1.3 All electrical power wiring by Division 26 (from emergency power source). All alarm and sensor wiring by Mechanical Contractor.
- 2.1.4 Acceptable Medical Gas Product Manufacturers/Suppliers: Unless otherwise specified, acceptable medical gas system product manufacturers/suppliers are:

2.1.4.1 Class 1 Inc.;

2.2 PIPE, FITTINGS AND JOINTS

- 2.2.1 Above Ground: Type "L" or Type "K" (as specified in Part 3) hard temper copper tubing to ASTM B819, "Standard Specification for Seamless Copper Tube for Medical Gas Systems", complete with wrought copper, brass or bronze "Silver Braze" fittings and silver brazed joints made with Silvaloy 15 or equal brazing alloy conforming to ANSI/AWS Standard A5.8 Classification BcuP-5.

2.3 SHUT-OFF VALVES

- 2.3.1 Valves shall be of bronze body, double seal, full port, union ball-type with teflon (TFE) seats and Viton seals, "O" ring packing, bronze ball which seals in both directions, blow-out proof stem, having a pressure rating of 2758 kPa (400 psig).
- 2.3.2 Valves shall be operated by a lever handle requiring only a quarter turn from a fully open position to a fully closed position. All valves shall be equipped with type "K" washed and degreased copper pipe stub extensions at both the inlet and outlet sides of the valve port to facilitate installation.

- 2.3.3 Valves shall be designed so that it can be "swung-out" during installation to prevent damage due to heat transfer during the brazing operation. A UL listed label showing the appropriate gas services and pressure rating shall be attached to each valve.
- 2.3.4 Each valve assembly shall be provided washed and degreased for oxygen service and pipe stub extensions shall be capped at both ends. The valve shall be supplied in a sealed plastic bag to prevent contamination prior to installation.
- 2.3.5 Valves shall be ULC and CRN Listed. All valves shall have a locking device. Locks by others.

2.4 ZONE VALVES AND BOXES

- 2.4.1 Wall mounting enamelled steel zone valve boxes with anchor brackets, sized to suit the number of valves in the box, designed for vertical ganging type installation and complete with shut-off valves as specified above (less the handle lock feature), securely mounted to the back of the box, and complete with:
 - 2.4.1.1 stainless steel or matte finish extruded aluminium trim;
 - 2.4.1.2 a re-installable front panel or widow with centre mounted pull ring and silk-screen bilingual wording to read "CAUTION: MEDICAL GAS CONTROL VALVE-CLOSE ONLY IN EMERGENCY";
 - 2.4.1.3 a gauge connection brazed onto the pipe stub at the downstream (patient) side of each valve assembly, with a 1½" diameter pressure (or vacuum) gauge conforming to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods, and with ranges as follows:
 - 2.4.1.3.1 vacuum – 0 to 760 kPa (0 to 30 "Hg);
 - 2.4.1.3.2 all other services – 0 to 700 kPa (0 to 100 psi).

2.5 LOCAL EMERGENCY ALARM PANELS

- 2.5.1 Modular, field expandable, 115 volt, solid-state, microprocessor controlled, electronic, flush wall mounting audio-visual alarm panels designed for constant monitoring of piping system pressure or vacuum as applicable, and initiation of an alarm function on any open circuit only. Each panel is to be complete with:
 - 2.5.1.1 minimum #18 gauge steel back box sized to suit gas service modules required and equipped with adjustable mounting brackets to accommodate different wall thicknesses, a 115 volt power connection terminal block, fused 24 volt secondary transformer, a motherboard for plug-in connection of modules, and matte finish extruded aluminium or equal trim;
 - 2.5.1.2 power module with green power on LED, audible alarm with silencing pushbutton, adjustable (2 to 60 minutes) alarm repeater;

- 2.5.1.3 gas specific colour coded sensors and displays with an error message for incorrect connection, each equipped with a microprocessor, LED digital readout in switch selected psi or kPa to facilitate a constant indication of each service being measured, a bar graph trend indicator to indicate green "NORMAL", yellow "CAUTION", and red "HIGH" or "LOW" alarm condition;
- 2.5.1.4 red alarm light which flashes and an audible alarm which sounds when an alarm condition occurs, and an "ALARM MUTE" pushbutton to silence audible alarm, however, panel will remain in alarm state until problem is rectified;
- 2.5.1.5 "TEST" pushbutton to test all panel functions;
- 2.5.1.6 dry contacts for remote monitoring of high and low alarms;
- 2.5.1.7 gas specific DISS connection (DISS body with check valve and DISS nut and gland) for each sensor module, supplied loose for field installation.

2.6 TERMINAL UNITS

2.6.1 Flush Mounting Modular Terminal Units: DISS type, gas specific, non-interchangeable, modular, flush mounting terminal units, either singular or in groups as shown on the drawings, each designed to accommodate mounting surface thickness variations of up to ½", and complete with a CRN and the following:

2.6.1.1 a die-cast outlet box;

2.6.1.2 cartridge type primary check valve and stainless steel ball type secondary check valve;

2.6.1.3 chrome plated brass outlet body with permanently embossed gas identification nameplate with bilingual labelling, all sealed behind a protective cover with chrome plated trim;

2.6.1.4 the required centreline spacing between multiple terminal units;

2.6.1.5 temporary protective covers, and standing pressure test caps.

2.6.2 Equipment Connection Terminal Units: DISS medical gas specific riser assemblies, factory cleaned and capped, complete with a protective dust cap, brass outlet body, Type "K" inlet supply tube and bulkhead mounting provision.

2.7 SIGNAGE & LABELS

2.7.1 For each medical gas isolation valve, install a lamacoid nameplate secured to wall at ceiling.

2.7.2 Nameplate shall be 100 mm x 50 mm (4" x 2"), black letters on white background, indicating "Shut-Off Valve" and name of medical gas, medical Vacuum, or medical oxygen.

2.7.3 All medical gas shut-off valves shall have a lamacoid nameplate attached by a chain to the valve handle indicating medical gas name and area served by valve and valve number. Label size shall be 80 mm x 50 mm (3" x 2").

PART 3 - EXECUTION

3.1 DEMOLITION

3.1.1 Do all required medical gas system demolition work. Refer to the mechanical work Section entitled Demolition and Revision Work for demolition requirements.

3.2 GENERAL RE: PIPING INSTALLATION

3.2.1 All pipe joint brazing work must be done in accordance with CAN/CSA-Z7396.1 and reviewed brazing procedures submitted to the Consultant prior to the start of work.

- 3.2.2 The Consultant reserves the right to cut-out and examine piping joints during the course of the work or after the work is complete, and if the interior of the cut-out sample and/or fittings are found to be contaminated with oxidation or any other material the piping will be considered unacceptable and must be cleaned or replaced.
- 3.2.3 Where low pressure connecting assemblies are used in retractable gas columns, articulating arms, or any other dispensing assembly the DISS body or terminal unit which is used to connect it to the copper pipeline must be brazed to the piping system.
- 3.2.4 Refer to architectural drawing plans and elevations for exact locations of terminal units, zone valve boxes, alarm panels, and other such items.

3.3 INSTALLATION OF MEDICAL GAS SYSTEM PIPING

- 3.3.1 Provide required medical gas system piping. Unless otherwise shown or specified, vacuum piping is to be minimum 20 mm ($\frac{3}{4}$ ") diameter, and piping for all other services is to be minimum 12 mm ($\frac{1}{2}$ ") diameter.
- 3.3.2 Whenever possible use pipes, valves and accessories that have been factory cleaned in accordance with CSA Standard Z7396-1 and all amendments. The ends of all factory cleaned materials shall be sealed using temporary caps. Thoroughly clean items not factory cleaned or which become contaminated, by washing in a hot solution of sodium carbonate or trisodium phosphate (proportion: one pound to three gallons of water or 33 g/litre). The use of organic solvents such as carbon tetrachloride is prohibited. Rinse materials thoroughly with clean, hot water.
- 3.3.3 Piping Above Ground: Piping above ground, unless otherwise specified, is to be Type "L" hard copper.
- 3.3.4 Unions: Provide threaded piping unions at all piping connections to source equipment. Do not silver braze unions. Braze a male NPT adaptor on the end of the pipe, wrap Teflon tape onto the adaptor (two threads back), and screw the union as tight as you can by hand, then with proper wrenches for final tightening. Do not over tighten.
- 3.3.5 Pipe Brazing Operations: In strict accordance with requirements of CAN/CSA-Z7396.1.
- 3.3.6 Tools: Ensure that all tools used during erection of the piping systems are kept clean and free from oil and grease.
- 3.3.7 Hangers and Supports: Support piping by means of support materials specified in the mechanical work Section entitled Basic Mechanical Materials and Methods, in accordance with requirements of Section 11.3 of CAN/CSA-Z7396.1 and with support spacing in accordance with Table 9 in CAN/CSA-Z7396.1.
- 3.3.8 Piping Identification: Refer to the mechanical work Section entitled Basic Mechanical Materials and Methods. Identify all piping system work, including valves, concealed and exposed, on a daily basis in accordance with requirements of CAN/CSA-Z7396.1.

- 3.3.9 Vacuum Piping: Install vacuum piping sloped to low points. Equip each low point, including the bottom of vertical risers, with drip pockets consisting of a full size pipe tee with one leg capped with a removable cap. Ensure that all drip points are accessible and indicated on as-built record drawings.
- 3.3.10 Connections to Headwalls: Provide identified piping connections to headwalls provided as part of this Section of the work or as part of the work of other Divisions of the Specification. Contractor to provide gas outlets to equipment supplier for factory assembly.
- 3.3.11 Capped Connections: Provide valved and capped connections for future extension where shown on the drawings. Clearly and permanently identify each capped connection and ensure that they are exactly located on as-built record drawings.
- 3.3.12 Branch Tees and Valves: As per CAN/CSA-Z7396.1, provide a full size branch tee with shut-off valve for each gas source (including vacuum) downstream of the main isolation valve.
- 3.3.13 Revision/Retrofit Work: Perform revision/retrofit work as shown, and in accordance with CAN/CSA-Z7396.1.

3.4 INSTALLATION OF VALVES

- 3.4.1 Provide shut-off/isolation valves where shown on the Contract Documents and/or required by CAN/CSA-Z7396.1. Valves in piping 75mm (3") diameter and larger are to be butterfly type. All other valves, unless otherwise specified, are to be ball type.
- 3.4.2 Provide check valves where shown and/or required by CAN/CSA-Z7396.1.
- 3.4.3 Ensure that all valves are located for easy access and operation.

3.5 INSTALLATION OF ZONE VALVES AND BOXES

- 3.5.1 Provide zone valves in zone valve boxes where shown. Provide a service isolation valve in piping immediately upstream of each zone valve and on the same floor.
- 3.5.2 Accurately install boxes with reference to wall finish, and confirm exact locations prior to roughing-in.
- 3.5.3 At each zone valve box location provide a typed, framed, and glazed list of all rooms and areas controlled by the zone valve. Submit lists and wording for review prior to framing and glazing.

3.6 INSTALLATION OF TERMINAL UNITS

- 3.6.1 Provide wall mounted medical gas terminal units where shown, either singular or in groups as indicated. Leave temporary caps in place.
- 3.6.2 Confirm exact locations prior to roughing-in. Refer to architectural drawings.
- 3.6.3 Equip each terminal unit with a faceplate.

- 3.6.4 Supply all medical gas terminal units for factory installation in consoles, headwalls, articulating arms, ceiling service columns, and other such manufactured assemblies, and ship the terminal units to the manufacturer's plant.

3.7 PIPING SYSTEM LEAKAGE AND PRESSURE TESTING

- 3.7.1 After erection of piping, and before installation of outlet valve stations, blow lines clear by means of oil-free, dry compressed air or nitrogen. Subject each section of each system to a test pressure of 150 psi (1034 kPa) for 24 hours by means of oil-free, compressed air or nitrogen. Maintain this test pressure until each joint has been examined for leakage by means of soap suds. Repair leaks and re-test sections. Maintain not less than 50 psi (345 kPa) during the remaining construction period. Supply the necessary test cylinders for testing purposes.
- 3.7.2 Pressure test each system independently. No interconnections between systems will be allowed.
- 3.7.3 Final testing of medical piping systems will be performed by an Independent Testing Agency under a separate Contract tendered by the Owner.
- 3.7.4 Make good each system not meeting the final test to the approval of the Testing Agency.

3.8 POWER AND CONTROL WIRING

- 3.8.1 Line Voltage Power Wiring: All line voltage power wiring to equipment, unless otherwise specified, will be done as part of the electrical work.
- 3.8.2 Alarm and Control Wiring: All control and alarm wiring, unless otherwise specified, is to be installed in conduit as part of the medical gas system work in accordance with electrical work wiring requirements, and manufacturer's/supplier's certified wiring schematics.
- 3.8.3 Generally, power wiring (part of the electrical work) and control and alarm wiring (part of the mechanical work) is to be as follows:

EQUIPMENT	LINE VOLTAGE POWER WIRING	CONTROL AND/ OR ALARM WIRING
local alarm panels	115 volt to panel	

3.9 JOINING MEDICAL GAS PIPING

- 3.9.1 Use only tradesmen holding a current TSSA Brazing and Pressure Vessel Certificate to do brazing work. Contractor must use TSSA, Pressure Vessels Safety Branch registered brazing procedure for medical gas piping.
- 3.9.2 Make copper-to-copper joints using Airosil 45 or equal silver brazing alloy conforming to AWS Standard BCUP-5. Use no flux.
- 3.9.3 Make copper-to-brass joints using Airosil flux or equal. Borax and alcohol mixture or resins and similar paste fluxes shall not be used.

- 3.9.4 Joint threaded fittings as outlined in CSA Standard Z7396-1.
- 3.9.5 Cut all piping accurately to site dimensions and assemble without springing or forcing.
- 3.9.6 During the brazing of pipe connections, purge the interior of the pipe continuously with nitrogen, except when making final connections.
- 3.9.7 Clean all pipe and fittings, which do not come pre-cleaned and factory sealed, in accordance with CSA Standard Z7396-1. Where flux is used, wash the outside of piping and fittings with hot water to remove residue flux.

3.10 IDENTIFICATION

- 3.10.1 Label all medical gas piping at 20' (6 metre) intervals maximum, at each side of walls and at least once in every room or small enclosed area as required by CSA Standard Z7396-1. This must be done on a daily basis as work progresses.
- 3.10.2 Use colour coding method which conforms to the CSA Standard Z7396-1.
- 3.10.3 Provide adhesive labels to identify the medical gas piping.
- 3.10.4 Identify all shut-off valves, except zone valves, with lamacoid tags (see above). Each tag to be imprinted with both type of service and valve number. Use brass chains to attach tags to valves. Provide typewritten valve charts complete with schematic diagrams to identify location of each valve within the system.
- 3.10.5 Refer to Section 23 05 53, Mechanical Identification.

3.11 HANGERS

- 3.11.1 Do not support piping from other piping or equipment.
- 3.11.2 Use clevis hangers of the proper size and strength, fastened to the building structure. Provide dielectric separation as required.
- 3.11.3 Spacing of hangers shall be as listed below:

1/2" (15 mm)	6' maximum (1800 mm)
3/4" (20 mm)	8' maximum (2400 mm)
1" (25 mm)	8' maximum (2400 mm)
1-1/4" (32 mm) and larger	10' maximum (3000 mm)

3.12 INTERFERENCE

- 3.12.1 Site measure space for available pipe space. Route piping to clear all other trades. Provide information for preparation of interference drawings.

3.13 MEDICAL GAS SYSTEM CERTIFICATION

- 3.13.1 When equipment start-up and certification as specified above is complete, notify the Owner and Consultant that the systems are ready for certification as per CAN/CSA-Z7396.1.
- 3.13.2 Arrange for the system installer to be part of the certification team.
- 3.13.3 Should the Owner's Certification Agency be delayed by your default or by the fact that you are not ready for the certification procedure, or if scheduled certification is cancelled with less than two days' notice because the systems are not ready, you will be responsible for all costs for the Certification Agency to repeat the tests, remain on site longer than could reasonably be expected, or reschedule the tests, as applicable.
- 3.13.4 The Owner's Certification Agency will make interim site visits during construction to review medical gas system work. Cooperate with and reasonably assist the Agency, and immediately correct any deficient work reported by the Agency.
- 3.13.5 Copies of all medical gas test results must be provided to the Hospital for review and sign off in advance to turnover of space.

3.14 RECORD DRAWINGS

- 3.14.1 Refer to Section 20 05 05.

3.15 SYSTEM TRAINING

- 3.15.1 Refer to Section 20 05 05.
- 3.15.2 Include for 2 site training sessions for a minimum of 3 people for 4 hours per session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 Summary

- .1 Section Includes:
 - .1 Procedures and cleaning solutions for cleaning mechanical piping systems.
- .2 Related Sections:
 - .1 Section 20 05 05 - Common Work Results for Mechanical

1.2 References

- .1 Comply with the latest edition of the following Codes and Standards.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 Submittals

- .1 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with section 01 33 00 - Submittals. Include product characteristics, performance criteria, and limitations.
 - .1 Submit two (2) copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Submittals.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittals.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.

1.4 Delivery, Storage, & Handling

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 Cleaning Solutions

- .1 **Tri-sodium phosphate:** 0.9 lbs per 26.5 gallons (0.40 kg per 100 L) water in system.

- .2 **Sodium carbonate:** 0.9 lbs per 26.5 gallons (0.40 kg per 100 L) water in system.
- .3 **Low-foaming detergent:** 0.2 lbs per 26.5 gallons (0.01 kg per 100 L) water in system.

PART 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 Cleaning Hydronic Systems

- .1 **Timing:** systems operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.
- .2 Cleaning Agency:
 - .1 Retain the following water treatment specialists to perform system cleaning and water treatment:
 - .1 PMC (contact: John Quish 1-800-668-0946)
- .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 Cleaning procedures:
 - .1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report to 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.
- .5 Conditions at time of cleaning of systems:
 - .1 Systems: free from construction debris, dirt and other foreign material.
 - .2 Control valves: operational, fully open to ensure that terminal units can be cleaned properly.
 - .3 Strainers: 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.

- .6 **Report on Completion of Cleaning:** When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.
- .7 **Hydronic Systems:**
 - .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 5 psi (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 140 degrees F (60 degrees C) for at least 36 hours. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
 - .6 Flush velocity in 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 maximum design 180 degrees F (82 degrees C) minimum. Circulate for 12 hours, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 100 degrees F (38 degrees C). Drain as quickly as possible. Refill with clean water. Circulate for 6 hours 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).

3.3 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 sliding type expansion joints bind or if bellows type expansion joints flex incorrectly, 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.

3.4 Cleaning

- .1 Proceed in accordance with Section 01 74 00 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1- GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section except piping and unions.

PART 2- PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- 2.1.1 Black Steel - Screwed Joint: Mild black carbon steel, Grade B, ASTM A53, complete with Class 125 cast iron threaded fittings to ANSI/ASME B16.4, and screwed joints.
- 2.1.2 Black Steel - Welded Joint: Mild black carbon steel, Grade B, ASTM A53, mill or site bevelled, complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, with long sweep pattern elbows unless otherwise specified, and welded joints.
- 2.1.3 Hard Copper - Solder Joint: Type "L" hard drawn seamless copper to ASTM B88, complete with wrought copper fittings to ANSI B16.22, and 95% tin/5% Antimony solder joints.

2.2 PIPING UNIONS

- 2.2.1 Screwed Piping: Malleable iron, ground joint, bronze or brass to iron or bronze to bronze seat screwed unions and union elbows with a minimum pressure rating of 1725 kPa (250 psi) steam at 260°C (500°F).
- 2.2.2 Flanged Piping: Forged carbon steel slip-on type raised faced welding flange unions to ASTM A105, 150 lb. Class for steel pipe, and slip-on type 150 lb. Class bronze flanges for copper pipe.

2.3 SHUT-OFF VALVES

- 2.3.1 Ball Type: Class 600, lead-free, 4140 kPa (600 psi) WOG rated full port ball valves, each complete with a forged brass or bronze body and cap, blowout-proof stem, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat, threaded ends, and removable lever handle. Acceptable products are:
- 2.3.1.1 Kitz Corp. Code 58;
 - 2.3.1.2 Jenkins (equal to Kitz model);
 - 2.3.1.3 NH (equal to Kitz model);
 - 2.3.1.4 Red & White (equal to Kitz model);
 - 2.3.1.5 MAS (equal to Kitz model).

- 2.3.2 Butterfly Type: Cast ductile iron, lug body style, 1200 kPa (175 psi) rated butterfly valve, each complete with a neck to permit 50 mm (2") of insulation above the flange, a field replaceable EPDM seat, ductile iron disc, stainless steel shaft with EPDM seal, a lever handle for valves to and including 150 mm (6") diameter, a handwheel and gear type operator for valves larger than 150 mm (6") diameter, and each suitable for bubble-tight dead end service with the valve closed and either side of the connecting piping removed. Acceptable products are:
- 2.3.2.1 Kitz Corp. 6112 Series;
 - 2.3.2.2 Jenkins (equal to Kitz model);
 - 2.3.2.3 NH (equal to Kitz model);
 - 2.3.2.4 Red & White (equal to Kitz model);
 - 2.3.2.5 MAS (equal to Kitz model).
- 2.4 Drain Valves
- 2.4.1 Minimum 2070 kPa (300 psi) WOG rated, 20 mm (¾") diameter straight pattern bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm (¾") diameter hose, and a cap and chain. Acceptable products are:
- 2.4.1.1 Kitz Corp. Code No. 68AC;
 - 2.4.1.2 Jenkins (equal to Kitz model);
 - 2.4.1.3 NH (equal to Kitz model);
 - 2.4.1.4 Red & White (equal to Kitz model);
 - 2.4.1.5 MAS (equal to Kitz model).
- 2.5 Circuit Balancing Valves
- 2.5.1 Screwed or flanged as required, globe style, non-ferrous circuit balancing valves designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off, complete with capped and valved drain connection, and valved ports for connection to a differential pressure meter. Acceptable products are:
- 2.5.1.1 Tour and Andersson Model Series 76X ICSS Low lead;

PART 3- EXECUTION

3.1 DEMOLITION

- 3.1.1 Do all required hydronic piping system demolition/revision work. Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 Piping Installation Requirements

- 3.2.1 Provide all required hydronic piping. Pipe, unless otherwise specified, is to be:
- 3.2.1.1 for pipe to and including 65 mm (2½") diameter, Schedule 40 black steel, screwed, or type "L" hard copper with solder joints or pressure coupled joints;
 - 3.2.1.2 for pipe 50 mm (2") to 300 mm (12") diameter and larger, Standard weight black steel (10 mm/0.375" thickness) with grooved ends and Victaulic fittings and couplings, or, Standard weight black steel (10 mm/0.375" thickness) with welding fittings and welded joints;
- 3.2.2 Slope horizontal piping mains to provide a minimum continuous up-grade of 25 mm (1") in 6 m (20') to high points. Slope branch supply and return piping connections to equipment a minimum of 25 mm (1") in 1.2 m (4'). Leave sufficient room at high points for installation and maintenance of air vents.
- 3.2.3 Install automatic control valves, piping wells and similar piping and/or equipment mounted control components required for automatic temperature control systems supplied as part of the control. Refer to drawing control diagrams and details.
- 3.2.4 Connect equipment provided as part of the work of other Sections of the Specification with piping as indicated and/or required. Refer to pipe connection details on drawings.
- 3.2.5 Unions: Provide screwed unions, removable mechanical joint couplings, or weld-on or solder-on flanges in piping at all connections to valves, strainers and similar piping system components which may need maintenance or repair, at all equipment connections, in runs of piping exceeding 9 m (30') at 4.5 m (15') regular intervals to permit removal of sections of piping, and wherever else indicated on the drawings.
- 3.2.6 Shut-off Valves: Provide shut-off valves in piping connections to equipment, to isolate piping risers, to isolate other sections of systems as shown, and wherever else indicated on the drawings. Valves in piping to and including 50 mm (2") diameter are to be ball type. All other shut-off valves are to be ball or butterfly type unless otherwise specified. Locate all valves so that they are easily accessible. Wherever possible, install valves at uniform height. Provide chain operators for valves which are inaccessible for operation from floor level.
- 3.2.7 Drain Valves: Provide a drain valve at the base of each piping riser, in drain connections to equipment, in low points of horizontal piping, and wherever else shown and/or specified.
- 3.2.8 Circuit Balancing Valves: Provide circuit balancing valves in piping generally where shown on the drawings but with exact locations in accordance with instructions of personnel doing system flow balancing work. Confirm locations prior to installation. Balancing valves to be sized according to design flow. Ensure that balancing valves are a minimum of 10 pipe diameters downstream of any pump, 5 pipe diameters downstream of any or fitting and a minimum of 2 pipe diameters upstream of any fitting.
- 3.3 FLUSHING AND CLEANING PIPING**
- 3.3.1 Flush and clean new piping in accordance with requirements specified in the mechanical work Section entitled HVAC Water Treatment.
- 3.4 Testing, Adjusting and Balancing

- 3.4.1 When work is complete and equipment is operating as intended, test, adjust and balance water flows in accordance with requirements specified in the mechanical work Section entitled Testing, Adjusting, and Balancing.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section. Shop drawings/product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 PRESSURE RELIEF VALVES

- 2.1.1 ASME tested, rated, and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each capable of relieving the full output of the equipment it is associated with, and each factory set at 415 kPa (60 psi) unless otherwise specified. Acceptable products are:

- 2.1.1.1 Bell & Gossett 3301/4100, or 790/1170;
- 2.1.1.2 Dresser Industries "CONSOLIDATED";
- 2.1.1.3 Spirax Sarco Ltd. SVI Series;
- 2.1.1.4 McDonnell & Miller Models 250 and 260;
- 2.1.1.5 Conbraco 10-600 Series;
- 2.1.1.6 Watts Industries (Canada) Inc. 174A or 740.

2.2 AIR VENTS

- 2.2.1 Manual Air Vents: Equal to Conbraco 27 Series, 3.2 mm ($\frac{1}{8}$ ") diameter with a key handle.

2.3 STRAINERS

- 2.3.1 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. Acceptable products are:

- 2.3.1.1 Spirax Sarco Ltd. Type IF-125 screwed or Type AF-250 flanged;
- 2.3.1.2 Toyo Valve Co. Ltd. Fig. 380A screwed or Fig. 381 flanged;
- 2.3.1.3 Victaulic Co. of Canada Style 732 or W732 "Vic-Strainer";
- 2.3.1.4 Armstrong International Inc. A1 Series;
- 2.3.1.5 Watts Industries (Canada) Inc. #77SCI;
- 2.3.1.6 Mueller Steam Specialty Products Model 11M screwed or Model 758 flanged.

2.4 EXPANSION TANK

2.4.1 Replaceable bladder type, factory pressurized expansion tank with permanent separation of air and water, as per the drawing schedule and complete with:

2.4.1.1 a steel pressure tank suitable for a working pressure of 870 kPa (125 psi) at 115°C (240°F), constructed and stamped in accordance with the ASME Code for Unfired Pressure Vessels and complete with a system connection, drain connection, air charging valve, and a red oxide primer finish;

2.4.1.2 a heavy-duty butyl rubber (EDPM) bladder;

2.4.1.3 a tapping for installation of a pressure gauge;

2.4.1.4 for horizontal tanks only, mounting saddles supplied loose;

2.4.1.5 Acceptable products are:

2.4.1.5.1 Armstrong Fluid Technology Series "AX-V" Series "L";

2.4.1.5.2 Bell & Gossett Series "B" (ASME);

2.4.1.5.3 Taco Canada Ltd.;

2.4.1.5.4 Amtrol "Extrol".

2.5 GLYCOL SOLUTION MIXING AND STORAGE TANK

2.5.1 Package type glycol solution mixing, storage and automatic feed assembly designed to maintain minimum system pressure levels and complete with:

2.5.1.1 a round, polyethylene or polypropylene tank sized to suit system capacity, complete with a solution level scale in litres and Imperial gallons, removable cover, and a welded steel angle stand assembly with legs, pump shelf, and control panel bracket, all factory finished with enamel;

2.5.1.2 a factory pre-piped minimum 1/3 HP, 115 volt, 1 phase rotary bronze gear pump with capacity and pressure differential to suit system requirements, factory wired to the control panel, mounted on a shelf integral with the steel stand assembly, and complete with shut-off valve and strainer;

2.5.1.3 a tank pressure relief valve with discharge piped back into the tank;

2.5.1.4 a tank low level switch;

2.5.1.5 a pressure gauge;

2.5.1.6 a Honeywell #L404A "Pressurtrol" or equal pipe mounting differential pressure switch with a 100-1000 kPa (15-150 psi) range;

2.5.1.7 a 115 volt, 1 phase, factory mounted and prewired control panel with an EEMAC 2 enamelled steel enclosure, designed to control and operate the glycol gear pump either manually or automatically to pump glycol solution into the system, and to stop the pump and initiate on audible/visual alarm if a low glycol solution level occurs in the tank, and complete with:

2.5.1.7.1 terminal blocks for power and control wiring connections;

2.5.1.7.2 a H-O-A switch with green "Power On" indicator light;

2.5.1.7.3 a 120 volt/12 volt control transformer;

2.5.1.7.4 a low glycol solution level alarm buzzer with silencing switch, an alarm light which remains illuminated until the low-level switch is reset, and an alarm push-to-test button;

2.5.1.7.5 dry contacts for building automation system alarm annunciation.

2.5.2 Acceptable products are:

2.5.2.1 Ashland Water Technologies Model 5800;

2.5.2.2 Bell & Gossett Series GMU;

2.5.2.3 Armstrong Fluid Technology GLA Standard Series.

2.6 GLYCOL

2.6.1 Propylene glycol blended with Nitrite based corrosion inhibitors.

PART 3 - EXECUTION

3.1 INSTALLATION OF PRESSURE RELIEF VALVES

3.1.1 Provide factory set pressure relief valves where shown. Pipe the discharge of each water piping relief valve to drain unless otherwise shown or specified.

3.1.2 Pipe the discharge of each glycol solution piping relief valve back to the system expansion tank or return piping.

3.1.3 Confirm relief valve settings.

3.2 INSTALLATION OF AIR VENTS

3.2.1 Provide an air vent in piping mains at all high points, at equipment connections, and wherever else shown and/or specified. Equip each air vent with a ball type shut-off valve. Install vents in 100 mm (4") dia. and larger piping and all vents in mechanical rooms in accordance with the drawing detail.

3.2.2 Provide 9 mm (3/8") dia. copper drain piping from each automatic air vent to nearest suitable drain and terminate so the discharge is visible. Identify the drain piping.

3.3 INSTALLATION OF STRAINERS

- 3.3.1 Provide strainers in piping where shown. Locate strainers so that baskets are easily accessible and removable. Clean strainer baskets during and after piping system flushing and cleaning is complete, and before water quantity balancing commences.

3.4 INSTALLATION OF EXPANSION TANK

- 3.4.1 Provide an expansion tank where shown.
- 3.4.2 Secure the horizontal expansion tank in place from the structure by means of properly sized galvanized steel hanger rods and support saddles supplied with the tank.
- 3.4.3 Secure the tank stand to a concrete housekeeping pad by means of machine bolts. Connect the tank with system piping as indicated.
- 3.4.4 Connect the tank with system piping as indicated. Extend a drain line from the tank piping as indicated and terminate the drain line with a drain valve. Provide an air vent.
- 3.4.5 Provide a water make-up connection line complete with relief valve and pressure gauge and connect to system piping as shown. Terminate the make-up piping for connection to domestic cold water piping as part of the work of the mechanical work Section entitled Domestic Water Piping and Valves. Check relief valve operation and adjust as required.
- 3.4.6 Check the tank air charge and adjust to suit the system.

3.5 INSTALLATION OF GLYCOL SOLUTION MIXING – STORAGE TANK

- 3.5.1 Provide a mixing - storage tank and feed assembly for each glycol solution circulating system as shown.
- 3.5.2 Secure the tank stand to a concrete housekeeping pad. Connect with system piping. Refer to the drawing detail.
- 3.5.3 Fill the tank with, unless otherwise specified, a solution of 50% water, 50% propylene glycol, and test the solution to confirm proper concentrations.
- 3.5.4 When installation is complete, test operation of the assembly, including alarms, and adjust as required. Adjust the pressure switch to suit the glycol solution circulating system pressure.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section. Submit motor product data sheets and certified performance curves with all pump shop drawings. All shop drawings and product data must confirm that the products proposed meet all requirements of the Contract Documents.
- 1.1.2 Factory Inspection and Test Report: Submit with delivery of each unit a copy of the factory inspection and test report, and include a copy of each report with O & M Manual project close-out data.
- 1.1.3 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.
- 1.1.4 Spare Seal Flush Line Filters: Prior to Substantial Performance, submit a spare seal flush line filter for each pump equipped with a seal flush line.

1.2 QUALITY ASSURANCE

- 1.2.1 All pump motors are to comply with requirements of the mechanical work Section entitled Basic Mechanical Materials and Methods.

PART 2 - PRODUCTS

2.1 GENERAL RE: CIRCULATING PUMPS

- 2.1.1 Pumps are to be bronze fitted centrifugal pumps as per the drawing schedule, each non-overloading under all operating conditions and factory tested at specified operating conditions.

2.2 SPLIT COUPLED VERTICAL IN-LINE PUMP

- 2.2.1 Split coupled, single stage, vertical in-line pump complete with:
 - 2.2.1.1 a radially split, gasketed cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and a cast iron motor mount bracket;
 - 2.2.1.2 a dynamically balanced cast bronze impeller secured to a Type 416 stainless steel shaft which is connected to the motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of the mechanical seal without disturbing the pump, motor, or electrical wiring;
 - 2.2.1.3 a TEFC vertical mount motor;
 - 2.2.1.4 a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure the stationary seat;

- 2.2.1.5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with two extra cartridges, a sight flow indicator, air vent, and valved tubing;

2.2.2 Acceptable manufacturers are:

- 2.2.2.1 Armstrong Fluid Technology;
- 2.2.2.2 Bell & Gossett;
- 2.2.2.3 Grundfos;
- 2.2.2.4 Patterson;
- 2.2.2.5 Taco Canada Ltd.

2.3 CLOSE COUPLED VERTICAL IN-LINE PUMP

2.3.1 Close coupled, single stage vertical in-line pump complete with:

- 2.3.1.1 a radially split, gasketed cast iron volute with equally sized suction and discharge flanged connections, and tappings for gauge, drain and flush line connections;
- 2.3.1.2 a dynamically balanced bronze impeller with bronze shaft sleeve, secured to the motor shaft;
- 2.3.1.3 a face mounted TEFC vertical motor;
- 2.3.1.4 a watertight John Crane Inc. #JC 8B2, XP1D1 or Durmetallic #RA EU5-FV carbon rotating face type inside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure the stationary seat.

2.3.2 Acceptable manufacturers are:

- 2.3.2.1 Armstrong Fluid Technology;
- 2.3.2.2 Bell & Gossett;
- 2.3.2.3 Grundfos;
- 2.3.2.4 Patterson;
- 2.3.2.5 Taco Canada Ltd.

2.4 VERTICAL IN-LINE PUMP VARIABLE FREQUENCY DRIVES

- 2.4.1 Variable frequency drives for vertical in-line pumps as scheduled are to be in accordance with the mechanical work Section entitled Variable Frequency Drives.

2.5 CIRCULATING PUMP SUCTION AND DISCHARGE CONNECTION ACCESSORIES

- 2.5.1 Circulating pump manufacturer supplied suction guides with a cast iron body, stainless steel strainer screen, removable fine mesh start-up strainer screen and steel guide vanes, and cast iron body, angle, or straight type control valve assemblies, each acting as a check valve, balancing valve, and shut-off valve. Unless otherwise shown or specified, suction and discharge connection accessories are to be piping line size. Acceptable products are:

- 2.5.1.1 Armstrong Fluid Technology Type "SG" suction guides and "Flo-Trex" triple duty valve assemblies;
- 2.5.1.2 Bell & Gossett Bulletin B-820D suction guides and Bulletin B-821F triple duty valve assemblies.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCULATING PUMPS

- 3.1.1 Provide centrifugal circulating pumps where shown.
- 3.1.2 Vertical Inline Pump(s): Secure vertical inline pumps in place in accordance with requirements of the drawing detail and provide flexible piping connections in the vertical suction and discharge piping approximately 450 mm (18") above the suction and discharge connection accessories.
- 3.1.3 Suction and Discharge Connection Accessories: Provide a shut-off valve and suction guide in pump suction piping, and a combination check-balance-shut-off valve assembly in pump discharge piping, installed in accordance with the manufacturer's instructions. Remove suction guide start-up strainer screens after piping flushing and cleaning is complete. Note that combination check-balance-shut-off valve assemblies are to be 150 mm (6") away from the pump discharge for discharge piping to 150 mm (6") dia., and 300 mm (12") away from the pump discharge for discharge pipe larger than 150 mm (6") dia.
- 3.1.4 Variable Frequency Drives: Supply variable frequency drives for pumps as scheduled. Hand the VFD's to the electrical trade at the site for installation as part of the electrical work.
- 3.1.5 Equipment and System Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.1.6 Start-Up: Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.1.7 Demonstration and Training: Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a one half day on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings and/or product data sheets for following:
 - .1 cross-linked polyethylene (PEX) heating grid tubing, fittings and accessories, manifold assembly, control components and controls;
 - .2 copies of system manufacturer's loop layout design printouts indicating water flows and temperatures, heated surface profiles, and heating outputs;
 - .3 certified tubing and piping layout and schematic for each system zone;
 - .4 certified power wiring schematic and a certified control wiring schematic with sequence of operation for each system zone;
 - .5 letter from system component manufacturer stating system components proposed meet all requirements of the Specification.
- .2 Submit, prior to Substantial Performance of the Work, start-up or test data specified in Part 3 of this Section.
- .3 Submit letters of installation certification from system manufacturer's representative as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Exterior grid heating system is to be installed by journeyman tradesmen with a minimum of 3 years successful installation of PEX radiant system components supplied by manufacturer of components.
- .2 Prior to installation of system components, meet on-site with system component manufacturer's representative and trades whose work is related to successful installation of system(s) to confirm heated areas involved are ready for tubing installation.
- .3 Acceptable system manufacturers are:
 - .1 Klimatrol Environment Systems.
 - .2 IPEX Inc.;
 - .3 Uponor Inc. (Base Design);
 - .4 Watts Radiant Inc.;
 - .5 Rehau Inc;
 - .6 Meltaway

1.3 Warranty

- .1 Submit, at Substantial Performance of the Work, a non-prorated transferable repair or replacement warranty in name of Owner, issued by and signed by system component manufacturer covering materials against failure due to defects in material and/or workmanship as follows:
 - .1 PEX tubing, 25 years;

- .2 manifold assemblies, 5 years;
- .3 controls and electrical components, 2 years.

PART 2 - PRODUCTS

1.1 System Materials and components

- .1 Radiant floor heating system components as follows:
 - .1 Cross-linked polyethylene (PEX) tubing to CAN/CSA B137.5, ASTM F876 and F877, and SDR-9 requirements with an oxygen barrier in accordance with German Standard DIN 4726, supplied in coils, and with characteristics and accessories as follows:
 - .1 Plastic Pipe Institute certified temperature and pressure ratings of 550 kPa at 93°C (80 psi at 200°F), 690 kPa at 82°C (100 psi at 180°F), and 1100 kPa at 23°C (160 psi at 74°F);
 - .2 where required, "ProPEX" cold expansion type fittings in accordance with ASTM F877, CAN/CSA B137.5, and ASTM F1960, each consisting of a barbed adapter with an o-ring and an applicable sized PEX ring;
 - .3 minimum bend radius of 6 times the tubing OD, with factory supplied bend supports required for tubing with a bend radius less than 6 times the tubing OD;
 - .4 all required installation and connection accessories to suit heated surface construction, all in accordance with tubing manufacturer's instructions and factory supplied with tubing.
 - .2 Package type copper or brass supply and return manifold assembly to suit number of heating zones, factory assembled and equipped with wall mounting brackets and following:
 - .1 main supply and return full flow ball type isolating valves, zone pipe connection couplings, and fill/drain valves for both supply and return manifolds;
 - .2 supply manifold automatic air vent, and zone on/off valves with 24 volt AC actuators to suit control system;
 - .3 return manifold pressure balancing by-pass valve, and zone balancing valves and flow rate indicators;
 - .4 combination pressure gauge and thermometer for each manifold, and individual zone return piping thermometers for accurate visual zone balancing by zone temperature drops;
 - .5 all other required fittings and connection accessories.
 - .3 Controls and control components in accordance with drawing control diagram, requirements of Section entitled Automatic Control Systems, and following:

- .1 snow/temperature sensor: weatherproof, aerial (conduit) mounted, 120 volt, 1-phase, 60 Hz, pre-wired, solid-state electronic sensor to automatically activate snow melting system(s) when moisture is present and temperature reaches preset temperature, complete with a 2-gang PVC enclosure, sun shield, replaceable precipitation sensor, adjustable temperature setting, and adjustable delay off cycle;
- .2 control panel: NEMA 2, surface wall mounting, factory pre-wired and programmed, digital, 120 volt, 1-phase, 60 Hz enamelled steel enclosure with door interlock disconnect switch, power and control wiring terminal blocks, programmable digital controller, fused 24 volt secondary control transformer, power "ON" LED, manual reset glycol solution high temperature limit switch with fault indicator LED, manual system activation pushbutton with LED, system activated LED, a schematic wiring diagram laminated to the back of panel door, and all hardware required for control as described below and connection of system into building automation system.
- .4 System is to be activated automatically by exterior snow/temperature sensor if ambient temperature is below 1.1°C (34°F) and moisture is present on sensor. Once activated, system control panel will control system equipment, monitor glycol temperatures and exterior conditions, and modulate control valves, etc., as required. Glycol temperature will be limited to 54°C (130°F) with a temperature differential to prevent thermal shock. System will deactivate 1 hour after snow/temperature sensor no longer detects moisture. System may be manually operated by pressing control panel manual activation pushbutton, and will be activated for 5 hours, after which it will automatically shut-down and return to its normal state, unless sensor calls for operation.

1.2 AboveGround Pipe, Fittings, Valves and Equipment

- .1 Refer to applicable Sections for black steel piping and fittings, valves, and system equipment and accessories.

PART 3 - EXECUTION

1.1 Piping Installation Requirements

- .1 Provide hydronic radiant snow melting heating zones and piping manifold assemblies. Install system in strict accordance with manufacturer's instructions.
- .2 Piping is to be as follows:
 - .1 for pipe inside building and aboveground, Schedule 40 black steel, screwed, ASTM A53, Grade B, ERW, or Type "K" hard temper copper with forged copper solder type fittings and 95% tin / 5% Antimony solder joints, all in accordance with Section entitled HVAC Piping and Pumps;
 - .2 for heated surface grid piping, PEX pipe installed in continuous lengths with required support and installation accessories.
- .3 Provide a strainer in piping to manifold supply header and clean strainer screen when system balancing is to commence.

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- .4 Ensure grid tubing has been successfully pressure tested prior to concealment. Be present when covering is being placed over grid tubing to ensure integrity of tubing is not compromised during placement of remainder of floor construction.
 - .5 Prior to system flow balancing, ensure air is purged from system and system operates successfully at design temperatures and pressure for a minimum of 2 days. Supply system manufacturer's software for final balancing flow adjustment settings.
 - .6 Install automatic control valves, piping wells and similar piping and/or equipment mounted control components required for automatic control. Install snow/temperature sensor on a PVC conduit riser/mast outside building, generally where shown but confirm exact location prior to roughing-in.
 - .7 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
 - .8 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements. Ensure system manufacturer inspects grid tubing installation prior to concealment and certifies each zone correct in writing. Submit a copy of each certification letter prior to Substantial Performance of the Work.
 - .9 Include for 4 hours of on-site training for 2 groups of 6 people. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section except piping and unions. Ensure that shop drawings and product data sheets confirm that products proposed meet all requirements of the Contract Documents.

1.2 QUALITY ASSURANCE

- 1.2.1 Canadian Registration Number: All valves and similar items for use in systems with a pressure rating of 105 kPa (15 psi) is to be stamped with a Canadian Registration Number (CRN).
- 1.2.2 Codes and Standards: All steam and condensate piping system work is to be in accordance with the following:
- 1.2.2.1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code;
 - 1.2.2.2 ASME B31, Standards of Pressure Piping;
 - 1.2.2.3 and governing Provincial and/or Municipal Codes and Regulations.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- 2.1.1 Black Steel - Screwed Joint: Mild black carbon steel, Grade B, ASTM A53, complete with Class 125 or Class 250 cast iron threaded fittings to ANSI/ASME B16.4, and screwed joints.
- 2.1.2 Black Steel - Welded Joint: Mild black carbon steel, Grade B, ASTM A53, mill or site bevelled, complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB with a wall thickness to match the pipe, and welded joints.

2.2 PIPING UNIONS

- 2.2.1 Screwed Low Pressure Steam Piping: Malleable iron, ground joint, brass to iron or bronze to bronze seat screwed unions and union elbows with a minimum pressure rating of 1725 kPa (250 psi) steam at 260°C (500°F).
- 2.2.2 Screwed Condensate Piping: Malleable iron, ground joint, factory tested screwed unions and union elbows with a brass to iron seat and a minimum pressure rating of 4140 kPa (600 psi) WOG (non-shock).
- 2.2.3 Screwed High Pressure Steam Piping: Screwed unions as specified above for screwed condensate piping.
- 2.2.4 Welded Low Pressure Steam Piping: Forged carbon steel slip-on raised face welding flange unions to ASTM A105, 150 lb. Class.

2.2.5 Welded Condensate Piping: Welding flange unions as specified above for welded low pressure steam piping but 300 lb. Class.

2.2.6 Welded High Pressure Steam Piping: 300 lb. Class welding flange unions as specified for welded condensate piping.

2.3 SHUT-OFF VALVES

2.3.1 Low Pressure Steam and Condensate: Ball, gate or globe type valves suitable in all respects for steam and condensate service, and as follows:

2.3.1.1 ball type to 50 mm (2"): forged brass or bronze full bore ball valve, 1035 kPa (150 psi) WSP rated, complete with a chrome plated forged brass ball, PTFE seat and gland packing, screwed ends and a carbon steel handle - acceptable products are:

2.3.1.1.1 Kitz Corp. Code No. 58;

2.3.1.1.2 Watts Industries (Canada) Inc. #FBV-3;

2.3.1.1.3 Toyo Valve Co. Fig. 5044A;

2.3.1.1.4 Apollo Valve # 77-100;

2.3.1.1.5 Nibco #T-FP-600, or #T-585-70.

2.3.1.2 ball type 65 mm (2½") and larger: cast iron, flanged, 860 kPa (125 psi) WSP rated ball valve with a cast iron Teflon fused ball, blow-out proof stainless steel stem, reinforced Teflon seats, and steel handle which is lockable in fully open and fully closed positions - acceptable products are:

2.3.1.2.1 American Valve, Inc. 4000 Series;

2.3.1.2.2 Nibco #F-510-CS-R-25, or #F-510-CS-R-66-FS.

2.3.1.3 bronze gate to 50 mm (2"): cast bronze, screwed, 860 kPa (125 psi) WSP rated rising stem gate valve with a screwed-in cast bronze bonnet, cast bronze disc, and zinc or aluminum die-cast handwheel - acceptable products are:

2.3.1.3.1 Kitz Corp. Code No. 24;

2.3.1.3.2 Nibco #T-111;

2.3.1.3.3 Toyo Valve Co. Fig. 293;

2.3.1.3.4 Watts Industries (Canada) Inc. #B31 00.

2.3.1.4 bronze globe to 50 mm (2"): cast bronze, screwed, 860 kPa (125 psi) WSP rated rising stem globe valve with a union bonnet, reinforced PTFE disc, and zinc or aluminum die-cast handwheel - acceptable products are:

- 2.3.1.4.1 Kitz Corp. Code. No. 03;
- 2.3.1.4.2 Nibco #T-235-Y;
- 2.3.1.4.3 Toyo Valve Co. Fig. 220;
- 2.3.1.4.4 Watts Industries (Canada) Inc. #B4000.
- 2.3.1.5 cast iron gate 65 mm (2.5") and larger: Class 125 cast iron bronze mounted rising stem flanged gate valves, each equipped with a cast iron disc and a cast or ductile iron handwheel - acceptable products are:
 - 2.3.1.5.1 Kitz Corp. Co. No. 72;
 - 2.3.1.5.2 Nibco #F-617-0;
 - 2.3.1.5.3 Toyo Valve Co. Fig. 421A;
 - 2.3.1.5.4 Watts Industries (Canada) Inc. #F-503.
- 2.3.1.6 cast iron globe 65 mm (2.5") and larger: Class 125 cast iron bronze fitted flanged globe valves, each equipped with a cast iron disc and a cast or ductile iron handwheel - acceptable products are:
 - 2.3.1.6.1 Kitz Corp. Code No. 76;
 - 2.3.1.6.2 Nibco #F-718-B;
 - 2.3.1.6.3 Toyo Valve Co. Fig. 400A;
 - 2.3.1.6.4 Watts Industries (Canada) Inc. #F-503.
- 2.3.2 High Pressure Steam and Condensate: Gate or globe type valves suitable in all respect for steam and condensate service, and as follows:
 - 2.3.2.1 bronze gate to 50 mm (2"): Class 150 cast bronze gate valves, each equipped with screwed ends, rising stem, cast bronze disc, and cast zinc, or aluminum handwheel - acceptable products are:
 - 2.3.2.1.1 Kitz Corp. Code No. 42;
 - 2.3.2.1.2 Nibco #T-134;
 - 2.3.2.1.3 Toyo Valve Co. Fig. 298;
 - 2.3.2.1.4 Watts Industries (Canada) Inc. #B-3110.
 - 2.3.2.2 bronze globe to 50 mm (2"): Class 150 cast bronze globe valves, each equipped with screwed ends, rising stem, non-metallic disc, and cast zinc or aluminum handwheel - acceptable products are:

- 2.3.2.2.1 Kitz Corp. Code No. 09;
- 2.3.2.2.2 Nibco #T-235-Y;
- 2.3.2.2.3 Toyo Valve Co. Fig. 221;
- 2.3.2.2.4 Watts Industries (Canada) Inc. #B-4000.
- 2.3.2.3 cast steel gate 65 mm (2½") and larger: Class 150 OS & Y, rising stem, bolted bonnet cast steel gate valve with plain solid wedge or flexible solid wedge depending on valve size, flanged ends, and ductile iron handwheel - acceptable products are:
 - 2.3.2.3.1 Kitz Corp. Fig. 150 SCLS;
 - 2.3.2.3.2 Bonney Forge Corp. Fig. 1-11-RF;
 - 2.3.2.3.3 BERIC Fig. 101-RF-AA08-H.
- 2.3.2.4 cast steel globe 65 mm (2½") and larger: Class 150 OS&Y, rising stem, bolted bonnet cast steel globe valve with swivel disc, flanged ends, and ductile iron handwheel - acceptable products are:
 - 2.3.2.4.1 Kitz Corp. Fig. 150 SCJS;
 - 2.3.2.4.2 Bonney Forge Corp. 1-31-RF;
 - 2.3.2.4.3 BERIC Fig. 201-RF-EA08-H.

2.4 SWING CHECK VALVES

2.4.1 Low Pressure Steam & Condensate: Horizontal swing check valves as follows:

- 2.4.1.1 bronze to 50 mm (2"): Class 125 "Y" pattern screwed cast bronze swing check valve - acceptable products are:
 - 2.4.1.1.1 Kitz Corp. Code No. 22;
 - 2.4.1.1.2 Nibco #TE-413-B;
 - 2.4.1.1.3 Toyo Valve Co. Fig. 236;
 - 2.4.1.1.4 Watts Industries (Canada) Inc. #B-5000.
- 2.4.1.2 cast iron check 65 mm (2½") and larger: Class 125 cast iron bronze trim swing check valve with flanged ends and bolted cover - acceptable products are:
 - 2.4.1.2.1 Kitz Corp. Code No. 78;
 - 2.4.1.2.2 Nibco #FE-918-B;

2.4.1.2.3 Toyo Valve Co. Fig. 435A;

2.4.1.2.4 Watts Industries (Canada) Inc. #F-511.

2.4.2 High Pressure Steam & Condensate: Horizontal swing check valves as follows:

2.4.2.1 bronze to 50 mm (2"): Class 300 cast bronze "Y" pattern swing check valve with screwed ends - acceptable products are:

2.4.2.1.1 Kitz Corp. Code No. 19;

2.4.2.1.2 Nibco #T-473;

2.4.2.1.3 Toyo Valve Co. Fig. 360;

2.4.2.1.4 Watts Industries (Canada) Inc. #B-5030.

2.4.2.2 cast steel 65 mm (2½") and larger: Class 300 cast steel swing check valves, each complete with flanged ends - acceptable products are:

2.4.2.2.1 Kitz Corp. Fig. 300SCOS;

2.4.2.2.2 Bonney Forge Corp. 3-61-RF;

2.4.2.2.3 BERIC Fig. 303-RF-EA08-X.

2.5 DRAIN VALVES

2.5.1 Minimum 1725 kPa (250 psi) water rated, 20 mm (¾") diameter straight pattern bronze or brass ball valves, each complete with a stainless steel ball and stem, threaded outlet suitable for coupling connection of 20 mm (¾") hose, locking handle, and a cap and chain. Acceptable products are:

2.5.1.1 Toyo Valve Co. Ltd. Fig 5046;

2.5.1.2 Nibco #T-585-70-HC;

2.5.1.3 Kitz Corp. Code No. 68AC;

2.5.1.4 Apollo Valve # 70-140-64;

2.5.1.5 Watts Industries (Canada) Inc. #B-6000-CC.

PART 3 - EXECUTION

3.1 DEMOLITION

3.1.1 Do all required steam and condensate piping demolition/revision work. Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 STEAM AND CONDENSATE PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide all required steam and condensate piping.
- 3.2.2 Do all piping work with working pressures above 105 kPa (15 psi) in accordance with requirements of CSA B51 and ASME B31.
- 3.2.3 Piping, unless otherwise specified, is to be mild black steel, screwed for pipe to and including 50 mm (2") diameter, screwed or welded for pipe 65 mm (2½") diameter and larger, and as follows:
- 3.2.3.1 low pressure steam – screwed: Schedule 40, complete with Class 125 screwed fittings;
 - 3.2.3.2 high pressure steam – screwed: Schedule 40, complete with Class 250 screwed fittings;
 - 3.2.3.3 condensate, all pressures – screwed: Schedule 80, complete with Class 250 screwed fittings;
 - 3.2.3.4 low pressure steam – welded: Schedule 40 with butt weld fittings;
 - 3.2.3.5 high pressure steam – welded: Schedule 40 with butt weld fittings;
 - 3.2.3.6 condensate, all pressures welded: Schedule 80 with butt weld fittings.
- 3.2.4 Unless otherwise specified, slope horizontal steam mains down 25 mm (1") in 6 m (20') in the direction of flow. Steam mains may be run level if frequently and adequately dripped with equal tee connections and trapped at and through riser connections, however, slope such steam mains, if no branches are connected thereto for more than 7.5 m (25'), 25 mm (1") in a 6 m (20') as specified above. Provide equal tee drip stations every 36 m (120') to 45 m (150") in steam mains greater than 100 mm (4") diameter.
- 3.2.5 Unless otherwise approved, slope horizontal condensate return mains 65 mm (2½") diameter and larger 25 mm (1") in 6 m (20'). Slope smaller condensate return lines and condensate drip piping not less than 25 mm (1") in 3 m (10'). Slope all condensate piping in the direction of flow.
- 3.2.6 Slope steam supply and condensate return branch connections to and from equipment a minimum of 25 mm (1") in 1.8 m (6'), the slope being downward to the risers to which the branch piping connects. Increase this slope wherever necessary to prevent trapping due to expansion of the risers, or provide steam drip trap assemblies.
- 3.2.7 Extend branch steam supply piping off the top of horizontal mains, either 90° vertically or at a 45° angle, as space permits.
- 3.2.8 Make all changes in pipe size in horizontal steam and condensate piping with eccentric fittings flush with the pipe on the bottom. Do not use bushings in any piping.
- 3.2.9 Install automatic control valves, piping wells and similar piping and/or equipment mounted control components required for automatic temperature control systems and supplied as part of the control work. Refer to drawing control diagrams and details.

3.2.10 Connect new air handling unit steam humidifiers with steam and condensate piping.

3.3 INSTALLATION OF UNIONS

3.3.1 Provide screwed unions or weld-on flange joint unions in all piping connections to valves, strainers and similar piping system components which may need maintenance or repair, at all equipment connections, in long runs of piping exceeding 9 m (30') at 4.5 m (15') intervals to permit removal of sections of piping, and wherever else indicated on the drawings.

3.4 INSTALLATION OF SHUT-OFF VALVES

3.4.1 Refer to Part 3 of the mechanical work Section entitled Basic Mechanical Materials and Methods.

3.4.2 Low Pressure Steam & Condensate: Valves in piping where a throttling or balancing action is required are to be globe type. All other valves are to be ball or gate type.

3.4.3 High Pressure Steam & Condensate: Valves in piping where a throttling or balancing action is required are to be globe type. All other valves are to be gate type.

3.5 INSTALLATION OF CHECK VALVES

3.5.1 Provide a check valve in the discharge piping of each pump whether shown on the drawings or not, and wherever else shown and/or specified on the drawings.

3.6 INSTALLATION OF DRAIN VALVES

3.6.1 Provide a drain valve at the base of each piping riser, in drain connections to equipment, and wherever else shown and/or specified. At the bottom of risers provide minimum 200 mm (8") long, minimum 25 mm (1") diameter capped dirt pockets with drain valves.

3.7 FLUSHING AND CLEANING PIPING

3.7.1 Flush and clean new piping in accordance with requirements specified in the mechanical work Section entitled HVAC Water Treatment.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section. Shop drawings/product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.
- 1.1.2 Steam Drip Trap Tester: Submit a hand-held steam drip trap tester as specified in Part 3 of this Section.

1.2 QUALITY ASSURANCE

- 1.2.1 Canadian Registration Number: All steam and condensate piping system specialties for use in systems with a pressure rating of above 105 kPa (15 psi) are to be stamped with a Canadian Registration Number (CRN).
- 1.2.2 Codes and Standards: All steam and condensate piping system specialties are to be in accordance with the following:
 - 1.2.2.1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code;
 - 1.2.2.2 ASME B31, Standards of Pressure Piping;
 - 1.2.2.3 governing Provincial and/or Municipal Codes and Regulations.

PART 2 - Products

2.1 STEAM PRESSURE REDUCING VALVES

- 2.1.1 Factory assembled and tested, self-contained, dead end shut-off, pilot operated pressure reducing valves as per the drawing schedule, screwed or flanged as required, each complete with a 1725 kPa (250 psi) rated cast iron valve and pilot body with stainless steel trim, stainless steel valve diaphragm, and phosphor bronze pilot diaphragm. Acceptable manufacturers are:
 - 2.1.1.1 Spirax Sarco Canada Ltd. Model 25P;
 - 2.1.1.2 Armstrong International Ltd..
 - 2.1.1.3 Singer Valve Co. Ltd.;
 - 2.1.1.4 Kieley & Mueller.

2.2 Steam Temperature Control Valves

- 2.2.1 Electrically-actuated steam temperature control valves are to have components as follows:

- 2.2.1.1 A factory assembled and tested, modulating, single-seat, two-port, globe-style steam temperature control valve. Valve body to be cast iron or ductile iron with stainless steel trim, NPT or ANSI 125/250 flange rated. Valve leakage rate to be ANSI class IV. Control valve to have equal percentage characteristics. The valve shall complete with a drop-in seat for ease or removal of valve trim;
- 2.2.1.2 A fast-acting SMART electric actuator with valve closing rate of not less than 1.7 mm/second to adequately respond to demand. Actuator is reversible with linear output. Actuator to be equipped with positioner function. Electric actuators powered by 24 Vac. Minimum thrust of 4.5 k-N required. Ambient operating temperature operating limits are -20degC to +60degC. Enclosure rating IP65 required. Materials are polycarbonate case and die-cast aluminium housing. Electrical super capacitor fail-safe option to be included.
- 2.2.1.3 Valve noise levels shall not exceed 90 dB at one meter distance from the valve. When required, a low noise trim shall be employed. A valve utilizing noise trim shall meet valve duty requirements as specified
- 2.2.1.4 Valve control by the Controls Contractor.
- 2.2.1.5 Refer to Steam flow diagram drawing where applicable
- 2.2.1.6 Acceptable manufacturers are:
 - 2.2.1.6.1 Spirax Sarco Canada Ltd. Model "L" or "K" Series Mark 2 with Model AEL6 series SMART electronic actuator;
 - 2.2.1.6.2 Singer Valve Co. Ltd.;
 - 2.2.1.6.3 Armstrong International Ltd.

2.3 STEAM SEPARATORS

- 2.3.1 Cast iron baffle type steam separators, each sized to the steam pipe size, each complete with screwed or flanged ends as required and a thermodynamic steam trap module. Acceptable products are:
 - 2.3.1.1 Spirax Sarco Canada Ltd. Model S2 or Model S3;
 - 2.3.1.2 Flowserve;
 - 2.3.1.3 Armstrong International Inc.;
 - 2.3.1.4 Colton Industries.

2.4 PRESSURE RELIEF VALVES

2.4.1 Factory tested, rated and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each factory tested, certified and sealed, and each capable of relieving the full output of the steam pressure reducing valve(s) located upstream. Acceptable products are:

2.4.1.1 Spirax Sarco Canada Ltd. "SVI" Series;

2.4.1.2 Dresser Industries;

2.4.1.3 ITT Bell & Gossett;

2.4.1.4 McDonnell & Miller;

2.4.1.5 Conbraco.

2.5 DRIP PAN ELBOWS

- 2.5.1 Cast iron drip pan elbow sized to the discharge pipe size of the associated pressure relief valve, each complete with screwed or flanged connections as required, and a drain connection tapping. Acceptable products are:

2.5.1.1 Spirax Sarco Canada Ltd. Type 299;

2.5.1.2 Flowserve;

2.5.1.3 Armstrong International Ltd.

2.6 STEAM VENT EXHAUST HEADS

- 2.6.1 Stainless steel exhaust head, screwed or flanged as required, designed and constructed to eliminate oil, grease and water from the discharged steam while not interrupting or restricting steam flow. Acceptable products are:

2.6.1.1 Spirax Sarco Canada Ltd. Model VH;

2.6.1.2 Flowserve;

2.6.1.3 Armstrong International Ltd.

2.7 AIR VENTS

- 2.7.1 Low Pressure Steam: Cast iron body float and thermostatic type air vent with stainless steel float, element and valve head, bronze valve seat, and nylon ball valve. Acceptable products are:

2.7.1.1 Spirax Sarco Canada Ltd. Model 6A;

2.7.1.2 Flowserve;

2.7.1.3 Colton Industries.

- 2.7.2 High Pressure Steam: Brass alloy body and cap float type air vent with plastic float, rubber valve, and stainless steel valve seat and check valve. Acceptable products are:

2.7.2.1 Spirax Sarco Canada Ltd. Model AE 30;

2.7.2.2 Flowserve;

2.7.2.3 Colton Industries.

2.8 STRAINERS

- 2.8.1 Cast iron wye shaped strainers, screwed or flanged as required, minimum 1035 kPa (150 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. Acceptable manufacturers are:

- 2.8.1.1 Spirax Sarco Canada Ltd.;
- 2.8.1.2 Toyo Valve Co, Ltd.;
- 2.8.1.3 Armstrong International Ltd.;
- 2.8.1.4 Kitz Corp.;
- 2.8.1.5 Watts Industries (Canada) Inc.;
- 2.8.1.6 Mueller Steam Specialty Products;
- 2.8.1.7 Colton Industries.

2.9 STEAM DRIP TRAPS

- 2.9.1 Steam drip traps are to be selected to suit the inlet pipe size and inlet steam pressure, and are to be as follows:

- 2.9.1.1 thermodynamic traps: maximum 4135 kPa (600 psi) rated, integral seat design stainless steel thermodynamic type traps, each complete with an integral strainer and insulating cover – acceptable products are:

- 2.9.1.1.1 Spirax Sarco Canada Ltd. "TD" Series;
- 2.9.1.1.2 Flowserve;
- 2.9.1.1.3 Armstrong International Ltd.;
- 2.9.1.1.4 Colton Industries.

- 2.9.1.2 float and thermostatic traps: modulating discharge mechanical ball float type, each complete with a ductile or cast iron body, stainless steel trim, screwed or flanged ends as required, and an integral thermostatic air vent – acceptable products are:

- 2.9.1.2.1 Spirax Sarco Canada Ltd "FT" Series;
- 2.9.1.2.2 Flowserve;
- 2.9.1.2.3 Armstrong International Ltd.;
- 2.9.1.2.4 Colton Industries.

2.10 STEAM DRIP TRAP TESTING COMPONENTS

2.10.1 Spirax Sarco Canada Ltd. "SPIRA-tec" steam drip trap testing components as follows:

- 2.10.1.1 sensor chambers: #ST 17 ductile iron or #ST 14 steel sensor chambers as required, each complete with a stainless steel sensor element, sensor plug gasket, and, except where connected to a remote test point, a removable stainless steel drain plug;
- 2.10.1.2 indicator: Type 30 hand held trap fault indicating unit complete with battery and indicator cable.

2.10.2 Acceptable manufacturers are:

- 2.10.2.1 Spirax Sarco Canada Ltd.;
- 2.10.2.2 Flowserve.

2.11 STEAM VACUUM BREAKERS

2.11.1 Screwed brass body vacuum breakers, each complete with screw-in brass cap, and stainless steel valve and valve seat. Acceptable products are:

- 2.11.1.1 Spirax Sarco Canada Ltd. Model VB14;
- 2.11.1.2 Flowserve;
- 2.11.1.3 Armstrong International;
- 2.11.1.4 Colton Industries.

2.12 CONDENSATE PUMP SET

2.12.1 Package type condensate pump set with receiver and control as per the drawing schedule, complete with:

- 2.12.1.1 pump(s): vertical, centrifugal, bronze fitted with a one-piece cast iron casing column, discharge pipe and elbow, and motor stand, an enclosed, machined bronze, hydraulically balanced impeller secured to a renewable stainless steel pump shaft, external stuffing box not subjected to discharge pressure, a non-metallic water lubricated lower submerged shaft bearing, and a 3600 RPM vertical motor conforming to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods;
- 2.12.1.2 control: for duplex pump packages, a control assembly consisting of a heavy-duty two-pole float switch actuated by a seamless copper float for each pump, and an alternator to alternate the lead pump on each successive cycle, all factory mounted and pre-wired;

2.12.1.3 high level alarm switch: McDonnell & Miller, Flow Tech Corp. "Flotect" or equal float actuated automatic reset alarm switch, minimum 690 kPa (100 psi) and 120°C (250°F) rated, capable of transmitting an alarm signal to an alarm device or a building management system;

2.12.1.4 receiver: a cast iron or steel (depending on receiver capacity) condensate receiver with integral support legs for securement to a concrete pad, screwed type pipe connection and float switch tappings, and, for single pump tanks, a second blank flanged opening for a second future pump.

2.12.2 Acceptable manufacturers are:

2.12.2.1 Armstrong International Ltd.;

2.12.2.2 Spirax Sarco Canada Ltd.;

2.12.2.3 G.S. Dunham "MEPCO";

2.12.2.4 Shipco Pumps.

PART 3 - EXECUTION

3.1 INSTALLATION OF STEAM SEPARATORS

3.1.1 Provide a steam separator assembly with thermodynamic trap module upstream of steam pressure reducing station as shown.

3.1.2 Each separator is to be the full line size of the pressure reducing station.

3.2 INSTALLATION OF STEAM PRESSURE CONTROL VALVES

3.2.1 Provide steam pressure control valve stations where shown and connect with piping as indicated, including a valved bypass.

3.2.2 Check and adjust each station and set at the required downstream pressure. Check relief valve operation and set to the proper operating pressure.

3.3 INSTALLATION OF PRESSURE RELIEF VALVES

3.3.1 Provide pressure relief valves where shown. Pipe the discharge of each steam safety relief valve to atmosphere through a properly sized drip pan elbow. Check and test the operation of all steam relief valves and adjust as required.

3.4 INSTALLATION OF DRIP PAN ELBOWS

3.4.1 Provide a drip pan elbow as close as possible to the discharge of each steam pressure relief valve. Install each drip pan elbow in accordance with the manufacturer's instructions. Provide drain piping at the bottom of the elbow and ensure that the steam vent pipe to atmosphere is rigidly supported independent of the drip pan elbow.

3.5 INSTALLATION OF STEAM VENT EXHAUST HEADS

- 3.5.1 Provide an exhaust head for the termination of each steam vent to atmosphere. Install each head a minimum of 200 mm (8") above the roof in accordance with the manufacturer's instructions. Coordinate installation with the roofing trade to ensure that piping to each exhaust head assembly is properly flashed into roof construction. Confirm exact locations prior to installation.
- 3.5.2 Do not locate exhaust heads within 300 mm (12") of roof walkways and within 3 m (10') of equipment air intakes or building openings.

3.6 INSTALLATION OF AIR VENTS

- 3.6.1 Provide proper air vents at the end of all steam mains, and at the top of all steam risers.

3.7 INSTALLATION OF STRAINERS

- 3.7.1 Provide a strainer at each steam drip trap, and in piping where shown. Locate strainers so that baskets are easily removable. Clean strainer baskets after piping system flushing and cleaning is complete.

3.8 INSTALLATION OF STEAM DRIP TRAPS

- 3.8.1 Provide a steam trap assembly in the condensate return piping from each piece of equipment, at the base of each riser, in horizontal steam mains as specified, and wherever it is necessary to raise the piping to avoid a reduction in ceiling height or minimum headroom allowances. Size traps to correspond with condensate return piping sizes unless otherwise specified. Equip each trap with shut-off valve(s), two unions located immediately upstream and downstream of the trap, a strainer, sensing chamber, and a dirt pocket.
- 3.8.2 Thermodynamic Traps: Drip traps in steam mains with a working pressure greater than 140 kPa (20 psi) and 140 kPa (20 psi) and greater piping to equipment, unless otherwise specified, are to be thermodynamic type traps.
- 3.8.3 Float and Thermostatic Traps: Drip traps in low pressure steam mains less than 140 kPa (20 psi) and in piping less than 140 kPa (20 psi) to equipment, unless otherwise specified are to be float and thermostatic type traps.
- 3.8.4 Connect low pressure condensate drip piping from steam drip trap assemblies into condensate return piping unless otherwise shown on the drawings or specified herein. Do not connect condensate return piping into the discharge of traps draining steam mains.

3.9 INSTALLATION OF STEAM DRIP TRAP TESTING COMPONENTS

- 3.9.1 Provide a drip trap testing sensor chamber in piping downstream of each trap to be tested as indicated on the drawings.
- 3.9.2 Confirm test point locations prior to roughing-in.

- 3.9.3 Supply a hand-held test indicator with battery and turn the unit over to the Owner prior to Substantial Performance.

3.10 INSTALLATION OF STEAM VACUUM BREAKERS

- 3.10.1 Provide vacuum breakers in steam inlet piping after each temperature control valve to closed steam actuated vessels such as coils and heat exchangers, and in steam piping wherever required to control induced vacuum within safety limits when condensate is discharged into the return line by gravity. Mount each vacuum breaker vertically, unless otherwise specified.

3.11 INSTALLATION OF CONDENSATE PUMP SET

- 3.11.1 Provide a condensate pump set where shown.
- 3.11.2 Secure the receiver by means of anchor bolts to a concrete housekeeping pad.
- 3.11.3 Connect the receiver with 20 mm ($\frac{3}{4}$ ") diameter valved condensate piping, vent piping the full size of the receiver vent tapping, 12 mm ($\frac{1}{2}$ ") diameter valved drain piping in receiver inlet piping ahead of the shut-off valve, and overflow piping connected to the drain piping downstream of the drain valve. Connect the pump discharge condensate return piping containing a shut-off valve and a check valve, and a 20 mm ($\frac{3}{4}$ ") diameter drain valve immediately downstream of the shut-off valve.
- 3.11.4 Check operation of each float valve and adjust as required.
- 3.11.5 Check operation of duplex set alternator and adjust as required.

3.12 EQUIPMENT CERTIFICATION, START-UP, AND TRAINING

- 3.12.1 For all piping specialties such as steam trap testing equipment, pumps, flow meters, and similar items, include for each item or group of similar items, manufacturer's on-site certification, start-up, and O & M training as follows:
- 3.12.1.1 Equipment and System Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
 - 3.12.1.2 Start-Up: Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
 - 3.12.1.3 Demonstration and Training: Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for four hours of on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in Part 2 of this Section except for pipe and fittings. Ensure that shop drawings/product data sheets confirm that products proposed meet all requirements of the Contract Documents.
- .2 **Refrigerant Piping Schematics:** Submit, in shop drawing form, a schematic piping diagram for each refrigerant piping system indicating pipe sizes, slopes, valves, traps, piping specialties and leak detection system. Piping schematics must be reviewed, approved, and signed by the refrigeration equipment manufacturers prior to being submitted to the Consultant for review.
- .3 **Certification Reports:** Submit letters from equipment suppliers certifying proper installation and start-up of the piping systems and equipment as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 **Codes and Standards:** Refrigerant piping systems are to be in accordance with CSA B52, Mechanical Refrigeration Code, and any applicable local Codes and Regulations.
- .2 Refrigerant piping installing contractor is to be certified by Technical Standards and Safety Authority (TSSA). Installing contractor is to install refrigerant piping in accordance with manufacturer's installation instructions and in accordance with local codes. Contractor is responsible for all regulatory approvals, if required. Upon completion of installation, documentation of refrigerant amount, test certificates and verification documentation, etc., is to be provided in a binder, in accordance with requirements of local authorities having jurisdiction.
- .3 **Installation Personnel:** Refrigerant piping and direct expansion refrigeration equipment must be installed by or under direct on site supervision of a licensed journeyman refrigeration mechanic.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 Type ACR hard drawn seamless copper refrigerant tubing to ASTM B280, factory degreased, dehydrated and capped or nitrogen filled and capped, complete with factory washed and bagged wrought copper soldering fittings to ASME B16.22, and brazed joints made with high melting point silver brazing alloy conforming to AWS Classification BcuP-5.

2.2 Piping Line Sets

- .1 Equal to Great Lakes Copper Inc. "EZ-Roll" soft annealed copper to ASTM B280, suitable for use with the refrigerant involved, factory cleaned and capped, and with sizes and lengths as required.

2.3 General Re: Valves and Piping Specialties

- .1 All refrigerant valves and piping specialties specified below are to factory cleaned, degreased, and supplied to the site with capped ends.

2.4 Shut-Off Valves

- .1 **Ball Valves:** Mueller Industries Inc. "Ballmaster", ¼ turn, CSA certified forged brass ball valves, each suitable for a maximum working pressure of 3445 kPa (500 psi) and complete with carbon filled Teflon ball seals, two O-ring stem seals, a gasketed seal cap, a flow direction arrow cast into the body, a ball position indicator on the stem, and extended copper tube connections to permit brazing the valve into the line without disassembling the valve.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.
- .3 **Diaphragm Valves:** Mueller Industries Inc. "Linemaster" forged brass, frost-proof, Type 1 Series, CSA certified packless diaphragm valves, each suitable for a 3445 kPa (500 psi) working pressure and complete with an O-ring to prevent moisture from entering the diaphragm chamber, one phosphor bronze and two stainless steel diaphragms, and extended copper tube brazing connections.
- .4 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.5 Check Valves

- .1 Mueller Industries Inc. "Checkmaster" straight through type for valves 6.4 mm to 16 mm (¼" to 5/8") diameter, globe type for valves 22 mm (7/8") diameter and larger, each complete with extended tubing for brazing connections, and as follows:
 - .1 straight through type check valves are to be complete with a machined brass gasketed body, phosphor bronze spring, and neoprene seat;
 - .2 globe type check valves are to be complete with a cast bronze body, forged brass cap, phosphor bronze spring, Teflon seat disc, and neoprene O-ring seal.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.6 Piping Traps

- .1 Mueller Industries Inc. Style No. WE-554P brazing end copper "P" traps.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.7 Pressure Vessel Relief Valves

- .1 Mueller Industries Inc. "Safety-master", factory set pressure relief valves, straight through or angle type as required, each constructed in accordance with requirements of ANSI Code B9.1 and the ASME Code for Unfired Pressure Vessels, and each complete with a brass body, neoprene seat disc, and lead seal and locking wire.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.8 Refrigerant Liquid Moisture Indicators

- .1 Mueller Industries Inc. "Vuemaster", forged brass, triple sealed, CSA certified liquid moisture indicators, each suitable for a maximum working pressure of 3445 kPa (500 psi) and complete with a liquid indicator which shows "FULL" when the system is fully charged with refrigerant and remains blank when there is a restriction or shortage of refrigerant in the liquid line, a moisture indicator which changes colour from blue to pink when moisture is present in the system, a plastic dust cover, and extended copper tube brazing connections.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.9 Liquid Line Filter-Drier

- .1 Mueller Industries Inc. "Drymaster Micro-Guard" CSA certified filter-driers, each suitable for a maximum 3445 kPa (500 psi) working pressure and complete with a combination of desiccants in a fluted briquette for drying, and a fluted briquette type filter.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.10 Flexible Piping Connections

- .1 Senior Flexonics Canada "VIBRA-SORBERS" phosphor bronze construction, factory cleaned, dried, and sealed flexible piping connections with copper tube brazing ends.
- .2 Acceptable manufacturers are:
 - .1 Senior Flexonics Canada;
 - .2 The Metraflex Co.

2.11 Thermostatic Expansion Valves

- .1 Factory tested, balanced port design thermostatic expansion valves, with exact selection to suit the application and refrigerant used, each complete within a replaceable stainless steel diaphragm and welded element construction thermostatic element charged with hydraulic fluid, and removable inlet strainer.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.12 Electronic Expansion Valves

- .1 Factory tested, mechanically driven by stepped motor that receives its drive signals from a separate control board hard-wired to the valve.
- .2 Acceptable manufacturers are:
 - .1 Bitzer Canada Inc.

2.13 Leak Detection System

- .1 Contractor to provide leak detection system as required based on the refrigerant system size, space, equipment layout and reviewed & approved, by the equipment supplier.

PART 3 - EXECUTION

3.1 Installation Of Refrigerant Piping, Valves and Specialties

- .1 Refrigerant piping shall not be installed vertically through floors from one storey to another, except where the piping is enclosed in an approved rigid and tight continuous fire-resistant chase or pipe that is completely sealed to floors not served by the refrigeration system. The chase or pipe shall be vented to the outdoors.
- .2 Provide all required refrigerant piping. Piping is to be type ACR copper with wrought copper fittings. Install piping in accordance with requirements of reviewed refrigerant piping schematics referred to in Part 1 of this Section.
- .3 Make all refrigerant piping joints using a light coat of approved brazing flux applied to both pipe and fitting. Do not use acid flux. During the brazing process, ensure that the pipe and fittings are kept full of nitrogen or carbon dioxide to prevent scale formation

inside the pipe and fitting.

- .4 Where shown or specified, use soft copper refrigerant piping line sets.
- .5 Provide shut-off valves to isolate each piece of equipment if shut-off valves are not supplied integral with the equipment. Shut-off valves inside the building are to be ball or diaphragm type. Shut-off valves outside the building are to be diaphragm type.
- .6 Provide a refrigerant charging valve for each system if such a valve is not supplied integral with the equipment.
- .7 Provide all refrigerant piping accessories shown and/or required and install in accordance with the manufacturer's recommendations.
- .8 Provide all required refrigerant.
- .9 Provide flexible connections at piping connections to roof mounted condensing units. Install in accordance with the manufacturer's instructions.
- .10 Provide expansion valves where shown and/or required, each matched to the coil and installed in accordance with the manufacturer's instructions.
- .11 All field assembled piping shall be leak tested using dry nitrogen at a minimum pressure of 30 psig for a minimum 24 hours prior to evacuation and charging insulating any refrigerant lines and prior to refrigerant line being enclosed by the building construction. Test each joint in the refrigeration piping for leaks using at least one of the following methods;
 - .1 Bubble test
 - .2 Electronic leak detector
 - .3 Halide leak detector
 - .4 Ultrasonic leak detector
 - .5 Repair all leaks and repeat the pressure test until the system holds pressure.

3.2 Installation of Leak Detection System

Installation shall be as per the manufacturer recommendation.

END OF SECTION

PART 1- GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all water treatment chemical feed equipment and associated hardware.
- 1.1.2 Submit product literature sheets for all chemicals, as well as WHMIS Material Safety Data Sheets for all chemicals.
- 1.1.3 Submit water treatment manufacturer/supplier certification letters as specified in Part 3 of this Section.
- 1.1.4 Submit water treatment test sets and spare chemicals as specified below and in Part 3 of this Section.

PART 2- PRODUCTS

2.1 CHARACTERISTICS OF CHEMICALS AND SPARE CHEMICALS

- 2.1.1 Chemicals specified in this Section are to be non-toxic when released to atmosphere, non-corrosive and non-staining if a leak occurs, and compatible with all system components.
- 2.1.2 Chemicals must be approved by governing authorities for release into Municipal sewer system.
- 2.1.3 For each treatment system for which chemicals are supplied, supply and hand to Owner, at Substantial Performance of the Work, spare chemical in original containers/packaging sufficient for 2 months of treatment system operation.

2.2 EXISTING TREATMENT SYSTEMS

- 2.1.4 Confirm with the owner for existing 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.

2.3 PIPING SYSTEM FLUSHING AND CLEANING CHEMICAL

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

2.4 CLOSED HEAT TRANSFER SYSTEM TREATMENT

- 2.1.6 Chemicals, chemical feed equipment, and test equipment to control corrosion in closed heat transfer circulating systems as indicated on drawings and as specified below.

- 2.1.7 Enamelled steel or cast iron by-pass feeders sized as shown, 2060 kPa (300 psi) rated and complete with 20 mm ($\frac{3}{4}$ ") diameter NPT pipe connection tapings, and a screw-on cast iron cap with "Buna N" "O" ring seal.
- 2.1.8 By-pass filter and flow indicator assembly equal to a Shelco Inc. FOS78, 1725 kPa (250 psi) rated replaceable cartridge filter assembly with a stainless steel housing and 20 mm ($\frac{3}{4}$ ") diameter piping connections, sized for approximately 5% of rated circulating pump flow and complete with a minimum of 6, 20 micron filter cartridges, and a sight flow indicator equal to an Anderson Midwest Model 350SS with 20 mm ($\frac{3}{4}$ ") diameter piping connections.
- 2.1.9 Chromate free, nitrite/borate type corrosion inhibitor suitable for use with both ferrous and non-ferrous metals.
- 2.1.10 Test kit for measuring inhibitor level.

PART 3- EXECUTION

3.1 PIPING SYSTEM FLUSHING AND CLEANING

- 3.1.1 After new heat transfer system piping has been installed and leakage testing has been satisfactorily completed, but before mechanical equipment start-up and performance tests, flush and chemically clean piping systems.
- 3.1.2 Provide required temporary piping connections, including bypass piping to isolate dirt sensitive mechanical plant equipment. Remove instrumentation such as flow meters and switches, orifice plates, meter valves and similar devices and plug pipe openings. Reinstall when flushing and cleaning work has been certified complete by chemical manufacturer/installer. Ensure control valves are operational and fully open during flushing and cleaning.
- 3.1.3 Prior to chemical cleaning, flush piping, including dead ends, with water to remove loose solids. Clean all strainers. Replace chemical feeder line filters as required. Flush and drain until water runs clear.
- 3.1.4 When flushing with water is complete, fill systems with fresh clean water. Meter amount of water required to fill each system or otherwise calculate system capacity. Ensure all air is vented from systems. Add cleaning chemical as instructed by chemical manufacturer and circulate solution for a period of time and at a temperature as required to produce a clean piping system. Conduct daily pH, conductivity, and total iron tests in accordance with chemical supplier's instructions.
- 3.1.5 After chemical cleaning when test results indicate a clean system, drain solution from piping, refill with clean water and circulate water for a minimum of 24 hours to flush out remaining chemical solution, then drain water from piping using all drain points and again clean all system strainers and replace filters. Arrange for chemical supplier to check each system after flushing and cleaning is complete and to certify in writing that flushing and cleaning procedures have been properly performed. Submit a copy of the certification letter. Fill systems.

3.2 INSTALLATION OF CLOSED HEAT TRANSFER SYSTEM TREATMENT

- 3.1.6 After flushing and cleaning procedures have been certified complete, provide a by-pass chemical feeder, a cartridge filter assembly, and corrosion test coupons for each closed heat transfer system. Install in accordance with requirements of drawing details.

- 3.1.7 Supply and feed into each system sufficient chemical to charge system to proper concentrations of chemical and maintain proper levels in system until Substantial Performance of the Work.

3.3 MANUFACTURER'S CERTIFICATION, START-UP, AND TRAINING

- 3.1.8 For all water treatment equipment include for on-site certification, start-up supervision, and system training by treatment chemical manufacturer's representative as follows:

- 3.1.8.1 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements;

- 3.1.8.2 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements;

- 3.1.8.3 Include for 4 hours of on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all products specified in this Section except shop fabricated ductwork and fittings.
- 1.1.2 Include capacity, throw and terminal velocity, noise criteria, and pressure drops with grille and diffuser shop drawing/product data sheet submission.
- 1.1.3 Submit manufacturer's colour chart(s) for all items for which a finish colour is to be selected.

1.2 QUALITY ASSURANCE

- 1.2.1 Grilles and diffusers are to be tested and performance certified to ANSI/ASHRAE 70, Method of Testing the Performance of Air Outlets and Air Inlets.

PART 2 - PRODUCTS

2.1 Galvanized Steel Ductwork

- 2.1.1 Galvanized steel sheet is to be hot dipped in accordance with requirements of ASTM A653. G60 galvanizing for bare uncovered duct to be finish painted. G90 for all other galvanizing.
- 2.1.2 Rectangular
 - 2.1.2.1 Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum #26 gauge.
- 2.1.3 Round
 - 2.1.3.1 Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.
- 2.1.4 Flat Oval
 - 2.1.4.1 Factory machine fabricated, single wall, 4-ply spiral lock seam duct, fittings and couplings.

2.2 Rectangular Stainless Steel Ductwork

- 2.1.4.2 300 Series stainless steel, type 304 or type 316 as specified in Part 3 of this Section, ASTM A167 and ASTM A480, with a #4 finish where bare (uncovered) and exposed in finished areas and a #2B finish elsewhere, with, unless otherwise specified, metal gauges in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit the duct location and working pressure classification, and stainless steel support hardware to match the duct material.

- 2.1.4.2.1 Systems with stainless steel ductwork
ISOLATION EXHAUST SYSTEM

2.3 Round Stainless Steel Ductwork

- 2.1.4.3 Factory made, spiral, mechanically locked flat seam, single wall duct fabricated from type 316 stainless steel to ASTM A240 with metal gauges in accordance with ANSI/SMACNA HVAC Duct Construction Standards - Metal and Flexible for 2.5 kPa (0.36 psi) pressure. Fittings and couplings are to be factory made type 316 stainless steel fittings equipped with leak-proof couplings secured to the connecting duct by means of stainless steel sheet metal screws and duct sealer. Duct system performance is to meet SMACNA's Leakage Class 3 requirements at the system design static pressure. The stainless steel finish is to be a #2B mill finish where concealed or exposed in unfinished areas, and a #4 finish where exposed in finished areas.

- 2.1.4.3.1 Systems with stainless steel ductwork
ISOLATION EXHAUST SYSTEM

2.4 Flexible Connection Material

- 2.1.5 Waterproof, indoor-outdoor type flexible connection material meeting requirements of NFPA 90A, consisting of woven glass fibre fabric coated on both sides with synthetic rubber. Acceptable products are:

- 2.1.5.1 Duro Dyne Canada Inc. "DUROLON";

- 2.1.5.2 Dyn Air Inc. "HYPALON".

2.5 Metal Duct System Joint Sealant

- 2.1.6 ULC listed and labelled, premium grade, grey colour, water base, non-flammable duct sealer, brush, or gun applied, with a CAN/ULC S102 tested maximum flame spread rating of 5 and smoke developed rating of 0.

- 2.1.7 Acceptable manufacturers are:

- 2.1.7.1 Johns Manville;

- 2.1.7.2 Manson Insulation;

- 2.1.7.3 Knauf Insulation.

2.6 Round to Rectangular Duct Connections

- 2.1.8 Equal to Flexmaster Canada Ltd. galvanized steel, flared, flanged or notched "Spin-On" round duct take-off collars with locking dampers in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 2.7 Splitter Dampers
 - 2.1.9 Minimum #20 gauge damper blade constructed of same material as duct, reinforced as required to suit blade size, system velocity, and to prevent "chatter", and complete with operating hardware equal to DynAir Inc. #Q-50 "DYN-A-QUAD S-S" quadrant regulator with RW-50 backup washers to prevent leakage, long square bearing pin, and slide pin.
- 2.8 Air Turning Vanes
 - 2.1.10 For square elbows, multiple-radius turning vanes interconnected with bars, adequately reinforced to suit pressure and velocity of system, constructed of same material as duct they are associated with, and in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
 - 2.1.11 For short branch ducts at grille and diffuser connections, air extractor type each equipped with a matching bottom operated 90° opposed blade volume control damper, constructed of same material as duct it is associated with and in accordance with requirements and details in ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 2.9 Manual Balancing (Volume) Dampers

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- 2.1.12 Flanged and drilled, single or parallel blade (depending on damper size) manual balancing dampers, each constructed of same material as connecting ductwork unless otherwise specified, each designed to maintain internal free area of connecting duct, and each complete with:
- 2.1.12.1 hexagonal or square shaft extension through frame;
 - 2.1.12.2 non-stick, non-corrosive synthetic bearings for rectangular dampers, flange stainless steel bearings for round dampers;
 - 2.1.12.3 blade stops for single blade dampers, designed to prevent blade from moving more than 90°;
 - 2.1.12.4 linkage for multiple blade dampers;
 - 2.1.12.5 locking hand quadrant damper operator with, for insulated ducts 50 mm (2") standoff mounting.
- 2.1.13 Rectangular Dampers: Nailor Industries Inc. 1800 Series, maximum size 1.2 m x 1.2 m (4' x 4') for a single damper.
- 2.1.14 Round Dampers: Nailor Industries Inc. Model 1890, maximum 600 mm (24") diameter, equipped with a minimum 200 mm (8") deep frame, and blade stiffeners where required.
- 2.1.15 Multiple Rectangular Damper Section Assembly: Rectangular assembly supplied with the dampers or site constructed, of same material as damper and designed for tight and secure mounting of individual dampers.
- 2.1.16 Acceptable manufacturers are:
- 2.1.16.1 Nailor Industries Inc.;
 - 2.1.16.2 T.A. Morrison & Co. Inc. "TAMCO";
 - 2.1.16.3 NCA Manufacturing Ltd.;
 - 2.1.16.4 Greenheck Fan Corp.;
 - 2.1.16.5 Ruskin Co.
- 2.10 Backdraft Dampers

- 2.1.17 Nailor Industries Model 1370CB counterbalanced backdraft dampers, vertical or horizontal mounting, 50 mm (2") wide, sized as shown and complete with:
 - 2.1.17.1 extruded 6063-T5 aluminum frame, 2.3 mm (0.090") nominal wall thickness, with mitred corners;
 - 2.1.17.2 extruded 6063-T5 aluminum blades, 1.3 mm (0.050") nominal wall thickness on 92 mm (3-5/8") centres, and with extruded PVC blade seals;
 - 2.1.17.3 corrosion-resistant synthetic bearings;
 - 2.1.17.4 adjustable plated steel counterweights mounted internally in the airstream;
 - 2.1.17.5 concealed blade linkage located out of the airstream.
- 2.1.18 Acceptable manufacturers are:
 - 2.1.18.1 Nailor Industries Inc.;
 - 2.1.18.2 T.A. Morrison & Co. Inc. "TAMCO";
 - 2.1.18.3 NCA Manufacturing Ltd.;
 - 2.1.18.4 Greenheck Fan Corp.;
 - 2.1.18.5 Ruskin Co.
- 2.11 Fusible Link Dampers

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- 2.1.19 Curtain blade type, dynamic, galvanized steel (unless otherwise specified) fusible link dampers, ULC classified to CAN/ULC S112 and in accordance with NFPA 90A requirements, factory tested for closure under airflow, 1-1/2 hour or 3 hour rated as required, and complete with a constant force type 301 stainless steel closure spring, a blade lock assembly, a steel sleeve, retaining angles, and, unless otherwise specified, a 74°C (165°F) rated standard fusible link.
- 2.1.20 Fusible link dampers are to be Type "B" or Type "C" (as required) with folded curtain blade out of air stream except where damper size or location requires use of type "A" dampers with curtain blade in air stream.
- 2.1.21 Dampers in ductwork other than galvanized steel are to be as specified above but constructed of type 316 stainless steel.
- 2.1.22 Acceptable manufacturers are:
- 2.1.22.1 Nailor Industries Inc.;
 - 2.1.22.2 Greenheck Fan Corp.;
 - 2.1.22.3 NCA Manufacturing Ltd.;
 - 2.1.22.4 Ruskin Co.;
 - 2.1.22.5 Price Industries (E.H. Price).
- 2.12 Combination Fire/Smoke Dampers

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- 2.1.23 Nailor Industries Series 1220, ULC listed to CAN/ULC S112 and CAN/ULC S112.1, meeting requirements of NFPA 80, 90A, 92, 101 and 105, consisting of type A, B, or C fusible link fire dampers as required and a fail-safe, opposed blade, normally closed, motor operated smoke damper complete with factory installed and tested 120 V electric actuator.
- 2.1.24 ULC 1-1/2 hour fire rated and ULC Class I leakage rated for smoke, and equipped with a 74°C (165°F) ULC classified fusible link that will cause damper to close and lock independent of actuator when duct temperature reaches maximum temperature of damper assembly.
- 2.1.25 Supply damper with factory installed sleeves of minimum 400 mm (16") length, field verified by contractor dependent on wall thickness. Caulk sleeves to ULC requirements and constructed of 20 gauge for sizes up to 2.1 m (84") wide and 18 gauge for sizes greater than 2.1 m (84") wide.
- 2.1.26 Acceptable manufacturers are:
- 2.1.26.1 Nailor Industries Inc.;
 - 2.1.26.2 Greenheck Fan Corp.;
 - 2.1.26.3 NCA Manufacturing Ltd.;
 - 2.1.26.4 Ruskin Co.;
 - 2.1.26.5 Price Industries (E.H. Price).
- 2.13 Roof Duct Supports
- 2.1.27 Equal to PHP Systems Design Model PHP-D adjustable duct support assemblies sized to suit duct size, each assembly complete with injection moulded recycled plastic and carbon black bases and tubular hot dip galvanized steel framing.
- 2.14 Duct Access Doors
- 2.1.28 In accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, with sizes suitable in all respects for purpose for which they are provided, and, unless otherwise specified, constructed of same material as duct they are associated with.
- 2.15 Ductwork Drain Points
- 2.1.29 Equal to Ductmate Canada Ltd. "Moisture Drain", 20 mm (¾") diameter moisture drains with galvanized sheet metal funnel, and chrome plated brass threaded drain, nut and cap.
- 2.16 Instrument Test Ports
- 2.1.30 Equal to Duro-Dyne of Canada Ltd. #IP1 or #IP2 (to suit insulation thickness where applicable) gasketed, leakproof instrument test ports for round or rectangular ducts as required, each complete with a neoprene expansion plug and a plug securing chain.
- 2.17 Grilles and Diffusers
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2.1.31 Grilles and diffusers of type, size, capacity, finish, and arrangement as shown on drawings and in accordance with drawing schedule, each equipped with all required mounting and connection accessories to suit mounting location and application.

2.1.32 Acceptable manufacturers are:

2.1.32.1 Price Industries Inc.;

2.1.32.2 Anemostat;

2.1.32.3 Krueger Division of Air System Components Inc.;

2.1.32.4 Titus;

2.1.32.5 Nailor Industries Inc.;

2.1.32.6 Tuttle & Bailey.

PART 3 - Execution

3.1 Cleanliness Requirements for Handling and Installation of Ductwork

3.1.1 Handle and install ductwork in accordance with CSA Z317.2, Special Requirements for Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Healthcare Facilities and SMACNA's Duct Cleanliness for New Construction Guidelines at the Advanced Level.

3.2 Fabrication and Installation of Galvanized Steel Ductwork

3.1.2 Provide required ductwork, rectangular, round and/or flat oval. Where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.

3.1.3 It is to be understood that all duct dimensions shown on drawings are clear internal dimensions.

3.1.4 Unless otherwise specified, construct and install ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit duct pressure class designation of minimum 500 Pa (2" w.c.) positive or negative as applicable, a maximum velocity of 10 m/s (2000 fpm), and so ductwork does not "drum". Flat surfaces of rectangular ductwork are to be cross-broken. Duct system sealing is to meet ANSI/SMACNA Seal Class A requirements.

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- 3.1.5 Confirm routing of all ductwork at site and site measure ductwork prior to fabrication. Duct dimensions may be revised to suit site routing and building element requirements, if dimension revisions are reviewed with and approved by Consultant. Duct routing and/or dimension revisions to suit conditions at site are not grounds for a claim for an extra cost.
- 3.1.6 Wherever ductwork is required at locations where sprayed fireproofing is applied to building construction, install ductwork only after fireproofing work is complete and do not compromise fire rating of sprayed fireproofing.
- 3.1.7 Install (but do not connect) duct system mounted automatic control components supplied as part of the automatic control work.
- 3.1.8 Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.
- 3.1.9 Flange connect ductwork to hot water reheat coils in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Coils will be suspended independent of connecting ductwork as part of the heat transfer work.
- 3.1.10 Support horizontal rectangular ducts inside building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but use trapeze hangers with, unless otherwise specified, galvanized steel channels, and galvanized steel hanger rods for exposed ducts and concealed ducts wider than 500 mm (20"). Support hardware constructed of same material as duct for metal duct, and, unless otherwise specified, type 316 stainless steel for non-metal duct. Supports for "heavy" duct such as cementitious core duct is to be suitable in all respects for the application and approved by Consultant.
- 3.1.11 Support round and flat oval ducts inside building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but, unless otherwise specified, for both uninsulated and insulated ducts exposed in finished areas, use bands and secure at top of duct to a hanger rod, all similar to Ductmate Canada Ltd. type "BA". If duct is insulated, size strap to suit diameter of insulated duct. Unless otherwise specified, duct support hardware for metal duct is constructed of same material as duct, and for non-metal duct, type 316 stainless steel.
- 3.1.12 Where flanged duct joints are used, do not locate joints in wall or slab openings, or immediately at wall or slab openings. Do not use flanged joints for exposed uninsulated ducts in finished areas.
- 3.1.13 Where watertight horizontal ductwork is required, construct ducts without bottom longitudinal seams. Solder or weld joints of bottom and side sheets. Seal all other joints with duct sealer. Slope horizontal duct to hoods, risers, or drain points. Provide drain points. Provide watertight ductwork for:
- 3.1.13.1 ductwork outside building or otherwise exposed to the elements;
- 3.1.13.2 wherever else shown.
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3.1.14 Leakage Testing:

3.1.14.1 Ductwork leakage is not to exceed following:

3.1.14.1.1 ductwork to 2" W.C. Class, 1% of total air quantity handled by respective fans;

3.1.14.1.2 ductwork exceeding 2" W.C. Class, 2% of total air quantity handled by respective fans.

3.1.14.2 Leakage testing is to be performed by the Testing, Adjusting and Balancing (TAB) agency in accordance with SMACNA HVAC Air Duct Leakage Test Manual and is to be witnessed by Consultant.

3.1.14.3 Be responsible for following:

3.1.14.3.1 preparing duct systems for leakage testing prior to installation of external insulation including capping duct runouts and provision of final tap-in for test equipment;

3.1.14.3.2 schedule testing with TAB agency in advance, be present for all testing and ensure notice is given to Consultant so they may witness testing;

3.1.14.3.3 resealing and/or replacement of defective ductwork;

3.1.14.3.4 bearing all costs associated with retesting ductwork which has failed to pass leakage testing.

3.1.15 Seal all ductwork in accordance with SMACNA Seal Class "A", except for round duct with self-sealing gasketed fittings and couplings which does not require site applied sealant. Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.

3.1.16 Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.

3.1.17 Clean exterior exposed (uninsulated) ducts and coat with a heavy full coverage of Bakor #410-02 black metal paint.

3.1.18 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material.

3.3 Installation of Round to Rectangular Duct Connections

3.1.19 Cut round holes in rectangular ducts and provide round to rectangular lock-in fittings with dampers for connection of flexible round ductwork.

3.4 Installation of Splitter Dampers

- 3.1.20 Provide splitter dampers in supply ductwork at branch duct connections off supply air mains, and wherever else shown and/or specified on drawings. Install splitter dampers so they cannot vibrate and rattle and so damper operation mechanisms are in an easily accessible and operable location. Ensure operators for dampers in insulated ducts are equipped with stand-off mounting brackets.

3.5 Installation of Turning Vanes

- 3.1.21 Provide turning vanes in ductwork elbows where shown on drawings and wherever else required where, due to site installation routing and duct elbow radius, turning vanes are recommended in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 3.1.22 Provide volume extractor type turning vanes in short branch supply duct connections off mains to grilles and diffusers where shown and/or specified.

3.6 Installation of Manual Balancing (Volume) Dampers

- 3.1.23 Provide manual balancing dampers as required to provide a fully balanced system, including but not limited to in all open end ductwork, in all duct mains, and wherever else shown and/or specified.
- 3.1.24 Install dampers so operating mechanism is accessible and positioned for easy operation, and so dampers cannot move or rattle. Ensure operating mechanisms for dampers in insulated ducts are complete with stand-off mounting brackets.
- 3.1.25 Confirm exact damper locations with personnel doing air quantity balancing testing work and install dampers to suit. Include for providing 5 additional dampers at no additional cost.

3.7 Installation of Backdraft Dampers

- 3.1.26 Provide backdraft dampers.
- 3.1.27 Install and secure dampers so they cannot move or rattle.

3.8 Installation of Fusible Link Dampers

- 3.1.28 Provide fusible link dampers. Ensure damper rating (1-½ or 3 hr.) is suitable for fire barrier it is associated with.
- 3.1.29 Install dampers with retaining angles on all 4 sides of sleeve on both sides of damper and connect with ductwork in accordance with damper manufacturer's instructions and details, and Code requirements.
- 3.1.30 Provide expansion clearance between damper or damper sleeve and opening in which damper is required. Ensure openings are properly sized and located, and all voids between damper sleeve and opening are properly sealed to maintain rating of fire barrier.

3.9 Installation of Combination Fire/Smoke Dampers

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- 3.1.31 Provide combination fire/smoke dampers. Install dampers with retaining angles on all 4 sides of each side of damper, and, where required, connect with ductwork, all in accordance with damper manufacturer's instructions and details, and Code requirements.
 - 3.1.32 Coordinate damper installation with electrical work where electrical connections to damper actuators are specified.
 - 3.10 Installation of Flexible Connection Material
 - 3.1.33 Provide a minimum of 100 mm (4") of flexible connection material where ducts, plenums, and/or easings connect to fans, and wherever else shown or specified.
 - 3.1.34 Rigidly secure a minimum of 75 mm (3") of duct material (minimum #24 gauge) to each edge of flexible fabric and to fan, duct, plenum, etc., in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Ensure connections to flexible fabric material are arranged and supported so as to not impose any external forces on the fabric.
 - 3.11 Installation of Roof Mounted Duct Supports
 - 3.1.35 Supply supports for roof mounted ductwork.
 - 3.1.36 Accurately mark location and spacing of roof support assemblies. At each plastic base location, carefully scrape away loose roof ballast (gravel) and all other debris and dirt. Prime existing membrane with a primer which is compatible with existing roofing components. Set bases in adhesive in accordance with manufacturer's installation instructions. Scrape loose ballast back around and on bases. Install framing, and install ductwork on the cross-members. Secure ductwork to cross-members with galvanized steel banding.
 - 3.12 Installation of Duct Access Doors
 - 3.1.37 Provide access doors in ductwork for access to all components which will or may need maintenance and/or repair, including reheat coils. Install in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
 - 3.1.38 Identify access doors provided for fusible link damper maintenance with "FLD" stencil painted or marker type red lettering and ensure doors are properly located for damper maintenance.
 - 3.1.39 When requested, submit a sample of proposed duct access doors for review.
 - 3.1.40 Where sectionalized fusible link dampers and/or balancing dampers are provided in large ducts, provide a plenum type access door to suit, and adequately reinforce ductwork to suit access door installed.
 - 3.13 Installation of Instruments Test Ports

- 3.1.41 Provide instrument test ports in all main ducts at connections to fans, plenums or casings, in all larger branch duct connections to mains, and wherever else required for proper air quantity balancing and testing.
- 3.1.42 Locate test ports where recommended by personnel performing air quantity testing and balancing work.
- 3.14 Installation of Grilles and Diffusers
 - 3.1.43 Provide grilles and diffusers. Wherever possible, grilles and diffusers are to be product of same manufacturer.
 - 3.1.44 Unless otherwise specified connect grilles and diffusers in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.
 - 3.1.45 Exactly locate grilles and diffusers to conform to final architectural reflected ceiling plans and detailed wall elevations, and to conform to final lighting arrangement, ceiling layout, ornamental and other wall treatment.
 - 3.1.46 Equip supply diffusers having a basic 4-way or all round air pattern for operation in 1-, 2-, or 3-way pattern where indicated on drawings.
- 3.15 Duct System Protection, Cleaning and Start-Up
 - 3.1.47 Temporarily cover all open ends of ducts during construction.
 - 3.1.48 Remove all dirt and foreign matter from entire duct systems and clean duct system terminals and interior of air handling units prior to operating fans.
 - 3.1.49 Prior to starting any supply air handling system provide 50 mm (2") thick glass fibre construction filters at fan equipment in place of permanent filters.
 - 3.1.50 Provide cheesecloth over duct system inlets and outlets and run system for 24 hours, after which remove cheesecloth and construction filters, and install new permanent filters.
 - 3.1.51 Include all labour for a complete site walk-through with testing and balancing personnel following route of all duct systems to be tested, adjusted and balanced for the purpose of confirming proper position and attitude of dampers, location of pitot tube openings, and any other work affecting testing and balancing procedures. Perform corrective work required as a result of this walk-through.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section except shop fabricated ductwork and fittings.
- .2 **Test Data:** Submit duct leakage test data prior to ductwork being covered from view.

PART 2 - PRODUCTS

2.1 Galvanized Steel Ductwork

- .1 **General:** Galvanized steel sheet is to be hot dipped in accordance with requirements of ASTM A653. Galvanizing for bare uncovered duct to be finish painted is to be G60. All other galvanizing is to be G90.
- .2 **Rectangular:** Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum #26 gauge.
- .3 **Round:** Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.
- .4 **Flat Oval:** Factory machine fabricated, single wall, 4-ply spiral lock seam duct, fittings and couplings.

2.2 Metal Duct System Joint Sealant

- .1 ULC listed and labelled, premium grade, grey colour, water base, non-flammable duct sealer, brush, or gun applied, with a CAN/ULC S102 maximum flame spread rating of 5 and smoke developed rating of 0.

PART 3 - EXECUTION

3.1 Fabrication and Installation of Galvanized Steel Ductwork

- .1 Provide all required standard galvanized steel ductwork, rectangular and/or round and/or flat oval as shown. **Note** that where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.
- .2 Unless otherwise specified, construct and install ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit the duct pressure class designation of **minimum** 625 Pa (2.5" w.c.) positive or negative as applicable, a minimum velocity of 10 m/s (2000 fpm), and so that the ductwork does not "drum". All flat surfaces of rectangular ductwork are to be cross-broken. Duct system sealing is to meet ANSI/SMACNA Seal Class A requirements.
- .3 Variable air volume ductwork from supply fans to boxes is to be as above but rectangular duct take-offs are to be double side straight taper type with a take-off length equal to 0.5 times the branch duct width but minimum 150 mm (6") length, and the double taper side is to have an included angle of minimum 60°.

- .4 **Duct Routing and Dimensions:** Confirm the routing of all ductwork at the site and site measure ductwork prior to fabrication. Note that duct dimensions may be revised to suit site routing and building element requirements, if dimension revisions are reviewed with and approved by the Consultant. Duct routing and/or dimension revisions to suit conditions at the site are not grounds for a claim for an extra cost.
- .5 **Ducts Run Within or Through OWSJ:** Refer to structural drawings. Where ductwork is to be run within or through open web steel joists, note that ductwork shown on the mechanical drawings is schematic only and is to be altered as required to suit the steel joist configuration, spacing, panel points, and cross-bridging at no additional cost.
- .6 **Ductwork Located at Sprayed Fireproofing:** Wherever ductwork is required at locations where sprayed fireproofing is applied to building construction, install the ductwork only after the fireproofing work is complete and do not compromise the fire rating of the sprayed fireproofing.
- .7 **Automatic Control Components:** Install (but do not connect) all duct system mounted automatic control components supplied as part of the automatic control work.
- .8 **Heat Transfer Equipment Connections:** Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.
- .9 **Separate Hot Water Reheat Coils:** Flange connect ductwork to hot water reheat coils in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. The coils will be suspended independent of connecting ductwork as part of the heat transfer work.
- .10 **Rectangular Duct Support Inside Building:** Support horizontal rectangular ducts inside the building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but use trapeze hangers with, unless otherwise specified, galvanized steel channels, and galvanized steel hanger rods for all ducts that are exposed, and all concealed ducts wider than 500 mm (20").
- .11 **Round and Flat Oval Duct Support Inside Building:** Support round and flat oval ducts inside the building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but, unless otherwise specified, for both uninsulated and insulated ducts exposed in finished areas, use bands and secure at the top of the duct to a hanger rod, all similar to Ductmate Canada Ltd. type "BA". If the duct is insulated, size the strap to suit the diameter of the insulated duct.
- .12 **Flanged Duct Joints:** Where flanged duct joints are used, do not locate the joints in wall or slab openings, or immediately at wall or slab openings. **Do not use flanged joints for exposed uninsulated ducts in finished areas.**
- .13 **Support of Roof Mounted Ducts:** As specified in the mechanical work Section entitled Duct System Dampers and Accessories.
- .14 **Watertight Ductwork:** Where watertight horizontal ductwork is required, construct the ducts without bottom longitudinal seams. Solder or weld the joints of bottom and side sheets. Seal all other joints with duct sealer. Slope horizontal duct to hoods, risers, or drain points. Provide the drain points. Provide watertight ductwork for:
 - .1 all galvanized steel ductwork outside the building or otherwise exposed to the elements;

- .2 fresh air intakes;
- .3 wherever else shown.

.15 Leakage Testing:

- .1 Leakage testing is to be performed by the Testing, Adjusting and Balancing Agency in accordance with the SMACNA HVAC Air Duct Leakage Test Manual and is to be witnessed by the Consultant.
 - .2 Ductwork leakage is not to exceed one percent of the total air quantity handled by the respective fans.
 - .3 Leakage test the following ductwork:
 - .1 All supply, exhaust and return air duct systems 25' (7.5 m) and longer;
 - .2 Other ductwork as required.
 - .4 Be responsible for the following:
 - .1 Preparing duct systems for leakage testing prior to installation of external insulation including capping duct runouts and provision of final tap-in for test equipment;
 - .2 Schedule testing with TAB agency in advance and ensure notice is given to Consultant so that they may witness testing. Be present for all testing;
 - .3 Resealing and/or replacement of defective ductwork;
 - .4 Bearing all costs associated with retesting ductwork which has failed to pass leakage testing.
- .16 Application of Sealants:** Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of the sealant.
- .17 Protective Coating for Exposed Exterior Ducts:** Clean exterior exposed (uninsulated) ducts with a heavy full coverage of Bakor #410-02 black metal paint.
- .18 Connection of Dissimilar Metal Ducts:** Where dissimilar metal ducts are to be connected, isolate the ducts by means of flexible duct connection material as specified in the Section entitled Duct System Dampers and Accessories.

3.2 Duct System Protection, Cleaning and Start-Up

- .1 Clean all new ductwork to meet the requirements of the NADCA ACR Standard.
- .2 Temporarily cover all open ends of ducts during construction.
- .3 Vacuum all dirt and foreign matter from the entire duct systems and clean duct system terminals and the interior of air handling units prior to operating fans.
- .4 Prior to starting any supply air handling system provide 50 mm (2") thick glass fibre construction filters at fan equipment in place of permanent filters.

- .5 Provide cheesecloth over all duct system inlets and outlets and run the system for twenty-four hours, after which remove the cheesecloth, the construction filters, and install new permanent filters.
- .6 Include all labour for a complete site walk-through with testing and balancing personnel following the route of all duct systems to be tested, adjusted and balanced for the purpose of confirming the proper position and attitude of dampers, the location of pitot tube openings, and any other work affecting the testing and balancing procedures. Perform all corrective work required as a result of this walk-through.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section. Shop drawings and product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.
- .2 **Colour Chart(s):** Submit manufacturer's colour chart(s) for all items for which a finish colour is to be selected.

PART 2 - PRODUCTS

2.1 Round to Rectangular Duct Connections

- .1 Equal to Flexmaster Canada Ltd. galvanized steel, flared, flanged or notched "SPIN-IN" round duct take-off collars with locking dampers in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.2 Air Turning Vanes

- .1 For square elbows - multiple-radius turning vanes, interconnected with bars, adequately reinforced to suit the pressure and velocity of the system, constructed of the same material as the duct they are associated with, and in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .2 For short branch ducts at grille and diffuser connections - air extractor type, each equipped with a matching bottom operated 90 degree opposed blade volume control damper, constructed of the same material as the duct it is associated with and in accordance with requirements and details in ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.3 Manual Balancing (Volume) Dampers

- .1 Flanged and drilled, single or parallel blade (depending on damper size) manual balancing dampers, each constructed of the same material as the connecting ductwork unless otherwise specified, each designed to maintain the internal free area of the connecting duct, and each complete with:
 - .1 a hexagonal or square shaft extension through the frame;
 - .2 non-stick, non-corrosive synthetic bearings for rectangular dampers, flange stainless steel bearings for round dampers;
 - .3 blade stops for single blade dampers, designed to prevent the blade from moving more than 90°;
 - .4 linkage for multiple blade dampers;
 - .5 a locking hand quadrant damper operator with, for insulated ducts 50 mm standoff mounting.
- .2 **Rectangular Dampers:** Nailor Industries Inc. #SP1010 FF 16G LC BS NS, maximum size 1.2 m x 1.2 m (4' x 4') for a single damper.

- .3 **Round Dampers:** Nailor Industries Inc. #1090 BS, maximum 600 mm (24") diameter, equipped with a minimum 200 mm (8") deep frame, and blade stiffeners where required.
- .4 **Multiple Rectangular Damper Section Assembly:** Rectangular assembly supplied with the dampers or site constructed, of the same material as the damper and designed for tight and secure mounting of the individual dampers.
- .5 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 T.A. Morrison & Co. Inc. "TAMCO";
 - .3 NCA Manufacturing Ltd.;
 - .4 Greenheck Fan Corp.;
 - .5 Ruskin Co.;
 - .6 Ventex.

2.4 Fusible Link Dampers

- .1 Curtain blade type, dynamic, galvanized steel (unless otherwise specified) fusible link dampers, ULC classified to Standard CAN/ULC-S112 and in accordance with NFPA 90A requirements, factory tested for closure under airflow, 1 1/2 hour or 3 hour rated as required, and complete with a constant force type 301 stainless steel closure spring, a blade lock assembly, a steel sleeve, retaining angles, and, unless otherwise specified, a 100°C (212°F) rated standard fusible link.
- .2 Fusible link dampers are to be Type "B" or Type "C" (as required) with the folded curtain blade out of the air stream except where damper size or location requires the use of type "A" dampers with the curtain blade in the air stream.
- .3 Fusible link dampers in ductwork other than galvanized steel are to be as specified above but constructed of Type 316 stainless steel.
- .4 Acceptable fusible link damper manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 Greenheck Fan Corp.;
 - .3 NCA Manufacturing Ltd.;
 - .4 Ruskin Co.;
 - .5 Ventex.

2.5 Duct Access Doors

- .1 In accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, with sizes suitable in all respects for the purpose for which they are provided, and, unless otherwise specified, constructed of the same material as the duct they are associated with.

2.6 Ductwork Drain Points

- .1 Equal to Ductmate Canada Ltd. "DUCTMATE MOISTURE DRAIN", 20 mm ($\frac{3}{4}$ ") diameter moisture drains with galvanized sheet metal funnel, and chrome plated brass threaded drain, nut and cap.

PART 3 - EXECUTION

3.1 Installation of Round to Rectangular Duct Connections

- .1 Cut round holes in rectangular ducts and provide round to rectangular lock-in fittings with dampers for connection of flexible round ductwork.

3.2 Installation of Turning Vanes

- .1 Provide turning vanes in ductwork elbows where shown on the drawings and wherever else required where, due to site installation routing and duct elbow radius, turning vanes are recommended in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .2 Provide volume extractor type turning vanes in short branch supply duct connections off mains to grilles and diffusers where shown and/or specified.

3.3 Installation of Manual Balancing (Volume) Dampers

- .1 Provide manual balancing dampers in all open end ductwork, in all duct mains, and wherever else shown and/or specified.
- .2 Install the dampers so that the operating mechanism is accessible and positioned for easy operation, and so that the dampers cannot move or rattle. Ensure that operating mechanisms for dampers in insulated ducts are complete with stand-off mounting brackets.
- .3 Where a duct for which a balancing damper is required has dimensions larger than the dimensions of the maximum size volume damper available, provide multiple dampers bolted together in a properly sized assembly, or bolted to a heavy-gauge black structural steel angle or channel framework which is properly sized. Seal to prevent air by-pass, and provide connecting linkage.
- .4 Confirm exact damper locations with personnel doing air quantity balancing testing work and install dampers to suit. Include for providing five additional dampers at no additional cost.

3.4 Installation of Fusible Link Dampers

- .1 Provide fusible link dampers where shown and/or specified on the drawings. Ensure that the damper rating ($1\frac{1}{2}$ or 3 hr.) is suitable for the fire barrier it is associated with.
- .2 Install dampers with retaining angles on all four sides of the sleeve on both sides of the damper and connect with ductwork in accordance with the damper manufacturer's instructions and details to meet Code requirements.
- .3 Provide expansion clearance between the damper or damper sleeve and the opening in which the damper is required. Ensure that the openings are properly sized and located,

and that all voids between the damper sleeve and the opening are properly sealed to maintain the rating of the fire barrier.

- .4 Where the size of the fire barrier opening requires the use of a sectionalized fire damper assembly, provide multiple fusible link dampers (sized to CAN/ULC - S112) bolted together in a properly sized assembly or bolted to a heavy-gauge black structural steel angle or channel framework.

3.5 Installation of Duct Access Doors

- .1 Provide access doors in ductwork for access to all components which will or may need maintenance and/or repair, including reheat coils. Install in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .2 Identify access doors provided for fusible link damper maintenance with "FLD" stencil painted or marker type red lettering and ensure that the doors are properly located for damper maintenance.
- .3 When requested, submit a sample of proposed duct access doors for review.
- .4 Where sectionalized fusible link dampers and/or balancing dampers are provided in large ducts, provide a plenum type access door to suit, and adequately reinforce the ductwork to suit the access door installed.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Product Data: Submit shop product data sheets for silencers. Include all construction, acoustic and aerodynamic performance data, and details with the submission. Acoustical data is to demonstrate that duct systems with silencers will reduce mechanical fan system noise to required levels in occupied spaces.
- 1.1.2 Silencer Test Data: Submit manufacturer's test data to indicate results of factory tests on the silencers prior to shipment.
- 1.1.3 Silencer Manufacturer's Laboratory Accreditation: Submit a copy of the silencer manufacturer's National Voluntary Laboratory Accreditation Program (NVLAP) accreditation certificate for ASTM E-477 test standards.
- 1.1.4 Manufacturer's Certification Letter: Submit an installation certification letter from the manufacturer of the silencers as specified in Part 3 of this Section.

1.2 QUALITY ASSURANCE

- 1.2.1 Silencer performance must be substantiated by laboratory testing in a duct-to-reverberant room test facility according to ASTM E477, Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers.
- 1.2.2 Silencer acoustic media and any lining/wrapping material must have a maximum flame spread rating of twenty-five and a smoke developed rating of fifty when tested in accordance with CAN/ULC-S102, Surface Burning Characteristics of Building Materials, and Accessories.
- 1.2.3 Acceptable silencer manufacturers are:
 - 1.2.3.1 Kinetics Noise Control;
 - 1.2.3.2 Vibro-Acoustics Ltd.;
 - 1.2.3.3 Price Industries Ltd.;
 - 1.2.3.4 VAW Systems.

PART 2 - PRODUCTS

2.1 GENERAL RE: SILENCERS

- 2.1.1 Silencers are to be factory fabricated by the same manufacturer and are to be in accordance with the drawing schedule.

- 2.1.2 Silencer inlet and outlet dimensions are to be equal to duct sizes shown on the drawings. Unless otherwise shown or specified, transitions will not be permitted.
- 2.1.3 Silencers are to be constructed in accordance with SMACNA HVAC Duct Construction Standards, Metal, and Flexible, to suit the duct system pressure and velocity classification. Unless otherwise specified, all casing seams and joints are to be lock-formed and sealed or stitch welded and sealed, and silencers are to be constructed so as not to fail when subjected to an internal static pressure of 3.9 kPa (8" wg).
- 2.1.4 All perforated steel is to be adequately stiffened to ensure flatness and form, and all welds are to be shop painted with zinc rich paint.
- 2.1.5 Silencers are to be shipped with factory installed end caps.
- 2.1.6 Galvanized steel is to be in accordance with ASTM A653.

2.2 OUTER CASING MATERIALS

- 2.2.1 Rectangular Straight and Transitional Straight Silencers: Minimum #22 gauge lock forming quality galvanized steel.
- 2.2.2 Elbow and Transitional Elbow Silencers: Minimum #18 gauge for elbow lock forming quality galvanized steel.
- 2.2.3 High Transmission Loss (HTL) Rectangular and Elbow Silencers: # 16 or #10 gauge stitch-welded and caulked galvanized steel in accordance with drawing schedule.
- 2.2.4 Circular Silencers: Lock forming quality galvanized steel with minimum gauges as follows:
 - 2.2.4.1 300 mm to 660 mm (12" to 26") diameter - #22 gauge;
 - 2.2.4.2 675 mm to 1.52 m (27" to 60") diameter - #18 gauge;
 - 2.2.4.3 1.55 m to 2.13 m (61" to 84") diameter - #16 gauge.

2.3 INTERIOR BAFFLE-LINER-BULLET MATERIAL

- 2.3.1 Minimum #22 gauge lock forming quality galvanized steel.

2.4 INTERIOR BAFFLE TRANSITION

- 2.4.1 Transitioning for interior transition silencers is to occur internal to the silencer such that the height of the air passage is uniformly changing with the length of the air passage.

2.5 ACOUSTIC MEDIA MATERIAL

- 2.5.1 Except for no media silencers, and unless otherwise specified, inert, inorganic glass fibre of a density to obtain the specified acoustic performance, packed under not less than 5% compression to eliminate voids due to vibration and settling.
- 2.5.2 No media silencers are not to contain absorptive media of any kind, achieve attenuation with controlled impedance membranes and broadly tuned resonators.
- 2.5.3 No media silencers are not to contain absorptive media of any kind, achieve attenuation with controlled impedance membranes and broadly tuned resonators.

2.6 HIGH TRANSMISSION LOSS CASINGS

- 2.6.1 High transmission loss casings for silencers as scheduled are to be externally shop applied, and completely sealed to the silencer casing. The HTL walls are to consist of media, air space, mass, and an outer protective metal skin as required to obtain room noise criteria.

PART 3 - EXECUTION

3.1 INSTALLATION OF SILENCERS

- 3.1.1 Provide silencers where shown and as scheduled. Ensure that silencers are installed with airflow arrows in the direction of airflow.
- 3.1.2 Support each silencer independent of connecting ductwork.
- 3.1.3 Properly layout ductwork for silencer locations to provide a minimum of five diameters of straight duct upstream of the silencer and ten diameters of straight duct downstream of the silencer.
- 3.1.4 Unless otherwise specified, do not install silencers in walls or slabs.
- 3.1.5 Seal all silencer connections to ducts with proper fire/smoke rated duct sealer.
- 3.1.6 When silencer installations are complete, arrange, and pay for the silencer manufacturer to examine the silencer installations. Do any corrective work required by the manufacturer, then obtain from the manufacturer and submit a signed letter certifying proper installation and operation of all silencers.

END OF SECTION

PART 1 - GENERAL

1.1 SUMMARY

1.1.1 Section Includes:

- 1.1.1.1 Fans, motors, accessories and hardware for commercial use.
- 1.1.1.2 Sustainable requirements for construction and verification.

1.1.2 Related Sections:

- 1.1.2.1 Division 1 – General Requirements.
- 1.1.2.2 Section 20 05 05 - Common Work Results for Mechanical.

1.2 QUALITY ASSURANCE

1.2.1 Comply with the latest edition of the following Codes and Standards.

1.2.2 Air Conditioning and Mechanical Contractors (AMCA)

- 1.2.2.1 AMCA Publication 99, Standards Handbook.
- 1.2.2.2 AMCA 300, Reverberant Room Method for Sound Testing of Fans.
- 1.2.2.3 AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

1.2.3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

- 1.2.3.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

1.2.4 Canadian General Standards Board (CGSB)

- 1.2.4.1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.

1.2.5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

- 1.2.5.1 Material Safety Data Sheets (MSDS).

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements:

- 1.3.1.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.
- 1.3.1.2 Capacity: flow rate, total static pressure, bhp W, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
- 1.3.1.3 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.
- 1.3.1.4 Sound ratings: comply with AMCA 301, tested to AMCA 300. Supply unit with AMCA certified sound rating seal.
- 1.3.1.5 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210. Supply unit with AMCA certified rating seal, except for propeller fans smaller than 12" (300 mm) diameter.

1.4 SUBMITTALS

- 1.4.1 **Product Data:** Submit manufacturer's printed product literature, specifications and datasheets. Include product characteristics, performance criteria, and limitations.
- 1.4.2 Provide:
 - 1.4.2.1 Fan performance curves showing point of operation, BHP kW and efficiency.
 - 1.4.2.2 Sound rating data at point of operation.
- 1.4.3 Indicate:
 - 1.4.3.1 Motors, sheaves, bearings, shaft details.
 - 1.4.3.2 Minimum performance achievable with variable speed controllers and variable inlet vanes as appropriate.
- 1.4.4 **Quality assurance submittals:** Submit following in accordance with Division 1 - General Requirements.
 - 1.4.4.1 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.4.4.2 Instructions: Submit manufacturer's installation instructions.
- 2.4.4.2.1 Contractor shall make available one (1) copy of systems supplier's installation instructions.

PART 2- PRODUCTS

2.1 FANS GENERAL

- 2.1.1 Space allocation, motor sizes, base details, connection arrangements and performance based on fan equipment by manufacturers as shown in schedules.
- 2.1.2 Fans:
 - 2.1.2.1 Labelled with Air Performance, or Sound and Air Performance AMCA Certified Rating Seals
 - 2.1.2.2 Of same manufacturer for similar applications, but may be chosen from other manufacturers' product lines for other different applications.
- 2.1.3 Motors:
 - 2.1.3.1 In accordance with Section 20 05 10 supplemented as specified herein.
 - 2.1.3.2 For use with variable speed controllers.
 - 2.1.3.3 Sizes as specified in schedule.
- 2.1.4 **Accessories and hardware:** matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards fan inlet and or outlet safety screens as indicated and as specified in Section 20 05 10, inlet outlet dampers and vanes and as indicated.
- 2.1.5 Factory primed before assembly in colour standard to manufacturer.
- 2.1.6 Fans serving outside air requires protective coating on wheels and internal casing. Apply ADSIL coating.
- 2.1.7 Scroll casing drains: as indicated.
- 2.1.8 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.
- 2.1.9 **Vibration isolation:** to Section 20 05 20 – Mechanical Vibration Control.
- 2.1.10 **Flexible connections:** to Section 23 33 00 – Duct Accessories & Dampers.
- 2.1.11 Acceptable manufacturers are:
 - 2.1.11.1 Greenhack Fan Corp.;

- 2.1.11.2 Loren Cook Co.;
- 2.1.11.3 Twin City Fan and Blower;
- 2.1.11.4 CML Northern Blower;
- 2.1.11.5 PennBarry Blower;
- 2.1.11.6 Carnes Company Inc.;
- 2.1.11.7 Woods;
- 2.1.11.8 Chicago Blower.

2.2 CENTRIFUGAL FANS

2.2.1 Fan wheels:

- 2.2.1.1 Welded steel or aluminum construction as indicated.
- 2.2.1.2 Maximum operating speed of centrifugal fans not more than 40 % of first critical speed.
- 2.2.1.3 Air foil, forward curved or backward inclined blades, as indicated.

2.2.2 Bearings: heavy duty grease lubricated ball or roller self aligning type with oil retaining, dust excluding seals and a certified minimum rated life of 100,000 hours.

2.2.3 Housings:

- 2.2.3.1 Volute with inlet cones: fabricated steel for wheels 300 mm or greater, steel, or aluminum as indicated, for smaller wheels, braced, and with welded supports.
- 2.2.3.2 For horizontally and vertically split housings provide flanges on each section for bolting together, with gaskets of non-oxidizing non-flammable material.
- 2.2.3.3 Provide latched airtight access doors with handles.

2.2.4 Variable volume control devices:

- 2.2.4.1 Mounted by fan manufacturer.
- 2.2.4.2 Adjustable inlet vanes: operated from a centre mechanism linked to each damper vane. Support each vane at ends in bronze bearings. On DWDI interconnect vanes to operate in unison. Provide locking devices for manual operation.
- 2.2.4.3 Variable Frequency Drives: refer to Section 20 05 30.

2.2.5 Provide electric motors, disconnect switches (on roof mounted units), vibration isolators (refer to Section 20 05 20), belts, belt guards, weatherhoods where mounted outdoors and back draft dampers on exhaust fans.

2.2.6 Provide integral bases on floor mounted Class I and Class II fans. Refer to Section 20 05 20 for requirements for inertia bases.

2.2.7 Sheaves and Belts:

- 2.2.7.1 Provide variable pitch sheaves on fans up to and including 3.7 KW (5 HP) and fixed pitch double belt sheaves on fans up to 7.47 KW (10 HP). For fans 11.2 KW (15 HP) and greater, provide a minimum of three groove fixed sheaves. Provide two sets of sheaves; one set to provide specified RPM and another set as specified by the air balance firm should field testing make this necessary.
- 2.2.7.2 Provide premium quality oil resistant B or C section V belts. For fans 11.2 (15 HP) and greater, provide multi groove power band belts.
- 2.2.7.3 Submit sheave and belt selection data with shop drawings.

2.2.8 Belt Guards: Provide expanded metal type with 25mm (1") dia. tachometer openings at both fan and motor shaft locations. Provide one opening with adjustable plate to compensate for motor position adjustment.

PART 3- EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

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

3.2 FAN INSTALLATION

- 3.2.1 Comply with manufacturers requirements. Ensure vibration free installation. Leave access for servicing. Install belt guards and weatherproof covers as required.
- 3.2.2 Install fans as indicated, complete with resilient mountings specified in Section 20 05 20 – Mechanical Vibration Control, flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Duct Accessories & Dampers.
- 3.2.3 Provide sheaves and belts required for final air balance.
- 3.2.4 Bearings and extension tubes to be easily accessible.
- 3.2.5 Access doors and access panels to be easily accessible.
- 3.2.6 Vane axial fans (mounted vertically or horizontally):
- 3.2.6.1 provide steel support brackets from floor or overhead with vibration isolators at centreline supports on fan Do not place isolators on floor or at overhead attachment point.
 - 3.2.6.2 Install snubbers parallel with fan horizontal longitudinal axis.

3.3 START-UP, DEMONSTRATION AND TRAINING

- 3.3.1 Refer to Section 20 05 05 - Common Work Results for Mechanical.
- 3.3.2 Include for a four-hour on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.4 CO-ORDINATION

- 3.4.1 Starter, disconnect and wiring as per the Schedule indicated on drawing.
- 3.4.2 Control wiring by Division 25.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for roof mounted exhaust fans and accessories. Shop drawings/product data sheets must confirm that the fans conform to requirements of the Contract Documents. Include the following:
 - .1 certified fan performance curves;
 - .2 product data for all accessories;
 - .3 product data for fan motors.
- .2 **Factory Inspection Report:** Submit with delivery of each unit a copy of the factory inspection report and include a copy of each report with O & M Manual project close-out data.
- .3 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.
- .4 **Roof Opening Coordination:** Supply reviewed copies of fan/curb assembly shop drawings or product data to the trade who will cut the roof openings for the fans and ensure that the openings are properly located.

1.2 Quality Assurance

- .1 Roof mounted exhaust fan manufacturers are to be current members of the Air Movement and Control Association International Inc. (AMCA), and the fans are to be rated (capacity and sound performance) and certified in accordance with requirements of the following standards:
 - .1 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - .3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;
 - .4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;
 - .5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.

PART 2 - PRODUCTS

2.1 Roof Mounted Exhaust Fans

- .1 Centrifugal, ULC listed, factory run tested roof mounted exhaust fans as per the drawing schedule.
- .2 **Curb Cap and Housing:** Spun aluminium with deep venturi inlet, aluminium curb cap

with continuously welded corners, pre-punched mounting holes, galvanized steel or aluminium bird screen, and EMT conduit chase to the motor compartment.

- .3 **Fan Wheel:** Centrifugal, non-overloading aluminum wheel with backward inclined blades matched to the inlet venturi, statically and dynamically balanced as an assembly.
- .4 **Fan Shaft, Bearings and Drive:** For belt-drive fans only, hot rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.25 times the maximum rated speed for the fan, and one-piece grease lubricated pillow block type bearings selected for an AFBMA L-50 minimum average life in excess of 500,000 hours at maximum catalogue operating speed and equipped with a lubrication fitting, and a heavy-gauge galvanized steel adjustable V-belt drive with guard conforming to requirements of the mechanical work Section entitled Basic Mechanical Materials and Methods.
- .5 **Motor and Disconnect Switch:** Motors are to conform to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods, mounted on vibration isolation in a compartment outside of the airstream, and factory prewired to a NEMA 4 disconnect switch.
- .6 **Roof Mounting Curb:** Prefabricated, minimum 300 mm (12") high heavy-duty aluminum roof mounting curb with factory installed wood nailer, 40 mm (1½") thick insulation, continuously welded seams, and damper tray.
- .7 **Accessories:** For fans as scheduled, factory supplied accessories as follows:
 - .1 a gravity backdraft damper with #20 gauge galvanized steel frame and #26 gauge aluminum blades with felt edge blade seals;
 - .2 a non-corrosive motorized damper with linkage, end switch, and motor with voltage to match the fan motor;
 - .3 a continuous non-corrosive piano type curb hinge to permit access to the fan, damper and connecting duct, complete with retaining chain and a security hasp to prevent removal of the unit from the curb cap and prevent building entry through connecting ductwork;
 - .4 a 2-speed switch and 2-speed double winding single phase motor in accordance with the mechanical work Section entitled Basic Mechanical Materials and Methods;
 - .5 factory secured seismic restraint connection hardware.
- .8 **Acceptable Manufacturers:** Acceptable roof mounted exhaust fan manufacturers are:
 - .1 Twin City Fan and Blower;
 - .2 Loren Cook Co.;
 - .3 Greenheck Fan Corp.;
 - .4 Jenco Fan;
 - .5 Carnes Company Inc.

.6 Penn Berry

PART 3 - EXECUTION

3.1 Installation of Roof Mounted Exhaust Fans

- .1 Provide roof mounted exhaust fans where shown.
- .2 Supply a roof mounting curb with each fan and hand the curbs to the roofing trade on the roof for mounting and flashing into roof construction as part of the roofing work. Secure fans in place on the curbs.
- .3 Install dampers in the curb damper tray and secure in place.
- .4 Brace and secure each unit in accordance with requirements specified in the mechanical work Section entitled Seismic Control and Restraint.
- .5 **Equipment and System Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- .6 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- .7 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a four hour on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

~~**SPECNOTE:** THIS MASTER SPECIFIES UNHEATED, NON-RECIRCULATING, STAINLESS STEEL CONSTRUCTION INDUSTRIAL AIR CURTAINS SUCH AS BERNER INTERNATIONAL FOR INSTALLATION OVER OR BESIDE MOTORIZED TYPE EXTERIOR DOORS FROM 10' TO 30' WIDE.~~

~~**SPECNOTE:** ENSURE AIR CURTAINS ARE SCHEDULED ON DRAWINGS, AND LOCATIONS AND MOUNTING ARRANGEMENTS ARE COORDINATED WITH STRUCTURAL DESIGNER.~~

~~**SPECNOTE:** ENSURE ELECT. DESIGNER KNOWS THAT EACH AIR CURTAIN IS COMPLETE WITH A WALL MOUNTING POWER AND CONTROL PANEL WITH DISCONNECT SWITCH AND REQUIRES ONLY A POWER CONNECTION. SHOW AIR CURTAIN POWER AND CONTROL PANELS ADJACENT TO DOOR CONTROL PANELS. A CONTROL CONNECTION TO DOOR CONTROL PANEL TO ACTIVATE AIR CURTAIN WHEN DOOR OPENS, AND SHUT-DOWN AIR CURTAIN WHEN DOOR CLOSES IS TO BE DONE AS PART OF THE MECHANICAL WORK.~~

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for air curtains. Include following:
 - .1 certified fan performance curves;
 - .2 product data for fan motors;
 - .3 mounting details to suit locations shown, indicating methods and hardware to be used;
 - .4 control wiring schematic.
- .2 Submit with delivery of each unit a copy of the factory inspection report, and include a copy of each report with O & M Manual project close-out data.
- .3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.
- .4 Submit a signed copy of manufacturer's extended 5 year parts and labour warranty.

1.2 Quality Assurance

- .1 Air Curtain manufacturers are to be current members of Air Movement and Control Association International Inc. (AMCA), and fans are to be rated (capacity and sound performance) and certified in accordance with requirements of following standards:
 - .1 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - .3 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.

PART 2 - PRODUCTS

2.1 Air Curtains

- .1 ~~Berner International Corp.~~ CSA certified factory assembled air curtains in accordance with drawing schedule, each factory performance tested and certified and of sufficient structural strength to be supported from the ends without deflection or intermediate support.
- .2 Cabinet constructed of welded stainless steel suitable for vertical or horizontal wall mounting or horizontal suspension and complete with removable panels for access to interior components, perforated stainless steel air intake with stainless steel filter and frame, and required stainless steel mounting accessories for mounting as indicated.
- .3 Stainless steel discharge nozzle to facilitate uniform velocity across width of door, complete with minimum 65 mm (2-½") wide aperture and airfoil shaped, adjustable, aluminium extrusion deflection vanes.
- .4 Non-overloading double width and inlet galvanized steel wheel with forward curved blades and galvanized steel housing complete with aerodynamically formed inlet venturi and statically and dynamically balanced as an assembly. Each wheel is to be driven through a flexible coupling and is to be supported by 2 permanently lubricated sealed ball type bearings encased in vibration isolating rubber cartridges.
- .5 TEFC motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods and direct connected to fan wheel.
- .6 Factory pre-wired power and control panel, air curtain mounted or supplied loose for field mounting as shown, complete with a NEMA 4 oil and dust tight enclosure with gasketed door, lockable unfused disconnect switch, motor starter, motor overloads, 24 volt secondary control transformer, power and control wiring terminal strip, adjustable time delay relay (0.1 second to 10 hours delay) factory set at 1 minute unless otherwise specified, and a H-O-A switch to permit manual on/off operation of air curtain or automatic on/off operation controlled by a door switch.

~~**SPECNOTE:** USE FOLLOWING PARAGRAPH IF AIR CURTAINS ARE TO BE CONNECTED TO BAS AND IF SO, ENSURE DRAWINGS INDICATE CONTROL INTERFACE/POINTS LIST REQUIREMENTS.~~

- .7 Dry contacts and any other required hardware in control panel for building automation system interface in accordance with drawings.

~~**SPECNOTE:** USE FOLLOWING PARAGRAPH FOR PROJECTS WHERE SEISMIC RESTRAINT IS REQUIRED.~~

- .8 Factory secured seismic restraint connection hardware.

~~.8.9 To be controlled with door contact~~

~~.9.10 Acceptable manufacturers are:~~

~~.1 Powered Aire~~

~~.2 Berner International Corp.;~~

- ~~2.3~~ Mars Air Systems Co.;
- ~~3.4~~ Biddle Climate Solutions;
- ~~4.5~~ Enershield Air Barriers;
- ~~5.6~~ Powered Aire Inc.

PART 3 - EXECUTION

3.1 Installation of Air Curtains

- .1 Provide air curtains at exterior doors.
- .2 Secure each air curtain in place from structure, as close as practicable to door entrance, square, level and plumb, using mounting hardware supplied, in accordance with requirements of reviewed shop drawings/product data and air curtain manufacturer's instructions. Provide any supplementary structural steel required.

~~SPECNOTE: USE FOLLOWING PARAGRAPH FOR PROJECTS WHERE SEISMIC RESTRAINT IS REQUIRED.~~

- .3 Brace and secure each unit in accordance with requirements specified in Section entitled Seismic Control and Restraint.
- .4 Take into account clearances required for door maintenance.
- .5 Wall mount control panel adjacent to door control panel. Provide interlock wiring between door switch dry contacts of the door panel and the air curtain panel such that air curtain operates when door opens, and shuts down when door closes. Interlock wiring is to be installed in conduit in accordance with wiring requirements of electrical work.
- .6 Adjust air curtain nozzles as required so air is directed, unobstructed, towards door opening.
- .7 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .8 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .9 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for air terminals. Shop drawings/product data sheets must confirm that the proposed air terminals conform to requirements of the Contract Documents. Include the following:
 - .1 capacity and pressure drop;
 - .2 sound power data to verify conformance with specified sound power levels;
 - .3 leakage and dimensions;
 - .4 mounting details to suit locations shown, indicating methods and hardware to be used;
 - .5 control components and a control wiring schematic.
- .2 **Test Report:** Submit with shop drawings/product data, a test report in accordance with ANSI/AMCA Standard 210 requirements and ISO 3741, published test data on DIN (Direct Internal Noise) made by an independent testing agency for 2.5 and 6 m/s (8.2 and 19.7 ft/min) branch velocity or inlet velocity, sound power levels with a minimum inlet pressure of 0.25 kPa (0.036 psi) as per ISO 3741 for the second through seventh octave bands, and confirmation that pressure loss through a silencer will not exceed 60% of inlet velocity pressure maximum.
- .3 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Air terminals manufacturers are to be current members of the Air-Conditioning, Heating and Refrigeration Institute (AHRI), and the terminals are to be in accordance with requirements of the following standards:
 - .1 AHRI Standard 880, Performance Rating for Air Terminals;
 - .2 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .3 International Organization of Standardization (ISO) Standard IS) 3741, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure-Precision Methods for Reverberation Rooms.
- .2 Equip boxes with factory secured seismic restraint connection hardware as applied. Coordinate with structural drawings.
- .3 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
- .4 Alternate manufacturers are (to be reviewed and approved by UHN):
 - .1 MetalAire;

- .2 Titus;
- .3 Nailor Industries Inc.;
- .4 Krueger Division of Air System Components Inc.

PART 2 - PRODUCTS

2.1 Variable Air Volume Terminal Boxes

- .1 Single duct, controller type, pressure independent variable air volume boxes as per the drawing schedule and/or the floor plans, each individually field adjustable to minimum and maximum air volumes. Terminal box sound power levels with an attenuator or lined discharge duct in place are not to exceed sound power levels, in decibels, of 61, 53, 48, 44, 42 and 41 in octave bands 2 to 7 respectively at specified air quantities and 370 kPa (55 psi) entering static pressure. Each box is to be complete with:
 - .1 **housing:** #22 gauge galvanized steel, sealed and gasketed, internally lined with hospital grade 25 mm (1") thick fibre free foam insulation meeting NFPA 90A and CAN/ULC-S102 flame spread and smoke developed requirements, and complete with:
 - .1 exposed cut edges of the liner material factory coated with NFPA 90A and CAN/ULC-S102 approved sealant;
 - .2 a 50 mm (2") long, round inlet duct connection;
 - .3 a rectangular discharge opening with slip and drive cleat duct connection facilities;
 - .4 a protective galvanized steel shroud for the controller and damper actuator .
 - .2 **air valve damper:** normally open, galvanized steel blade with peripheral gasket, pivoting in self-lubricating bearings and with air leakage past a closed damper of 2% or less of rated capacity at 750 Pa (3" wc) inlet static pressure;
 - .3 **air flow sensor:** located at the box inlet, complete with gauge taps, multiple pressure sensing ports, and an averaging chamber designed to accurately average the flow across the inlet of the box with an accuracy of within 5% with a 90° sheet metal elbow located directly at the inlet, and amplify the sensed air flow signal;
 - .4 **controller/actuator:** supplied as part of the controls work specified in mechanical work Automatic Controls Section, shipped to the box manufacturer's plant by the controls supplier, and factory installed, connected, tested, calibrated and set by the box manufacturer;

- .5 factory tested hot water reheat coils integrated to the box in accordance with drawing schedule, each complete with copper tubes mechanically expanded into plate type aluminium fins, factory mounted in an enclosure insulated with foil faced insulation meeting NFPA 90A and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, and complete with a quick-opening insulated access panel sized and located for coil inspection and maintenance;
- .6 **attenuators:** galvanized steel attenuators, lined as per box housings, each factory supplied loose and with a length of 3'0";
- .2 Terminal box sound power levels with an attenuator or lined discharge duct in place are not to exceed sound power levels, in decibels, of 61, 53, 48, 44, 42 and 41 in octave bands 2 to 7 respectively at specified air quantities and 370 kPa (55 psi) entering static pressure.

2.2 Constant Volume Terminal Boxes

- .1 Single duct constant volume by-pass boxes in accordance with drawing schedule, each complete with:
 - .1 #22 gauge galvanized steel housing, sealed and gasketed, internally lined with 25 mm (1") thick glass fibre duct lining material with a neoprene coating meeting NFPA 90A and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, and complete with:
 - .1 exposed cut edges of the liner material factory coated with NFPA 90A and CAN/ULC S102 approved sealant;
 - .2 round inlet collar and a rectangular by-pass discharge collar for connection to return air ductwork;
 - .3 integral inlet and by-pass balancing dampers;
 - .4 field adjustable minimum air volume stop;
 - .5 protective galvanized steel shroud for controller and damper actuator.
 - .2 sliding gate type supply/by-pass air valve equipped with polyethylene linear bearings which slide in stainless steel tracks, and adjustable end stops;
 - .3 air valve actuator, factory installed, electronic, 24 volt, direct connected, tri-state, reversible floating actuator suitable in all respects for the application;
 - .4 galvanized steel attenuators, lined as per box housings, each factory supplied loose and with a length of 3'0";
 - .5 factory tested hot water reheat coils in accordance with drawing schedule, each integral to the box and complete with copper tubes mechanically expanded into plate type aluminium fins, factory mounted in an enclosure insulated with foil faced insulation meeting NFPA 90A and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, and complete with a quick-opening insulated access panel sized and located for coil inspection and maintenance;

PART 3 - EXECUTION

3.1 Installation of Terminal Boxes

- .1 Provide ceiling mounted terminal boxes where shown.
- .2 Secure each box in place from the structure by means of galvanized steel angles and hanger rods, independent of connecting ductwork.
- .3 Brace and secure each unit in accordance with requirements specified in the mechanical work Section entitled Seismic Control and Restraint.
- .4 Connect each box with ductwork as indicated. Provide straight inlet duct the same size as the box inlet and of a length equal to a minimum of four duct diameters. Refer to the drawing detail. Co-ordinate final box adjustments and settings with personnel doing system testing and balancing work.
- .5 **Start-Up:** Refer to the Section entitled Common Work Results for Mechanical.
- .6 **Demonstration and Training:** Refer to Section entitled Common Work Results for Mechanical. Include for a one-half day on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, and setting and adjusting controls.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for grilles and diffusers. Shop drawings/product data is to include capacity, throw and terminal velocity, noise criteria, pressure drops, and all other data to confirm that the products proposed meet all requirements of the Contract Documents.
- .2 **Damper Adjustment Keys:** Supply and hand to the Owner at Substantial Performance, a minimum of ten identified (with tags) grille/diffuser volume control damper adjustment keys.
- .3 **Colour Chart(s):** Submit manufacturer's colour chart(s) for all grilles and diffusers for which a finish colour is to be selected.

1.2 Quality Assurance

- .1 Grilles and diffusers are to be tested and performance certified to the Air-Conditioning and Refrigeration Institute Standard ARI 650, Standard for Air Outlets and Inlets.
- .2 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .3 Alternate manufacturers (to be accepted by UHN)
 - .1 MetalAire;
 - .2 Krueger Division of Air System Components Inc.;
 - .3 Titus;
 - .4 Nailor Industries Inc.

PART 2 - PRODUCTS

2.1 Grilles and Diffusers

- .1 Grilles and diffusers of the type, size, capacity, finish, and arrangement as shown on the drawings and as per the drawing schedule, each equipped with all required mounting and connection accessories to suit the mounting location and application.
 - .1 **mounting gasket:** roll type gasket material supplied with the units for site installation on T-bar ceiling members;

PART 3 - EXECUTION

3.1 Installation of Grilles and Diffusers

- .1 Provide grilles and diffusers where shown on the drawings. Wherever possible, grilles and diffusers are to be the product of one manufacturer.

- .2 Unless otherwise specified connect grilles and diffusers in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .3 Exactly locate grilles and diffusers to conform to the final architectural reflected ceiling plans and detailed wall elevations, and to conform to the final lighting arrangement, ceiling layout, ornamental and other wall treatment.
- .4 Equip supply diffusers having a basic four-way or all round air pattern for operation in one, two, or three way pattern where indicated on the drawings.
- .5 Attach troffer type diffusers associated with typical ceiling mounted fluorescent lighting fixtures to the fixtures on the floor prior to fixture installation in the ceiling. When fixtures are installed, connect diffuser boots with flexible ductwork.
- .6 Provide sheet metal plenums, constructed of the same material as the connecting duct, for linear grilles and/or diffusers where shown. Construct and install the plenums in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible. Where individual sections of linear grilles or diffusers are not equipped with a volume control device, equip the duct connection collar(s) with volume control device(s).
- .7 Where linear type diffusers/grilles are installed in suspended T-bar ceilings, clip the diffusers/grilles in place using clip supplied by the diffuser/grille manufacturer.
- ~~.7.8~~ All linear grilles to be coordinated with the finish and include for concealed mudding frame on the drywall ceiling.
- ~~.8.9~~ Confirm grille and diffuser finishes prior to ordering.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all products specified in this Section. Shop drawings and product data sheets must confirm that the products proposed meet all requirements of the Contract Document.
- 1.1.2 Spare Filters: Prior to Substantial Performance submit a set of spare filters in original identified packaging for each air handling unit requiring filters. Store filters on the site where directed by the Consultant or Owner.

PART 2 - PRODUCTS

2.1 GENERAL

- 2.1.1 Unless otherwise specified or noted, filters are to be synthetic and/or glass fibre disposable media type in accordance with the drawing schedule(s).
- 2.1.2 Minimum Efficiency Reporting Values (MERV) ratings are to be as per ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Sizes.
- 2.1.3 Unless otherwise specified or noted, filters are to be UL/ULC Class 1 in accordance with UL Standard 900, Air Filter Units, ULC Standard ULC-S111, Standard Method of Fire Tests for Air Filter Units, and CAN/CGSB-115.10, Disposable Air Filters for Removal of Particulate Matter from Ventilation Systems.
- 2.1.4 Acceptable filter manufacturers are:
 - 2.1.4.1 AAF International;
 - 2.1.4.2 Camfil Farr Inc.;
 - 2.1.4.3 Modern Air Filter Corp.;
 - 2.1.4.4 Dafco.

2.2 HEPA FILTERS

- 2.2.1 HEPA high capacity filters as per the drawing schedule, in accordance with UL Standard 586, High-Efficiency, Particulate, Air Filter Units, 99.995% efficient on 0.12 µm particles, consisting of a continuous pleating of water-proof micro glass fibre media with pleats uniformly separated by aluminum separators, urethane sealant to encapsulate the filter pack in the minimum #16 gauge galvanized steel frame with one-piece urethane gasket or neoprene dove-tailed gasket for positive leak-free filter-to-holding mechanism seal.

2.3 FILTER FRAMING AND RACKS

- 2.3.1 Constructed of 12 and 14 GA. material, 300 Series stainless steel hardware, aluminium star knobs, tested to ASME N510, 1989, 1995 reaffirmed to ± 10 " wg, and each unit is designed for 610 mm x 610 mm x 292 mm (24" x 24" x 11-1/2") or 610 mm x 300 mm x 292 mm (24" x 12" x 11-1/2") actual sized HEPA filters and 610 mm x 610 mm x (50, 100 or 150)mm (24" x 24" x [2, 4 or 6]) or 610 mm x 300 mm x (50, 100 or 150)mm (24" x 12" x [2, 4 or 6]) nominal sized prefilters.

PART 3 - EXECUTION

3.1 INSTALLATION OF FILTERS

- 3.1.1 Provide all required filter media when fan equipment is ready for start-up and performance testing. Provide any required filter framing/racks.
- 3.1.2 Prior to Substantial Performance supply a complete spare set of filter media in original packaging and clearly identified as to the applicable system for each air handling system with filters. Store the filters at the site where directed by the Owner.

END OF SECTION

PART 1- GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for heat exchangers, including accessories. Shop drawings/product data sheets must confirm that equipment conforms to requirements of the Contract Documents.
- 1.1.2 Factory Inspection Report: Submit with delivery of each unit a copy of the factory inspection report, and include a copy of each report with O & M Manual project close-out data.
- 1.1.3 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

1.2 QUALITY ASSURANCE

- 1.2.1 Canadian Registration Number: All heat exchanger equipment is to be stamped with a Canadian Registration Number (CRN).
- 1.2.2 Codes and Standards: All heat exchangers and accessories are to be in accordance with the following:
 - 1.2.2.1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code;
 - 1.2.2.2 ASME Boiler and Pressure Vessel Code;
 - 1.2.2.3 governing Provincial and/or Municipal Codes and Regulations.

PART 2- PRODUCTS

2.1 SHELL-AND-TUBE HEAT EXCHANGERS

- 2.1.1 Horizontal, multi-pass shell-and-tube heat exchangers as per the drawing schedule, selected with a shell scale factor allowance of 0.0005 and a tube scale factor of 0.001, each factory pressure tested and complete with:
 - 2.1.1.1 shell: steel shell, 1035 kPa (150 psi) working pressure rated, with screwed or flanged inlet and outlet connections as required, and tappings for a relief valve, pressure gauge, drain valve, and vacuum breaker;
 - 2.1.1.2 head: cast iron construction unless otherwise specified or scheduled, removable, flange bolted to the shell with alloy steel bolts, complete with screwed or flanged inlet and outlet connections as required, and tappings for a drain valve and vacuum breaker;
 - 2.1.1.3 tubes: removable, return bend, 20 mm ($\frac{3}{4}$ ") seamless copper tubes unless otherwise specified or scheduled, 860 kPa (125 psi) working pressure rated, complete with brass spacers and tube supports;
 - 2.1.1.4 tube sheet: steel, unless otherwise specified or scheduled;

2.1.1.5 mounting supports: steel or cast iron saddles.

2.1.2 Acceptable manufacturers are:

2.1.2.1 Armstrong Fluid Technology;

2.1.2.2 Bell & Gossett;

2.1.2.3 Taco (Canada) Ltd.;

2.1.2.4 AIC Inc.

2.2 TSSA

2.2.1 The successful bidder is fully responsible for obtaining approval from the Authorities Having Jurisdiction, such as TSSA, for the work as detailed in this project.

2.2.2 Provide all necessary paper works as required and pay all fees as required.

2.2.3 Submit TSSA certification letters to Engineer and Owner.

PART 3- EXECUTION

3.1 INSTALLATION OF SHELL-AND-TUBE HEAT EXCHANGERS

3.1.1 Provide shell-and-tube heat exchangers where shown.

3.1.2 Secure each heater in place, level, and plumb, on a wall bracket or a floor mounted welded structural steel support assembly as indicated. Provide each support assembly and ensure that each is designed and fabricated to support the heat exchanger when full of liquid. Submit support design and fabrication drawings in shop drawing form for review.

3.1.3 Connect with piping in accordance with the drawing detail, arranged so that the tube bundle can be removed after disconnecting two unions or flanges without disturbing other equipment or systems.

3.1.4 When installation is complete and piping has been permanently filled, start-up each heat exchanger, check and test all safeties and operating controls, and set controls to design conditions.

3.1.5 Equipment and System Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.

3.1.6 Start-Up: Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.

- 3.1.7 Demonstration and Training: Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a one half day on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all custom made air handling units. Shop drawings/product data sheets must confirm that the units proposed meet all requirements of the Contract Documents. Include the following:
- 1.1.1.1 computer generated and certified fan performance curves;
 - 1.1.1.2 computer generated psychometric chart for each cooling coil;
 - 1.1.1.3 certified sound power data for discharge, radiated, and return positions by octave band;
 - 1.1.1.4 hardware for section-to-section site connections as applicable;
 - 1.1.1.5 dimensioned layouts;
 - 1.1.1.6 product data sheets for fan motors.
- 1.1.2 Colour Chart and Touch-Up Paint: Submit the manufacturer's colour chart to indicate the standard colour range of paint finishes. Supply 4 L (3.5 qt) of touch-up paint with each custom made air handling unit.
- 1.1.3 Spare Air Filters: Submit spare air filters as specified in Part 2 of this Section.
- 1.1.4 Factory Test and Inspection Report: Submit with delivery of each unit a copy of the factory test and inspection report as specified in Part 2 of this Section, and include a copy of each report with O & M Manual project close-out data.
- 1.1.5 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

1.2 QUALITY ASSURANCE

- 1.2.1 Custom made air handling equipment is to be rated (capacity, performance, efficiency and sound) and certified in accordance with requirements of the following American National Standards Institute/Air-Conditioning and Refrigeration Institute Standards, and Air Movement and Control Association International Inc. Standards:
- 1.2.1.1 AHRI 410, Forced-Circulation Air-Cooling and Air-Heating Coils;
 - 1.2.1.2 AHRI 1060, Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment;
 - 1.2.1.3 ANSI/AHRI 430, Central Station Air-Handling Units;

- 1.2.1.4 ANSI/AMCA Standard 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating;
- 1.2.1.5 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
- 1.2.1.6 AMCA Standard 311, Certified Ratings Program – Product Rating Manual for Fan Sound Performance;
- 1.2.1.7 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.
- 1.2.2 Custom made air handling equipment is also to be in accordance with requirement of the following Codes, Standards, and Regulations:
 - 1.2.2.1 CAN/CSA-C22.2 No. 236/UL 1995, Heating and Cooling Units;
 - 1.2.2.2 ANSI/ASHRAE 90.1, Energy Standard for Buildings Except Low Rise Residential Buildings;
 - 1.2.2.3 CSA or ETL certification and labelling for all electrical components;
 - 1.2.2.4 governing local Codes and Regulations.
- 1.2.3 Acceptable manufacturers are:
 - 1.2.3.1 Haakon Industries Ltd. (HTS);
 - 1.2.3.2 Ventrol (EFI Concepts);
 - 1.2.3.3 Scott Springfield;
 - 1.2.3.4 Ingenia Technologies Inc.
 - 1.2.3.41.2.3.5 AnnexAir
- 1.2.4 Acceptable components as follows:
 - 1.2.4.1 fans: Twin City Fan and Blower, Loren Cook Co., Greenheck Fan Corp., Huntair and CML Northern Blower Inc.;
 - 1.2.4.2 heat transfer coils: Aerofin Canada Services Inc., Heatcraft Inc., Ventrol and Daikin Industries Ltd.;
 - 1.2.4.3 steam humidifier: Nortec, Vapac, DriSteem;
 - 1.2.4.4 electric heating coils: Indeeco, Thermolec Manufacturing Ltd., Chromalox, and Caloritech Inc.;
 - 1.2.4.5 filters: Camfil Farr Canada Inc., AAF International, Modern Air Filter Corp.

1.2.4.6 enthalpy wheels: SG America

PART 2 - PRODUCTS

2.1 GENERAL

- 2.1.1 Provide factory assembled air handling unit in configuration as indicated on drawings. Unit shall include all specified components installed at the factory. Field fabrication of units and their components will not be accepted.
- 2.1.2 All units shall be inspected by the customer prior to shipment. Inspection shall be of unit completely assembled.
- 2.1.3 The unit shall be designed to be supported by a roof curb.
- 2.1.4 Units too large to fit on a standard tractor trailer may be shipped to site in sections. Otherwise units shall be shipped in one piece.

2.2 ROOF CURBS

- 2.2.1 Roof curbs shall be manufactured from 12 gauge galvanized steel.
- 2.2.2 A pressure treated 2 x 4 nailing strip shall be provided around the upper perimeter.
- 2.2.3 Roof curb height shall be as specified on the drawings. Manufacturer shall supply seismic restraints to secure the air handling unit to the roof curb in accordance with the Ontario Building Code.

2.3 ACOUSTICAL PERFORMANCE

- 2.3.1 The casing shall have been tested for acoustical performance by an independent laboratory that is accredited. Manufacturers shall submit sound data in compliance with the following:
- 2.3.2 Test methods and facilities used to establish sound transmission loss values shall conform explicitly with the ASTM designation E90-85 and E413-73.
- 2.3.3 Sound Transmission Loss DB ASTM E-90 & E413-73

	1	2	3	4	5	6	7	8	
2" wall	18	19	27	33	43	52	52	52	STC=37
4" wall	20	20	28	41	51	56	55	57	STC=40

- 2.3.4 Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83.

Sound Absorption ASTM C423-84A & E795-83

	1	2	3	4	5	6	7	8	
2" wall	.10	.23	.75	1.08	1.05	.99	.97	.95	STC=37
4" wall	.40	.65	1.38	1.28	1.09	1.05	1.02	1.02	STC=40

2.4 CASING

- 2.4.1 Walls and roofs shall be constructed of 1.6 mm (16 gauge) galvanized steel 100mm (4") thick acoustic thermal panels. The inner liner shall be 0.7 mm (22 gauge) solid galvanized (washdown galvanized steel). Insulation shall be 100 mm (4") thick 4.0 lb. density mineral fiber. Provide neoprene liner to seal insulation in sections with perforated panels. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 3 mm (1/8") X 9 mm (3/8") tape sealer. Wall seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.
- 2.4.2 Inner liner of walls including upstream side of a plenum fan wall, and roofs of the cooling coil and Humidifier sections shall be constructed of 0.7 mm (22 gauge) solid stainless steel.
- 2.4.3 Outdoor units shall have roof panels broken outward to provide a lapped joint watertight seal. Outdoor roofs shall be sloped a minimum of 16 mm (5/8") away from the access side.
- 2.4.4 On outdoor units, screws and other similar fastening devices shall not penetrate the roof deck or the top of standing seems.

2.5 INSULATION

- 2.5.1 All insulation used in air handling unit walls, roof and base shall have a Flame spread rating of less than 25 and a Smoke Developed rating of less than 50 per the latest version of CAN/ULC S102.
- 2.5.2 Insulation shall meet NFPA 90A and 90B.

2.6 SERVICE CORRIDOR

- 2.6.1 Supply and install a 2.4 m (96") service corridor the entire length of the supply side of the unit. The corridor shall be a minimum of 2.21 m (87") tall if it houses electrical panel boards accessed from inside the corridor. Casing construction is the same as the rest of the air handler. Factory mount, wire, and pipe the fan motor VFDs, humidifier, and enthalpy wheel VFD.
- 2.6.2 Supply ceiling mounted fluorescent marine lights with wall mounted duplex receptacles and switch with indicator light. Mount the switch outside the unit. Factory wire from switch to all lights in EMT conduit with liquid tight connections. Electric power is 120 volt/1 phase/60 hertz
- 2.6.3 Install access door to outside and inside access doors in a manner that does not interfere with the other components.

- 2.6.4 Provide an electric unit baseboard heater and thermostat sized to offset heat loss of corridor.
- 2.6.5 Provide a propeller exhaust fan and thermostat sized to ventilate the corridor at a rate of 1 CFM/Sq Ft with motorized intake damper and louver and motorized exhaust damper and louver.
- 2.6.6 Provide pipe/electrical chases thru the base including 38 mm (1½") perimeter collar to maintain watertight integrity.
- 2.6.7 As detailed on the drawings, stacked units shall be complete with full upper-level floor for service and access to the upper deck complete with ladder at the end.
- 2.6.8 Full upper-level corridor floor shall consist of removable welded bar grates spanning the entire width and length. Material shall be equal in quality to Fisher Ludlow style 1-3/16" 19-W-4 welded grates. Provide grates in sections no greater than 60 inches x 48 inches throughout the upper corridor, allowing full access for service.

2.7 STRUCTURAL BASE CONSTRUCTION

- 2.7.1 Units shall be constructed from a minimum C6x8.2 lb./sq.ft. channel structural steel perimeter base, with intermediate tubular steel supports. Perimeter structural steel base shall be designed to directly support the weight of the walls. Intermediate tubular structural steel and channel iron shall support the weight of all internal components (i.e. fans, coils, enthalpy wheels, etc.). The structural steel base shall be either I-beam construction or C-channel (not box channel) so that the base will shed all water. Base shall be provided with lifting lugs, minimum four (4) per shipping split. Formed metal bases formed from sheet metal will not be acceptable. Base shall prevent wall panel joints from separating during lifting, transportation and rigging.
- 2.7.2 Lifting lugs shall be located and engineered to properly support the loads within. Manufacturers shall provide a load point calculation along with detailed lifting lug information as part of the shop drawing package.
- 2.7.3 A 3 mm (0.12") thick aluminium checker plate floor shall be installed on the base. Floor seams shall be continuously welded providing a completely flat unit floor. Standing seams will not be accepted in any section. A 38 mm (1-1/2") perimeter collar shall be provided to ensure the unit is internally watertight. The collar shall be alternately screwed down and tack welded to the unit base on 300 mm (one (1) foot) centres. Caulk joint to be watertight.
- 2.7.4 The base shall be insulated with 75 mm (3") thick, 1-1/2 lb. density fibreglass insulation and sheeted with a 0.7mm (22 gauge) galvanized steel liner. The base liner shall be broken, tack welded and sealed for rigidity and vapour barrier integrity.

2.8 ACCESS DOORS

- 2.8.1 Access door construction and thickness shall match the rest of the unit casing. Corners shall be welded for rigidity. Spot welding of corner seams will not be accepted. 4.0 lb. density insulation shall be sandwiched between the outer and inner skins. A 254 mm (10") round, double pane tempered glass window shall be provided in each door.

2.8.2 Provide Two chrome plated "Ventlok" Model #310 high pressure latches operable from either side of the door. Hinges shall be continuous piano type stainless steel. Door openings shall be fully gasketed with continuous 12 mm (1/2") closed cell hollow round black gasket with a metal encapsulated reinforced backing that mechanically fastens to the door opening perimeter. Door frames shall be framed from 1.6 mm (16 gauge) galvanized steel with the outside of the door flush to the unit. Minimum door width shall be as shown on the plans but in no case shall an access door be less than 450 mm (18"). Door height shall be the maximum permitted by the height of the unit up to 1.8 m (72").

2.8.3 Doors shall open against positive pressure.

2.9 FANS

2.9.1 All fans shall be tested in accordance with AMCA Standards 210-70 and 310 Test Codes for Air Moving Devices. Backward inclined fans shall bear the AMCA sticker for both air and sound performance.

2.9.2 Fan Wheels and Shafts: Provide air foil blades on all fan wheels. Provide solid shafts keyed to the fan wheel. Coat fan shaft with rust inhibitor. Hollow shafts will not be acceptable.

2.9.3 Fan bearings shall be self-aligning pillow block, grease lubricated, extra heavy-duty anti-friction ball or spherical roller type selected for an L10 life of 200,000 hours at design operating conditions.

2.9.4 Fan and motor shall be mounted on an all welded, structural steel, prime coated internal isolation base. The outlet of the fan shall be separated from the unit casing by means of a factory installed flexible connection. The internally mounted motor shall be provided on a slide rail base to allow proper adjustment of belt tension.

2.9.5 Provide an OSHA approved fully enclosed metal belt guard having side of galvanized steel and expanded metal face. Belt guard shall be sized to allow either sheave to be increased by two sizes.

2.9.6 Provide fixed pitch sheaves rated at 150% of motor nameplate H.P. On air handling units with variable speed drives, mount the VSD on the unit. Factory wire between the VSD and fan motors. Ensure all casing penetrations are sealed to be air tight. Provide a terminal block within the VSD for field termination of line side wiring.

2.9.7 Provide plenum fan inlets on the fan wall and air outlets from the casing with a smooth bellmouth fitting with radius to match casing thickness, and free of protruding structural members and flanges.

2.9.8 Plenum fan assembly must have an enclosed safety screen as per OSHA Standards.

2.9.9 Provide I beam hoist rail above fan section access doors to remove motors 25hp and above. An extendable arm shall also be provided to transport the motor to the unit exterior.

2.10 MOTORS

- 2.10.1 Motors shall be designed for severe duty in accordance with IEEE 841 standards and shall meet NEMA MG1 Part 31. Motors shall be operable at 575Volts, 60 Hz, 3-phase.
- 2.10.2 Motor enclosure shall be totally enclosed fan cooled and rated to IP55. A non-metallic cooling fan shall be provided. Frame, end bells and fan cowl shall be manufactured of heavy duty cast iron. The end plates shall be sealed to the frame joints. Enclosure shall be epoxy coated and rated for ASTM B117-90 96-hour salt spray test.
- 2.10.3 Motor windings shall have class F insulation with class B temperature rise ratings. Windings shall be 200 °C inverter spike resistant wire. Motor windings shall withstand 2000V transients. Motor service factor shall be 1.15 on sine wave power and 1.0 on VFD power.
- 2.10.4 Bearings shall be re-greasable without disassembly and provide for the elimination of purged grease. Bearing life shall be a minimum of L10 at 50000 hours. Bearing seals shall be Inpro or equivalent.
- 2.10.5 Motors shall be balanced to less than 0.08 inches per second (filter out) and the vibration test data shall be shipped with the motor.
- 2.10.6 Nameplates shall be stainless steel and contain both NEMA data and bearing data.
- 2.10.7 Motors used with variable frequency drives shall be provided with a brush system to electrically ground the shaft and discharge any induced voltage on the motor shaft, with a direct path to ground.

2.11 AIRFLOW MEASURING PROBES

- 2.11.1 Provide on each fan, air flow measuring probes.
- 2.11.2 Each airflow probe shall contain multiple, averaged velocity pressure taps located symmetrically around the throat of the fan inlet and a single static pressure tap located on the fan housing. The entire airflow monitoring probe must be located outside the inlet throat as to not obstruct airflow.
- 2.11.3 The probes shall be capable of producing steady, non-pulsating signal of the velocity pressure, independent of the upstream static pressure without adversely affecting the performance of the fan. The sensing probes shall be accurate $\pm 3\%$ of actual fan airflow.

2.12 AIRFLOW DISPLAY

- 2.12.1 Provide on indicated fans a method of displaying digitally, in real time, the fans current air flow.
- 2.12.2 For interaction with a controller, the display shall output BACnet communication for each fan being monitored and be capable of outputting one (1) 0-10VDC signal.
- 2.12.3 The display shall be capable of showing the airflow of ten (10) independent fans simultaneously and communicating all connected fans through BACnet.
- 2.12.4 The controller shall incorporate two high accuracy low pressure transducers per connected fan.

2.12.5 The output signal shall be $\pm 0.5\%$ full scale accuracy.

2.12.6 The display must be watertight allowing for use in outdoor locations. If the display is not watertight it shall be enclosed in a weatherproof housing.

2.13 VIBRATION ISOLATION

2.13.1 An integral all weld steel vibration isolation base shall be provided for the fan and motor.

2.13.2 Provide open spring mounts with iso stiff springs, sound deadening pads and levelling bolts.

2.13.3 Horizontal stiffness shall be equal to vertical stiffness.

2.13.4 Spring deflection shall be 50 mm (2")

2.13.5 Isolators shall have earthquake restraints. Upon request, the unit manufacturer shall submit a restraint detail certified by a professional engineer.

2.14 COILS

2.14.1 Coils shall be fully enclosed within casing and mounted on angle frames manufactured to allow coils to be individually removed. Cooling coil racks shall be 12 Ga. 304 stainless steel. Heating coils shall be mounted on galvanized angle racks.

2.14.2 Removable coil access panels shall be provided to remove coils through casing wall. Coil covers shall be double wall construction with all exposed edges of insulation covered with sheet metal including holes through the cover for coil header stub outs. Coils shall be individually removable towards (away from) the access side.

2.14.3 All drain pans shall be double wall continuously welded 304 stainless steel. Intermediate drain pans shall be interconnected with stainless steel 1" down pipes. Condensate drain shall be a minimum 1-1/4" diameter stainless steel tube extending 1" out from unit for solder connection to trap. Drain pans shall be sloped within unit and fully drainable.

2.14.4 Coils shall be certified in accordance with ARI Standard 410.

2.14.5 Construction:

Tubes	Horizontal, copper.
Fins	Aluminium mechanically bonded to tubes.
Headers	Seamless copper with vent and drain connections.
Casing	1.6 mm (16-gauge), galvanized steel for heating coils and stainless steel for cooling coils channels with 1.6 mm (16 gauge) centre and end supports.
Connections	Same end, counterflow, with vent, drain, supply and return stubs extended to outside of unit casing with grommets for airtight casing.

2.15 ULTRAVIOLET LIGHTS

- 2.15.1 The UVGI surface irradiation system shall consist of heavy duty, factory assembled and tested light fixtures that emit short wave UVC light. Units shall be constructed and tested for HVAC environments, be suitable for operating temperatures between 32°F and 150°F, and suitable for airflow velocities up to 1000 FPM.
- 2.15.2 Unit housings shall be made of 304 stainless steel, with electrical connectors on both ends. Reflectors or approved equivalent shall be constructed of high spectral finished aluminum alloy with a minimum 85% reflectance of 254-nm UVC energy.
- 2.15.3 Emitter tube shall be of the high output, hot cathode, T5 (15mm) diameter, and medium bi-pin type or single ended four pin connectors. They shall produce 95% of their energy at 254 nm and be capable of producing the specified output at airflow velocities to 1000 fpm at temperatures of 35 - 1500 F. UVC Emitters shall produce no ozone or other secondary contamination.
- 2.15.4 Power source shall be 120 VAC 60hz.
- 2.15.5 Emitters and fixtures shall be installed downstream of the cooling coil at right angles to the coil fins, such that UVC energy bathes all surfaces of the coil and drain pan.
- 2.15.6 Access door to UVC emitters shall be provided with an interlock switch which will cut power to the emitters when the door is opened. The window in this door shall be tested for use with UV lights.

2.16 PREFILTERS

- 2.16.1 Prefilters shall be 50mm (2") medium efficiency MERV 8A, pleated, disposable type. The filter shall be listed by Underwriters Laboratories as Class 2.
- 2.16.2 Prefilters shall be installed in a prefabricated channel rack.
- 2.16.3 Prefilters shall be lift out from upstream access section.

2.17 FINAL FILTERS

- 2.17.1 Final filters shall be high performance, deep pleated 300 mm (12") long cartridge disposable type. Each filter shall consist of glass fibre media, media support grid, contour stabilizer and enclosing frame.
- 2.17.2 Final filter media shall be of high density microfine glass fibres laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of MERV 14A on the ASHRAE Test Standard 52. The filter shall be listed by Underwriters Laboratories as Class 2.
- 2.17.3 Holding frames shall be factory fabricated of 1.6 mm (16-gauge) galvanized steel and shall be equipped with gaskets and 2 heavy duty positive sealing fasteners. Each fastener shall be capable of withstanding 25 lb. pressure without deflection. They will be capable of being attached or removed without the use of tools.
- 2.17.4 Final filters shall be lift out from upstream access section.

2.18 DRAINS

- 2.18.1 Provide 1 1/4" capped floor drain connections on the side of the unit for complete drainability of the base pan for the following sections:

Fresh Air Plenums

Humidifier Sections

Service Corridors

Sections downstream of cooling coils

2.19 LIGHTS

- 2.19.1 Marine lights with LED bulbs and protective cast metal cage and glass globes complete with duplex receptacles shall be installed on the wall beside the access doors. One (1) switch with an indicator light shall be installed on the exterior of the unit. Factory wire from switch to all lights in EMT conduit with liquid tight connections. At all split sections, provide a 300 mm (one foot) long piece of flexible conduit, with the extra wire spooled, for reconnection on site by the installing contractor. Electrical power shall be 120 volt/1 phase/60 hertz.

2.20 FILTER GAUGES

- 2.20.1 Provide Dwyer 2000 magnehelic gauges.
- 2.20.2 Magnehelic gauges shall be accurate to +/- 2% of full range.
- 2.20.3 Provide sensing probes for each gauge.
- 2.20.4 Provide one gauge flush mounted into the casing for each filter bank.

2.21 UNIT MOUNTED SILENCERS

- 2.21.1 Each silencer pod shall consist of radiused noses and tails, perforated metal panels, stiffened for flatness.
- 2.21.2 Acoustic media shall be compressed and supported to minimized dusting and erosion. Mineral wool is not acceptable.
- 2.21.3 Performance and size to be as per schedule.
- 2.21.4 Silencer pods shall be full height and full width of the plenum.
- 2.21.5 Stacked duct type silencers are not acceptable.
- 2.21.6 Encapsulate the insulation with Mylar.

2.22 LOUVERS

- 2.22.1 Louver blades shall be fixed on a 45° angle. Blades shall be 100 mm (4") wide, made of extruded aluminium construction.
- 2.22.2 Bird screen shall be galvanized mesh with 12 mm x 12 mm (0.5" x 0.5") openings and shall be fixed to the rear with cadmium plated screws.
- 2.22.3 Finish shall be natural mill finish.

2.23 HOODS

- 2.23.1 Fresh air and exhaust air hoods shall be provided complete with 12 mm x 12 mm (1/2" x 1/2") bird screen and finished to match the unit. A rain gutter shall be provided on all edges of the hood. Outside air hoods shall be sized for maximum inlet velocity of 2.54 m/s (500 FPM).

2.24 ALUMINUM AIRFOIL DAMPERS

- 2.24.1 Aluminium air foil frames and blades shall be a minimum of 2.6 mm (12 gauge) extruded aluminium. Blades to be 150 mm (6") wide single air foil design.
- 2.24.2 Frames shall be extruded aluminium channel with grooved inserts for vinyl seals. Standard frames 50 mm x 100 mm x 16 mm ((2" x 4" x 5/8") on linkage side, 25 mm x 100 mm x 25 mm (1" x 4" x 1") on the other sides.
- 2.24.3 Pivot rods shall be 11 mm (7/16") hexagon extruded aluminium interlocking into blade section. Bearings to be double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into frame so that the outer bearing cannot rotate.
- 2.24.4 Bearing shall be designed so that there are no metal-to-metal or metal-to-bearing riding surfaces. Interconnecting linkage shall have a separate Celcon bearing to eliminate friction in linkage.
- 2.24.5 Blade linkage hardware is to be installed in frame out of airstream. All hardware to be on non-corrosive reinforced material or cadmium plated steel.
- 2.24.6 Damper seals shall be designed for minimum air leakage by means of overlapping seals.
- 2.24.7 OA and EA DAMPERS: Internal hollows shall be insulated with 22 mm (7/8") thick polyurethane foam with R factor of 5.0 per inch. Blades shall be 100% thermally broken. Frame shall be insulated with polystyrene, R factor of 5.0 per inch. TAMCO 9000 or equal
- 2.24.8 Damper blades shall be maximum 1 m (40") long per section.
- 2.24.9 Dampers greater than 2 sections wide shall be provided with a blade jumper
- 2.24.10 Acceptable dampers are: T.A. Morrison "TAMCO series 9000" and "RUSKIN CD-50".

2.25 TEST PORTS

- 2.25.1 Provide 12 mm (0.5") diameter test ports for unit air stream testing in each plenum section between each component within the AHU. Test ports shall have a tube that extends between the inside and outside of the unit and a screwed cap on the exterior to allow access. The test ports shall have been flanged on the exterior to allow air seal and shall be flanged on the interior to cover the penetration of the casing.

2.26 STEAM HUMIDIFIERS

- 2.26.1 Air handling unit manufacturer shall mount steam grid provided by humidifier manufacturer. Balance of steam humidifier components shall be mounted in the field by the contractor. Provide minimum absorption distance downstream of humidifier as scheduled.
- 2.26.2 Steam supply and drain connections shall be on the same side of the AHU with both pipe connections extended 150 mm (6") beyond the casing exterior wall at the factory.

2.27 ELECTRICAL

- 2.27.1 Factory wire and test all air handling units. Have units approved by CSA or ETLc.
- 2.27.2 For each AHU (air tunnel) supply one @ 575 volt/3 phase/60 hertz power connection for motors and other large electrical devices and one @ 120 volt/1 phase/60 hertz power connection for lights, controls, heaters, etc.
- 2.27.3 Provide a separate 120 volt/1 phase/60 hertz feed for the service corridor and separate 575 volt/3 phase/60 hertz feed for the corridor electric heater.
- 2.27.4 Provide necessary circuit breakers and/or fuses for each type of electric device.
- 2.27.5 A bonding wire shall be provided between the motor loads and the electrical panel. Use of the air handling unit casing for a bond will not be accepted.
- 2.27.6 Label and number code all wiring and electrical devices in accordance with the unit electrical diagram. Mount the devices in a control panel inside the unit's service enclosure or on the outside. Ensure the control panel meets the CSA or Canadian Electrical Code (CEC) standard for the specific installation.
- 2.27.7 Provide a system of motor control including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, auxiliary contactors and terminals for the connection of external control devices or relays. Individually fuse all fan and branch circuits.
- 2.27.8 Wire from the motors to the motor control in accordance with the local electrical code and contained by EMT conduit with liquid tight connections. Seal the casing penetrations in a manner that eliminates air leaks. At all split sections, provide a 300 mm (1 foot) long piece of flexible conduit, with the extra wire spooled, for reconnection on site by the installing contractor.
- 2.27.9 External disconnects shall be provided in a NEMA 4 enclosure for superior water protection. Disconnects must be interlocked with the electrical panels for added personnel safety.

2.28 FINISH

- 2.28.1 Unit shall be finished painted with two components, etch bond primer and finish painted with alkyd enamel, colour as selected by Owner. All uncoated steel shall be painted with grey enamel. All metal surfaces shall be pre-painted with vinyl wash primer to ensure paint bonds to metal. Outdoor unit shall be finish coated with polyurethane paint. Paint for outdoor units shall be tested to ATSM B117 for 5000hr salt spray endurance.

2.29 AIR LEAKAGE TESTING

- 2.29.1 Unit manufacturer shall factory pressure test each air handling unit to ensure the leakage rate of the casing does not exceed 0.5% of the unit airflow at 1.5 times the rated total static pressure for 4" thick casing units. Leakage test shall be performed with VFD and humidifier panels installed.
- 2.29.2 Test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure leakage airflow.
- 2.29.3 An officer of the air handling unit company shall certify test results. Forward copies of certified test results to the consultant. The consultant shall witness the pressure test. Provide for all transportation for the consultant and owner to the factory.
- 2.29.4 "Double duct" or "side by side" units shall have each duct or side tested independently.

PART 3 - EXECUTION

3.1 INSTALLATION OF CUSTOM-MADE AIR HANDLING UNITS

- 3.1.1 Provide custom made air handling units where shown.
- 3.1.2 Install per manufacturers' instructions.
- 3.1.3 Install with required clearance for service and maintenance.
- 3.1.4 Install accessories in accordance with manufacturers' recommendations.
- 3.1.5 Provide all required rigging and hoisting/moving equipment required to move the units to the required locations. Do all rigging/hoisting/moving in accordance with the unit manufacturer's directions and details.
- 3.1.6 Secure base mounting units in place, level, and plumb, on a concrete pad.
- 3.1.7 Secure suspended units in place from the structure, level, and plumb, by means of properly sized galvanized steel hanger rods and galvanized structural steel angle or channel trapeze supports.
- 3.1.8 Remove fan base hold-down clamps and all other shipping restraints and protective packaging.

- 3.1.9 Carefully coordinate the installation of each unit with all other trades making connections to the unit, in particular, control connections.
- 3.1.10 Equipment and System Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions. When installation is complete but prior to duct connections, arrange for the unit manufacturer's representative to conduct a site leakage test on each unit. Site leakage tests are to duplicate factory leakage tests and if results of site tests indicate leakage in excess of factory test results, re-seal the unit(s) and repeat the tests until satisfactory results are obtained. Submit leakage test documentation to the Consultant.
- 3.1.11 Start-Up: Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.1.12 Demonstration and Training: Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a one full 8-hour day on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 -GENERAL

1.1 Summary

1. This section includes Dedicated Outdoor Air System (DOAS) or an ERV (Energy recovery) units for ceiling mounted indoor applications.

1.2 Submittals

1. Product Data: Submit product data for specified products with the following information
2. General layout drawing with plan and elevation views including are relevant dimensions
3. Performance schedule including airflow, heating and cooling capacities, electrical data, unit weight.
4. Full fan curve.
5. Sound power data by octave band for all openings and radiated through the cabinet.
6. Electrical schematics including field wiring connections.
7. Component details including construction method and materials.
8. Control point schematic and complete written sequence of operation.
9. Curb mounting details.

1.3 Quality assurance

1. Entire unit shall be UL 1812 or UL 1995 certified and bear certification label by ETL, UL or CSA.
2. Unit shall meet ASHRAE Standard 90.1 performance requirements.
3. Unit sound data will be tested in accordance to AHRI 260

1.4 Delivery, storage and handling

1. Store equipment away from construction areas where it may be damage and protected from harmful weather conditions.
2. Keep factory shipping packaging in place until unit is ready to be installed.
3. Follow manufacturer's instructions for rigging and placement of equipment.

1.5 Coordination

1. Coordinate all system connections and building penetrations including electrical, gasglycol piping and duct connections._

1.6 Warranty

1. Standard Warranty for the Unit: 24 months (2 years) from shipment date

PART 2 -PRODUCTS

2.1 Manufacturers

1. Subject to compliance with project plans and specifications the following manufacturers are approved to supply products.

1. Acceptable Manufacturers

1. Oxygen8 (Base Design)
2. Mitsubishi Electric LOSSNAY;
3. Venmar CES;
4. Lennox Canada Ltd.;
5. Aldes Canada;
6. Price Industries Ltd.
7. Greenheck Fan Corp.;
- 4-8. Carrier Corp.

2.2 DOAS Units

1. DOAS units shall be factory assembled and tested. Units shall include insulated steel cabinet with steel base, total plate heat exchanger, electric heat, fan and motor assembly, filter rack, and integral controls. [Unit shall have single point power connections].

2.3 Cabinet

1. Cabinet shall be nominal 1 inch double wall panel with R6.5 2.5lb/ft3 polyurethane foam thermal insulation. Cabinet exterior shall be 20-gauge pre-painted steel that meets or exceeds 650-hour salt spray test based on ASTM B117. 22 Gauge liners and other steel components shall be galvanized steel. All seams shall be sealed to provide airtight casing.
2. Doors shall be nominal 1 inch double wall panel with the same construction as cabinet. Doors shall be fitted with hinges and door handles. The doors shall have one lockable handle as standard.
3. The unit will be designed for service and maintenance on one side only to allow for a compact installation.

2.4 Filters

1. Unit shall include 2" filter rack for the supply air and return air paths upstream of energy recovery exchanger. Filters shall be accessed through hinged filter access door. Supply one set of MERV 13 pleated filters for the Outdoor air stream and one set of MERV8 for the Return air stream. All filters must be UL approved.

2. Provide factory mounted pressure sensors to measure filter pressure drop across pre-filter and main filter. Pressure drop shall be digitally feedback to controller for utilization in control and alarm sequencing. Unit controller shall monitor filter pressure level and report when filter changes are required.

2.5 Fans

1. Fans shall be mixed flow plenum type with direct drive motor. Fan and motor assembly shall be factory mounted and balanced. The fans will be capable of operating in ambient temperatures of up to 40°C.
2. Fan motors shall be permanent magnet, synchronous motor type with integral digital motor controller. Fan bearings shall be serviceable type with an L-10 life of 40,000 hours. Fan motors will be UL approved.
3. All fans shall be equipped with integral airflow monitoring system connected to the unit controller.
4. Provide means to easily remove fan-motor assembly for service through standard doors.
5. Fans should be designed such that all service can be performed in the field, including replacement of bearings.
6. Fan motor drives shall be 208-230/60/1 and be UL approved. Fans will be protected by UL approved motor protection circuit breaker.

2.6 Energy [heat] recovery device

1. Where indicated, units shall include plate type cross flow heat exchanger fabricated from polymer membrane. Unit shall be capable of withstanding a maximum of 7.2" w.c. Maximum leakage between airstreams shall be 0.5% of nominal airflow.
2. The energy recover efficiency must be a minimum of 50% Total to meet ASHRAE 90.1.
3. The energy recovery device must have an ISO Hygiene rating of 0.
4. Energy recovery device shall be AHRI 1060 certified

2.7 Electric pre-heating coil

1. Provide open coil electric heaters of the size, capacity and performance shown in the equipment schedules.
2. All duct heaters shall be tested and certified to UL and CSA.
3. Frame to be corrosion-resistant and made of galvanized steel.
4. Coils shall be made of high-grade Nickel-Chrome alloy and shall be insulated from the frame by means of non-rotating ceramic bushings.
5. Heater to come with door mounted disconnect switch and air proving switch
6. SCR control is time proportioning type that modulates the heater and supplies the exact amount of power to match the demand. Input signal will be 0-10V.

7. Heaters shall be equipped with a fail-safe automatic reset disc-type thermal cut-out located in the top frame component above the heating element.
8. Duct heaters shall be non-sensitive to air flow direction and interchangeable for horizontal or vertical ducts without impairing safety.

2.8 Controls

1. Unit shall include an integrated microprocessor-based unit controller. The controls shall be located in the electrical enclosure. All unit controls shall operate off a transformer from the main power supply for single point power connection. All internal controls and sensors shall be factory prewired and tested.
2. The control system will regulate temperatures, airflows and other functions as required. Unit controller shall be pre-programmed with factory tested software for all possible functions.
3. The controller shall provide the following, refer to sequence of operation for specific unit control sequences;
 1. Control of fans correcting for both changes in total static pressure and air density in both VAV and constant airflow applications.
 2. Fan performance monitoring.
 3. Ventilation airflow monitoring and control.
 4. Airflow density correction for winter and summer conditions.
 5. Energy recovery optimization including operation of bypass damper.
 6. Supplemental heating and cooling when included.
 7. Frost protection.
 8. Monitoring alarms, faults and maintenance points including filter changeout.
 9. Time and date schedules.
 10. Humidity control.
 11. Data logging and trending.
4. Include wireless capability that will allow the client to access remotely via internal wi-fi network.
5. If non factory controls are proposed as an option, a factory witness test is required to show integration and functionality.
6. Controller shall be BACnet IP and BTL certified and include Modbus communication. Communication shall include monitoring, control, alarms, faults and maintenance information.
7. Provide factory installed and tested contactors, overloads, fusing, starters motor speed controllers for supply and exhaust. Include all necessary control transformers.
8. Provide unit mounted non-fused disconnect switch with single point power connection.
9. Supply all necessary temperature and pressure sensors complete with plug in wiring harnesses for proper operation of unit.

10. When VRV integration is used, the AHU integration controller (EKEQ) must be factory mounted and wired to EKEXV expansion valve kit.
11. Liquid and Gas thermistors are to be mounted to coil and wired to EKEQ kit in the factory.

2.9 Plastic components

1. All plastic components that are in the airstream, must be of a UL94 rated material.
2. If gasketing is used to join unit sections together, gasketing must be a UL94 approved compound.

PART 3 -EXECUTION

3.1 Installation

1. Install equipment in accordance with manufacturer instructions, these specification, best practices and all applicable building codes.

3.2 Start-up service

1. Engage factory authorized service technician to start up and commission units. Provide start up report to owner.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets, complete with control components, and piping and wiring schematics. Shop drawings and product data sheets must confirm that the equipment proposed meets all requirements of the Contract Documents.
- .2 **Start-up and Certification Letter:** Submit a start-up and certification letter from the equipment supplier as specified in Part 3 of this Section.
- .3 **Refrigerant Piping Schematic:** Prepare and submit a schematic layout of refrigerant piping showing all piping components required for satisfactory operation and maintenance of the system(s), including but not limited to pipe sizes, charging valve, isolating valves, sight glasses, strainers, driers, traps, etc. **Note** that the schematic diagram must be reviewed with and approved by the air conditioning equipment supplier prior to submittal to the Consultant.

1.2 Quality Assurance

- .1 **Codes and Regulations:** Split system air conditioning equipment and installation of the equipment are to be in accordance with requirements of the following:
 - .1 all applicable Provincial Codes and Standards;
 - .2 AHRI Standard 210/240, Performance Rating of Unitary Air Conditioning and Air-Source Heat Pumps.
- .2 **Installation Tradesmen:** Split system air conditioning system installation tradesmen are to be journeyman refrigeration mechanics.

PART 2 - PRODUCTS

2.1 Split System Air Conditioning Equipment

- .1 Factory assembled and tested, package type equipment consisting of an indoor evaporator unit and an exterior condensing unit as per the drawing schedule, CSA or ETL listed and labelled, ARI rated and certified and with a minimum system efficiency of 13 SEER.
- .2 **Evaporator:** Wall mounting assembly consisting of a white moulded high-strength plastic cabinet with front access panel, a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction and which closes when fan operation is stopped, motorized vertical vanes controlled remotely, and a mounting plate supplied loose. The evaporator is to be complete with:
 - .1 casing/panel:
 - .1 Unit case shall be manufactured of heavy duty Acrylonitrile Butadiene Styrene (ABS) and High Impact Polystyrene (HIPS) plastic.
 - .2 Unit case shall have a pearl white finish.

- .3 The front surface of the unit shall have an architectural curved panel with pearl white finish.
- .2 cabinet assembly:
 - .1 Unit shall have one supply air outlet and one return air inlet.
 - .2 Unit shall be equipped with factory installed temperature thermistors for
 - .1 Return air;
 - .2 Refrigerant entering coil;
 - .3 Refrigerant leaving coil
 - .3 Unit shall have a built-in control panel to communicate with the outdoor unit.
 - .4 Unit shall have the following functions as standard
 - .1 Self-diagnostic function;
 - .2 Auto restart function;
 - .3 Auto changeover function;
 - .4 Auto clean function;
 - .5 Dehumidifying function;
 - .6 Hot Start;
 - .7 Sleep mode
 - .5 Unit shall be capable of refrigerant piping in 4 different directions.
 - .6 Unit shall be capable of drain piping in 2 different directions.
- .3 **fan:** double inlet, forward curve fan(s) direct driven by a single four-speed motor and;
- .4 **filter:** removable and washable return air filter;
- .5 **coil:** factory pressure tested multi-angled coil of non-ferrous construction with aluminium fins, copper tubes with silver alloy solder joints, and an insulated condensate drain pan sloped to a drain connection for positive drainage.
- .3 **Condensing Unit:** Factory run tested weatherproof condensing unit equipped with a control board to interface with the indoor unit and perform all necessary operation functions. The unit is to be pre-charged with R-410a refrigerant for a minimum of 21 m (70') of refrigerant tubing, is to be capable of operation at -18°C (0°F) without additional low ambient controls, and with a height difference between the condensing unit and evaporator of 30 m (100'). Each condensing unit is to be complete with:
 - .1 **cabinet:** galvanized steel plate cabinet with an electrostatically applied thermally fused polyester powder finish, and an ABS plastic fan grille;
 - .2 **fan:** draw-through direct driven balanced fan with horizontal air discharge, mounted in front of the coil, arranged to pull air across the coil, and equipped with a raised fan guard;

- .3 **condenser coil:** "L" shaped coil with copper tubes and aluminium fins, factory pressure tested, complete with an integral metal guard and refrigerant flow controlled by a linear expansion valve metering orifice controlled by a microprocessor controlled step motor;
- .4 **compressor:** vibration isolated DC rotary compressor driven by an inverter circuit to dynamically control compressor speed to match the room load, complete with an accumulator, high pressure safety switch, and circuitry to permit a minimal amount of current to be applied to the motor to maintain enough heat during the off cycle to prevent liquid from accumulating.
- .5 Defrost Operations
 - .1 The outdoor unit shall be capable of auto defrost operation to melt accumulated ice off the outdoor unit heat exchanger. The defrost cycle control shall be based on outdoor ambient temperatures and outdoor unit heat exchanger temperatures.
- .6 Oil Management
 - .1 The outdoor unit shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts at low speed.
 - .2 The outdoor unit shall have an oil separator to separate oil mixed with the refrigerant gas during compression and return oil to the compressor.
- .7 Sound Levels
 - .1 The outdoor unit shall have sound levels not exceeding 55 dB(A) tested in an anechoic chamber under ISO1996 standard.
- .8 Sensors: The outdoor unit shall have:
 - .1 Suction temperature sensor;
 - .2 Discharge temperature sensor;
 - .3 High pressure sensor;
 - .4 Low Pressure sensor;
 - .5 Outdoor temperature sensor;
 - .6 Outdoor unit heat exchanger temperature sensor
- .4 **Controls:** System controls are to consist of a microprocessor in each indoor and outdoor unit, and an indoor wall mounted controller site connected to the indoor evaporator unit. The system is to be capable of automatic restart after power interruption, and is to have self-diagnostics ability and indication of total compressor run time.
 - .1 **microprocessors:** the indoor unit microprocessor is to be capable of monitoring return air temperature and evaporator coil temperature, receiving and processing commands from the wall mounted controller, providing emergency operation, and controlling the outdoor unit through its microprocessor and interface board;
 - .2 **wall mounted controller:** the controller is to be complete with an integral temperature sensor, is to perform input and output functions necessary to operate the system, and is to be equipped with the following:

- .1 a large DOT liquid crystal display to indicate diagnostic codes for both the indoor and outdoor units, compressor run time, a weekly timer with up to 8 pattern settings per day, set temperature, room temperature, refrigerant piping temperatures, compressor operating conditions, and linear expansion valve opening pulses, sub-cooling and discharge super heat;
 - .2 On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Dry/Fan mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Vane Position selector, a Louvre Swing button, a Ventilation button, a Test Run button, and a Check Mode button.
- .5 **Acceptable Manufacturers:** Acceptable manufacturers are:
- .1 Mitsubishi Electric Sales Canada Inc.;
 - .2 LG Electronics Canada Inc.;
 - .3 Fujitsu General America Inc.;
 - .4 Samsung HVAC;
 - .5 Trane Canada Inc.;
 - .6 Carrier Enterprise Canada.

PART 3 - EXECUTION

3.1 Installation Of SPLIT SYSTEM AIR CONDITIONING EQUIPMENT

- .1 Provide split system air conditioning equipment consisting of an exterior condensing unit and an indoor evaporator, where shown.
- .2 Secure the condensing unit in place, level and plumb, on vibration isolation pads on pressure treated wooden sleepers as indicated. Unit shall be placed on wooden sleepers
- .3 Mount the indoor evaporator unit where indicated. Confirm exact location prior to roughing-in.
- .4 Connect the condensing unit and the indoor evaporator with refrigerant piping in accordance with the piping shop drawing schematic. Refer to the mechanical work Section entitled Refrigerant Piping, Valves, and Accessories. Provide any required additional refrigerant.
- .5 Install all loose control components and do all required control wiring (except building automation system connections) between the condensing unit and the evaporator in conduit in accordance with the manufacturer's control wiring schematic and wiring standards of the electrical work.
- .6 **Equipment and System Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- .7 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.

- .8 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for four hours of on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with control set-up and abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for heating coils, including accessories. Shop drawings/product data sheets must confirm that equipment conforms to requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 DUCT MOUNTED HYDRONIC HEATING COILS

- 2.1.1 Hydronic coils as per the drawing schedule, one or two row as indicated, each certified to ANSI/ARI Standard 410, Forced-Circulation Air-Cooling and Air-Heating Coils, each factory leakage tested at 2070 kPa (300 psi) under water, drainable, self-venting, and complete with:
- 2.1.1.1 tubes and fins: horizontal, continuous, 15.9 mm (5/8") diameter, 0.050 mm (0.020") wall thickness seamless copper tubes permanently bonded to plate or spirally wound aluminium fins and equipped with threaded female same end connections;
 - 2.1.1.2 casing: flanged galvanized steel casing arranged to prevent air bypass around the coil and factory punched for duct connections.
- 2.1.2 Where required, coils are to be manufactured as "Registered Fittings" with a Canadian Registration Number (CRN).
- 2.1.3 Acceptable manufacturers are:
- 2.1.3.1 Aerofin Canada Services Inc.;
 - 2.1.3.2 Luvata;
 - 2.1.3.3 Daikin Industries Ltd.;
 - 2.1.3.4 Engineered Air;
 - 2.1.3.5 Carrier Enterprise Canada;
 - 2.1.3.6 Direct Coil;
 - 2.1.3.7 Coilmaster.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCT MOUNTED HYDRONIC HEATING COILS

- 3.1.1 Provide duct mounting heating coils in supply ductwork where shown.

- 3.1.2 Secure each coil in place from the structure by means of hanger rods, independent of connecting ductwork but ready for duct connection and located for easy removal and access to the power and control panel.
- 3.1.3 Connect with piping in accordance with the drawing detail.

END OF SECTION

PART 1: General

1.1 Section Includes

1. Horizontal Air Handler

1.2 References

1. Load ratings and fatigue life for ball bearings.
2. Standards handbook.
3. Laboratory methods of testing fans for rating purposes.
4. Test code for sound rating air moving devices.
5. Test methods for louver, dampers, and shutters
6. Room fan coil unit
7. Standard practice for operating salt spray apparatus.
8. Motors and generators.
9. National electrical code.
10. HVAC duct construction standards - metal and flexible
11. Test for surface burning characteristics of building materials.
12. Test performance of air filter units.
13. Standard for heating and cooling equipment.
14. Test for flammability of plastic materials for parts in devices and appliances.

1.3 Submittals

1. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
2. Product Data
 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, and electrical characteristics and connection requirements.

1.4 Operation and Maintenance Data

1. Maintenance Data: Include instructions for lubrication and filter replacement.

1.5 Qualifications

1. Manufacturer: Company specializing in manufacturing Air Handler products specified in this section must show a minimum five years documented experience and complete catalog data on total product.

1.6 Delivery, Storage, and Handling

1. Deliver, store, protect and handle products to site.
2. Accept products on site wrapped in protective cardboard wrap. Inspect for damage.

3. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

1.7 Environmental Requirements

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

PART 2: Products

2.1 Acceptable Manufacturers

1. The following manufacturers are approved for use. No substitutions will be permitted.
 1. Daikin Applied – “PreciseLine” air handler is the basis of design, including standard product features and all special features required per plans and specifications
 2. Price
 3. First Co.

2.2 Fan Coil Type And Arrangement

1. The air handler shall be furnished as a draw-through style hydronic air handler.

2.3 General Construction

1. Unit will be supplied with 1-inch, double-wall panels. The cabinet is to be thermally isolated through injected foam insulation inside each cabinet. Single wall cabinets with fiberglass insulation exposed in the airstream are not acceptable. Frame channels which allow heat conductance between the inside and outside of the cabinet are not acceptable. Base rails used for unit mounting/hanging are acceptable. Panel shall have a minimum thermal insulation of R6. Foam injected insulation conforms to:
 1. ASTM C1071 (including C665)
 2. UL 181 for erosion
 3. 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A

2.4 Supply Fan

1. Supply fans shall be a DWDI forward-curved type. Fan assemblies shall be balance tested dynamically by the manufacturer. Manufacturer must ensure maximum fan RPM is below the first critical speed.
2. The complete fan assembly, including motor and main drain pan shall be easily removable.
3. Fan motor(s) assembly shall be direct-drive style and not include belts, pulleys, or sheaves.
4. Fan motor(s) shall be of Direct Current Brushless type of minimum motor efficiency of 85 percent when rated in accordance of NEMA Standard MG 1-2016 at full load conditions.

5. Manufacturer's supply fan motor must have means to adjust motor speed for field balancing.
6. Units shall be certified in accordance with the Central Station Air Handler certification program that is based on AHRI Standard 430.
7. Forward-curved fan must be capable of delivering 1.5" w.g. external static pressure and 3.0" w.g. total static pressure at nominal cabinet CFM.

2.5 Electrical

1. Supply fans shall be driven by Electrically Commutated motors that are run-tested in the assembled unit and permanently lubricated. All motors shall have integral thermal overload protection with a maximum ambient operating temperature of 55°C. Motors shall be capable operating at 90 percent of rated voltage on all speed settings. Motors can operate up to 10 percent overvoltage.
2. Motor wires shall include a quick-disconnect motor plug.
3. All controls equipment including ECM control module, low voltage transformers, safety switches, disconnects, fusing, and terminal strips must be located inside the main unit cabinet. Units require a 0-10V control input for fan speed control.
4. All controls equipment including ECM control module, low voltage transformers, safety switches, disconnects, fusing, and terminal strips must be located inside the main unit cabinet.

2.6 Cooling and Heating

1. Cooling Coils
 1. Cooling performance shall be as specified on the unit schedule.
 2. Direct expansion coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins. Coil casing shall be constructed of galvanized steel.
 3. Direct expansion coils shall be provided with distributors.
 4. All steel parts exposed to moisture shall be galvanized.
 5. Unit shall include a galvanized primary and secondary drain pan. The primary drain pan to be positively sloped in every plane. Primary and secondary drain pans to be insulated with anti-microbial closed-cell insulation. The drain pan shall be designed to ensure no pooling of condensate water per ASHRAE 62.2.
2. Heating Coils
 1. Heating performance shall be as specified on the unit schedule.
 2. Coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-

secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

3. Coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be sweat pipe thread connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections shall be provided at the highest point to ensure proper venting. Drain connections shall be provided at the lowest point.

2.7 Filters

1. Filter section shall be a 4" flat type furnished with MERV 13 deep pleated panel filters.
2. Filter media shall be UL 900 listed, Class I or Class II.
3. Filters shall be arranged in a flat manner.
4. Filters shall be 4" in depth.
5. Filter shall be of disposable type with a minimum arrestance greater than 98% and rating of MERV 13.
6. Filters shall be easily accessible via a panel or door located on the bottom of the unit.

2.8 Controls

1. Unit shall be supplied with a digital controls ready interface. This interface is to be located inside the control box internal to the main unit. This interface shall include a 24VAC transformer and terminal blocks for connections to fan motor control, sensor control, safety switches, valve actuators, and damper control if applicable.
2. Unit shall be furnished with a disconnect switch. The disconnect switch shall be operable from the outside of the cabinet to reduce hazards during field service and commissioning.
3. Fan motor control to be furnished as 0-10VDC.

PART 3: EXECUTION

3.1 Installation

1. The air handling unit shall be installed per manufacturer's Installation & Maintenance Bulletin.
 1. Selected field mounted kits shall be specified on the unit schedule and installed per manufacturer's instruction.

END OF SECTION

PART 1- GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data Sheets: Submit shop drawings/product data sheets for radiation units, including accessories, and any required control wiring schematics. Shop drawings/product data sheets must confirm that the radiation units proposed conform to all requirements of the Contract Documents.
- 1.1.2 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

PART 2- PRODUCTS

2.1 LINEAR RADIANT CEILING PANELS

- 2.1.1 Continuous linear radiant ceiling panels sized and arranged as shown and scheduled on the drawings, complete with:
 - 2.1.1.1 extruded aluminum panels with aluminum saddles to secure 12 mm (1/2") diameter type "L" copper piping, non-hardening heat conductive paste between the piping and the panels, and a white finish factory applied to the face of each panel;
 - 2.1.1.2 cross channel braces in quantities as recommended by the panel manufacturer to suit the panel length, and end and centre clips;
 - 2.1.1.3 all required type "L" copper piping return bends and connection fittings.
- 2.1.2 Acceptable manufacturers are:
 - 2.1.2.1 Engineered Air Airtex;
 - 2.1.2.2 Frenger Systems Ltd.;
 - 2.1.2.3 Rosemex Inc.;
 - 2.1.2.4 Sigma Corp.;
 - 2.1.2.5 Zehnder-Rittling.;
 - 2.1.2.6 Airtite.

PART 3- EXECUTION

3.1 INSTALLATION OF RADIANT CEILING PANELS

- 3.1.1 Provide linear radiant ceiling panels where shown. Install cross channel braces, end and centre clips as per the panel manufacturer's published details.

- 3.1.2 Secure panels in place on T-bars and/or wall channel moulding provided as part of the suspended ceiling system work, and provide ceiling hanger wire at 1.2 m centres between the structure and the cross channel braces.
- 3.1.3 Interconnect radiant panels by means of 12 mm dia. soft copper tubing or connection accessories supplied with the panels, as required. Ensure that the heating piping system has been flushed and cleaned prior to connecting the radiant panels.
- 3.1.4 Personnel handling the unprotected panels are to wear clean white gloves to avoid soiling the panel face finish.
- 3.1.5 When installation of the panels is complete, cover the top of all active panels with 25 mm thick glass fibre batt insulation.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for humidifier manifold(s), including accessories. Shop drawings/product data sheets must confirm that equipment conforms to requirements of the Contract Documents.
- 1.1.2 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

PART 2 - PRODUCTS

2.1 STEAM INJECTION HUMIDIFIER

- 2.1.1 Package type low pressure steam injection humidifier as per the drawing schedule, each capable of discharging clean dry steam without condensate drip or objectionable noise, and complete with:
 - 2.1.1.1 an inlet strainer;
 - 2.1.1.2 a stainless steel steam jacketed manifold, a dispersing tube, and a stainless steel noise attenuator;
 - 2.1.1.3 a stainless steel separator;
 - 2.1.1.4 a normally closed brass body control valve with a modulating motor operator to suit the control system, and a temperature switch to prevent the humidifier from operating until the entire unit is up to steam temperature;
 - 2.1.1.5 a cast iron float and thermostatic drip trap with stainless steel internal components for each manifold.
- 2.1.2 . Acceptable manufacturers are:
 - 2.1.2.1 Spirax Sarco Canada Ltd.;
 - 2.1.2.2 Armstrong International Ltd.;
 - 2.1.2.3 DRI-STEEM Corp.

PART 3 - EXECUTION

3.1 INSTALLATION OF STEAM INJECTION HUMIDIFIER MANIFOLD

- 3.1.1 Provide steam injection humidifier manifold assemblies where shown.
- 3.1.2 Install each manifold assembly in accordance with the manufacturer's instructions. Coordinate installation with the sheet metal trade.

- 3.1.3 Connect with valved steam and condensate piping.
- 3.1.4 Equipment Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.1.5 Start-Up: Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.1.6 Demonstration and Training: Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a one half day on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL**1.1 Submittals**

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for the following:
- 1.1.1.1 System Configuration Schematics: Provide drawing(s) of all components of monitoring and control system. Identify all central and field processor units, communications links, etc. by label and location. End devices need not be shown. Schematics must be clearly drawn and well arranged.
 - 1.1.1.2 Show all electric interlocks and controlling devices provided by Division 26. Show layout of terminal strips of all processor units and field interface devices.
 - 1.1.1.3 On pneumatic control loops, indicate equipment model numbers, controller settings, set point and reset schedules, air piping and wiring layouts.
 - 1.1.1.4 On completion of work, submit schematics and as-builts.
- 1.1.2 Equipment Description: Provide technical specifications of all equipment employed in the system, including sensors and actuated devices. Include manufacturer, model, input requirements, accuracy and calibration data, capacity, environmental limitations, parts lists, etc. Identify by point label.
- 1.1.3 Provide a points list describing type, function and label of all DDC control points. The label for each point shall be common to all documentation, e.g. system schematics, as-builts, field lamacoids.
- 1.1.4 Provide valve and damper schedule indicating size, configuration, capacity and location. If size varies greater than 10% from specification, obtain approval of Consultant.
- 1.1.5 Submit a complete print-out of the BAS data base at time of turnover to Owner. Include the value of each system point, configuration data on processor units, display devices, etc. Provide a separate list for each processor unit.
- 1.1.6 Provide a print-out of each page of screen display showing summary of point status.
- 1.1.7 Provide an Operator's Manual containing instructions, program listings and documentation.
- 1.1.8 Provide detail wiring diagrams to Consultant for review within two months after award of Contract. Wiring diagrams shall include equipment wiring.
- 1.1.9 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.
- 1.1.10 Confirmation of Installation Personnel Qualifications: Submit written confirmation from the control component manufacturer that the site installation personnel are qualified and experienced in the installation of the components and have parts and service availability on a 24/7 basis.

1.2 QUALITY ASSURANCE

- 1.2.1 The control systems are to be installed by the control component manufacturer or by licensed personnel authorized by the control component manufacturer. Submit written confirmation from the control component manufacturer.
- 1.2.2 The control system installation company is to have local parts and service availability on a 24/7 basis.
- 1.2.3 All control wiring work is to be performed by licensed journeyman electricians, or under direct daily supervision of journeyman electricians.
- 1.2.4 Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:
 - 1.2.4.1 National Electric Code (NEC)
 - 1.2.4.2 ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.3 SYSTEM PERFORMANCE

- 1.3.1 Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).
 - 1.3.1.1 Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
 - 1.3.1.2 Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
 - 1.3.1.3 Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
 - 1.3.1.4 Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
 - 1.3.1.5 Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
 - 1.3.1.6 Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.

- 1.3.1.7 Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
- 1.3.1.8 Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
- 1.3.1.9 Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
- 1.3.1.10 Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

TABLE-1 REPORTING ACCURACY

Measured Variable	Reported Accuracy
Space Temperature	$\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$)
Ducted Air	$\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$)
Water Temperature	$\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$)
Relative Humidity	$\pm 5\%$ RH
Water Flow	$\pm 2\%$ of full scale
Air Pressure (ducts)	± 25 Pa (± 0.1 in. w.g.)
Air Pressure (space)	± 3 Pa (± 0.01 in. w.g.)
Water Pressure	$\pm 2\%$ of full scale (see Note 2)
Electrical	$\pm 1\%$ of reading (see Note 3)

NOTE 1: ACCURACY APPLIES TO 10%–100% OF SCALE

NOTE 2: FOR BOTH ABSOLUTE AND DIFFERENTIAL PRESSURE

NOTE 3: NOT INCLUDING UTILITY-SUPPLIED METERS

TABLE-2 CONTROL STABILITY AND ACCURACY

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	± 50 Pa (± 0.2 in. w.g.) ± 3 Pa (± 0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	$\pm 10\%$ of full scale	
Space Temperature	$\pm 1.0^{\circ}\text{C}$ ($\pm 2.0^{\circ}\text{F}$)	
Duct Temperature	$\pm 1.5^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$)	
Humidity	$\pm 5\%$ RH	
Fluid Pressure	± 10 kPa (± 1.5 psi) ± 250 Pa (± 1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.4 APPROVED CONTROL SYSTEM MANUFACTURERS

1.4.1 The following are approved control system suppliers, manufacturers, and product lines:

1.4.1.1 Honeywell

1.4.2 Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

1.4.2.1 The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.

1.4.2.2 Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.5 INTEGRATION WITH THIRD PARTY MANUFACTURER'S EQUIPMENT

1.5.1 Monitor and control the equipment as described in the points list, schematic, sequence of operation and respective equipment specification. The BAS contractor must provide control system overlay of the points specified. Points inputs and outputs from the third party controllers shall have real-time inter-operability with BAS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Dial-Up and Local Area Network Communications, as mentioned in the specification.

PART 2 - PRODUCTS

2.1 AUTOMATIC CONTROL VALVES AND OPERATORS

2.1.1 Each control valve must be suitable in all respects for the application, including system pressure, and must have design output and flow rates with maximum pressure drops as follows:

2.1.1.1 heating water/glycol solution valves for coils: 17.5 kPa (2.5 psi);

2.1.2 Unless otherwise indicated, control valves for proportional operation are to have equal percentage characteristics, and control valves for open/shut two position operation are to have straight line flow characteristics. All valves are to have position indicators. Valves for outdoor applications must be suitable in all respects for the application.

2.1.3 Heating valves are to be normally open unless otherwise specified.

2.1.4 Hydronic Piping Valves: Unless otherwise specified, control valves in hydronic piping systems are to conform to requirements specified in the mechanical work Section entitled Hydronic Piping and Valves.

- 2.1.5 Steam and Condensate Piping Valves: Unless otherwise specified, valves in steam/condensate piping are to generally conform to requirements specified in the mechanical work Section entitled Steam and Condensate Piping specialties but must be equipped with stainless steel plugs and stems, removable screwed stainless steel seat rings, and spring loaded Teflon V-ring packing.
- 2.1.6 General Re: Valve Operators: All control valve operators are to be spring return type for fail safe operation, sized to tightly shut the control valves against differentials imposed by the system, equipped with position indicators, and suitable in all respects for the environment in which they are located.
- 2.1.7 Electric Valve Operators: Unless otherwise specified, enclosed reversible gear type operators that can accept modulating control signals as required. Each is to be 1 phase AC, 120 or 24 volt as required or indicated, overload protected, and complete with an enclosure to suit the mounting location.

2.2 CONTROL SYSTEM COMPONENTS

- 2.2.1 Components specified below are required for control of equipment and systems as per the drawing control diagrams and sequences of operation. Not all required components may be specified.
- 2.2.2 Sensor/Transmitter Input Devices: Sensor/transmitter input devices must be suitable in all respects for the application and mounting location. Devices are to be as follows:
- 2.2.2.1 general re: temperature sensors: resistance type, either two-wire 1000 ohm nickel RTD or two-wire 1000 ohm platinum RTD with accuracy (includes errors associated with the sensor, lead wire, and A to D conversion), equipped with type 316 stainless steel thermowells for pipe mounting applications, as follows:
- 2.2.2.1.1 chilled water, room temperature, and duct temperature points, $\pm 1^{\circ}\text{C}$ ($\pm 0.5^{\circ}\text{F}$);
- 2.2.2.1.2 all other points, $\pm 0.75^{\circ}\text{C}$ ($\pm 1.3^{\circ}\text{F}$).
- 2.2.2.2 room temperature sensors: constructed for surface or recessed wall box mounting, complete with an adjustable set-point reset slide switch with a $\pm 1.66^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$) range, individual heating/cooling set-point slide switches as required, a momentary override request pushbutton for activation of after-hours operation, an analogue thermometer;
- 2.2.2.3 outside air sensors: designed and constructed for ambient temperatures and to withstand the environmental conditions to which they are exposed, complete with a NEMA/EMAC 3R enclosure, solar shield, and a perforated plate surrounding the sensor element where exposed to wind velocity pressure;
- 2.2.2.4 duct mounting sensors: insertion type with lock nut and mounting plate, designed to mount in an electrical box (weather-proof with gasket and cover where outside) through a hole in the duct;

- 2.2.2.5 duct/plenum averaging sensors: for ducts greater than 1.2 m (4') or for ducts where air temperature stratification occurs, averaging type sensors with multiple sensing points, and for plenums for applications such as mixed air temperature measurement to account for air turbulence and/or stratification, an averaging string of sensors with capillary supports on the sides of the duct/plenum;
- 2.2.2.6 humidity sensors: factory solid-state relative humidity sensors with an element that resists contamination, weather-proof with a NEMA/EEMAC 3R enclosure for outside air applications, supplied with a type 304 stainless steel probe with mounting bracket and hardware for duct mounting, each complete with a factory calibrated humidity transmitter which is accurate (including lead loss and analog to digital conversion) to 3% between 20 to 80% RH at 25°C (77°F) and equipped with non-interactive span and zero adjustments, and a two-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output;
- 2.2.3 Differential Pressure Transmitters: Pressure transmitters are to be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input. Pressure transmitters are to transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal. Differential pressure transmitters used for flow measurement are to be sized to the flow sensing device and supplied with a tee fitting and shut-off valves in the high and low sensing pick-up lines to allow permanent ease of use connection for balancing, etc. Transmitter housing are to suit the mounting location. Standalone pressure transmitters are to be mounted in a minimum NEMA/EEMAC 1 (NEMA/EEMAC 2 in sprinklered area) by-pass valve assembly panel with high and low connections piped and valved, air bleed units, by-pass valves, and compression fittings. Transmitters are to be as follows:
- 2.2.3.1 low differential water pressure, 0 to 5 kPa (0 to 20" wc): equal to Setra or Mamac industrial quality transmitter capable of transmitting a linear 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points, each complete with non-interactive zero and span adjustments that are adjustable from outside the cover, and performance as follows:
- 2.2.3.1.1 maintain accuracy up to 20 to 1 ratio turndown;
- 2.2.3.1.2 reference accuracy - +0.2% of full scale.
- 2.2.3.2 medium to high differential water pressure, over 5 kPa (20" wc): equal to Setra or Mamac transmitters as specified above for low pressure transmitters but with a pressure range of from 2.5 kPa (10" wc) to 2070kPa (300 psi), a reference accuracy of $\pm 1\%$ of full span (includes non-linearity, hysteresis, and repeatability)
- 2.2.3.3 building differential air pressure: industrial quality transmitter with a range suitable for the application, capable of transmitting a linear 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points, each complete with non-interactive zero and span adjustments that are adjustable from outside the cover, and performance as follows:
- 2.2.3.3.1 maintain accuracy up to 20 to 1 ratio turndown;
- 2.2.3.3.2 reference accuracy - +0.2% of full span.

2.2.3.4 low differential air pressure, 0 to 1.25 kPa (0" to 5" wc): industrial quality transmitter with a range suitable for the application, capable of transmitting a linear 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points, each complete with non-interactive zero and span adjustments that are adjustable from outside the cover, and performance as follows:

2.2.3.4.1 maintain accuracy up to 20 to 1 ratio turndown;

2.2.3.4.2 reference accuracy - +0.2% of full span.

2.2.3.5 medium differential air pressure, over 1.5 kPa (5" wc): transmitters as specified above for low pressure air transmitters but performance requirements as follows:

2.2.3.5.1 zero & span: (c/o F.S./Deg. F); .04% including linearity, hysteresis, and repeatability;

2.2.3.5.2 accuracy: 1% F.S. (best straight line); static pressure effect: 0.5% F. S.;

2.2.3.5.3 thermal effects: <+0.33 F.S./Deg. F over 40°F to 100°F (calibrated at 70°F).

2.2.4 **Room Pressure Monitor:** thin mount, touch screen room pressure monitor, digital differential pressure sensor, capable of alarming and monitoring the space temperature, space humidity, space pressure relative to adjacent area, with additional inputs for integration to door contact and to monitor filter status.

2.2.4.1 A centralized monitoring station shall be provided to monitor all room pressure monitors included in the scope of work. The centralized monitoring station shall display all critical parameters and alarms. Refer to location of the centralized monitoring station on drawings.

2.2.4.1.1 Centralized monitor shall be a 15" touch display screen with ethernet, BACnet MS/TP and BACnet IP interface, 24V power supply, capable of dynamic graphical pages.

2.2.4.2 Local User Interface - The Room Pressure Monitor shall have both audible and visual local alarms. It shall include a touch-screen display with a menu system and color-coded screens that can simultaneously display:

2.2.4.2.1 Room pressure

2.2.4.2.2 Room/alarm status

2.2.4.2.3 Humidity

2.2.4.2.4 Air changes per hour

2.2.4.2.5 Volumetric air flow

2.2.4.2.6 Temperature

2.2.4.2.7 Carbon Dioxide (CO₂) concentration

2.2.4.2.8 Time and date

2.2.4.3 Pressure monitor performance requirements as follows,

2.2.4.3.1 Pressure range, alarm range & display range: $\pm 0.25''$ WC;

2.2.4.3.2 Accuracy: $\pm 0.5\%$ FS;

2.2.4.3.3 Air Flow Sensor: Digital differential pressure

2.2.4.3.4 Control Resolution: ± 0.0010 inches WC

2.2.4.3.5 Control Capability: Up to 4 independent spaces

2.2.4.3.6 Power Requirement: 24Vac $\pm 10\%$, 30VA

2.2.4.3.7 4 universal analog inputs and outputs, 4 digital inputs and 4 relay outputs;

2.2.4.3.8 Capable of BACnet MS/TP communication;

2.2.4.3.9 BTL & ETL listed

2.2.4.3.10 Display: 720 pixels x 1280 pixels, colour, 5 inches (127 mm) diagonal

2.2.4.3.11 User Interface: Capacitive touchscreen

2.2.4.3.12 Equivalent to Honeywell XXXX

2.2.4.4 The pressure monitor shall be integrated to Field Equipment Controllers supplied by the Base Building Controls contractor (Honeywell) for integration to the BAS and execute control sequences identified in the drawings.

2.2.5 Air and Water Flow Monitoring: Flow monitoring stations and probes for air and water are to be Air Monitor/Onicon, Tek-Air Systems Inc., Ebtron, or Dwyer Instruments International products as follows:

2.2.5.1 fan inlet air flow measuring station: at the fan inlet and near the exit of the inlet sound trap, air flow traverse probes are to continuously monitor the fan air volume and system velocity pressure, and traverse probes are to be as follows:

2.2.5.1.1 each probe is to be of a dual manifold, cylindrical, anodized type 3003 extruded aluminium construction probe with sensors located along the stagnation plane of the approaching air flow, and the static pressure manifold is to incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow angle variations for as much as $\pm 20^\circ$ in the approaching air stream;

2.2.5.1.2 each probe is not to introduce a measurable pressure drop, nor is the sound level within the duct to be amplified by its singular or multiple presence in the air stream, and each probe is to contain multiple static and total pressure sensors placed at equal distances along its length in accordance with ASHRAE Standards for duct traversing.

- 2.2.5.2 Single Probe Air Flow Measuring Sensor: Duct mounting hot wire anemometer type which utilizes two temperature sensors, one a heater element temperature sensor and the other to measure the downstream temperature, with the temperature differential related directly to air flow velocity. Sensor insertion length is to be adjustable up to 200 mm (8"), and the transmitter is to produce a 4 to 20 mA or 0 to 10 VDC signal linear to air velocity.
- 2.2.5.3 Duct Flow Measuring Stations: No. 14 gauge galvanized steel casing with duct connection flanges of a size to mate with the connecting ductwork, and complete with an air directionalizer and a 98% free area parallel cell 20 mm (¾") honeycomb profile suppressor across the entering air stream to equalize the velocity profile and eliminate turbulent and rotational flow from the air stream prior to the measuring point, mechanically fastened to the casing so as to withstand velocities of up to 1828 m (6000') per minute. Additional requirements are as follows:
- 2.2.5.3.1 the total pressure measurement side (high side) is to be designed and spaced to requirements of the Industrial Ventilation Manual, 16th. Edition, page 9-5, and the self-averaging manifolding is to be constructed of brass and copper components;
- 2.2.5.3.2 the static pressure sensing probes (low side) is to be bullet-nose shaped, per detailed radius, as illustrated in the Industrial Ventilation Manual referred to above, page 9-5;
- 2.2.5.3.3 the main take-off point from both the total pressure and the static pressure manifolds is to be symmetrical, and the manifolds are to terminate with external ports for connection to control tubing;
- 2.2.5.3.4 each station is to be equipped with a label on the casing indicating unit model number, size, area, and specified air flow capacity;
- 2.2.5.3.5 each station is to have a self-generated sound rating of less than NC40, and the sound level within the duct is not to be amplified nor is additional sound to be generated.
- 2.2.5.4 Static Pressure Traverse Probe: Duct mounting, complete with multiple static pressure sensors located along the exterior surface of the cylindrical probe.
- 2.2.5.5 Shielded Static Air Probe: Indoor type or outdoor type as required, each with multiple sensing ports, an impulse suppression chamber, and air flow shielding.
- 2.2.5.6 Water Flow Monitoring: equal to Onicon microprocessor based electromagnetic water flow meters with an accuracy of 0.25%.
- 2.2.6 Power Monitoring Devices: Power (amps.) monitoring is to be performed by a combination of a current transformer and a current transducer with the transformer sized to reduce the full amperage of the monitored circuit to a maximum 5 ampere signal which will be converted to a 4 to 20 mA DDC compatible circuit for use by the building automation system. The current transformer and the current transducer are to be as follows:

- 2.2.6.1 current transformer: equal to Veris Industries split core current transformer with an operating frequency of from 50 to 400 Hz, 0.6 Kv class, 10 Kv BIL insulation, and 5 ampere secondary;
- 2.2.6.2 current transducer: equal to Veris Industries current to voltage or current to mA transducer with an accuracy of $\pm 5\%$, a minimum load resistance of 30 kOhm, an input of 0 to 20 amperes and an output of 4 to 20 mA, and a 24 VDC regulated power supply.
- 2.2.7 Smoke Detectors: Ionization type duct mounting detectors supplied as part of the electrical work for mounting as part of the control system work.
- 2.2.8 Status and Safety Switches: Double contact switches to monitor equipment status and safety conditions and generate alarms when a failure or abnormal condition occurs. Status and safety switches are to be as follows:
 - 2.2.8.1 current sensing switches: equal to Veris Industries self-powered dry contact output switches for sensing the run status of motor loads, each calibrated to indicate a positive run status only when the motor is operating under load, and each consisting of a current transformer, a solid-state current sensing circuit, adjustable trip point, solid-state switch, SPDT relay, and a LED to indicate on or off status;
 - 2.2.8.2 air filter status switches: automatic reset type differential pressure switches, each complete with SPDT contacts rated for 2 amperes at 120 VAC, a scale range and differential pressure adjustment appropriate for the service, and an installation kit which includes static pressure taps, tubing, fittings, and air filters;
 - 2.2.8.3 air flow switches: pressure flow switches, bellows actuated mercury switch or snap-acting micro-switch type with an appropriate scale range and pressure adjustment;
 - 2.2.8.4 air pressure safety switches: manual reset switches, each complete with SPDT contacts rated for 2 amperes at 120 VAC and an appropriate scale range and pressure adjustment;
 - 2.2.8.5 water flow switches: Equal to Honeywell WFS-1001-H;;
 - 2.2.8.6 low temperature limit switches: manual reset type each complete with DPST snap acting contacts rated for 16 amperes at 120 VAC, a minimum 4.5 m (15') sensing element for mounting horizontally across the duct/plenum with sensing reaction from the coldest 450 mm (18") section of element, and where the sensing element does not provide full coverage of the air stream, additional switches are to be supplied as required.
- 2.2.9 Control Relays: Control relays are to be as follows:
 - 2.2.9.1 control pilot relays: modular plug-in design with snap-mount mounting bases, retaining springs or clips, DPDT, 3PDT or 4PDT as required for the application, with contacts rated for 10 amperes at 120 VAC;

- 2.2.9.2 lighting control relays: latching type with integral status contacts rated for 20 amperes at 120 VAC, each complete with a split low voltage coil that moves the voltage contact armature to the On or Off latched position, each controlled by a pulsed tri-state output (preferred) or pulsed paired binary outputs, and each designed so that power outages will not result in a change-of-state and so that multiple same state commands will simply maintain the commanded state.
- 2.2.10 Electronic Signal Isolation Transducers: Equal to Advanced Control Technologies signal isolation transducers for installation whenever an analog output signal from the building automation system is to be connected to an external control system as an input (i.e. equipment control panel), or is to receive as an input signal from a remote system, and to provide ground plane isolation between systems.
- 2.2.11 External Manual Override Stations: Each manual override station is to be complete with contacts rated minimum 1 ampere at 24 VAC and is to provide the following:
 - 2.2.11.1 an integral HAND/OFF/AUTO switch to override the controlled device pilot relay;
 - 2.2.11.2 a status input to the building automation system to indicate whenever the switch is not in the AUTO position;
 - 2.2.11.3 a status LED to illuminate whenever the output is On;
 - 2.2.11.4 an override LED to illuminate whenever the HOA switch is in either the HAND or OFF position.
- 2.2.12 Building Automation System Interface Hardware: Hardware to permit building automation system control and monitoring of input/output points as per the mechanical work Section entitled Building Automation System, the points schedule, and drawing control diagrams and operation sequences. All such hardware is to be suitable in all respects for interface with the existing Honeywell EBI building automation system.
- 2.3 System Wiring Materials**
 - 2.3.1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in the appropriate Section(s) of the Electrical Work Division of the specification..
- 2.4 Thermostats**
 - 2.4.1 Constructed for surface or recessed wall box mounting, complete with adjustable set-point range of $\pm 1.66^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$), a momentary override request pushbutton for activation of after-hours operation, and a digital temperature display.
- 2.5 Low Temperature Freeze Protection**
 - 2.5.1 Airstream Protection:
 - 2.5.1.1 Electric low limit temperature in airstream with 20'-0" (6000 mm) low point sensitivity element to serpentine entire coil face.

2.5.1.2 Each coil bank shall have thermostat wired in series to shut down supply fan.

2.5.1.3 Two-position, manual reset type.

PART 3 - EXECUTION

3.1 GENERAL RE: INSTALLATION OF CONTROLS

3.1.1 Provide complete systems of control and instrumentation to control and supervise building equipment and systems in accordance with this Section of the Specification and the drawings.

3.1.2 The control systems are to generally be as indicated on drawing control diagrams and are to have all the elements therein indicated or implied.

3.1.3 The control diagrams show only the principal components controlling the equipment and systems. Supplement each control system with all relays, transformers, sensors, etc., required to enable each system to perform as specified and to permit proper operation and supervision.

3.2 SUPPLY OF AUTOMATIC CONTROL VALVES AND OPERATORS

3.2.1 Unless otherwise specified, supply all required automatic control valves. Hand the valves to the appropriate piping trades at the site in the locations they are required for installation as part of the piping work. Ensure that each valve is properly located and installed.

3.2.2 Provide an operator for each valve.

3.3 INSTALLATION OF CONTROL SYSTEM COMPONENTS

3.3.1 Provide all required control system components and related hardware. Refer to drawing control diagrams and sequences.

3.3.2 Where components are pipe, duct, or equipment mounted supply the components at the proper time, coordinate installation with the appropriate trade, and ensure that the components are properly located and mounted.

3.4 INSTALLATION OF SENSORS

3.4.1 Install sensors in accordance with the manufacturer's recommendations.

3.4.2 Mount sensors rigidly and adequately for environment within which the sensor operates.

3.4.3 Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

3.4.4 All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

- 3.4.5 Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- 3.4.6 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m (1 ft) of sensing element for each 1 m²(1 ft²) of coil area.
- 3.4.7 Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 3 m (10 ft) downstream.
- 3.4.8 All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
- 3.4.9 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
- 3.4.10 Differential Air Static Pressure.
- 3.4.10.1 Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
- 3.4.10.2 Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
- 3.4.10.3 Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
- 3.4.10.4 The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
- 3.4.10.5 All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
- 3.4.10.6 All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.
- 3.4.11 Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- 3.4.12 Install humidity sensors for duct mounted humidifiers at least 3 m (10 ft) downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.5 FLOW SWITCH INSTALLATION

- 3.5.1 Use correct paddle for pipe diameter.
- 3.5.2 Adjust flow switch according to manufacturer's instructions.

3.6 COMMUNICATIONS REQUIREMENTS

- 3.6.1 The existing Honeywell BAS shall be able to request values of input signals, reset values, switch or position devices, and receive alarms.
- 3.6.2 The BAS system shall be capable of being user-programmed locally and at the terminals.
- 3.6.3 The BAS shall be capable of sending alarm messages to the remote printer.

3.7 THERMOSTAT PROTECTION & LOCATION

- 3.7.1 All thermostats and sensors in unsupervised public use space shall have 7'-0" (2200 mm) mounting height with solid locking covers, locking adjustment, locking stops or heavy plastic locking covers where these features are not available.
- 3.7.2 In offices and supervised or personal use space, locate thermostats at 5'-6" (1650 mm) with face thermometers, temperature adjustment and locking stops.

3.8 CONTROL WIRING

- 3.8.1 All wiring in connection with the control system shall be furnished by this Contractor, except where specifically noted in Division 26. For controls wired by Division 26, supply adequate drawings to him to wire these controls. Inspect installation after. All relays and thermostats and controlling devices shall be of a suitable voltage for the starters specified.
- 3.8.2 All other power wiring, distribution wiring to the transmitters and devices and a dedicated power circuit for temperature control valves by this Section.
- 3.8.3 All wiring must conform to the requirements for Division 26. 110V and higher voltage shall be in conduit. 24V wiring shall be in FT6 Teflon covered cable, concealed except in Mechanical rooms and where permitted exposed in finished areas by Consultant. The exposed 24 Volt wiring dropping from the ceiling to the panel shall be in conduit.
- 3.8.4 All wiring must be identified with E-Z code, self-sticking wire markers, indicating circuit number at all points of termination, i.e. at panels, pull boxes, junction boxes, equipment, etc.
- 3.8.5 Do all required control wiring from 15A-1P circuits terminated as part of the electrical work in junction boxes in equipment rooms/areas. Coordinate exact junction box locations at the site with the electrical trade.
- 3.8.6 Except as specified below, install all wiring in conduit. Unless otherwise specified the final 600 mm (2') connections to sensors and transmitters, and wherever conduit extends across flexible duct connections is to be liquid-tight flexible conduit.

3.8.7 Control wiring in ceiling spaces and wall cavities may be plenum rated cable installed without conduit but neatly harnessed, secured, and identified.

3.8.8 All wiring work is to be in accordance with certified wiring schematics and instructions, and the wiring standards specified in the appropriate Sections of the Electrical Work Division of this Specification.

3.9 CONTROLLERS

3.9.1 Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

3.9.2 Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in Sequences of Operation.

3.10 PROGRAMMING

3.10.1 Provide sufficient internal memory for the specified sequences of operation and trend logging.

3.10.2 Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in this section may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

3.10.3 Software Programming.

3.10.3.1 Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

3.10.3.1.1 Text-based:

3.10.3.1.1.1 Must provide actions for all possible situations

3.10.3.1.1.2 Must be modular and structured

3.10.3.1.1.3 Must be commented

3.10.3.1.2 Graphic-based:

3.10.3.1.2.1 Must provide actions for all possible situations

3.10.3.1.2.2 Must be documented

3.10.3.1.3 Parameter-based:

3.10.3.1.3.1 Must provide actions for all possible situations

3.10.3.1.3.2 Must be documented.

3.10.4 Operator Interface.

3.10.4.1 Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all relevant input and output points for that equipment. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List.

3.10.4.2 The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.11 IDENTIFICATION AND LABELLING OF EQUIPMENT AND CIRCUITS

3.11.1 Refer to identification requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods.

3.11.2 Identify equipment as follows:

3.11.2.1 enclosures and components: engraved laminated nameplates with all wording listed and approved prior to manufacture of the nameplates;

3.11.2.2 wiring: numbered sleeves or plastic rings at both ends of the conductor, with numbering corresponding to conductor identification on shop drawings and "as-built" record drawings.

3.12 TESTING, ADJUSTING, CERTIFICATION, START-UP, AND TRAINING

3.12.1 Testing and Adjusting: When control work is complete, check the installation of components and all wiring connections, make any required adjustments, and coordinate adjustments with personnel doing HVAC testing, adjusting and balancing work.

3.12.2 Equipment and System Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.

3.12.3 Start-Up:

3.12.3.1 Start up, check out, and test all hardware and software and verify communication between all components.

3.12.3.1.1 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

3.12.3.1.2 Verify that all analog and binary input/output points read properly.

3.12.3.1.3 Verify alarms and interlocks.

3.12.3.1.4 Verify operation of the integrated system.

3.12.4 Demonstration and Training: Refer to Section 25 05 10 for further detail on training

3.13 CLEANING

3.13.1 The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

3.13.2 At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

3.13.3 At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.14 CONTROL SEQUENCES

3.14.1 Refer to drawings for control sequences.

END OF SECTION

PART 1 - GENERAL

1.1 ABBREVIATIONS AND DEFINITIONS

1.1.1 Abbreviations used in this Specification are as follows:

- .1 BAS building automation system;
- .2 DDC direct digital controls;
- .3 LAN local area network;
- .4 EMCS Energy Management and Controls System;
- .5 OEM original equipment manufacturer;
- .6 PC personal computer.

1.2 SUBMITTALS

1.2.1 Shop Drawings/Product Data: Submit shop drawings/product data sheets for all BAS/EMCS components. Shop drawings/product data sheets must confirm that the components proposed meet all requirements of the Contract Documents. As a minimum, submit the following:

- .1 network architecture, including all modes and interconnections;
- .2 systems schematics, sequences, and flow diagrams;
- .3 points schedule for each control point, including point type, object name, expanded ID, display units, controller type, and address;
- .4 samples of graphic display screen types and associated menus;
- .5 a detailed Bill of Materials for each system or application, identifying quantities, part numbers, descriptions, and optional features;
- .6 control damper schedule including a separate line for each damper and a column for each of the damper attributes including code number, fail position, damper type, damper operator, duct size, damper size, mounting and actuator type;
- .7 control valve schedules including a separate line for each valve and a column for valves as for control dampers;
- .8 a room schedule including a separate line for each HVAC terminal unit indicating type, location and address;
- .9 details of all interfaces and connections to other systems;
- .10 product data sheets or marked catalogue pages including part number, photograph and description for all BAS hardware and software.

- 1.2.2 Site Inspection and Start-Up Report: Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.
- 1.2.3 Portable Operator's Terminal: At the time of start-up and commissioning of the BAS, supply portable operator's terminal(s) as specified in Part 2 of this Section and hand to the Owner at the site. Ensure that the Owner signs for receipt of the terminal(s).

1.3 DESCRIPTION OF THE CONTROL SYSTEM

- 1.3.1 The building automation system is to form an extension of the existing Facility's Honeywell control system. New equipment and devices shall be BACnet compatible to the greatest extent possible, and shall be integrated into the building's existing automation system
- 1.3.2 The BAS system expansion is to include, but not be limited to, the following:
- .1 standalone network automation engine(s);
 - .2 field equipment controllers;
 - .3 input/output modules;
 - .4 local display devices;
 - .5 distributed user interfaces;
 - .6 network processing, data storage and communication equipment;
 - .7 all other components required for a complete and operating BAS, fully integrated in to the existing system.
- 1.3.3 The BAS hardware and software is to be installed by experienced personnel employed and trained by the system equipment manufacturer/supplier. All system wiring is to be installed by journeyman electricians or under direct on-site supervision of journeyman electricians.
- 1.3.4 The BAS supplier/installer is to have a branch facility with parts within a 100 km radius of the building and have available complete maintenance and support services on a 24 hour, 7 day-a-week basis.

PART 2 - PRODUCTS

2.1 GENERAL RE: CONTROL SYSTEM

- 2.1.1 Control System Components: Control system components (field devices) other than those specified in this Section are generally specified in the mechanical work Section entitled Automatic Control Systems. Components factory installed with equipment or supplied with equipment are specified in mechanical work Sections with the equipment.
- 2.1.2 Acceptable BAS Manufacturers: The BAS specified in this Section is an expansion of the existing DDC building automation system as per drawing control diagrams and sequences, and points lists. Acceptable BAS manufacturers are:

- .1 Honeywell.

2.2 BAS SYSTEM ARCHITECTURE

- 2.2.1 Automation Network: The BAS expansion is to be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards are to be standard "off-the-shelf" products available through normal PC vendor channels. The BAS is to be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication. The BAS is to be compatible with other enterprise-wide networks, and where indicated, the BAS is to be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
- 2.2.2 Control Network: Network automation engines are to provide supervisory control over the control network and are to support the BACnet Standard MS/TP bus communication protocol (ASHRAE SSPC-135, Clause 9). The control networks are to provide either a "peer-to-peer", master-slave, or supervised token passing communications and are to operate at a minimum communication speed of 9600 baud. DDC controllers are to reside on the control network.
- 2.2.3 Integration: The BAS expansion is to include appropriate hardware and software to allow BACnet bi-directional data communications between the BAS and building equipment/system control panels. The BAS is to receive, react to, and return information from the equipment and systems. All data required by the application is to be mapped into the automation engine's data base and is to be transparent to the operator. Point inputs and outputs from building equipment/system control panels is to have real-time inter-operability with BAS software features such as control software, energy management, custom process programming, alarm management, historical data and trend analysis, totalization, and local area network communications.

2.3 NETWORK AUTOMATION ENGINES

- 2.3.1 Network automation engines are to be UL listed and labelled, BACnet Testing Labs certified and labelled, fully user programmable supervisory controllers to monitor a network of a minimum of one hundred distributed application-specific controllers for a global strategy and direction and to communicate on a peer-to-peer basis with other network automation engines.
- 2.3.2 User Interface: Each network automation engine is to have the ability to deliver a web based user interface as specified above, and all computers connected physically or virtually to the automation network are to have access to the web based user interface. Additional characteristics/requirements are as follows:
 - .1 the web based user interface software is to be imbedded in each network automation engine;
 - .2 each network automation engine is to support a minimum of four concurrent users;
 - .3 the user is to be capable of accessing all system data through one network automation engine;
 - .4 remote users connected to the network through an internet service provider or by telephone dial-up are also to have total system access through one network automation engine;

- .5 each network automation engine is to be capable of generating web based user interface graphics, and this capability is to be imbedded in the network automation engine;
 - .6 the user interface is to support the following functions using a standard version of Microsoft Internet Explorer:
 - .1 configuration;
 - .2 commissioning;
 - .3 data archiving;
 - .4 monitoring;
 - .5 commanding;
 - .6 system diagnostics.
 - .7 each network automation engine is to permit temporary use of portable devices without interrupting the normal operation of permanently connected modems.
- 2.3.3 Processor: Each network automation engine is to be a multi-tasking, multi-user, microprocessor based real time digital control processor sized to meet requirements of the system with a minimum word size of 32 bits, and standard operating systems.
- 2.3.4 Memory: Each network automation engine is to have sufficient memory to support its own operating system, databases, and control programs to provide supervisory control for all control level devices.
- 2.3.5 Real Time Clock: Each network automation engine is to include an integrated, hardware based real time clock.
- 2.3.6 LED Indicators: Each network automation engine is to be equipped with LED indicators to identify the following conditions:
- .1 Power, On/Off;
 - .2 Ethernet Traffic, Ethernet Traffic/No Ethernet Traffic;
 - .3 Ethernet Connection Speed, 10 Mbps/100 Mbps;
 - .4 FC Bus A, Normal Communications/No Field Communications;
 - .5 FC Bus B, Normal Communications/No Field Communications;
 - .6 Peer Communication, Data Traffic Between Network Automation Engines;
 - .7 Run, NAE Running/NAE in Start-up/NAE Shutting Down/Software Not Running;
 - .8 Battery Fault, Battery Defective/Data Protection Battery Not Installed;

- .9 24 VAC, 24 VAC Present/Loss of 24 VAC;
 - .10 Fault, General Fault;
 - .11 Modem RX, NAE Modem Receiving Data;
 - .12 Modem TX, NAE Modem Transmitting Data.
- 2.3.7 Communications Ports: Each network automation engine is to be equipped with ports for operation of operator input/output devices such as industry standard computers, modems, and portable operator's terminals. Ports are to be as follows:
- .1 two USB ports;
 - .2 two URS-232 serial data communication ports;
 - .3 two RS-485 ports;
 - .4 one Ethernet port.
- 2.3.8 Diagnostics: Each network automation engine is to continually perform self-diagnostics, communications diagnostics, and diagnostics of all pane components, and transmit both local and remote annunciation of any detected component failure, low battery condition, and repeated failures to establish communication.
- 2.3.9 Power Failure: In the event of loss of normal power each network automation engine is to continue to operate for a user adjustable period of up to ten minutes after which there is to be an orderly shut-down of all programs to prevent the loss of database or operating system software, and:
- .1 during a loss of normal power the control sequences are to go to the normal system shutdown conditions, and all critical configuration data is to be saved into Flash memory;
 - .2 upon restoration of normal power and after a minimum off-time delay the controller is to automatically resume full operation through a normal soft-start sequence without manual intervention.

2.4 FIELD EQUIPMENT CONTROLLERS

- 2.4.1 Each field equipment controller is to be a fully user programmable BACnet Testing Labs certified and labelled digital controller that communicates via BACnet MS/TP protocol. Each controller is to be housed in a plenum rated plastic housing with removable base to permit pre-wiring of analog and binary input/output field points without the controller in place.
- 2.4.2 Each controller is to employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences, and are to be factory programmed with a continuous adaptive tuning algorithm that sense changes in the physical environment and continually adjusts loop tuning parameters appropriately.

- 2.4.3 BAS and ancillary equipment shall be a computerized distributed, BTL listed, open protocol, non-proprietary system;
- 2.4.4 BAS shall be a graphic based system with access through the facility's building automation network system. The system shall have internet access and capability for remote dial-out;

2.4.5 Each field equipment controller is to:

- .1 include troubleshooting LED's to identify the following conditions:
 - .1 Power On;
 - .2 Power Off;
 - .3 Download or Start-Up In Progress-Not Ready For Normal Operation;
 - .4 No Faults;
 - .5 Device Fault;
 - .6 Field Controller Bus-Normal Data Transmission;
 - .7 Field Controller Bus-No Data Transmission;
 - .8 Field Controller Bus-No Communication;
 - .9 Sensor Actuator Bus-Normal Data Transmission;
 - .10 Sensor Actuator Bus-No Data Transmission;
 - .11 Sensor Actuator Bus-No Communication.
- .2 support universal inputs, configured to monitor any of the following:
 - .1 analog input, voltage mode;
 - .2 analog output, current mode;
 - .3 analog input, resistive mode;
 - .4 binary input, dry contact maintained mode;
 - .5 binary input, pulse counter mode.
- .3 support binary inputs configured to monitor either of the following:
 - .1 dry contact maintained mode;
 - .2 pulse counter mode.
- .4 support analog outputs configured to output either of the following:
 - .1 analog output, voltage mode;
 - .2 analog output, current mode.

- .5 support binary outputs, 24 VAC Triac;
- .6 support configurable outputs capable of the following:
 - .1 analog output, voltage mode;
 - .2 binary output mode.
- .7 have the ability to reside on a master-slave/token-passing field controller bus supporting BACnet standard protocol as follows:
 - .1 support communications, including input/output communications between the field controllers and the network automation engines;
 - .2 support a minimum of one hundred input/output modules and field equipment controllers in any combination;
 - .3 operate at a maximum distance of 4560 m (15,000') between the field controller and the furthest connected device.
- .8 have the ability to monitor and control a network of sensors and actuators over a master-slave/token-passing sensor-actuator bus supporting BACnet standard protocol as follows:
 - .1 the bus is to support a minimum of ten devices per trunk;
 - .2 the bus is to operate at a maximum distance of 365 m (1200') between the field controller and the furthest connected device.
- .9 the capability of executing complex control sequences involving direct wired input/output points as well as input and output devices communicating over the field controller bus or sensor-actuator bus;
- .10 support, but not limited to, the following:
 - .1 hot water, chilled water/central plant applications;
 - .2 custom air handling units for special applications;
 - .3 terminal units;
 - .4 special programs as required for systems control.
- .11 support a password protected local controller LCD back-lit display with six key keypad as an integral part of the field controller or as a remote device communicating over the sensor-actuator bus to permit the user to view monitored points without logging into the system, and to view and change set-points, modes of operation, and parameters;

2.5 INPUT/OUTPUT MODULES

- 2.5.1 Input/output modules to facilitate additional inputs and outputs for use in the field equipment controllers are to be similar to the field equipment controllers but less the display and with a minimum of four and a maximum of seventeen points.
- 2.5.2 and with a minimum of four and a maximum of seventeen points.

2.6 SYSTEM CONFIGURATION TOOLS

- 2.6.1 System Configuration Tool: The system configuration tool is a software package supplied with the BAS to enable a computer platform to be used as a stand-alone engineering configuration tool for a network automation engine and to permit programming of field equipment controllers. The configuration tool is to provide an archive database for the configuration and application data and is to have the same look and feel at the user interface regardless of whether the configuration is being done online or offline. Additional features and characteristics are as follows:
- .1 the tool is to include:
 - .1 basic system navigation tree for connected networks;
 - .2 integration of system enabled devices;
 - .3 customized user navigation tree;
 - .4 point naming operator parameter setting;
 - .5 graphic diagram configuration;
 - .6 alarm and event message routing;
 - .7 graphical logic connector tool for custom programming;
 - .8 downloading, uploading, and archiving databases.
 - .2 the tool is to have the capability to automatically discover field devices on connected buses and networks;
 - .3 the tool is to be capable of configuring from a library of standard applications, simulating to verify applications, and commissioning field equipment controllers and field devices;
 - .4 the tool is to be complete with a Bluetooth Wireless Technology wireless access point to enable a wireless enabled portable computer to make a temporary Ethernet connection to the automation network.

2.6.2 Wireless MS/TP Converter: The Bluetooth Wireless Technology converter is to provide temporary wireless connection between the sensor-actuator bus or field-controller bus and a wireless enabled portable computer. The converter is to be powered through a connection to either the sensor-actuator bus or the field-controller bus and is to support downloading and troubleshooting field equipment controllers and field devices from the portable computer over the wireless connection. The converter is to be complete with LED indicators for the following conditions:

- .1 Power: On/Off;
- .2 Fault: Fault/No Fault;
- .3 SA/FC Bus: Bus Activity/No Bus Activity;
- .4 Bluetooth: Bluetooth Communication Established/Bluetooth Communication Not Established.

2.7 WIRING MATERIALS

2.7.1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in the appropriate Section(s) of the Electrical Work Division of the specification.

2.8 POWER TO BAS COMPONENTS

2.8.1 All power supplied to BAS system components, excluding terminal devices, to be connected to the Facility's emergency power distribution with UPS back-up.

2.8.2 All power supplied to BAS system terminal devices to be connected to the Facility's emergency power distribution.

2.9 AIRFLOW CONTROL SYSTEM FOR PATIENT ISOLATION ROOMS

2.9.1 General

- .1 The Airflow Control System (ACS) will control the Patient Room and Ante Room containment zones. The ACS will maintain volumetric offset to achieve room pressurization in relation to adjacent spaces. The ACS will also provide temperature and environmental control while maintaining minimum ventilation rates as per design schedule.
- .2 ACS devices will include the Integrated Room Controller (IRC) with an Integrated Room Display (PM) located at each entrance. Each user interface shall communicate clear, unambiguous indication of the current relative pressurization condition and mode in plain language via full colour touch screen.
- .3 All room level control shall be hardwired inputs and outputs. Systems utilizing network communication or proprietary communication languages shall not be accepted. ACS controllers shall be configurable through local touch screen display(s) and not require additional proprietary software for setup or commissioning.

2.9.2 ACS Control Strategies

- .1 Airflow control shall be volumetric offset to maintain secondary containment and pressurization.
 - .1 The ACS shall continuously measure the sum of all exhaust air valves and the sum of all supply air valves and maintain a constant offset based on measured airflows.
 - .2 Volumetric offset tracking shall ensure supply air set point is determined from measured total exhaust airflow. Systems utilizing independent set points not based on measured values shall not be acceptable.
 - .3 The ACS shall maintain proper room pressurization regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or changes in duct static pressure. Systems achieving room pressurization control by means of direct pressure control are unacceptable.
- .2 Temperature control shall utilize dual loop and variable ventilation rates to maintain temperature.
 - .1 The ACS shall use dual loop temperature control on all rooms serving critical spaces to maintain consistent room temperatures regardless of air volume changes.
 - .2 The ACS shall continuously measure both room temperature and supply air duct temperature. The ACS shall continuously modulate reheat valve based on difference in calculated supply air duct temperature set point and the measured room temperature.
 - .3 The ACS shall modulate the reheat valve closed on a call for cooling and then modulate the general exhaust air valve from minimum to maximum ventilation set point until the room temperature set point is met.
The ACS shall modulate the reheat valve open on a call for heating after modulating the general exhaust air valve to minimum ventilation set point until the room temperature set point is met.
 - .4 The ACS shall maintain the reheat valve position last commanded to achieve proper heat load in the space.
 - .5 The ACS shall maintain the ventilation set point last commanded to achieve proper cooling load in the space.

2.9.4 Integrated Room Controller (IRC)

- .1 Room shall consist of one controller for room level control. Each air valve shall not require a controller for the ACS to operate.
- .2 Controller shall utilize analog signals (scaled voltage) to control air valves. Room level networks shall not be acceptable.
- .3 Controller shall be BACnet native, BTL Listed, and utilize BACnet MS/TP communication protocol for integration.
- .4 Controller shall be application specific for volumetric offset control and not require logic- based programming.
- .5 Controller shall be configurable through local environmental condition display with password protection.
- .6 Controller shall serve as power source for all sensors within the ACS.
- .7 Controller shall support up to five modes that each have customizable parameters, alarms, set points, etc.
- .8 Environmental Condition Display
- .9 The display shall be wall mounted and capable to be mounted up to 200' from IRC.
- .10 Each display shall be a 7-inch resistive touch screen display capable of sensing touch with a gloved hand.
- .11 The IRC shall support multiple display formats for environmental condition with information in an icon or pill-based display. Refer to project plans for display types.
- .12 PM - Pressure Monitor view with full color background and icon for room condition. Points of information accessible from slider bar at bottom of display.
- .13 MV - MultiVIEW Monitor view with point of information displayed in pill format. Ability to swipe screen to view 28 points of information.
 - .1 User Defined Modes:
 - .2 15-character customizable name text.
 - .3 Background color customizable, including, but not limited to; green, blue, red, yellow, grey, etc.

- .4 Monitor icon customizable, including, but not limited to; patient bed, surgeon mask, beaker, stop hand, caution triangle, mop, etc.
- .5 Customizable set points per mode
- .6 Modes shall be able to be changed locally from display, through the building automation system or through hardware signal.
- .14 Displayed Information
 - .1 The room pressure monitor shall have the ability to display 28 points of information.
 - .2 Each point shall be fully customizable from the display
- .15 Each point shall include:
 - .1 15-character customizable point name
 - .2 Engineering unit customizable: including, but not limited to, CFM, "WC, ACH, %, °, etc.
 - .3 Resolution selection of Oto 0.0000
 - .4 Ability to hide, show or adjust set points
 - .5 Customizable alarm parameters
- .16 Displayed information shall be configurable from (14) analog inputs and/or writable through the building automation system

.17 Alarm and Security:

- .1 The monitor shall include audible and visual alarming customizable for each point of information, including, but not limited to; low pressure, high pressure, emergency condition, temperature, humidity, ACH, etc.
- .2 Each point of information within the room pressure monitor shall have ability to enable or disable alarming for each user defined mode.
- .3 Each point of information within the room pressure monitor shall have user defined alarm delay.

.18 .During alarm delay the display shall have visual indication of point outside alarm parameters.

- .1 The display and/or through the BAS, shall have the ability to mute alarms while maintaining visual alarm state.
- .2 The display shall have the ability to alarm individual point or entire display screen; with the screen alarm being a pulsated visual.
- .3 Each display shall utilize four levels of password-protected access. Different levels of secure access shall include: administrative, mode change, more information, and set point.
- .4 Each display shall include up to three unique user passwords and each user be configurable for level of access.

.19 Building Automation System (BAS) Interface:

- .1 The environmental condition display shall allow BAS to write points of information to be displayed.
- .2 The environmental condition display shall allow settings adjustments over the building network, including, but not limited to; set point, alarm parameters, modes, etc.
- .3 The BMS shall use either analog inputs, digital inputs, or utilize BACnet network protocol to view points or status of the room being measured. The use of BACnet protocol shall be native to the device and shall not require the use of an external gateway.
- .4 The display shall include the ability to change MAC address, device instance ID, and baud rate (9600, 19200, 38400, 76800, 115200) without the use of rotary dial or dip switches.

2.9.5 Venturi Air Valves

- .1 A pressure independent medium pressure device capable of operating at static pressures of 0.6 to 3 inches water gauge

- .2 Volume control accurate to $\pm 5\%$ of airflow command signal.
- .3 No additional straight duct runs needed before or after valve.
- .4 Response time to change in command signal: <1 second.
- .5 Response time to change in duct static pressure: <1 second.
- .6 Construction:
 - .1 Stainless Steel Shell Thickness: 18 gauge (1.0 mm)
 - .2 Internal Assembly Construction Materials: Stainless steel shaft and struts with Teflon[®] PTFE bearings
- .7 Actuation:
 - .1 A UL or CSA listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications). Loss of main power shall cause the valve to maintain its last airflow position. This position shall be maintained until power is restored.
 - .2 Supply/make-up air valves: Fail to last airflow position.
 - .3 General exhaust air valves: Fail to last airflow position.
- .8 Certification:
 - .1 Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of no more than plus or minus one percent of signal over the entire range of measurement. Airflow control devices shall be further calibrated and their accuracy verified to plus or minus five percent of signal at a minimum of 48 different airflows across the full operating range of the device.
 - .2 The calibration laboratory shall measure volumetric flow rate with the following calibration accuracy, in accordance with the scope of accreditation to ISO/IEC 17025:
 - .3 30 standard cubic feet per minute to 100 standard cubic feet per minute shall have 4.0 percent expanded uncertainty.
 - .4 100 standard cubic feet per minute to 250 standard cubic feet per minute shall have 2.5 percent expanded uncertainty.
 - .5 250 standard cubic feet per minute to 4200 standard cubic feet per minute shall have 1.4 percent expanded uncertainty.

.6 Each airflow control device shall be marked with device-specific factory calibration data, a unique serial number and a tag number. At a minimum this serial number shall be traceable to, the model number, characterization information (for electronic devices), and quality control documentation. All information shall be stored by the manufacturer for use with as-built documentation.

2.9.6 Acceptable manufacturers

- .1 Johnson controls
- .2 Honeywell

2.9.7 Alternate manufacturers (to be reviewed and approved by UHN)

- .1 CRC
- .2 AJM (Titus)
- .3 Price
- .4 Air Genuity
- .5 Accutrol

.6 Room Pressure Monitoring

.1 Room Pressure Sensor

- .1 The room pressure sensor shall hardwire to ACS and not require additional controller and/or display within the space.
- .2 The room pressure sensor shall continuously monitor bi-directional room pressure between the associated referenced space.
- .3 The room pressure sensor shall be capable to be mounted up to 250 feet from pressure pickup plates.
- .4 The room pressure sensor shall utilize industrial quality differential pressure transducer technology.
- .5 Pressure sensing technology shall be direct pressure measurement by means of dead ended silicon imbedded glass sensing device to measure differential.
 - .1 Implied pressure measurement systems utilizing thermal hot wire, thermal mass air velocity measurement, metallic diaphragm or non-dead ended are not acceptable.
- .6 Pressure sensor shall not be integral to room pressure monitor.
- .7 The pressure sensor shall be capable of replacement without removing room pressure monitor.

- .1 Room pressure monitor suppliers with pressure sensing integral to monitor shall include one (1) monitor/sensor for every five (5) monitors required for project.
- .8 The room pressure sensor shall be factory calibrated with NIST traceable standards.
 - .1 The room pressure sensor shall be individually calibrated for installed and scheduled range.
 - .2 The room pressure sensors that catalogue accuracy based on larger transducer ranges will not be accepted.
- .9 Sensing accuracy statement shall include the effects of non-linearity, non-repeatability, hysteresis, zero offset and span setting errors.
 - .1 Accuracy statements and claims that use the (RSS) root sum squares of non-linearity (BFSL), non-repeatability and hysteresis or exclude zero offset and span setting errors are not acceptable.
- .10 The room pressure sensors shall be dead ended to protect from the effects of dust, dirt and lint. Sensors with elements exposed to the airstream are not acceptable.

2.10 CAV/VAV TERMINAL AIRFLOW DEVICES:

- .1 Shall be equipped with an inlet airflow velocity sensor and shall be integrated into the facility BAS;
- .2 Shall be equipped with a discharge airflow temperature sensor and shall be integrated into the facility BAS;
- .3 Shall be equipped with optimization control with the following requirements:
- .4 Zone airflow and temperature shall include night setback adjustment of the space temperature set-point and airflow according to space occupancy to the greatest extent possible. To the greatest extent possible, the implementation of night setback strategies shall not interfere with relative pressurization of the space and adjacent areas.
- .5 A review of the zone weekly occupancy schedule as determined by the User and reviewed with UHN;
- .6 A review of zone local and remote occupancy override requirements as determined by the User and reviewed with UHN;
- .7 A review of adjacent zones to ensure that space pressurization is not compromised with implementing any optimization features.

- .8 Acceptable Manufacturer: EH Price

2.11 VENTILATION & EXHAUST AIRFLOW SYSTEMS:

2.11.1 Shall be equipped with optimization control with the following requirements:

- .1 Fan static pressure re-set according to constant air volume/variable air volume terminal device static pressure demand;
- .2 Air handling unit supply air discharge temperature re-set according to zone temperature demand.

2.12 SPACE TEMPERATURE THERMOSTATS:

- .1 Adjustable space temperature sensor with display (patient care spaces/office spaces) for only 2-3 degrees. The main control is via BAS system.
- .2 For measurement and adjustment of space temperature as shown on the floor plans and/or as described in the Sequence of Operation;
- .3 .Digital set-point operating temperature adjustment range from 4°C to 60°C (40°F to 140°F);
- .4 Set-point adjustment shall be accessible through the cover;
- .5 .Surface mounted plastic mono-chromatic guard with surface mounting
- .6 plate and wall anchors;
- .7 On/off button to allow occupant override feature;
- .8 .Three-digit LED digital temperature display with 0.2° display resolution;
- .9 5% to 95% relative humidity, non-condensing;
- .10 .Minimum/maximum limit set point values adjustable from the BAS
- .11 operator interface and controller.

2.13 .OEM Integration:

- .1 Original Equipment Manufacturer (OEM) controllers shall have BACnet interface for integration of monitoring and control points with BAS system;
- .2 Monitoring and control points for OEM equipment shall be integrated to the BAS through BACnet.

2.13.2 Acceptable manufacturers

- .1 Johnson controls
- .2 Honeywell

2.13.3 Alternate manufacturers (to be reviewed and approved by UHN)

- .1 CRC
- .2 AJM (Titus)
- .3 Price

PART 3 - EXECUTION

3.1 GENERAL RE: INSTALLATION OF THE BAS

- 3.1.1 Provide a complete expansion of the existing building's automation system in accordance with requirements of this Section of the Specification, the mechanical work Section entitled Automatic Control Systems, the drawings, and/or the input/output points list(s).
- 3.1.2 Unless otherwise specified do all BAS work in accordance with the system manufacturer's instructions.

3.2 INSTALLATION OF DIRECT DIGITAL CONTROL SYSTEM COMPONENTS

- 3.2.1 Provide all required direct digital control hardware, software, accessories, and wiring for a complete BAS. Refer to drawing control diagrams and sequences, the points list(s), and the mechanical work Section entitled Automatic Control Systems.
- 3.2.2 Surface mount control units in IT rooms, electrical rooms, mechanical rooms, etc. Connect a maximum of two major mechanical systems to each field controller. Ensure that mounting surfaces do not vibrate.
- 3.2.3 Consult with the Owner and Consultant to ensure that all required input/output points are entered into the system.

3.3 CONTROL WIRING

- 3.3.1 Do all required BAS wiring from 15A-1P circuits terminated as part of the electrical work in junction boxes in equipment rooms/areas.
- 3.3.2 Except as specified below, install all wiring in conduit. Unless otherwise specified the final 600 mm (2') connections to sensors and transmitters, and wherever conduit extends across flexible duct connections is to be liquid-tight flexible conduit.
- 3.3.3 All wiring work is to be in accordance with the BAS manufacturer's certified wiring schematics and instructions, and the wiring standards specified in the electrical work Division of this Specification.

3.4 IDENTIFICATION AND LABELLING OF EQUIPMENT AND CIRCUITS

- 3.4.1 Refer to the mechanical work Section entitled Basic Mechanical Materials and Methods.
- 3.4.2 Identify BAS equipment as follows:
 - .1 enclosures: engraved laminated nameplates with lettering such as BAS Panel CP2, or BAS Relays, or BAS E/P Transformers, with all wording listed and approved prior to manufacture of the nameplates;
 - .2 panel points: a weather-proof input/output layout sheet for each controller with the name of each point connected to the controller, and the associated wire labelling information;
 - .3 wiring: numbered sleeves or plastic rings at both ends of the conductor, with numbering corresponding to conductor identification on shop drawings and "as-built" record drawings;

- .4 interface components: a weather-proof layout sheet clearly illustrating/identifying the purpose of each component within the enclosure such that an operator or service technician can quickly identify the exact use of each relay, transducer, contactor, etc., with each sheet fastened securely to the back of the enclosure door.

3.5 TESTING, ADJUSTING, CERTIFICATION, START-UP, AND TRAINING

- 3.5.1 Equipment and System Manufacturer's Certification: Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.5.2 Start-Up: Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- 3.5.3 Demonstration and Training: Refer to Section entitled Common Work Results for Mechanical. Include for demonstration and training sessions for each of two groups of Owner's operating and maintenance personnel as follows:
 - .1 three half day orientation sessions at the system manufacturer's office to educate personnel on BAS architecture, hardware, and software, with an overview of BAS operation and capabilities including but not limited to operational programmes, equipment functions (both individually and as part of a total integrated system), BAS commands, advisories, alarms, and appropriate operator intervention required in responding to the BAS operation;
 - .2 two half day sessions at the site using the BAS for a "hands-on" demonstration of all BAS functions and features with instruction regarding the chronological flow of information from field devices, contacts and sensors to the operator's work station, an overview of the communications network describing the interplay between initiating devices, field hardware panels, systems communications, and their importance within the operating BAS, and alarm indications and appropriate responses;
- 3.5.4 Additional Training: Include for two follow-up site training (half day each) and troubleshooting visits, one six months after Substantial Completion and the other at the end of the warranty period, both when arranged by the Owner and for half day to provide additional system training as required.

3.6 INSTALLATION OF AIRFLOW CONTROL SYSTEM FOR PATIENT ISOLATION ROOMS

- 3.6.1 Provide airflow control system for Patient Isolation rooms as shown on drawings.
- 3.6.2 Install system in accordance with manufacturer's instructions and recommendations.
- 3.6.3 Mount actuators on same side of air valve device as coil connections to ensure service access.
- 3.6.4 Connect air valves to ductwork with joints as detailed.

3.7 PROJECT CLOSEOUT WORK

- 3.7.1 Refer to the mechanical work Section entitled Mechanical Work General Instructions.

3.7.2 Record "As-Built" drawings are to include:

- .1 a schematic outline of the BAS for quick reference of the overall system scope;
- .2 an adequate record of the work as installed, including the locations and routing of system wiring.

3.7.3 The Operation and Maintenance Manual is to contain:

- .1 a hardware specification manual which gives a functional description of all hardware components;
- .2 an operator's manual which outlines concise instructions for operation of the system and an explanation and recovery route for all system alarms;
- .3 an engineering manual which outlines and defines system set-up, definition and application;
- .4 a data manual which indicates the applications data programmed into the system;
- .5 system software documentation.

END OF SECTION



**SMITH
& LONG**

SMITH AND LONG MECHANICAL
115 Idema Rd Markham ON L3R 1A9
Mechanical • HVAC Services • Electrical • 24 Hour Response

Submittal

Date: Jan 31, 2020

Project: Toronto Western Hospital - MRI Phase 2 & 3

Project #: C003237

Submittal #: C3237-08

Submitted for: Approval

Submitted by: Alejandra Perez

Supplier:

Contractor: Smith and Long Mechanical


Specification section/ drawing number:

Title: Chiller Shop Drawing

Review by: Joseph Lombardo

Description
<ul style="list-style-type: none">Chiller Shop Drawing

Notes:

	Callidus Engineering
<small>THE DRAWINGS OR EQUIPMENT ATTACHED HAVE BEEN REVIEWED FOR COMPLIANCE WITH THE DESIGN INTENT SHOWN ON THE DRAWINGS. THEY HAVE NOT BEEN REVIEWED FOR QUANTITY OR SPECIFIC EQUIPMENT DESIGN. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO ENSURE THAT THE EQUIPMENT PROPOSED WILL FIT IN THE SPACE SHOWN ON THE DRAWINGS.</small>	
<input type="checkbox"/> REVIEWED <input checked="" type="checkbox"/> REVIEWED AS MODIFIED <input type="checkbox"/> REJECTED - RESUBMIT	
REVD BY: <u>EMF</u> DATE: <u>R1 20.02.20</u>	



**Submittal
30667**

APPROVAL REQUIRED

Project 21808637-MECH-TWH-MRI- TWH - MRI Redevelopment Project Phase 2 and 3
Leader Ryan Hiscott
Job Site 399 Bathurst St., Toronto, ON, Canada
Submission Date 2020-01-29
Sold To SMITH & LONG
Submitted By Ryan Hiscott

Contacts

Role	Customer	Contact	Our Rep
Owner	Toronto Western Hospital (UHN)		Steve Cukrovani
Mechanical Contractor	Smith & Long Mechanical Ltd.	Joe Lombardo	Ryan Hiscott
Designer	Callidus		Terry Arcese

Deliverables

Track #	103504		
Tag	CH-101		
Description	Modular Air Cooled Scroll Chiller		
Quantity	4		
Manufacturer	ArcticChill		
Model #	PACVMV0250D5		
Specification	23 64 10		
Production Lead Time	13-15 weeks		
Revision #	0		

Notes:

****PLEASE CONFIRM BAS COMMUNICATION TYPE**** -PROVIDE BACNET INTERFACE

c/w

- Air-Cooled Chiller Modules (Qty. 4)
- 575V /3ph / 60Hz
- Power Distribution Panel for Single Point Power
- Chiller Modules Ship Loose For Field Install and Power Wiring Connection
- Dual R-410a Refrigeration Circuits on Each Module
- Digital Scroll Compressors on Lead Circuits
- Flooded Condenser Head Pressure Control
- Microprocessor Controller with Remote Interface Display

Tank and Pump Module

- Dual Centrifugal Pumps
- Premium Efficient TEFC Motors
- VFD
- Glycol Makeup Tank with Charging Pump
- Sealed Stainless Steel Buffer Tank



- Single Point Power 575V from Main Chiller Distribution Panel

Attention:

- 1) HTS will provide equipment in accordance with the attached shop drawings.
- 2) Upon approved submittal and customer release, HTS will release equipment to fabrication per the published lead times. Any storage fees associated with project schedule changes will be the responsibility of the purchaser.
- 3) HTS can provide freight and logistics to the purchaser as an added benefit of doing business with HTS. When freight is received by the purchaser, any noticeable damage must be recorded. Otherwise, HTS is not responsible for subsequent damage claims.

Approval Stamps

Part 1 General

1.1 SECTION INCLUDES

- .1 Chiller package.
- .2 Charge of refrigerant and oil.
- .3 Controls and control connections.
- .4 Chilled water connections.
- .5 Starters.

1.2 RELATED SECTIONS

- .1 Section 23 05 13 - Motors.
- .2 Section 23 05 48 - Vibration Isolation.
- .3 Section 23 05 93 - Testing, Adjusting, And Balancing.
- .4 Section 23 21 00 - Hydronic Piping.
- .5 Section 23 21 23 - HVAC Pumps.
- .6 Section 23 23 00 - Refrigerant Piping And Specialties.
- .7 Section 26 05 80 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCES

- .1 AHRI 550/590 (I-P)-2012 - Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle.
- .2 ASME Boiler and Pressure Vessels Code (BPVC), Section VIII-1-2105 - Rules for Construction of Pressure Vessels.
- .3 CSA-B52-13 - Mechanical Refrigeration Code.
- .4 CSA (Canadian Standards Association).
- .5 NEMA ICS 6-1993 (R2001, R2006, R2011) - Industrial Control and Systems: Enclosures.
- .6 UL (Underwriters Laboratories Inc.).

1.4 SUBMITTALS FOR REVIEW

- .1 Section 01 33 00: Submission procedures.
- .2 Product Data: Provide rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- .3 Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate valves, strainers, and thermostatic valves required for complete system.

1.5 SUBMITTALS FOR INFORMATION

- .1 Section 01 33 00: Submission procedures.
- .2 Installation Data: Manufacturer's special installation requirements.
- .3 Manufacturer's Certificate: Certify that components of package not provided by manufacturer have been selected to manufacturer's requirements.
- .4 Submit complete drawings including cabinet dimensional details and anchor point locations, required clearances, location and sizes of field connections, performance data, electrical wiring diagrams, dry and operation weights, and all required electrical data.

1.6 CLOSEOUT SUBMITTALS

- .1 Section 01 78 10: Submission procedures.
- .2 Maintenance Contracts: Provide service and maintenance of complete assembly for one (1) year from Date of Substantial Completion.
- .3 Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories. Include trouble-shooting guide.
- .4 Submit manufacturer's installation instructions, including any remote panel installation instructions.
- .5 Operating and Maintenance manuals: provide two copies of current commercial manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- .1 Section 01 78 40: Maintenance and extra material requirements.
- .2 Extra Stock Materials: Provide two (2) containers of lubricating oil.

1.8 QUALITY ASSURANCE

- .1 Products of This Section: Manufactured to ISO 9000 certification requirements.
- .2 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.
- .3 Chiller modules shall be constructed in accordance with the UL 1995 and NEC standards and be UL or ETL listed.
- .4 Chiller modules shall be rated and tested in accordance with ARI 550/590 – Standard for Water Chilling Packages.
- .5 Chiller modules shall meet the safety standards of ANSI/ASHRAE 15 – Safety Standard for Refrigerated Systems.

1.9 REGULATORY REQUIREMENTS

- .1 Provide certification of inspection for conforming authority having jurisdiction approval.
- .2 Products Requiring Electrical Connection: Listed and classified by ULC or CSA testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.10 DELIVERY, STORAGE, AND PROTECTION

- .1 Section 01 61 00: Transport, handle, store, and protect products.
- .2 Comply with manufacturer's installation written instructions for rigging, unloading, and transporting units.
- .3 Protect units from physical damage.

✓ **1.11 WARRANTY**

- .1 Section 01 78 10: Warranties.
- .2 Entire chiller system: one (1) year parts. Compressor: five (5) years parts.

Part 2 Products

2.1 MANUFACTURERS

- .1 Manufacturers:
 - ✓ .1 ArticChill
 - .2 Substitutions: Refer to Section 01 62 00.

2.2 CHILLER

- ✓ .1 General:
 - .1 Provide factory assembled and tested outdoor air cooled liquid chillers consisting of compressors, condenser, evaporator, thermal expansion valve, refrigeration accessories, and control panel. Construction, testing, and ratings to AHRI 550/590.
 - .2 Conform to ASME BPVC-Section VIII for construction and testing of reciprocating water chillers.
 - .3 Conform to CSA-B52 code for construction, operation, and installation of water chillers.
 - .4 Each chiller module shall be assembled on an integral epoxy coated welded channel steel frame with formed galvanized sheet metal frame with a white painted finish. They shall be shipped as individual modules and assembled on site. Each chiller module shall be fully charged with R-410A refrigerant and factory tested for capacity and controller functions prior to shipment. The system is built for a single point power supply to an electrical distribution panel mounted on the tank and pump module. The electrical distribution panel shall incorporate circuit breakers to provide branch circuit overload protection and electrical isolation for each module. Electrical supply to each module shall consist of flexible conduit. No electrical connection to a module shall carry the load of more than that module. The electrical supply connections for each module shall be factory assembled and shipped with each module for field connection into the electrical distribution.
- ✓ .2 Frame:
 - .1 Frame shall be constructed of welded structural channel steel and be epoxy powder coated with an oven baked finish.

- ✓ .3 Cabinet:
 - .1 Cabinet panels shall be epoxy coated aluminum mounted on a welded steel frame. The cabinet enclosure shall include easily removable access panels for service. Access panels shall be removable via stainless steel fasteners and retaining clips. Chiller modules shall not require access via sheet metal screws or protruding threaded fasteners.
- ✓ .4 Compressors:
 - .1 Hermetically sealed scroll compressors with rotalock connections, crankcase heaters, oil level sight glasses, suction gas-cooled motor with solid-state sensors in the windings for overload protection, and in-line circuit breaker protection. There shall be two independent compressors and refrigerant circuits per module with a digital scroll compressor on the lead refrigeration circuit of the lead module for close temperature control and unloading to 30% (10% for 7.5 hp compressors and smaller) of the compressor capacity. If required, each module may have a digital scroll lead compressor for redundancy. Compressors shall be mounted to the heavy gauge steel frame with rubber-in-shear isolators.
- ✓ .5 Evaporators:
 - .1 Dual circuit, brazed plate evaporators constructed of 316 stainless steel plates and copper brazing. The supply and return fluid piping connections to each evaporator shall include manual and electronic modulating valves to allow servicing of each module individually, while the remaining modules continue to operate and to allow for variable flow or N+1 operation. The fluid connections to each evaporator shall use roll grooved couplings for service convenience and ease of installation. Evaporators shall be insulated with ¾" closed cell insulation. The maximum working pressure shall be 650 psi.
- ✓ .6 Electronic Control Valves:
 - .1 Each chiller module shall include an electronic isolation valve that allows system flow to the active module(s) to match the cooling requirements to the system load. The valves shall be the slow opening type to minimize the sudden change in flow to the previously active modules. The valves shall have a minimum opening cycle time of not less than 60 seconds between the fully closed and open position. The valves shall have a minimum close off pressure of not less than 75 psi.
- ✓ .7 Filters:
 - .1 A 40-mesh industrial grade filter strainer shall be factory installed between the header system and each evaporator inlet. The strainer shall be serviceable by manual and electronic isolation valves that permit each strainer to be removed and cleaned without shutting down fluid flow to the remaining chiller modules to allow them to continue operating. In-line strainers that require complete system shutdown for service and isolation are not acceptable.
- ✓ .8 Condenser Fan Motors:
 - .1 The condenser fan motors shall have double sealed ball bearings rated for thrust duty with slingers. The motors shall be rated for high ambient operation with a minimum rating of 60°C.

- ✓ .9 Condenser Coil:
- .1 Aluminum fins mechanically bonded to copper tubes with integral subcooling circuits. Fin spacing shall not exceed 12 fins per inch. The coils shall be sized to provide full heat of rejection at jobsite elevation above sea level, at a maximum 25 degree F temperature difference between the condensing temperature and ambient air temperature. The coils shall be factory tested to a minimum of 600 psig.
- ✓ .10 Head Pressure Control:
- .1 Flooded head pressure control shall be capable of operation down to -28.9°C.
- ✓ .11 Refrigerant Piping:
- .1 Piping shall be Type L seamless copper, and shall have an insulated suction line using closed cell pipe insulation, compressor rotalock service valves, solenoid valves for compressor pump down, and Schrader service valves in the suction, discharge, and liquid lines.
- ✓ .12 Fluid Piping:
- .1 The fluid piping shall be Schedule 40 steel, and be insulated using closed cell pipe insulation to prevent condensation. The chiller shall have service valves for the independent isolation of each evaporator, without affecting the fluid flow to the remaining evaporators. Each chiller module shall connect to the adjacent module using Victaulic type roll grooved steel couplings and neoprene gaskets. Any type of module-to-module connection external to the modules is unacceptable.
- ✓ .13 Controls:
- .1 The master chiller module shall incorporate the master microprocessor controller. The master microprocessor shall communicate with the remaining slave microprocessors in each module via a local network communications protocol. The master microprocessor shall include a phase monitor to protect against low voltage, phase unbalance, phase loss, and phase reversal conditions. The master controller shall read all analog and fault port values from all slave module controllers and shall pass these values to the Building Automation System via BACnet, Modbus or Lonworks protocols.
- .2 Each chiller control system shall include operational switches for each compressor; high- and low-pressure transmitters to provide indication of refrigeration pressures in each circuit; high and low refrigeration pressure alarms including shutting shut down the responsible compressor(s); anti-short cycling compressor timers; minimum compressor run timers; connection to Building Automation System.
- ✓ .14 Microprocessor:
- .1 The microprocessor shall provide the following minimum functions and alarms:
- .1 Adjustable fluid temperature set point
- .2 Multiple stage compressor control, including compressor rotation to provide even compressor usage and wear.
- .3 High and low fluid temperature alarm set points

PLEASE CONFIRM
REQUIRED BAS
COMMUNICATION
TYPE

- .4 Fluid inlet and outlet temperature
- .5 Suction and discharge refrigeration pressures
- .6 Compressor run status
- .7 Current alarm status
- .8 Demand load
- .9 Compressor run hours
- .10 Alarm logging with minimum of previously 100 logged alarms with time and date of each occurrence
- .11 Remote start stop input
- .12 Dry contact for general alarm

✓ .15 Interface Panel:

- .1 A remote operator interface panel shall be provided to allow operator adjustment of user set points, and alarm monitoring. The remote interface panel shall be installed in the operator's control room. The wiring between the chiller and the remote panel shall be provided and installed by the electrical contractor. The wiring shall be 6-conductor wiring with straight-through connections. The master controller shall be compatible with BACnet, Modbus or Lonworks Gateways and allow for its installation and connection to the electrical service inside the master chiller control panel.

✓ 2.3 TANK AND PUMP MODULE

✓ .1 General:

- .1 The chiller modules shall be shipped as a separate module and assembled on site. The module shall be fully factory tested prior to shipment. Electrical supply shall be via factory provided assembled wiring in flexible, liquid tight conduit and factory connected to the load distribution panel on the end of the module.

✓ .2 Frame:

- .1 The frame shall be constructed of welded structural channel steel and be epoxy powder coated with an oven baked finish.

✓ .3 Cabinet:

- .1 Cabinet panels shall be epoxy coated aluminum mounted on a welded steel frame. The cabinet enclosure shall include easily removable access panels for service. Access panels shall be removable via stainless steel fasteners and retaining clips. Chiller modules shall not require access via sheet metal screws or protruding threaded fasteners.

✓ .4 Pumps:

- .1 Pumps shall be dual, independent cast iron bronze fitted centrifugal pumps or stainless-steel centrifugal pumps. Each pump shall have a cast bronze dynamically balanced impeller, stainless steel shaft, carbon ceramic seal with stainless steel nuts and bolts. The pump motors shall be TEFC design and rated for a maximum speed of 3500 rpm. The pumps shall include inlet and discharge ports for venting and draining. The pumps shall not require disassembly from the chilled fluid piping for service access or repair.

- ✓ .5 Pump Motors:
 - .1 The pump motors shall be TEFC design and rated for a maximum speed of 3500 rpm. The motor shall be premium efficient.

- ✓ .6 Reservoir:
 - .1 The chiller shall have a factory-mounted pressurized stainless-steel storage reservoir to provide for system expansion and thermal storage for close temperature control of the leaving chiller fluid. The tank shall have a working pressure of not less than 125 psi and include a pressure relief valve set to operate at 100 psi to prevent over pressurization. The tank shall have a vacuum vent valve to prevent collapse of the tank under severe fluid discharge conditions. The low tank level switch shall be connected to the system microprocessor controller to provide visual indication and alarming of a low tank level condition. The tank shall include an air charging port at the top of the tank to allow for system pre-charge of the air cushion. The tank shall be insulated with $\frac{3}{4}$ " closed cell insulation to prevent condensation and thermal absorption.

- ✓ .7 Glycol Fill Tank:
 - .1 The tank and pump module shall incorporate a glycol fill tank to automatically fill the glycol in the system as the air is purged. The tank shall include a glycol-charging pump that is activated by an integral adjustable pressure switch. The tank and pump module shall include a low tank level switch to prevent pump operation when the reservoir is empty. An integral pressure reducing valve shall be field adjustable to set the system pressure at the desired pre-charge system pressure. The initial fill pressure shall be factory set at 12 psi. The system shall include a low tank level switch that shall activate an alarm on the microprocessor controller should the tank level fall below the minimum level.

- ✓ .8 Fluid Piping:
 - .1 The fluid piping shall be Schedule 40 steel, and be insulated with closed cell pipe insulation to prevent condensation. The tank and pump module shall connect to the adjacent module using roll grooved steel couplings and neoprene gaskets. Any type of module-to-module connection external to the package is unacceptable.

- ✓ .9 Controls:
 - .1 Each pump shall be sized for 100% capacity, and shall include variable frequency drives and disconnect switches on each pump to allow for service repair while operating the back-up pump. The tank and pump module shall incorporate microprocessor controller to control all the operations of the pumps. The microprocessor shall communicate with the remaining microprocessors in each module via a local network communications protocol. Controls shall include operational switches for each pump; leaving fluid pressure transmitters to display the leaving fluid pressure; and integral pressure differential switch to switch to the backup pump upon loss of pressure of the primary pump.

- ✓ .10 Microprocessor:
- .1 The microprocessor shall provide the following minimum functions and alarms:
- .1 Pump run status
 - .2 Current alarm status
 - .3 Pump run hours
 - .4 Alarm logging with minimum of previously 100 logged alarms with time and date of each occurrence
 - .5 Automatic lead/lag switchover of the pumps once per week
 - .6 Pump discharge pressure

✓ 2.4 **PERFORMANCE**

- .1 Air Cooled Water Chiller:
- .1 Refer to Schedules on Drawings for performance.

✓ 2.5 **ELECTRICAL CHARACTERISTICS AND COMPONENTS**

- .1 Refer to Schedules on Drawings for Electrical Characteristics:
- .2 Disconnect Switch: Factory mount disconnect switch.

Part 3 Execution

3.1 INSTALLATION

- .1 All modules shall be installed in accordance with the Manufacturer's recommendations where shown on the drawings and other provided installation documents Align chiller package on steel or concrete foundations.
- .2 Install units on vibration isolation. Refer to Section 23 05 48.
- .3 Connect to electrical service. Refer to Section 26 05 80.
- .4 Connect to chilled water piping. Refer to Section 23 21 00.
- .1 On inlet, provide:
- .1 Thermometer well for temperature controller.
 - .2 Thermometer well for temperature limit controller.
 - .3 Flexible pipe connector.
 - .4 Shut-off valve.
- .2 On outlet, provide:
- .1 Flexible pipe connector.
 - .2 Shut-off valve.
- .5 Each module is shipped individually for field assembly. Field assembly of chiller system shall consist of the following minimum steps:
- .1 Manifold chilled fluid piping with factory supplied rolled groove connections. Insulate rolled groove connections after assembly.

BY OTHERS

- .2 Connect factory supplied power supply wiring harnesses to the load distribution panel. Install wires to the proper terminals for proper phasing. Unit is wired for A, B, C phase right to left in the load distribution panel. Each wire on the wire harness is identified as to its respective phase.
- .3 Connect all microprocessors together to form the local communication network. Wiring must be 20-gauge minimum, single twisted pair, shielded wiring.
- .6 Arrange piping for easy dismantling to permit tube cleaning.

3.2 PIPING FLUSHING PROCEDURE

- .1 Prior to connecting the modules to the building chilled water loop, the piping shall be flushed with a detergent and hot water (110-130 F) mixture to remove previously accumulated dirt and other organic residue. In old piping systems with heavy encrustation of inorganic materials, consult a water treatment specialist for proper passivation and/or removal of these contaminants.
- .2 Prior to flushing, install a 30 mesh or finer Y-type strainer or equivalent in the system piping. During the flushing process, examine and clean the strainer periodically as necessary to remove collected residue. The flushing process shall take not less than 6 hours or until the strainers, when examined after each flushing, are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours or until the strainers run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer's instructions. After flushing with detergent and/or dilute acid concentrations, the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.

BY OTHERS

3.3 MANUFACTURER'S FIELD SERVICES

- .1 Section 01 78 10: Prepare and start components.
- .2 Factory-supervised start-up and checkout with start-up report shall be provided for each module. Owner training by factory representative shall be provided.
- .3 Supply initial charge of refrigerant and oil.

3.4 CLOSEOUT ACTIVITIES

- .1 Demonstration: Demonstrate system operation and verify specified performance. Refer to Section 23 05 93.

END OF SECTION

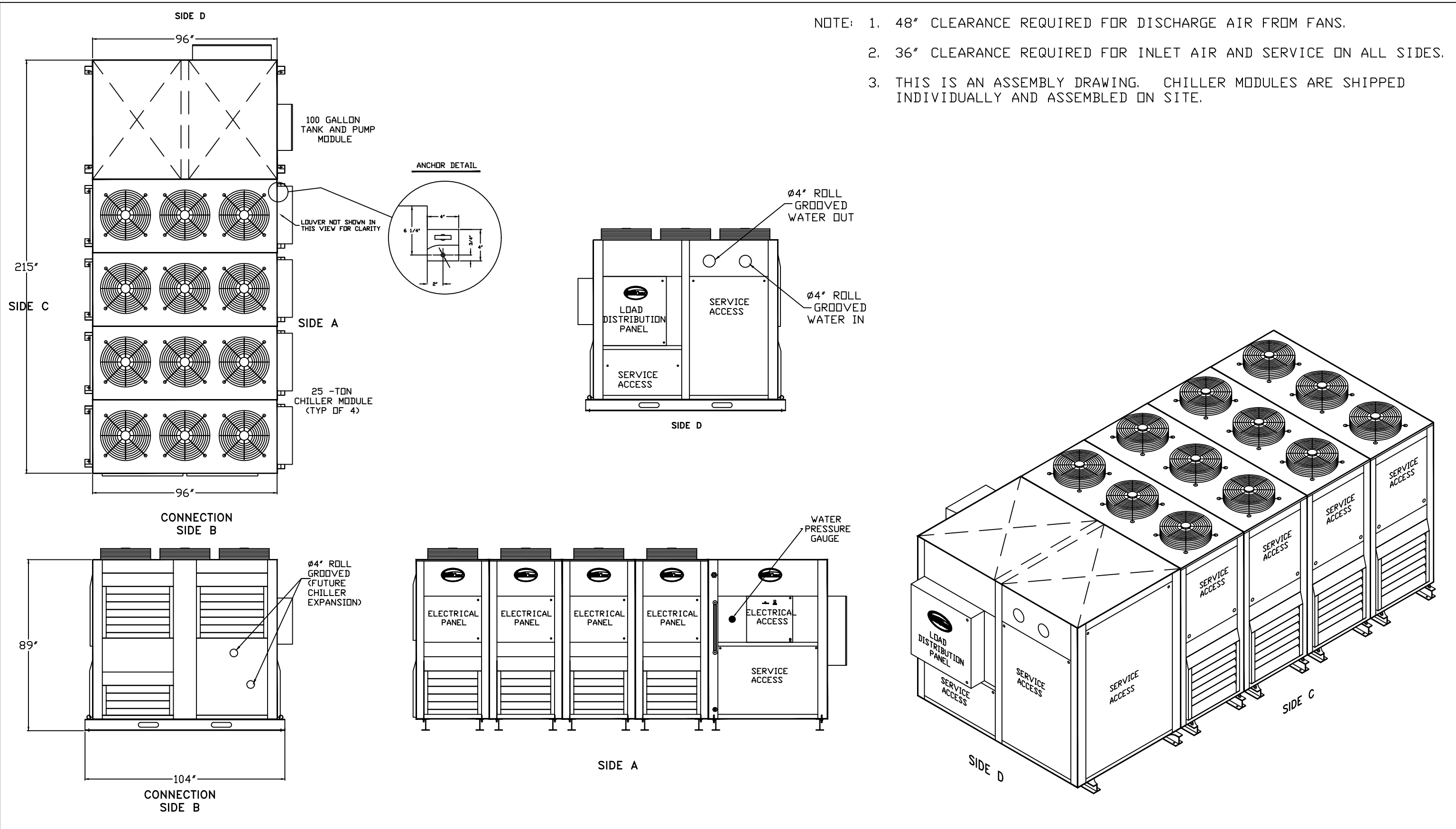


Toronto Western Hospital - 4 MRI Suite

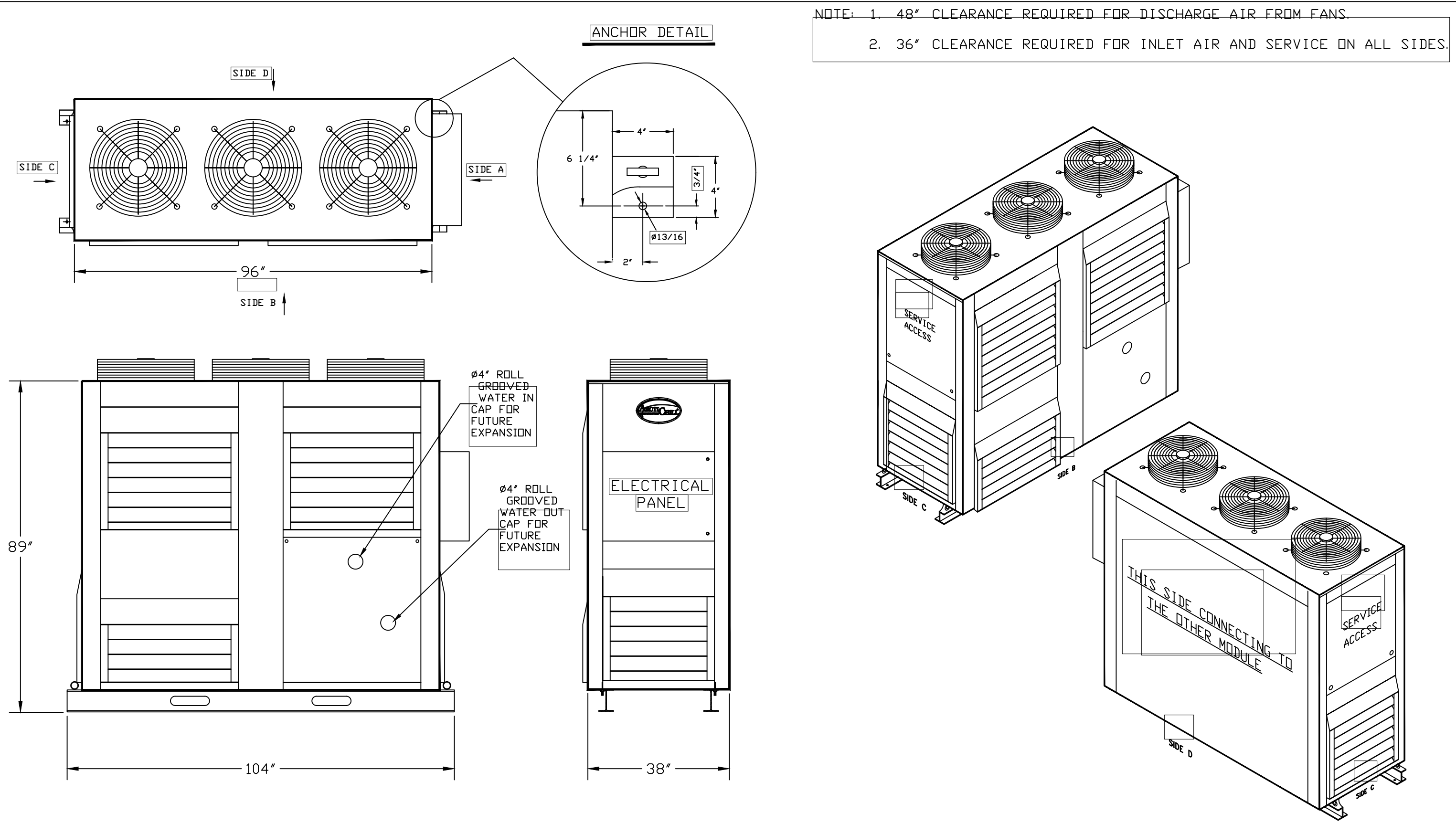
Air Cooled **Modular Chiller**

Model Number (qty)	(4) PACVMV0250D5-MM-DS1 4x25 nominal ton air cooled chiller modules with digital scroll lead compressor)
Chiller System	
Evaporator (brazed plate)	
Design Flow Rate	168 gpm
Fluid	50% propylene glycol
Refrigerant	R-410A
Chiller Pressure Drop	4.2 psi
Entering Fluid Temperature	61 F
Leaving Fluid Temperature	46 F
Ambient Design Temperature	95 F
System Capacity	1,104,000 Btu/hr (92 tons)
Electrical Power Supply	575/60/3
<u>Chiller Modules (4)</u>	
Compressors	2/module (digital scroll lead compressor on each module for close temperature control and unloading down to 4% of the chiller system capacity)
HP	13
LRA	109 amps
RLA	15.3 amps (ea)
Fans (Qty 3)	2.1 amps (ea)
Total FLA	38.9 amps/module
<u>Tank and Pump Module</u>	
HP	10 hp each
RPM	3600
Flow Rate	168 gpm
Pressure Head	105 ft TDH (80 ft external)
Buffer tank size	100 gallons
Glycol Feeder (with charging pump)	17 gallons
FLA	11 amps
Total FLA	13 amps
<u>System (4 Chiller Modules, Tank and Pump Mod)</u>	
Total FLA	168.6 amps
MCA	173 amps
MOP	200 amps (minimum of one 3/0 wire per pole)
<u>Dimensions</u>	
Chiller Module (each)	38" W x 96" L x 89" H
Tank and Pump Module	62" W x 96" L x 68" H
System	214" W x 96" L x 89" H
<u>Connections</u>	4" roll grooved FLANGED
<u>Weights</u>	
Chiller Module (each)	2,500 lbs/ea
Tank and Pump Module	2,500 lbs. (3,500 lbs. operating)
System	12,500 lbs (13,500 lbs. operating)

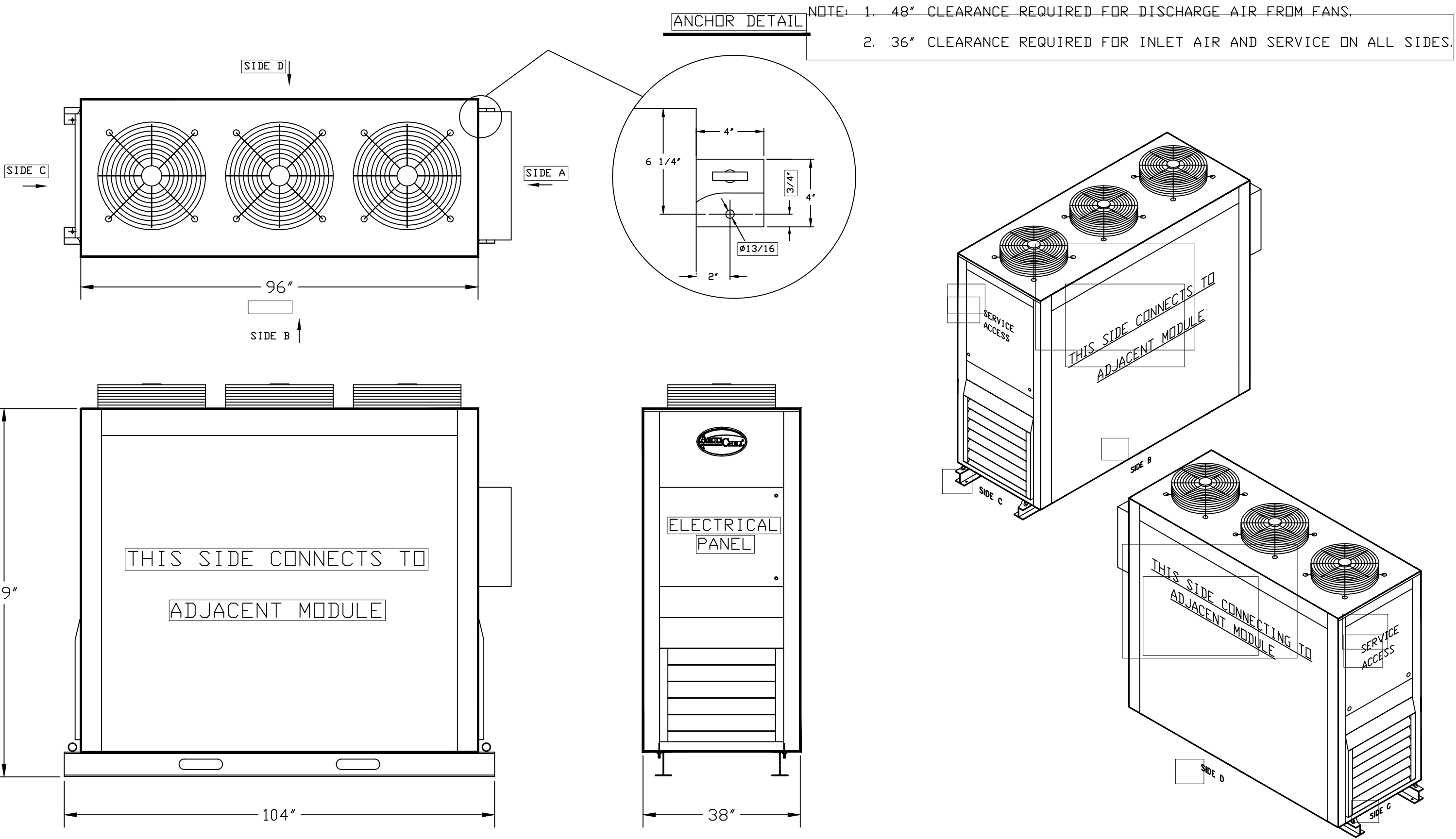
Date: January 20, 2020



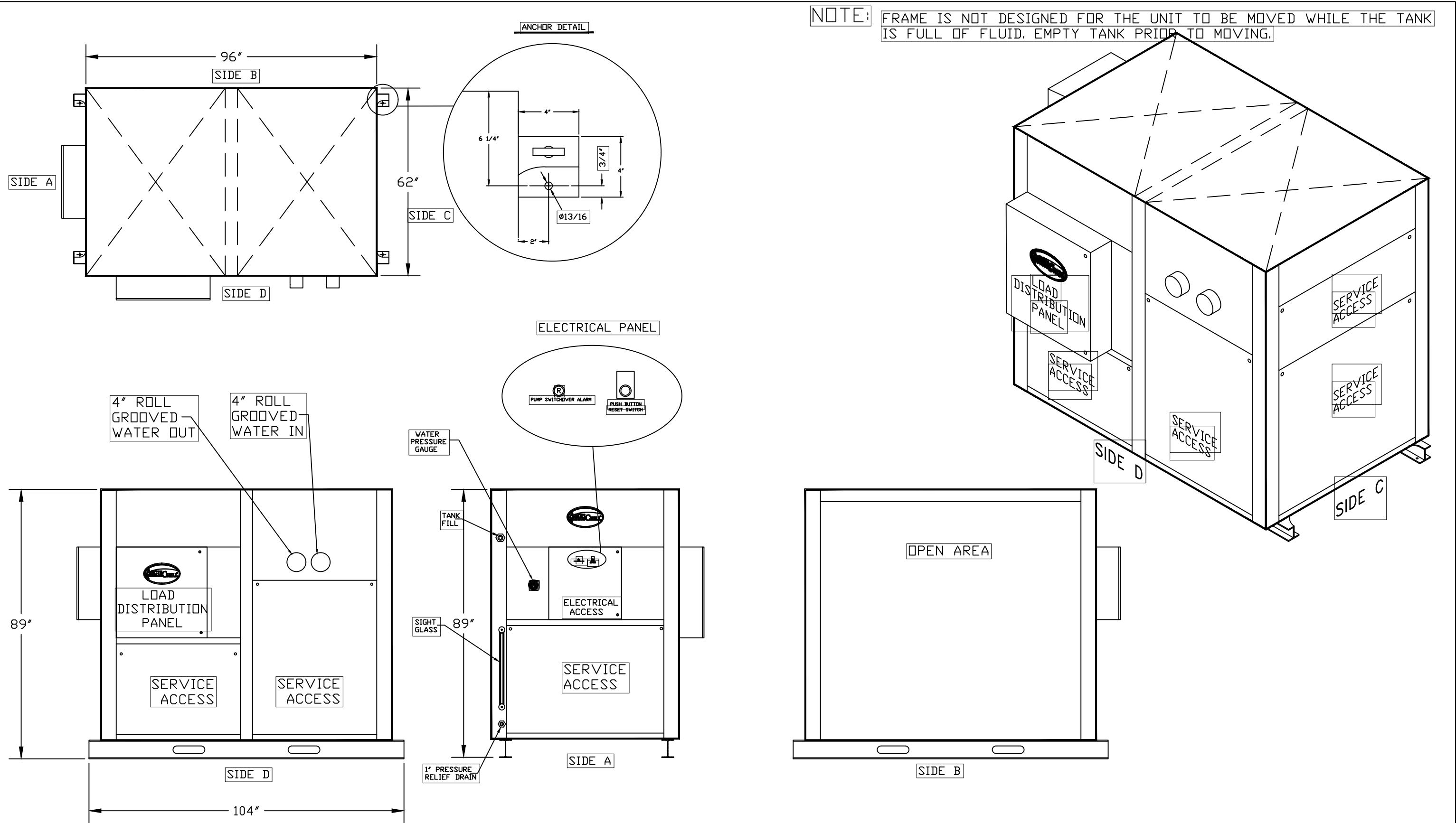
<div>ARCTIC CHILL</div> <div>CHILLED WATER SYSTEMS</div> <div>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</div>	TITLE: <i>PROCESS 100 TON AIR COOLED</i> <i>MANHATTAN CHILLER SYSTEM</i>		ENGINEER:					DWG#
			CUSTOMER: HTS ENGINEERING, LTD.					C1-A
			JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE					
			DRAWN BY: CW	REV:	REV BY:	DATE: 01/24/20	SCALE: NTS	
	MODEL:		FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV100\DUAL\575\CAB\100TON_TP_4C					



<div><div>ARCTIC HILL</div><div>CHILLED WATER SYSTEMS</div></div> <div>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</div>	TITLE: <div>PROCESS 25 TON AIR COOLED</div> <div>VERTICAL DISCHARGE</div> <div>MANHATTAN CHILLER MODULE</div> <div>PHYSICAL DIMENSIONS</div>		ENGINEER:					DWG# <div>C1</div>
	MODEL: <div>PACVMV0250D5-MM</div>		CUSTOMER: HTS ENGINEERING, LTD.					
			JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE					
			DRAWN BY: CW	REV:	REV BY:	DATE: 01/24/20	SCALE: NTS	
			FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\CABINET\25TONA					

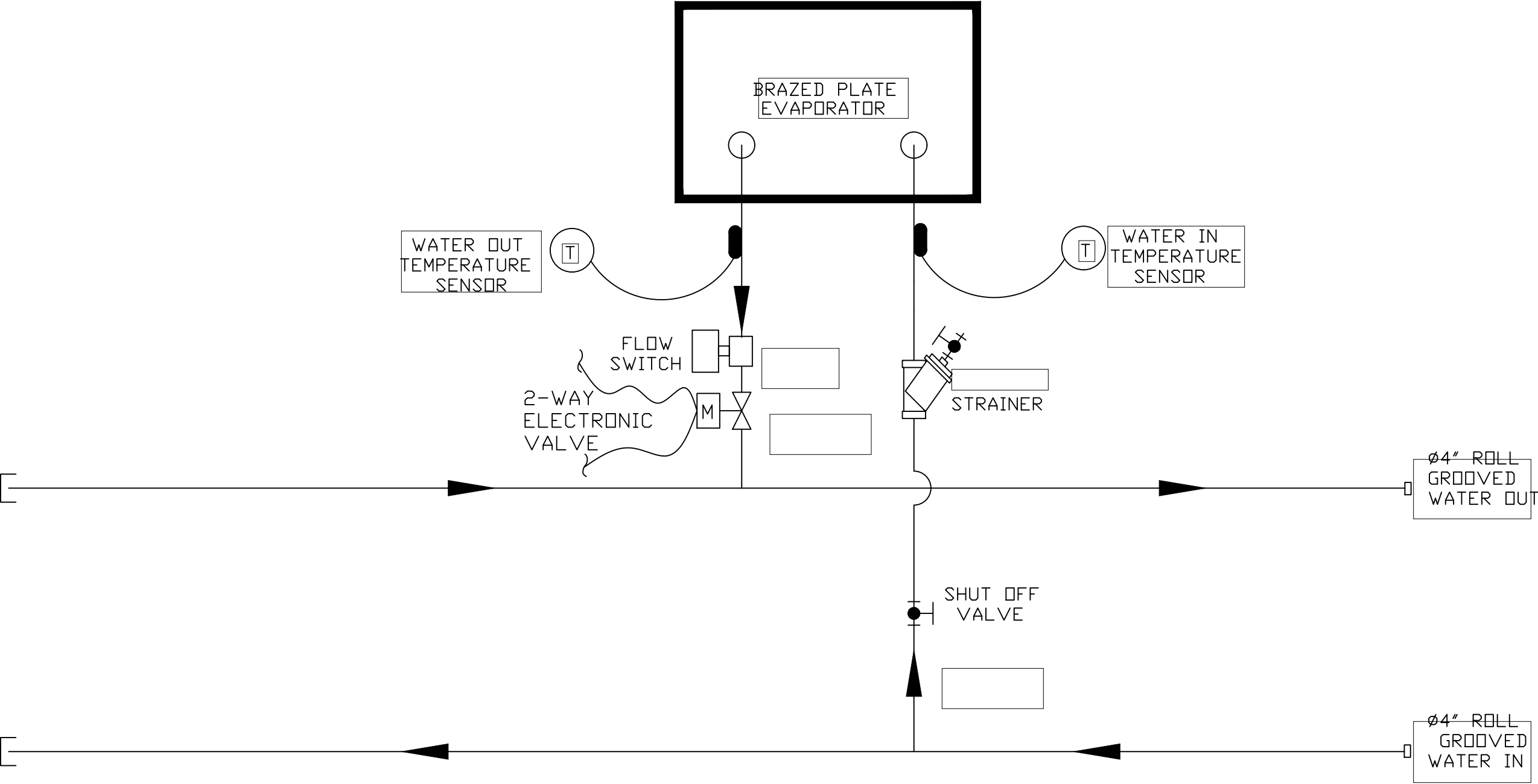


<div><div>ARCTIC HILL</div><div>CHILLED WATER SYSTEMS</div></div> <div>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</div>	TITLE: <div>PROCESS 25 TON AIR COOLED</div> <div>VERTICAL DISCHARGE</div> <div>MANHATTAN CHILLER MODULE</div> <div>PHYSICAL DIMENSIONS</div>		ENGINEER:						DWG#	
	MODEL: <div>PACVMV0250D5-MM</div>		CUSTOMER: HTS ENGINEERING, LTD.						C2	
			JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE							
			DRAWN BY: CW		REV:	REV BY:	DATE: 01/24/20	SCALE: NTS		
			FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\CABINET\25TONB							

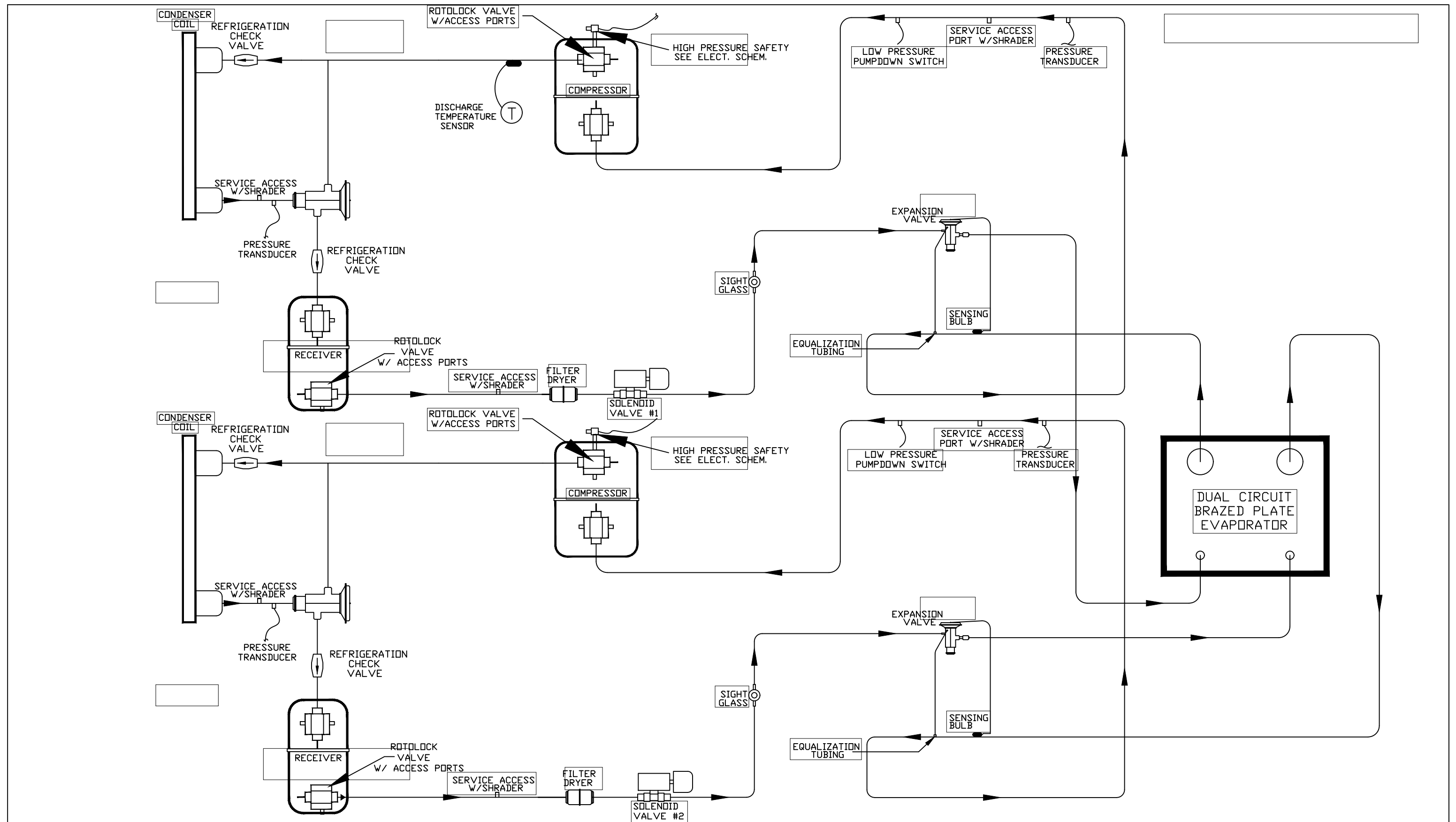


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			CUSTOMER: HTS ENGINEERING, LTD.									
			JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE						TPC1			
			DRAWN BY: CW		REV:		REV BY:		DATE: 01/24/20		SCALE: NTS	
					FILE PATH: ACADDWGS\TP MOD\0100\5100\CABINET\100							
	MODEL: TP01005100											

- NOTE:
- 1.) ALL PIPING IS TO BE INSULATED INSIDE THE CABINET.
 - 2.) ALL PIPING IS TO BE SCHEDULE 40 CARBON STEEL.
 - 3.) VALVES TO BE CARBON STEEL.

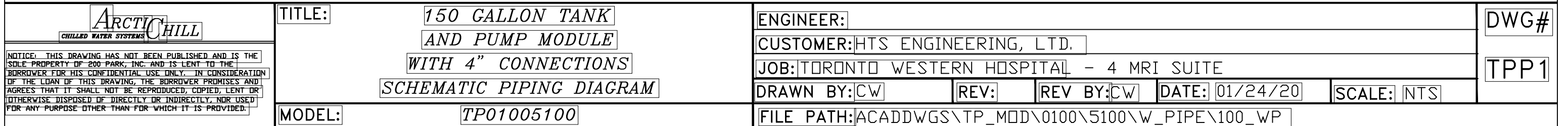


<div><div>ARCTIC HILL</div><div>CHILLED WATER SYSTEMS</div></div> <div>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</div>	TITLE: <div>PROCESS 25 TON AIR COOLED</div> <div>VERTICAL DISCHARGE</div> <div>MANHATTAN CHILLER MODULE</div> <div>SLAVE SCHEMATIC PIPING DIAGRAM</div>		ENGINEER:					DWG# <div>P2</div>
	MODEL: <div>PACVMV0250D5-MM</div>		CUSTOMER:HTS ENGINEERING, LTD					
			JOB:TORONTO WESTERN HOSPITAL - 4 MRI SUITE					
			DRAWN BY:CW REV: REV BY:CW DATE: 01/24/20 SCALE: NTS					
			FILE PATH:ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\W_PIPE\25TON_BP					



<p>ARCTIC HILL CHILLED WATER SYSTEMS</p> <p>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</p>	<p>TITLE: <i>PROCESS 25 TON AIR COOLED VERTICAL DISCHARGE MANHATTAN CHILLER MODULE SCHEMATIC REFRIGERATION DIAGRAM</i></p> <p>MODEL: <i>PACVMV0250D5-MM-DS1</i></p>	<p>ENGINEER:</p> <p>CUSTOMER: HTS ENGINEERING, LTD</p> <p>JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE</p> <p>DRAWN BY: CW REV: REV BY: CW DATE: 01/24/20 SCALE: NTS</p> <p>FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\REFRIG\25DUAL</p>	<p>DWG#</p> <p>R1</p>
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1.) ALL PIPING SHALL BE CARBON STEEL (EXCEPT MANUAL FILL & DRAIN).
2.) ALL COPPER PIPING SHALL BE INSULATED INSIDE THE FRAME.



QTY.	LEGEND	
1	SL-1	MAIN SYSTEM LUG
1	CB-1-5	CIRCUIT BREAKER (INSIDE DISTRIBUTION PANEL)
1	DB-1-5	DISTRIBUTION BLOCK (INSIDE EACH MODULE)

NOTES:

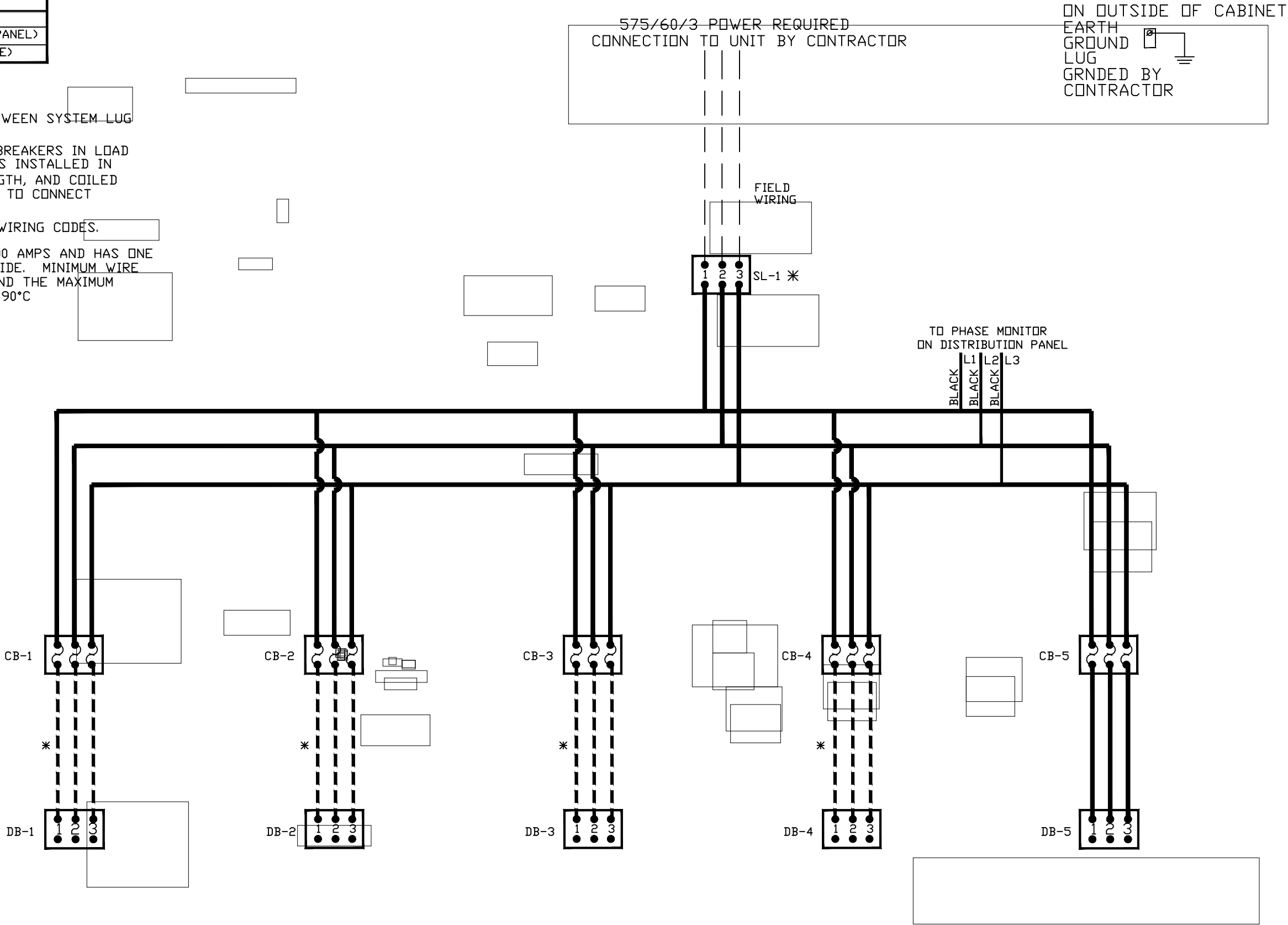
- CONTRACTOR IS TO FURNISH ALL WIRING BETWEEN SYSTEM LUG AND CONTRACTOR PROVIDED DISCONNECT.
- FACTORY ASSEMBLED WIRING FROM CIRCUIT BREAKERS IN LOAD DISTRIBUTION PANEL TO CHILLER MODULES IS INSTALLED IN LIQUID TIGHT CONDUIT, CUT TO PROPER LENGTH, AND COILED INSIDE EACH CHILLER MODULE. CONTRACTOR TO CONNECT WIRING TO CIRCUIT BREAKERS.
- WIRING IS TO MEET ALL LOCAL AND STATE WIRING CODES.
- SYSTEM LUG IS SIZED FOR A MAXIMUM OF 200 AMPS AND HAS ONE CONNECTION PER POLE ON INCOMING WIRE SIDE. MINIMUM WIRE SIZE SHALL BE 3/0 AWG RATED AT 90°C. AND THE MAXIMUM WIRE SIZE SHALL BE 350 KCMIL RATED AT 90°C

POWER —————

FIELD WIRING - - - - -

GROUND WIRING — — — — —

* FACTORY
ASSEMBLED WIRING - - - - -



ARCTIC CHILL
CHILLED WATER SYSTEMS

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TITLE: *PROCESS 100 TON AIR COOLED
MANHATTAN CHILLER SYSTEM*

MODEL:

ENGINEER: _____

CUSTOMER: HTS ENGINEERING, LTD.

JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE

DRAWN BY: CW REV: _____ REV BY: _____ DATE: 01/24/20 SCALE: NTS

FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV100\DUAL\575\ELECT\HIGH PWR_E1

DWG# E1-A

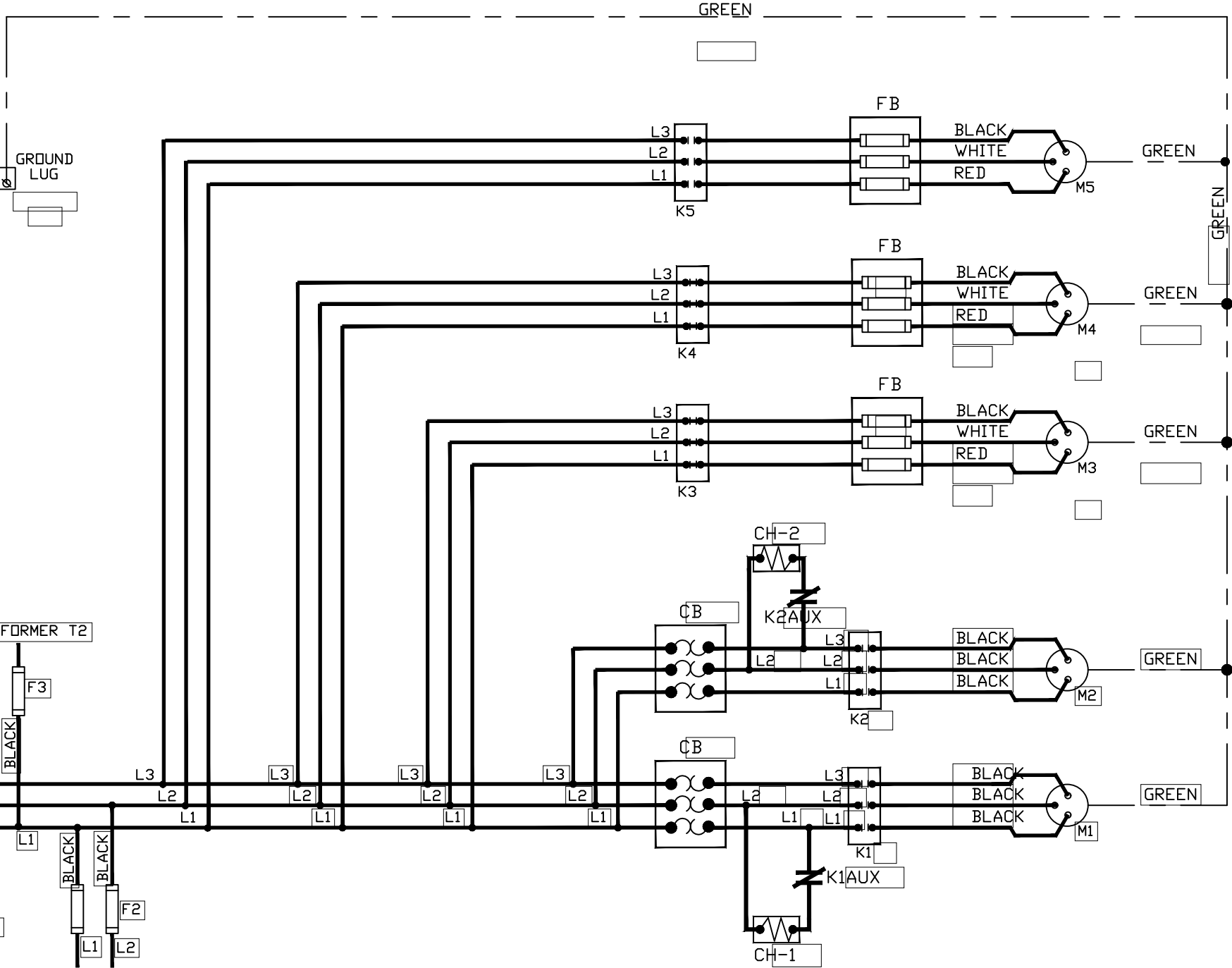
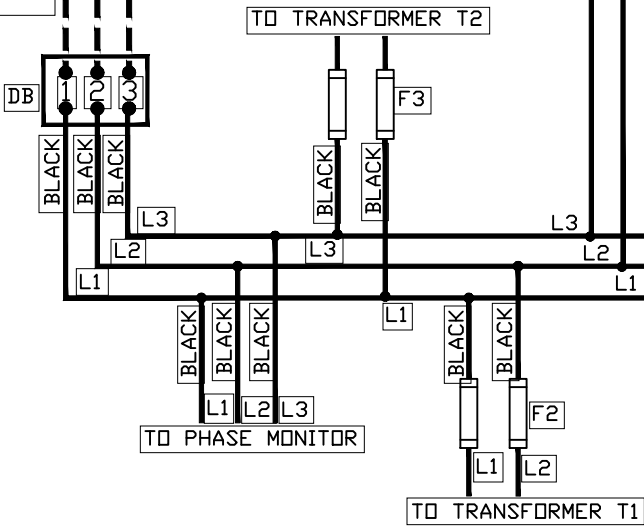
LEGEND		
QTY.		
2	CB	CIRCUIT BREAKER
1	CH-1	CRANKCASE HEATER FOR COMPRESSOR #1 (M1)
1	CH-2	CRANKCASE HEATER FOR COMPRESSOR #2 (M2)
2	FB	FUSE BLOCK
2	DB	DISTRIBUTION BLOCK
2	F2	T1 TRANSFORMER PRIMARY FUSES (1/2A)
2	F3	T2 TRANSFORMER PRIMARY FUSES (1A)
2		GROUND LUGS
1	K1	COMPRESSOR #1 CONTACTOR
1	K2	COMPRESSOR #2 CONTACTOR
1	K3	FAN #1 CONTACTOR
1	K4	FAN #2 CONTACTOR
1	K5	FAN #3 CONTACTOR
1	K1AUX	CRANKCASE HEATER - AUXILIARY CONTACTOR #1
1	K2AUX	CRANKCASE HEATER - AUXILIARY CONTACTOR #2
1	M1	COMPRESSOR #1 MOTOR
1	M2	COMPRESSOR #2 MOTOR
1	M3	BALL BEARING FAN MOTOR #1
1	M4	BALL BEARING FAN MOTOR #2
1	M5	BALL BEARING FAN MOTOR #3


GROUND WIRING

- NOTES:
- CONTRACTOR IS TO FURNISH ALL WIRING BETWEEN EQUIPMENT.
 - WIRING IS TO MEET ALL LOCAL AND STATE WIRING CODES.

*FACTORY
ASSEMBLED WIRING

575/60/3 POWER TO
DISTRIBUTION PANEL BY
BY CONTRACTOR





CHILLED WATER SYSTEMS

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TITLE: **PROCESS 25 TON AIR COOLED
VERTICAL DISCHARGE
MANHATTAN CHILLER MODULE**

MASTER HIGH VOLTAGE ELECTRICAL SCHEMATIC

MODEL: **PACVMV0250D5-MM**

ENGINEER:

CUSTOMER: HTS ENGINEERING, LTD.

JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE

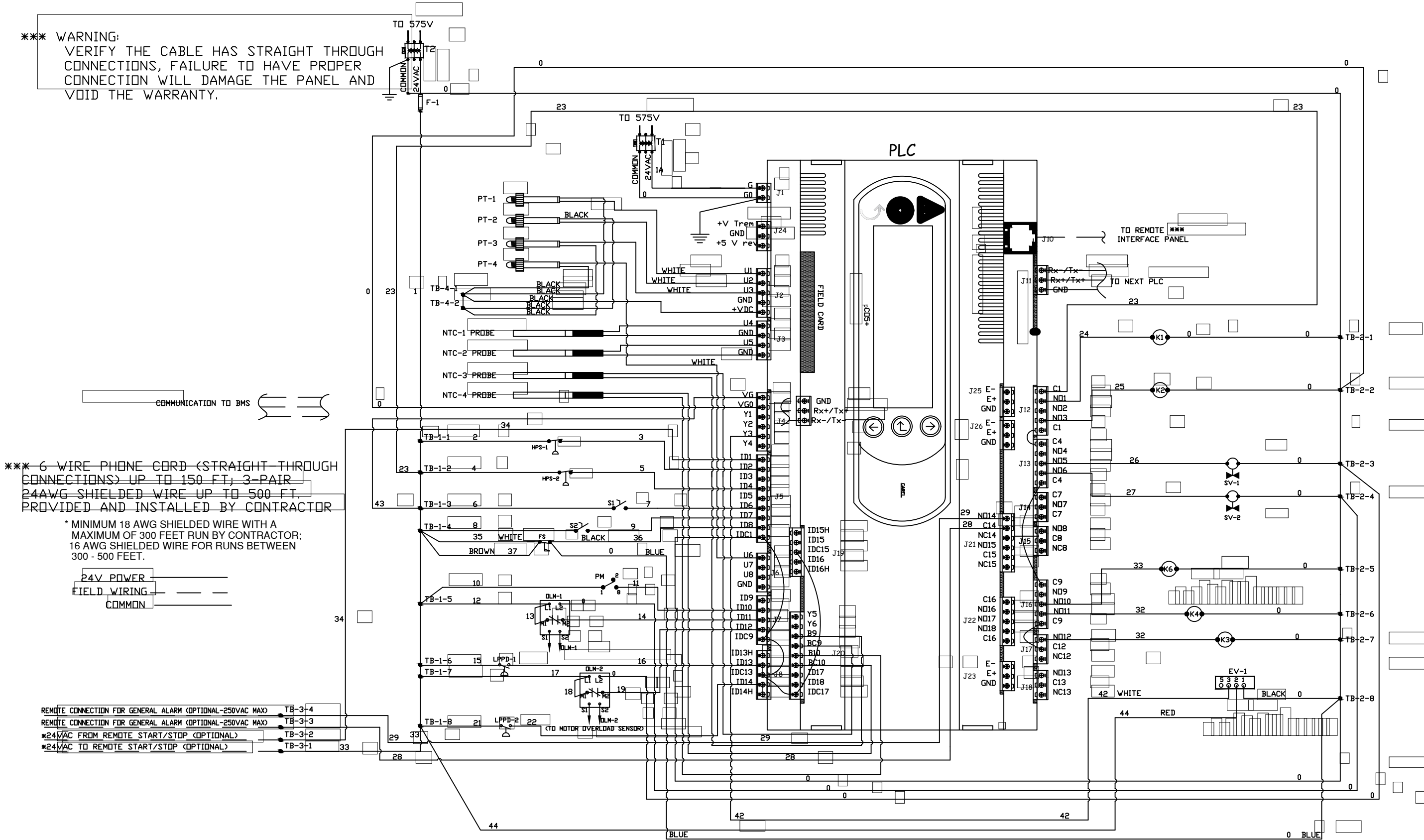
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FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\ELECT\HIGHVWR

DWG#

E1

*** WARNING:
VERIFY THE CABLE HAS STRAIGHT THROUGH
CONNECTIONS, FAILURE TO HAVE PROPER
CONNECTION WILL DAMAGE THE PANEL AND
VOID THE WARRANTY.



ARCTIC HILL
CHILLED WATER SYSTEMS

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FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.

TITLE: **PROCESS 25 TON AIR COOLED
VERTICAL DISCHARGE
MANHATTAN CHILLER MODULE
MASTER CONTROL ELECTRICAL SCHEMATIC**

MODEL: **PACVMV0250D5-MM**

ENGINEER:
CUSTOMER: HTS ENGINEERING, LTD.
JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE
DRAWN BY: CW REV: 2 REV BY: CW DATE: 01/27/20 SCALE: NTS
FILE PATH: ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\ELECT\PLC_02_#1

DWG#
E2

QTY.	LEGEND	
1	EV-1	ELECTRONIC ISOLATION VALVE
1	F-1	FUSE (10A)
1	FS	FLOW SWITCH - CLOSE ON FLOW INCREASE
1	HPS-1	HIGH PRESSURE SAFETY SWITCH CIRCUIT #1 - OPENS ON HIGH PRESSURE
1	HPS-2	HIGH PRESSURE SAFETY SWITCH CIRCUIT #2 - OPENS ON HIGH PRESSURE
1	K1	COMPRESSOR #1 CONTACTOR
1	K2	COMPRESSOR #2 CONTACTOR
1	K3	FAN #1 CONTACTOR
1	K4	FAN #2 CONTACTOR
1	K5	FAN #3 CONTACTOR
1	LPPD-1	LOW PRESSURE PUMPDOWN - CIRCUIT #1
1	LPPD-2	LOW PRESSURE PUMPDOWN - CIRCUIT #2
1	NTC-1	TEMPERATURE SENSOR - ENTERING WATER TEMPERATURE
1	NTC-2	TEMPERATURE SENSOR - LEAVING WATER TEMPERATURE
1	NTC-3	TEMPERATURE SENSOR - SYSTEM ENTERING WATER TEMPERATURE
1	NTC-4	TEMPERATURE SENSOR - SYSTEM LEAVING WATER TEMPERATURE
1	OLM-1	COMPRESSOR #1 OVERLOAD MODULE
1	OLM-2	COMPRESSOR #2 OVERLOAD MODULE
1	PLC	PC05+ PROGRAMMABLE LOGIC CONTROLLER
1	PM	PHASE MONITOR
1	PT-1	4-20 mA OUTPUT PRESSURE TRANSMITTER - LOW PRESSURE CIRCUIT #1
1	PT-2	4-20 mA OUTPUT PRESSURE TRANSMITTER - HIGH PRESSURE CIRCUIT #1
1	PT-3	4-20 mA OUTPUT PRESSURE TRANSMITTER - LOW PRESSURE CIRCUIT #2
1	PT-4	4-20 mA OUTPUT PRESSURE TRANSMITTER - HIGH PRESSURE CIRCUIT #2
1	S1	COMPRESSOR CIRCUIT #1 CONTROL SWITCH
1	S2	COMPRESSOR CIRCUIT #2 CONTROL SWITCH
1	SV-1	LIQUID LINE SOLENOID VALVE #1 CIRCUIT #1
1	SV-2	LIQUID LINE SOLENOID VALVE #2 CIRCUIT #2
1	T1	575 V PRIMARY, 24 V SECONDARY - 50 VA TRANSFORMER
1	T2	575 V PRIMARY, 24 V SECONDARY - 150 VA TRANSFORMER
1	TB-1	CHILLER - 24V AC TERMINAL BLOCK
1	TB-2	CHILLER - COMMON TERMINAL BLOCK
1	TB-3	CUSTOMER CONNECTION TERMINAL BLOCK
1	TB-4	24V DC TERMINAL BLOCK

NOTES:

1. CONTRACTOR IS TO FURNISH ALL WIRING BETWEEN EQUIPMENT.
2. WIRING IS TO MEET ALL LOCAL AND STATE WIRING CODES.

* MINIMUM 18 AWG SHIELDED WIRE WITH A
MAXIMUM OF 300 FEET RUN BY CONTRACTOR;
16 AWG SHIELDED WIRE FOR RUNS BETWEEN
300 - 500 FEET.

24V POWER _____
FIELD WIRING — — — — (6 WIRE PHONE CORD)
COMMON _____



ARCTIC CHILL

CHILLED WATER SYSTEMS

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TITLE:

PROCESS 25 TON AIR COOLED
VERTICAL DISCHARGE
MANHATTAN CHILLER MODULE
MASTER ELECTRICAL SCHEMATIC LEGEND

MODEL:

PACVMV0250D5-MM

ENGINEER:

CUSTOMER: HTS ENGINEERING, LTD.

JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE

DRAWN BY: CW

REV: 2

REV BY: CW

DATE: 01/27/20

SCALE: NTS

FILE PATH:

ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\ELECT\PLC_02_#2

DWG#

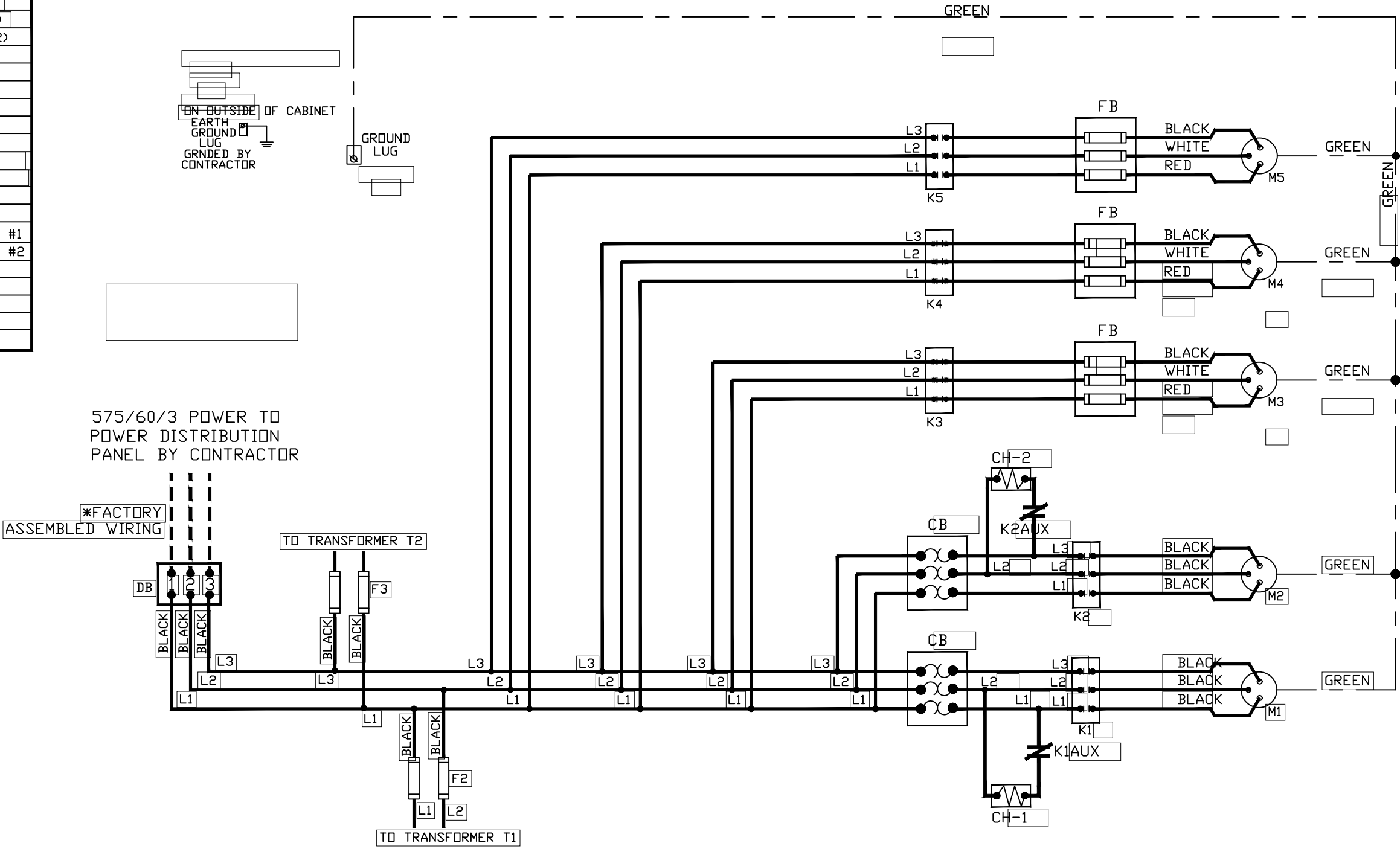
E3

LEGEND		
QTY.		
2	CB	CIRCUIT BREAKER
1	CH-1	CRANKCASE HEATER FOR COMPRESSOR #1 (M1)
1	CH-2	CRANKCASE HEATER FOR COMPRESSOR #2 (M2)
2	FB	FUSE BLOCK
2	DB	DISTRIBUTION BLOCK
2	F2	T1 TRANSFORMER PRIMARY FUSES (1/2A)
2	F3	T2 TRANSFORMER PRIMARY FUSES (1A)
2		GROUND LUGS
1	K1	COMPRESSOR #1 CONTACTOR
1	K2	COMPRESSOR #2 CONTACTOR
1	K3	FAN #1 CONTACTOR
1	K4	FAN #2 CONTACTOR
1	K5	FAN #3 CONTACTOR
1	K1AUX	CRANKCASE HEATER - AUXILIARY CONTACTOR #1
1	K2AUX	CRANKCASE HEATER - AUXILIARY CONTACTOR #2
1	M1	COMPRESSOR #1 MOTOR
1	M2	COMPRESSOR #2 MOTOR
1	M3	BALL BEARING FAN MOTOR #1
1	M4	BALL BEARING FAN MOTOR #2
1	M5	BALL BEARING FAN MOTOR #3

GROUND WIRING ————

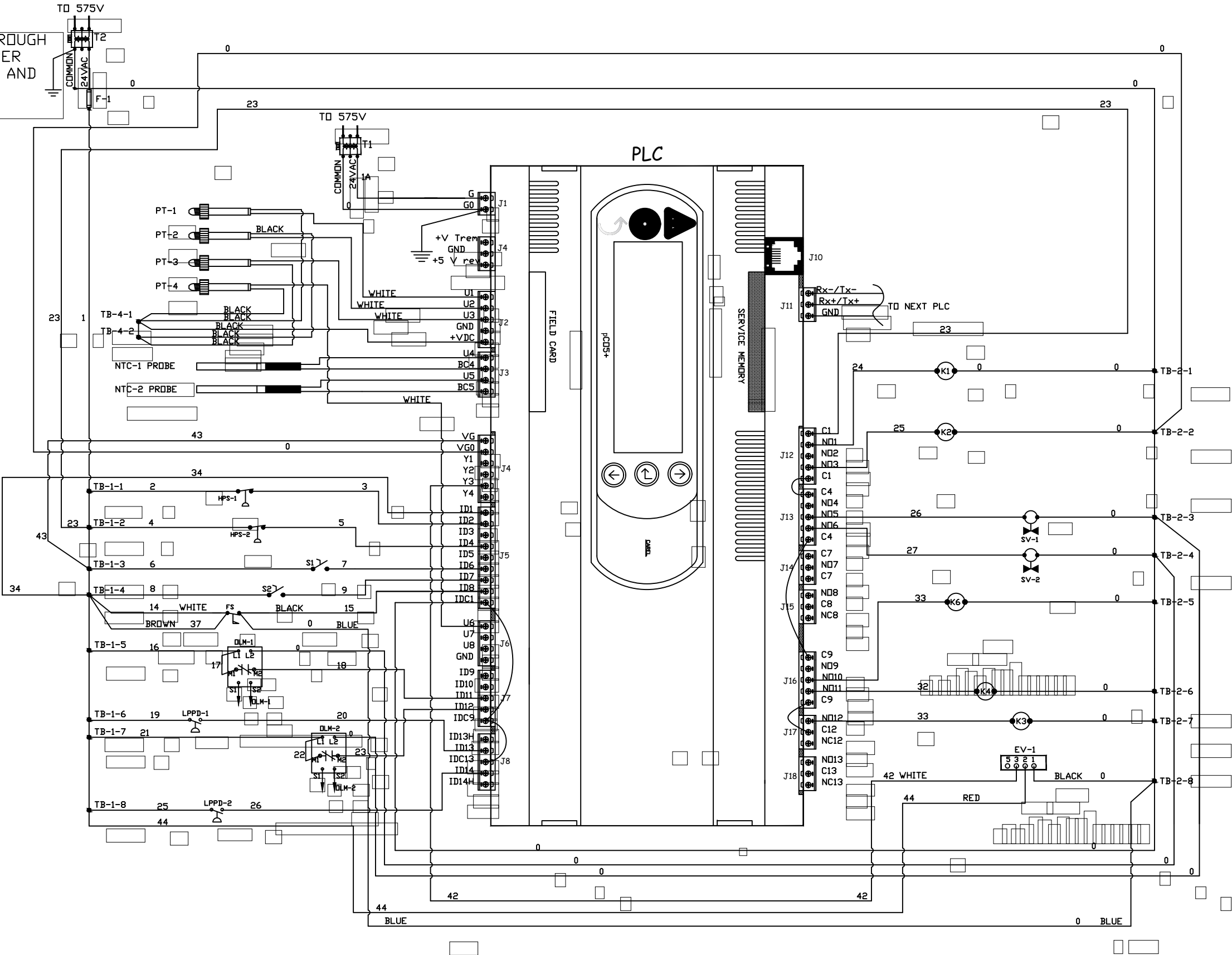
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 - WIRING IS TO MEET ALL LOCAL AND STATE WIRING CODES.

*FACTORY
ASSEMBLED WIRING ————



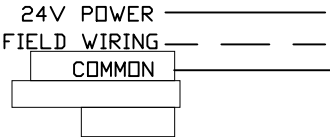
<div>ARCTIC HILL CHILLED WATER SYSTEMS</div> <div>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</div>	TITLE:	PROCESS 25 TON AIR COOLED VERTICAL DISCHARGE MANHATTAN CHILLER MODULE SLAVE HIGH VOLTAGE ELECTRICAL SCHEMATIC	ENGINEER:		DWG#	E4
	MODEL:	PACVMV0250D5-MM	CUSTOMER:	HTS ENGINEERING, LTD.		
			JOB:	TORONTO WESTERN HOSPITAL - 4 MRI SUITE		
			DRAWN BY:	CW	REV:	
			REV BY:		DATE:	01/24/20
			SCALE:	NTS		
			FILE PATH:	ACADDWGS\PROCESS\PACVMV\PACVMV25\Dual\575\ELECT\HIGHVWR		

*** WARNING:
VERIFY THE CABLE HAS STRAIGHT THROUGH
CONNECTIONS, FAILURE TO HAVE PROPER
CONNECTION WILL DAMAGE THE PANEL AND
VOID THE WARRANTY.



*** 6 WIRE PHONE CORD (STRAIGHT-THROUGH
CONNECTIONS) UP TO 150 FT; 3-PAIR
24AWG SHIELDED WIRE UP TO 500 FT.
PROVIDED AND INSTALLED BY CONTRACTOR

* MINIMUM 18 AWG SHIELDED WIRE WITH A
MAXIMUM OF 300 FEET RUN BY CONTRACTOR;
16 AWG SHIELDED WIRE FOR RUNS BETWEEN
300 - 500 FEET.



ARCTIC HILL
CHILLED WATER SYSTEMS

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TITLE: **PROCESS 25 TON AIR COOLED
VERTICAL DISCHARGE
MANHATTAN CHILLER MODULE
SLAVE CONTROL ELECTRICAL SCHEMATIC**

MODEL: **PACVMV0250D5-MM**

ENGINEER:
CUSTOMER: **HTS ENGINEERING, LTD.**
JOB: **TORONTO WESTERN HOSPITAL - 4 MRI SUITE**
DRAWN BY: **CW** REV: **2** REV BY: **CW** DATE: **01/27/20** SCALE: **NTS**

FILE PATH: **ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\ELECT\PLC_02_#1**

DWG#
E5

QTY.	LEGEND	
1	EV-1	ELECTRONIC ISOLATION VALVE
1	F-1	FUSE (10A)
1	FS	FLOW SWITCH - CLOSSES ON FLOW INCREASE
1	HPS-1	HIGH PRESSURE SAFETY SWITCH CIRCUIT #1 - OPENS ON HIGH PRESSURE
1	HPS-2	HIGH PRESSURE SAFETY SWITCH CIRCUIT #2 - OPENS ON HIGH PRESSURE
1	K1	COMPRESSOR #1 CONTACTOR
1	K2	COMPRESSOR #2 CONTACTOR
1	K3	FAN #1 CONTACTOR
1	K4	FAN #2 CONTACTOR
1	K5	FAN #3 CONTACTOR
1	LPPD-1	LOW PRESSURE PUMPDOWN - CIRCUIT #1
1	LPPD-2	LOW PRESSURE PUMPDOWN - CIRCUIT #2
1	NTC-1	TEMPERATURE SENSOR - ENTERING WATER TEMPERATURE
1	NTC-2	TEMPERATURE SENSOR - LEAVING WATER TEMPERATURE
1	OLM-1	COMPRESSOR #1 OVERLOAD MODULE
1	OLM-2	COMPRESSOR #2 OVERLOAD MODULE
1	PLC	PC05+ PROGRAMMABLE LOGIC CONTROLLER
1	PT-1	4-20 mA OUTPUT PRESSURE TRANSMITTER - LOW PRESSURE CIRCUIT #1
1	PT-2	4-20 mA OUTPUT PRESSURE TRANSMITTER - HIGH PRESSURE CIRCUIT #1
1	PT-3	4-20 mA OUTPUT PRESSURE TRANSMITTER - LOW PRESSURE CIRCUIT #2
1	PT-4	4-20 mA OUTPUT PRESSURE TRANSMITTER - HIGH PRESSURE CIRCUIT #2
1	S1	COMPRESSOR CIRCUIT #1 CONTROL SWITCH
1	S2	COMPRESSOR CIRCUIT #2 CONTROL SWITCH
1	SV-1	LIQUID LINE SOLENOID VALVE CIRCUIT #1
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1	T1	575 V PRIMARY, 24 V SECONDARY - 50 VA TRANSFORMER
1	T2	575 V PRIMARY, 24 V SECONDARY - 150 VA TRANSFORMER
1	TB-1	CHILLER - 24V AC TERMINAL BLOCK
1	TB-2	CHILLER - COMMON TERMINAL BLOCK
1	TB-4	24V DC TERMINAL BLOCK

NOTES:

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* MINIMUM 18 AWG SHIELDED WIRE WITH A
MAXIMUM OF 300 FEET RUN BY CONTRACTOR;
16 AWG SHIELDED WIRE FOR RUNS BETWEEN
300 - 500 FEET.

24V POWER

FIELD WIRING (6 WIRE PHONE CORD)

COMMON

ARCTIC HILL

CHILLED WATER SYSTEMS

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TITLE:

PROCESS 25 TON AIR COOLED
VERTICAL DISCHARGE
MANHATTAN CHILLER MODULE
SLAVE ELECTRICAL SCHEMATIC LEGEND

MODEL:

PACVMV0250D5-MM

ENGINEER:

CUSTOMER:HTS ENGINEERING, LTD.

JOB:TORONTO WESTERN HOSPITAL - 4 MRI SUITE

DRAWN BY:CW

REV:2

REV BY:CW

DATE:01/27/20

SCALE:NTS

FILE PATH:ACADDWGS\PROCESS\PACVMV\PACVMV25\DUAL\575\ELECT\PLC_02_#2

DWG#

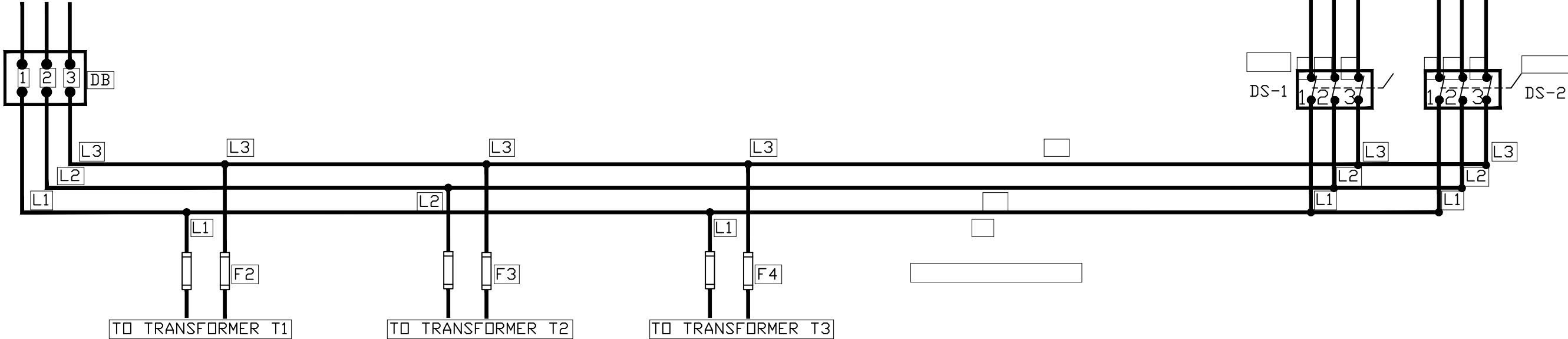
E6


QTY.	LEGEND	
2	DB	3 POLE DISTRIBUTION BLOCK
1	DS-1	3 POLE DISCONNECT SWITCH
1	DS-2	3 POLE DISCONNECT SWITCH
2	F2	T1 TRANSFORMER PRIMARY FUSES (1/2A)
2	F3	T2 TRANSFORMER PRIMARY FUSES (1/2A)
2	F4	T3 TRANSFORMER PRIMARY FUSES (1A)
1	M1	PUMP MOTOR #1
1	M2	PUMP MOTOR #2
1	VFD-1	VARIABLE FREQUENCY DRIVE #1
1	VFD-2	VARIABLE FREQUENCY DRIVE #2
2		GROUND LUGS

ON OUTSIDE OF CABINET
EARTH
GROUND LUG
GRNDED BY
CONTRACTOR

POWER —————
FIELD WIRING - - - - -
GROUND WIRING - - - - -

575/60/3 POWER REQUIRED
WIRING CONNECTION TO
POWER DISTRIBUTION PANEL
BY ARCTIC HILL





CHILLED WATER SYSTEMS

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TITLE: 100 GALLON TANK
AND PUMP MODULE
WITH 4" CONNECTIONS
HIGH VOLTAGE ELECTRICAL SCHEMATIC

MODEL: TP01005100

ENGINEER:

CUSTOMER: HTS ENGINEERING, LTD.

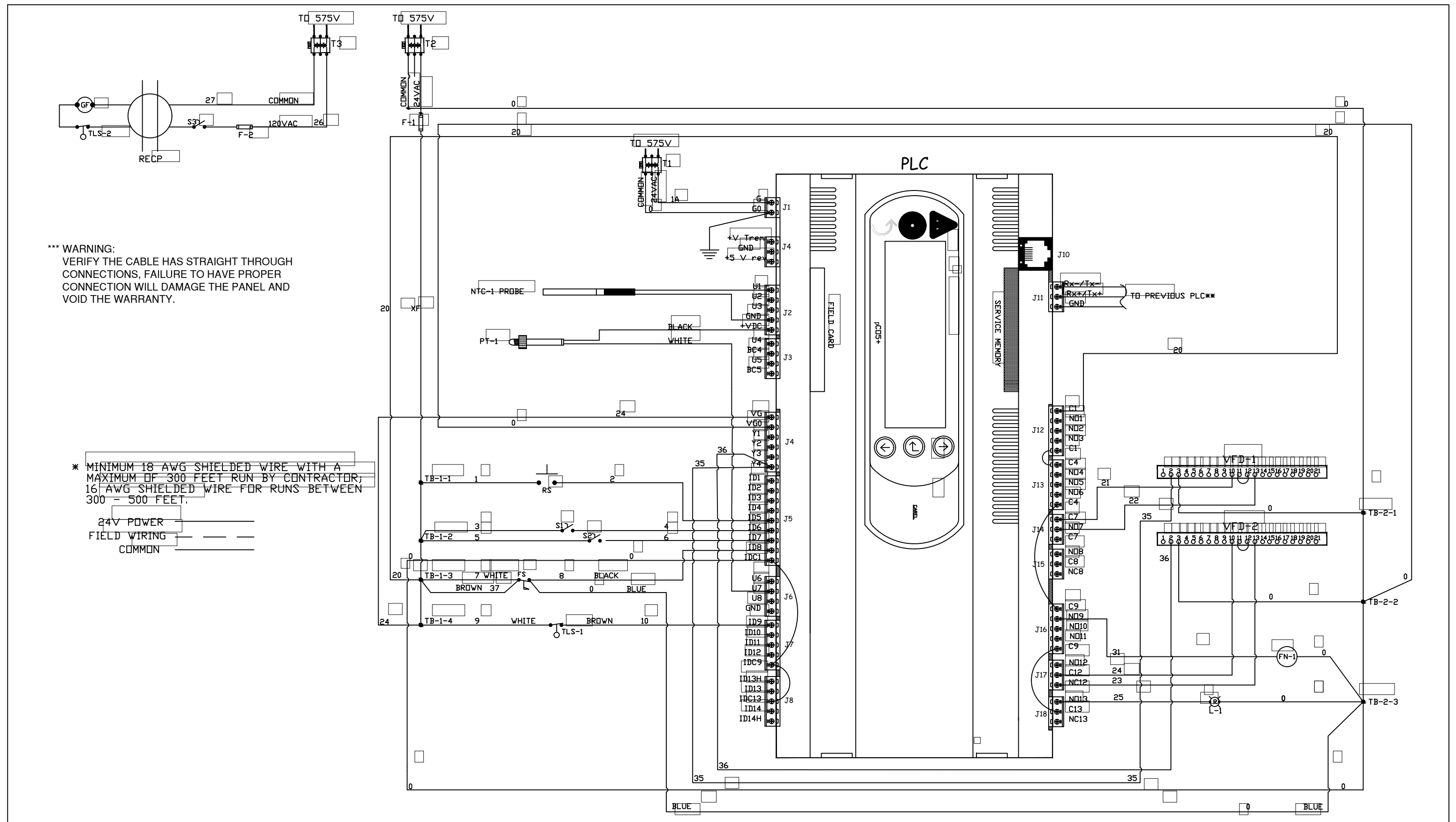
JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE

DRAWN BY: CW REV: REV BY: DATE: 01/24/20 SCALE: NTS

FILE PATH: ACADDWGS\TP_MOD\0100\5100\ELECT\HIGHPWR

DWG#

TPE1



<p>ARCTIC HILL CHILLED WATER SYSTEMS</p> <p>NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF 200 PARK, INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY. IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN FOR WHICH IT IS PROVIDED.</p>	<p>TITLE: 100 GALLON TANK AND PUMP MODULE WITH 4" CONNECTIONS CONTROL ELECTRICAL SCHEMATIC</p> <p>MODEL: TP01005100</p>	<p>ENGINEER:</p> <p>CUSTOMER: HTS ENGINEERING, LTD.</p> <p>JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE</p> <p>DRAWN BY: CW REV: 1 REV BY: DATE: 01/27/20 SCALE: NTS</p> <p>FILE PATH: ACADDWGS\TP_MOD\0100\5100\PLC_02_#1</p>	<p>DWG#</p> <p>TPE2</p>
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QTY.		LEGEND
1	F-1	FUSE (5A)
1	F-2	FUSE (2A)
1	FN-1	VFD BOX FAN
1	FS	FLOW SWITCH - CLOSE ON FLOW INCREASE
1	GF	GLYCOL FEEDER
1	L-1	PUMP SWITCHOVER ALARM - RED INDICATOR LIGHT
1	NTC-1	TEMPERATURE SENSOR - VFD BOX TEMPERATURE
1	PT-1	4-20 mA OUTPUT PRESSURE TRANSMITTER - SYSTEM DISCHARGE PRESSURE
1	PLC	PC05+ PROGRAMMABLE LOGIC CONTROLLER
1	RECP	120V RECEPTACLE
1	RS	PUMP LEAD/LAG SWITCHOVER RESET (N.O.)
1	S1	PUMP #1 CONTROL SWITCH
1	S2	PUMP #2 CONTROL SWITCH
1	S3	GLYCOL FEEDER CONTROL SWITCH
1	T1	575 V PRIMARY, 24 V SECONDARY - 50 VA TRANSFORMER
1	T2	575 V PRIMARY, 24 V SECONDARY - 75 VA TRANSFORMER
1	T3	575 V PRIMARY, 120 V SECONDARY - 150 VA TRANSFORMER
1	TB-1	CHILLER - 24V AC TERMINAL BLOCK
1	TB-2	CHILLER - COMMON TERMINAL BLOCK
1	TLS-1	TANK LEVEL SWITCH (NORMALLY CLOSED)
1	TLS-2	TANK LEVEL SWITCH (FOR GLYCOL FEEDER SHUT OFF)
1	VFD-1	VARIABLE FREQUENCY DRIVE - PUMP #1
1	VFD-2	VARIABLE FREQUENCY DRIVE - PUMP #2

NOTES:

1. CONTRACTOR IS TO FURNISH ALL WIRING BETWEEN EQUIPMENT.
2. WIRING IS TO MEET ALL LOCAL AND STATE WIRING CODES.

* MINIMUM 18 AWG SHIELDED WIRE WITH A
MAXIMUM OF 300 FEET RUN BY CONTRACTOR;
16 AWG SHIELDED WIRE FOR RUNS BETWEEN
300 - 500 FEET.

24V POWER _____
FIELD WIRING — — — —
COMMON _____

ARCTIC

CHILL

CHILLED WATER SYSTEMS

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TITLE:	100 GALLON TANK		ENGINEER:				DWG#	
	AND PUMP MODULE		CUSTOMER: HTS ENGINEERING, LTD.					
	WITH 4" CONNECTIONS		JOB: TORONTO WESTERN HOSPITAL - 4 MRI SUITE				TPE3	
	CONTROL ELECTRICAL SCHEMATIC LEGEND		DRAWN BY: CW		REV:	REV BY:	DATE: 01/24/20	SCALE: NTS
MODEL:	TP01005100		FILE PATH: ACADDWGS\TP_MOD\0100\5100\ELECT\PLC_02_#2					

Additional Compressor Information

ZP154KCE-TEE

HFC, R-410A, 60Hz, 3- Phase, 575 V

Air Conditioning



Production Status: Available for sale to all U.S. customers. Please check with your local Emerson Climate Technologies Representative for international availability.

Mechanical

Number of Cylinders:	0	Displ(in^3/Rev):	8.72
Bore Size(in):	0.00	Displ(ft^3/hr):	1059.85
Stroke(in):	0.00		
Overall Length (in):	12.93	Mounting Length (in):	7.50
Overall Width (in):	11.73	Mounting Width (in):	7.50
Overall Height (in):	22.21	Mounting Height (in):	23.02 *
Suction Size (in):	1 3/8 Stub		
Discharge Size (in):	7/8 Stub		
Oil Recharge (oz):	110		
Initial Oil Charge (oz):	114		
Net Weight (lbs):	143		
Internal Free Volume (in^3):			
Horse Power:			
*Overall compressor height on Copeland Brand Product's specified mounting grommets.			

Electrical

LRA-High*:	109.0	MCC (Amps):	31.0	UL File No:	SA-2337
LRA-Half Winding:		RPM:	3500	UL File Date:	27-Sep-1996
LRA Low*:		Max Operating Current:	24.0		
RLA(=MCC/1.4;use for contactor selection):	22.1				
RLA(=MCC/1.56;use for breaker & wire size selection):	19.9				
*Low and High refer to the low and high nominal voltage ranges for which the motor is approved.					

Alternate Applications

<u>Refrigerant</u>	<u>Freq (Hz)</u>	<u>Phase</u>	<u>Voltage</u>	<u>Application</u>
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ZPD154KCE-TE5

HFC, R-410A, 60Hz, 3- Phase, 200/230 V

Air Conditioning



Production Status: Available for sale to all U.S. customers. Please check with your local Emerson Climate Technologies Representative for international availability.

Mechanical

Number of Cylinders:	0	Displ(in^3/Rev):	8.72
Bore Size(in):	0.00	Displ(ft^3/hr):	1059.85
Stroke(in):	0.00		
Overall Length (in):	12.94	Mounting Length (in):	7.50
Overall Width (in):	11.73	Mounting Width (in):	7.50
Overall Height (in):	22.21	Mounting Height (in):	23.02 *
Suction Size (in):	1 3/8 Stub		
Discharge Size (in):	7/8 Stub		
Oil Recharge (oz):	110		
Initial Oil Charge (oz):	114		
Net Weight (lbs):	144		
Internal Free Volume (in^3):			
Horse Power:			
*Overall compressor height on Copeland Brand Product's specified mounting grommets.			

Electrical

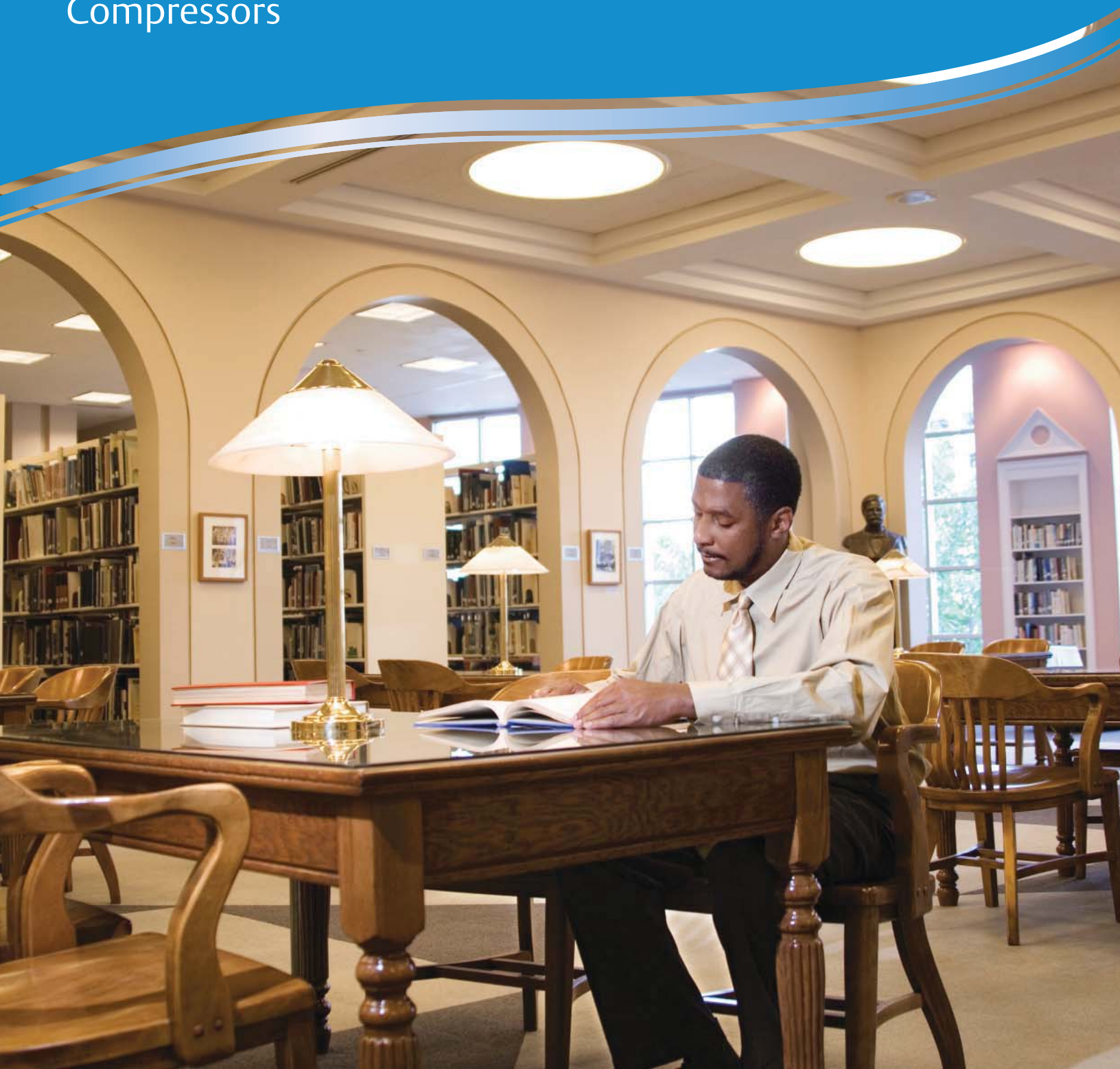
LRA-High*:	300.0	MCC (Amps):	80.0	UL File No:	SA-2337
LRA-Half Winding:		RPM:	3500	UL File Date:	07-Feb-2007
LRA Low*:		Max Operating Current:	59.0		
RLA(=MCC/1.4;use for contactor selection):	57.1				
RLA(=MCC/1.56;use for breaker & wire size selection):	51.3				
*Low and High refer to the low and high nominal voltage ranges for which the motor is approved.					

Alternate Applications

Refrigerant	Freq (Hz)	Phase	Voltage	Application
R-410A HFC	50	3	200/220	A/C, 50% Load Of Compressor
R-410A HFC	60	3	200/230	A/C, 50% Load Of Compressor
R-410A HFC	50	3	200/220	Air Conditioning

Copeland Scroll Digital™

Compressors



Maximize comfort while minimizing energy consumption

In today's commercial heating and air conditioning world, many challenges face your customers. Whether reducing energy consumption in a system, offering greener solutions, or simply improving comfort levels, one technology stands above the rest – the Copeland Scroll Digital™ compressor. The award winning Copeland Scroll Digital compressor offers improved comfort through precise temperature and humidity control and can achieve energy savings versus traditional methods of system modulation through its unique capacity modulation capabilities.

Superior-efficiency performance

Traditional means of modulation such as hot gas bypass unload without changing compressor capacity. Unfortunately, that means a compressor running at full capacity is consuming the maximum amount of energy during the bypass cycle. This scenario is a recipe for energy inefficiency and unnecessary operating costs.

The Copeland Scroll Digital offers compressor modulation from 10-100%, allowing your customers' cooling systems to automatically adjust capacity as needed while reducing energy consumption. This newest scroll technology is up to 30 percent more efficient than traditional methods of system modulation.

Comfort to match your needs

Imagine a restaurant dining room, a theater, or a classroom. Each application has its peak hours, when maximum cooling is

needed to maintain complete comfort. You can count on the Copeland Scroll Digital compressor to be right there, cooling at 100 percent capacity.

Remember, comfort is needed at off-peak hours too. That's where this compressor really impresses. When less cooling is needed, the Copeland Scroll Digital compressor can cool at as little as 10 percent capacity. So a constant temperature can be easily maintained within ± 0.5 degrees Fahrenheit at any time of day, whether the room is mostly empty or standing room only.

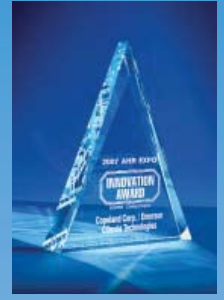
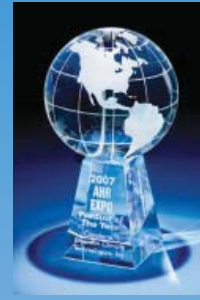
Fewer start-stops mean enhanced reliability.

It's the worst thing you can do to a compressor. Turn it on. Then turn it off. Then turn it on again. But when your compressor offers a capacity range of 10 to 100 percent, it doesn't need to start-stop as often as a traditional compressor. That means enhanced reliability and less maintenance.



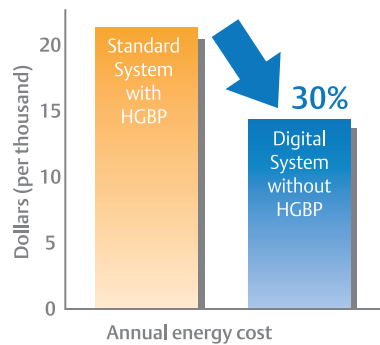
Award winning design

- ◆ Comfortech Product Showcase Award 2008
- ◆ Dealer Design Award Gold 2008
- ◆ AHR Expo Innovation Award Winner 2007
- ◆ AHR Expo Product of the Year Award 2007



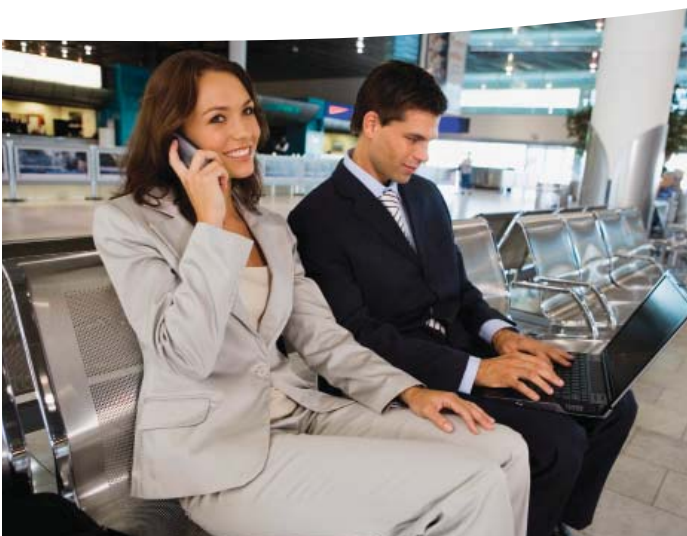
With Copeland Scroll Digital as your technology solution, you can offer your customers:

- Improved full-load and part-load efficiencies
- The ability to hold a precise temperature/humidity to $\pm 0.5^{\circ}\text{F}$
- Lower operating costs due to more efficient modulation methods
- Proven oil return enhancing system reliability
- Peace of mind with a simple, reliable design



Don't get left behind – include the Copeland Scroll Digital compressor in your product offering today.

Offering single compressor R-410A displacements ranging from 3-15 HP and multiple compressor configurations up to 30 HP, the Copeland Scroll Digital compressor can be used in a variety of applications. Whether it's a single-circuit packaged system or a multi-circuit rooftop system, the Copeland Scroll Digital compressor offers a reliable and affordable solution for the toughest application challenges.



Copeland Scroll Digital™ models

Model	ARI Capacity Btu/hr	EER @ ARI	Height (In)	Length (In)	Weight (lbs)	Suction Diameter (In)	Discharge Diameter (In)
Single Compressors							
ZPD34K5E-PFV/PFJ	34500	10.2	17.7	9.6	68	0.785	0.5
ZPD34K5E-TFD/TF5/TF7	34600	10.2	17.7	9.6	68	0.785	0.5
ZPD42K5E-PFV	42000	10.3	18.4	9.3	72	0.785	0.5
ZPD42K5E-TFD/TF5/TF7	42600	10.7	18.4	9.3	72	0.785	0.5
ZPD51K5E-PFV	51500	10.5	18.4	9.3	76	0.785	0.5
ZPD51K5E-TFD/TF5/TF7	51000	10.6	18.4	9.3	76	0.785	0.5
ZPD54K5E-PFV	54000	10.5	18.4	9.3	76	0.785	0.5
ZPD54K5E-TFD/TF5/TF7	54500	10.7	18.4	9.3	76	0.785	0.5
ZPD61KCE-TFD/TF5/TF7	62000	10.5	19.5	9.5	89	0.785	0.5
ZPD72KCE-TFD/TF5/TF7	71500	10.5	19.5	9.5	90	0.785	0.5
ZPD83KCE-TFD/TF5/TF7	82500	10.5	19.5	9.5	90	0.785	0.5
ZPD91KCE-TFD/TF5/TFE/TF7	90100	10.9	18.9	9.67	91.5	0.875	0.75
ZPD103KCE-TFD/TF5/TFE/TF7	105000	11.0	21.0	11.5	134	1.375	0.875
ZPD104KCE-TFD/TF5/TFE/TF7	106000	11.0	24.3	10.6	108	1.125	0.875
ZPD120KCE-TFD/TF5/TFE/TF7	123000	11.1	21.0	11.5	136	1.375	0.875
ZPD122KCE-TFD/TF5/TFE/TF7	123000	11.0	24.3	10.6	111	1.125	0.8875
ZPD137KCE-TFD/TF5/TFE/TF7	137500	11.0	21.0	11.5	135	1.375	0.875
ZPD154KCE-TWD/TW5/TWE/TW7	155000	11.0	21.7	12.83	147	1.375	0.875
ZPD182KCE-TWD/TW5/TWE/TW7	183000	11.0	21.7	12.83	147	1.375	0.875
Uneven Tandems							
ZPDU58K5E-TF5/TFD/TFE	59300	10.4	19.95	24.36	116.4	1.125	0.75
ZPDU76K5E-TF5/TFD/TFE	78500	10.8	19.95	24.29	136.4	1.125	0.75
ZPDU85K5E-TF5/TFD/TFE	86100	10.5	19.95	24.29	136.4	1.125	0.75
ZPDU10M5E-TF5/TFD/TFE	103000	10.1	19.95	24.29	155.4	1.125	0.75
ZPDU12MCE-TF5/TFD/TFE	121000	10.2	20.55	24.67	218	1.125	0.75
ZPDU13MCE-TFD	130000	10.3	20.49	24.62	205	0.75	1.125
ZPDU15MCE-TF5/TFD/TF7/TFE	149500	10.6	19.74	24.65	190	1.125	0.75
ZPDU17MCE-TF5/TFD/TF7/TFE	171000	10.3	19.74	24.65	190	1.125	0.75
ZPDU21MCE-TF5/TF7/TFD/TFE	208000	10.8	22.73	29.37	271	1.625	1.375
ZPDT22MCE-TFD/TF5/TFE/TF7	210000	10.9	25.6	29.6	232	1.625	1.375
ZPDT25MCE-TFD/TF5/TFE/TF7	243000	10.9	25.6	29.6	232	1.625	1.375
ZPDU26MCE-TXD/TX7/TXE	258000	10.9	23.5	29.37	278	1.625	1.375
Even Tandems							
ZPDT12MCE-TFD/TF5	123000	10.3	20.5	24.62	204	1.125	0.75
ZPDT14MCE-TFD/TF5	143000	10.1	20.5	24.62	205	1.125	0.75
ZPDT16MCE-TFD/TF5	162000	10.6	20.5	24.62	205	1.125	0.75
ZPDT18MCE-TFD/TF5/TFE/TF7	179000	10.8	20.55	24.66	190	1.125	1.125
ZPDT21MCE-TFD/TF5/TFE/TF7	209000	11.0	22.7	29.37	289	1.625	1.375
ZPDT24MCE-TFD/TF5/TFE/TF7	246000	11.0	22.7	29.37	289	1.625	1.375
ZPDT27MCE-TFD/TF5/TFE/TF7	270000	11.0	22.7	29.37	289	1.625	1.375
ZPDT31MCE-TWD/TW5/TWE/TW7	309000	11.0	23.5	29.37	286	1.625	1.375
ZPDT36MCE-TWD/TW5/TWE/TW7	364000	11.0	23.5	29.37	292	1.625	1.375

Copeland Scroll compressor nomenclature

Z	P	D	4	2	K	5	E	-	T	F	D	-	1	3	0
Z scroll family series	AC, R-410A	D = Digital S = UltraTech® T = Tandem (even) U = Uneven Tandem	Nominal Capacity at Rating Condition	Capacity Multiplier K = 1,000 M = 10,000	Model Variation 4, 5, C	Oil type E = POE Oil = AK/ DA or 3MA			P = Single Phase Motor T = Three Phase Motor	F = Internal Inherent Protection W = External Protection Module E = CoreSense Module X = TW* + TF* and/or TE* + TF*	Code D 60 Hz. 460-3 5 200-230-3 E 575-3 7 380-3 V 208-230-1 J 265-1 *only on some A/C scroll models				Bill of Material Product Variation

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EMERSON. CONSIDER IT SOLVED.™

Additional Component Information

The DP300 is equipped with our patented AsyMatrix® technology and is an asymmetric evaporator combining low water pressure drop with high performance. The DP300 is a highly effective, versatile True Dual evaporator which is the perfect choice for chillers and heat pump applications. Its advantage is its ability to deliver full performance at both full and half load.

Connections*



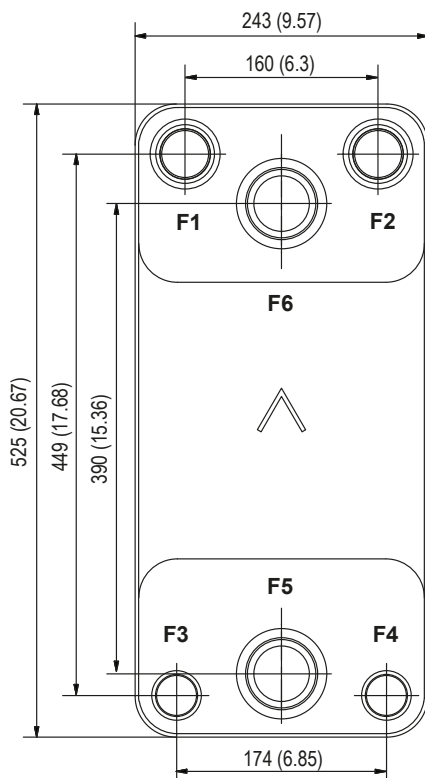
*For specific dimensions, or information about other types of connections, please contact your SWEP sales representative.

Pressure classes

M Medium, evaluated per EN 13345 (38-48 bar/550-696 PSI).



Max number of plates (NoP)	346
Port size F1/P1	47 mm (1.85 in)
Port size F2/P2	47 mm (1.85 in)
Port size F3/P3	20 mm (0.787 in)
Port size F4/P4	20 mm (0.787 in)
Port size F5/P5	62 mm (2.441 in)
Port size F6/P6	62 mm (2.441 in)
Max volume flow	60 m³/h (264 gpm)

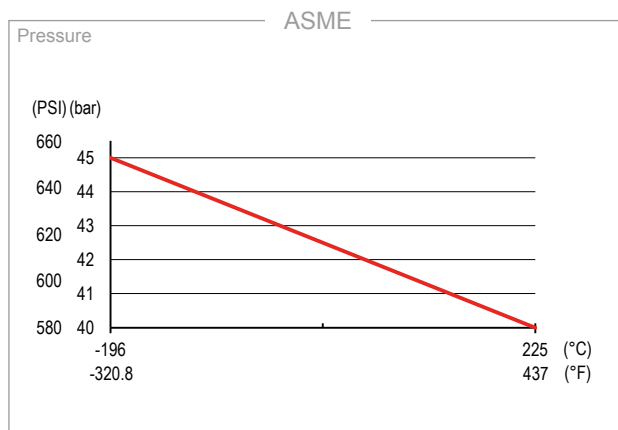
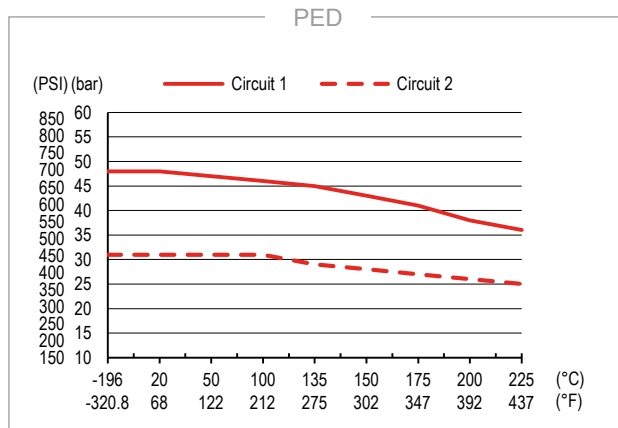


Materials

	Channel plate	Brazing
SC	Stainless steel	Copper
NC	Stainless steel	Copper
MC	Mo-steel	Copper
NSC	Stainless steel	Copper

Size

	Height of plate pack	Total weight
SC M NC M NSC M MC M	10+(1,91×NoP) mm	7,75+(0,338×NoP) kg
	0.394+(0.075×NoP) in	17.08+0.745×(NoP) lb



Third party approvals

SWEP BPHEs are generally approved by listed below certification organizations:

Europe, Pressure Equipment Directive (PED)

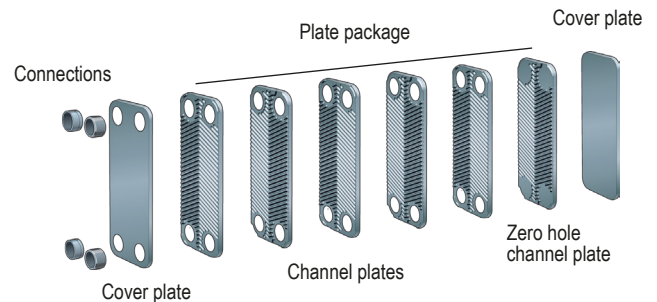
America, Underwriters Laboratories Inc (UL)

Japan, Kouatsu-Gas Hoan Kyoukai (KHK)

Additionally SWEP holds approvals from a vast variety of other certification organizations. For approval information regarding a specific product please contact your local SWEP representative. SWEP reserves the right to make changes without prior notice.

The BPHE concept

The Brazed Plate Heat Exchanger (BPHE) is constructed as a plate package of corrugated channel plates with a filler material between each plate. During the vacuum brazing process, the filler material forms a brazed joint at every contact point between the plates, creating complex channels. The BPHE allows media at different temperatures to come into close proximity, separated only by channel plates that enable heat from one media to be transferred to the other with very high efficiency. The concept is similar to other plate and frame technology, but without the gaskets and frame parts.



SSP calculation software

With SWEP's unique SSP, the SWEP Software Package, you can do advanced heat transfer calculations yourself, and choose the product solution that suits your application best. It's also easy to choose connections and generate drawings of the complete product. If you would like advice, or you would like to discuss different product solutions, SWEP offers all the service and support your need.

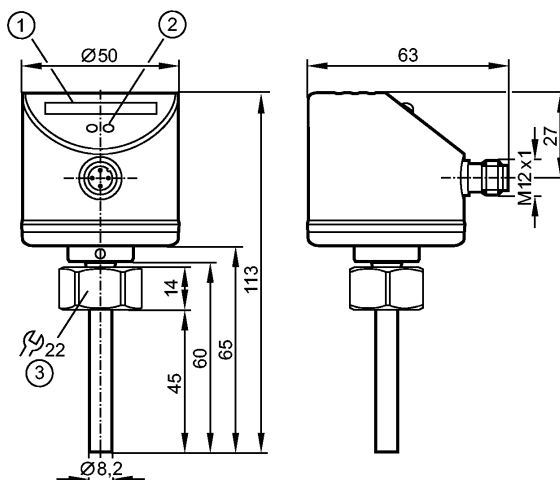
Material disclaimer

The information and recommendations in regards to the products are presented in good faith, however, SWEP makes no representations or warranties as to the completeness or accuracy of the information. Information is supplied upon the condition that the purchasers will make their own determination as to the products' suitability for their purposes prior to use. Purchasers should note that the properties of the products are both application and material selection dependent and that products containing stainless steel are still subject to corrosion if used in unsuitable environments.

SI0558

SID10XDBAKOA/US-100

Flow sensors



- 1: LED display
 2: setting pushbutton
 3: tightening torque 25 Nm


Product characteristics

Flow monitor
Compact type for adapter
Process connection: internal thread M18 x 1.5 for adapter
Probe length: 45 mm
Pressure rating: 300 bar
Setting range: 3...300 cm/s (liquids)

Application

Application	liquids and gases
Pressure rating [bar]	300
Medium temperature [°C]	-25...70

Electrical data

Electrical design	AC/DC
Operating voltage [V]	18...36 DC / 24 AC $\pm 15\%$ (47...63 Hz); to SELV/PELV
Current consumption [mA]	< 80
Protection class	III
Reverse polarity protection	no

Outputs

Output function	normally open
Contact rating	2 A, 36 V AC/DC; to EN 50178, SELV, PELV
Short-circuit protection	no
Overload protection	no

Measuring / setting range

Liquids	
Setting range [cm/s]	3...300
Set point, SP [cm/s]	20
Greatest sensitivity [cm/s]	3...100
Gases	
Setting range [cm/s]	200...3000

Thermostatic Expansion Valves

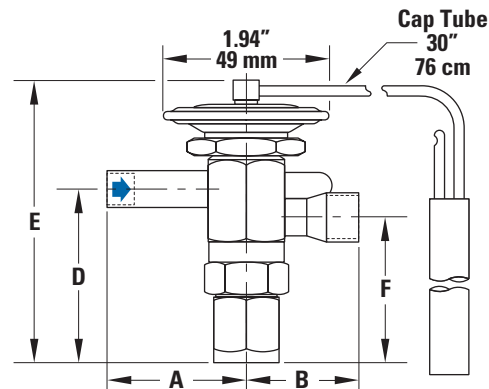
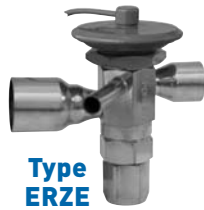
410A

Type ERZE

Knife Edge Joint

Standard Cap Tube Length 30 in. (76 cm)

The ERZE valve is an externally adjustable balance ported TEV designed for R-410A air conditioning applications. This makes the ERZE valve an excellent replacement for all OEM BI and BBI valves as well as other applications requiring a R-410A expansion valve such as I and RI valves. The ERZE valve utilizes the KT-45 element design for the higher pressures of R-410A. This valve may also be applied in bi-directional applications.



Dimensions

Connections

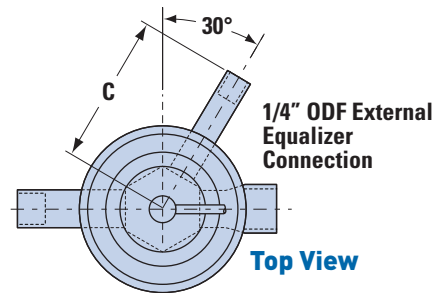
VALVE TYPE	FITTING SIZE** Inches	Inches						mm					
		A	B	C	D	E	F	A	B	C	D	E	F
ERZE-1, 1-1/2 & 2*	3/8 ODF	1.69	1.35					42.9	34.3				
	1/2 ODF	1.75*	1.35					44.4*	34.3				
	5/8 ODF	—	2.51					—	63.8				
ERZE-3, 4, 5, 6 & 8	3/8 ODF	1.69	—	1.81	2.17	3.53	1.83	42.9	—	46.0	55.1	89.7	46.5
	1/2 ODF	1.75	1.35					44.5	34.3				
	5/8 ODF	1.29	2.51					32.8	63.8				
	7/8 ODF	—	2.41					—	61.2				
ERZE-12-1/2 & 15	5/8 ODF	1.52	—					38.6	—				
	7/8 ODF	2.08	—					52.8	—				
	5/8 ODF Ext.	—	2.51	1.90	2.30	3.79	1.83	—	63.8	48.3	58.4	96.3	46.5
	7/8 ODF Ext.	—	2.51					—	63.8				
	1-1/8 ODF Ext.	—	2.51					—	63.8				

*1/2 ODF inlet available on 2 ton valves only.

** Not all fitting combinations are available.

Bulb Sizes

THERMOSTATIC CHARGE	Inches	mm
ZCP180	0.50 OD x 3.00	13 OD x 76
ZGA	0.75 OD x 2.00	19 OD x 51



Capacities

Tons • psi • °F

kW • bar • °C

VALVE TYPE	NOMINAL CAPACITY (Tons)	EVAPORATOR TEMPERATURE °F			VALVE TYPE	NOMINAL CAPACITY (kW)	EVAPORATOR TEMPERATURE °C		
		40	20	0			5	-5	-15
		PRESSURE DROP ACROSS VALVE (psi)					PRESSURE DROP ACROSS VALVE (bar)		
		160	200	200			11	14	14
ERZE-1-GA	1	1.2	1.3	1.2	ERZE-1-GA	4.20	4.20	4.64	4.25
ERZE-1-1/2-GA	1-1/2	2.1	2.3	2.0	ERZE-1-1/2-GA	7.35	7.35	8.11	7.44
ERZE-2-GA	2	2.7	3.0	2.7	ERZE-2-GA	9.66	9.66	10.7	9.77
ERZE-3-GA	3	3.8	4.1	3.7	ERZE-3-GA	13.4	13.4	14.8	13.6
ERZE-4-GA	4	5.0	5.4	4.9	ERZE-4-GA	17.6	17.6	19.5	17.8
ERZE-5-GA	5	5.9	6.5	5.8	ERZE-5-GA	21.0	21.0	23.2	21.2
ERZE-6-GA	6	7.1	7.8	6.3	ERZE-6-GA	25.2	25.2	27.8	23.7
ERZE-8-GA	8	9.5	10.4	9.3	ERZE-8-GA	33.6	33.6	37.1	34.0
ERZE-12-1/2-GA	12-1/2	12.3	13.5	12.1	ERZE-12-1/2-GA	43.8	43.8	48.4	44.3
ERZE-15-GA	15	14.3	15.7	14.0	ERZE-15-GA	50.8	50.8	56.1	51.4

LIQUID TEMPERATURE ENTERING TEV °F											LIQUID TEMPERATURE ENTERING TEV °C												
40	50	60	70	80	90	100	110	120	130	140	5	10	15	20	25	30	35	40	45	50	55	60	
CORRECTION FACTOR, CF LIQUID TEMPERATURE											CORRECTION FACTOR, CF LIQUID TEMPERATURE												
1.47	1.39	1.32	1.23	1.16	1.09	1.00	0.93	0.83	0.75	0.64	1.46	1.39	1.32	1.25	1.18	1.11	1.04	0.97	0.89	0.81	0.72	0.62	

EVAPORATOR TEMPERATURE °F	PRESSURE DROP ACROSS TEV (psi)								EVAPORATOR TEMPERATURE °C	PRESSURE DROP ACROSS TEV (bar)								
	80	120	160	200	240	280	320	360		8	10	11	12	13	14	16	18	20
	CORRECTION FACTOR, CF PRESSURE DROP									CORRECTION FACTOR, CF PRESSURE DROP								
40°	0.71	0.87	1.00	1.12	1.22	1.32	1.41	1.50	5°	0.85	0.95	1.00	1.04	1.09	1.13	1.21	1.28	1.35
20°	0.63	0.77	0.89	1.00	1.10	1.18	1.26	1.34	-5°	0.76	0.85	0.89	0.93	0.96	1.00	1.07	1.13	1.20
0°	0.63	0.77	0.89	1.00	1.10	1.18	1.26	1.34	-15°	0.76	0.85	0.89	0.93	0.96	1.00	1.07	1.13	1.20

Butterfly Valves

SERIES 700

Victaulic Series 700 butterfly valves are designed for bubble-tight shut-off to 200psi/1400kPa. Two piece stem permits narrow disc design for low pressure drop performance and is self-centering for positive shut-off. Valves are available with liners molded from EPDM for water service to +230°F/+110°C or nitrile for oil services to +180°F/+82°C. Refer to Liner/Disc Selection for general service recommendations.

Series 700 butterfly valves are available in 1 ½ – 6" / 40 – 150mm sizes. The body is fully rubber lined, and the valve housing is cast of durable ductile iron. Standard disc is aluminum bronze (also available in 316 stainless steel), with a two position cast handle with padlock feature as the standard operator.

Victaulic recommends the use of Style 07 Zero-Flex®/Style 107 QuickVic rigid couplings with the Series 700 butterfly valve to eliminate joint deflection or valve rotation at the coupling connection to the piping system.



LEVER HANDLE

MATERIAL SPECIFICATIONS

Housing: Ductile iron conforming to ASTM A-536, grade 65-45-12, painted black.

Body: Carbon steel, elastomer lined.

Seat/Liner: (specify choice*)

- **Grade "E" EPDM**

EPDM (Green color code). Temperature range –30°F to +230°F/–34°C to +110°C.

Recommended for cold and hot water service within the specified temperature range plus a variety of dilute acids, oil-free air and many chemical services. UL classified in accordance with ANSI/NSF 61 for cold +86°F/+30°C and hot 180°F/+82°C potable water service. NOT RECOMMENDED FOR PETROLEUM SERVICES.

- **Grade "T" nitrile**

Nitrile (Orange color code). Temperature range –20°F to +180°F/–29°C to +82°C.

Recommended for petroleum products, air with oil vapors, vegetable and mineral oils within the specified temperature range. Not recommended for hot water services over +150°F/+66°C or for hot dry air over +140°F/+60°C.

* Services listed are General Service Recommendations only. It should be noted that there are services for which these gaskets are not recommended. Reference should always be made to the latest Victaulic Liner/Disc Selection for specific service recommendations and for a listing of services which are not recommended.

Stem-Upper/Lower: 416 stainless steel

Disc: Aluminum bronze

- **Optional:** 316 stainless steel

Handle: Cast ductile iron

O-ring: (Same as seat)

Track Bolts: Steel, Electroplated

Nuts: Steel, Electroplated

JOB OWNER

System No. _____

Location _____

CONTRACTOR

Submitted By _____

Date _____

ENGINEER

Spec Sect _____ Para _____

Approved _____

Date _____

www.victaulic.com

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REV_E

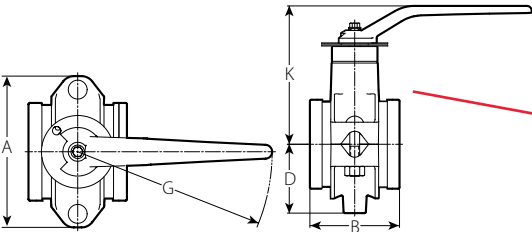


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Butterfly Valves

SERIES 700

DIMENSIONS



1 ½ – 6"/40 – 150 MM (TYPICAL)

STANDARD PROFILE BFV

Size		Dimensions – Inches/millimeters					Aprx. Weight Each
Nominal Size Inches/mm	Actual Outside Dia. Inches/mm	A	B	D	G	K	Lbs./kg
1 ½ 40	1.900 48.3	3.63 92.2	3.38 85.9	1.63 41.4	5.50 139.7	4.44 112.8	2.8 1.3
2 50	2.375 60.3	4.06 103.1	3.19 81.0	1.87 47.5	5.50 139.7	4.71 119.6	3.3 1.5
2 ½ 65	2.875 73.0	4.87 123.7	3.81 96.8	2.50 63.5	7.00 177.8	5.31 134.9	6.4 2.9
3 80	3.500 88.9	5.62 142.7	3.81 96.8	2.75 69.9	7.00 177.8	5.62 142.7	6.8 3.1
4 100	4.500 114.3	7.00 177.8	4.56 115.8	3.50 88.9	9.00 228.6	6.69 179.9	12.1 5.5
5 125	5.563 141.3	8.50 215.9	5.81 147.6	4.00 101.6	12.00 304.8	8.25 209.6	26.1 11.8
6 150	6.625 168.3	9.50 241.3	5.81 147.6	4.50 114.3	12.00 304.8	8.78 223.0	32.5 14.7
165.1 mm	6.500 165.1	9.50 241.3	5.81 147.6	4.50 114.3	12.00 304.8	8.78 223.0	30.5 13.8

Butterfly Valves

SERIES 700

PERFORMANCE

C_v values for flow of water at +60°F/+16°C with various disc positions are shown in the table below.

Formulas for C_v Values:

$$\Delta P = \frac{Q^2}{C_v^2}$$


$$Q = C_v \times \sqrt{\Delta P}$$

Where:

Q = Flow (GPM)

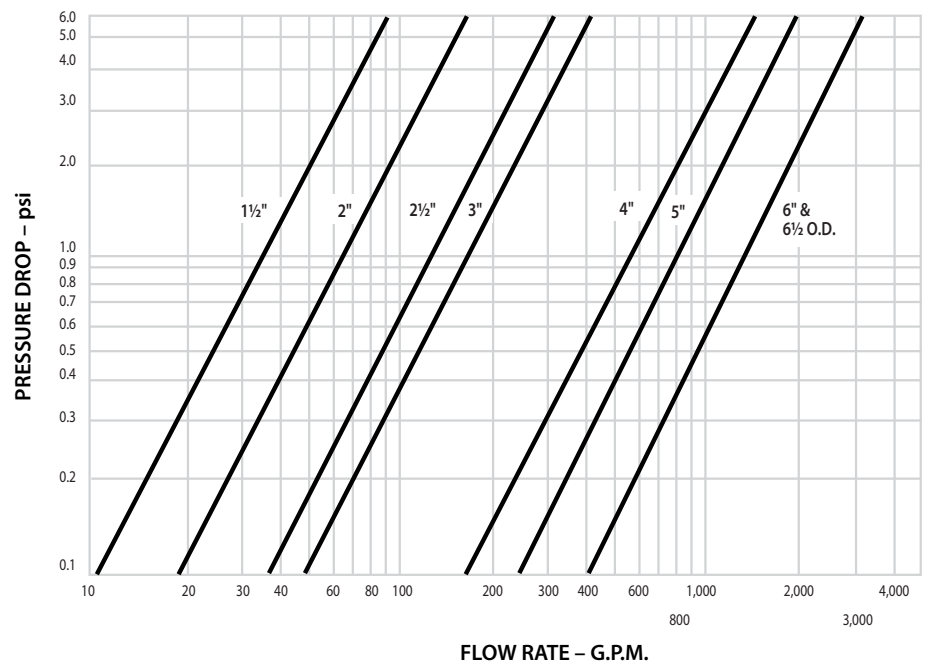
ΔP = Pressure Drop (psi)

C_v = Flow Coefficient

Size		FLOW COEFFICIENTS – C_v
Nominal Size Inches/mm	Actual Outside Diameter Inches/mm	Disc Position (Degrees open)
		90 
1½ 40	1.900 48.3	36
2 50	2.375 60.3	70
2½ 65	2.875 73.0	120
3 80	3.500 88.9	180
4 100	4.500 114.3	520
5 125	5.563 141.3	800
6 150	6.625 168.3	1300
165.1 mm	6.500 165.1	1300

FLOW CHARACTERISTICS

The chart below expresses the flow of water at 65°F/18°C through a full open valve.



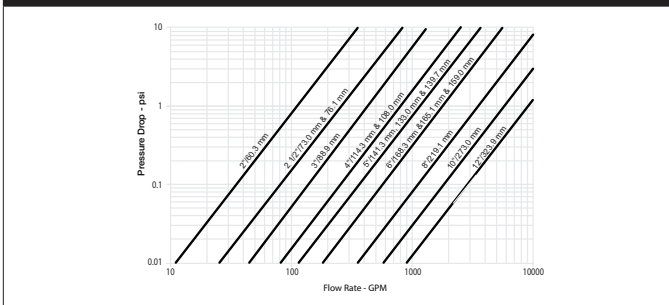
F650VIC, 2", 2-Way Victaulic Butterfly Valve Pressure Enhanced Rubber Seat



Technical Data	
Media	chilled, hot water, up to 60% glycol
Flow characteristic	modified equal percentage
Controllable flow range	90° rotation
Valve Size	2 " [50]
Pipe connection	grooved ANSI/AWWA (c606)
Housing	ductile iron ASTM A536 grade 65-45-12
Surface treatment	black alkyd enamel
Stem	stainless steel AISI 416
Spindle bearing	fiberglass with TFE lining
Seat	EPDM
Disc	electroless nickel coated ductile iron
Body Pressure Rating	300 psi
ANSI Class	Grooved AWWA
Rangeability Sv	100:1
Maximum Velocity	20 FPS
Cv	115
Weight	3.31 lb [1.5 kg]
Media Temp Range (water)	-22...250°F [-30...120°C]
Leakage rate	0%
Maintenance	maintenance free

Close-off pressures are variable and actuator dependent, consult Select Pro and/or Price Guide for specifics.

Flow Pattern



Application

These valves are designed to meet the needs of HVAC and commercial applications requiring bubble tight shut-off for liquids. Typical applications include chiller insulation, cooling tower isolation, change-over systems, large air handler coil control, bypass and process control applications. The large Cv values provide for an economical control valve solution for larger flow applications. Designed for use in Victaulic piping systems.

Jobsite Note

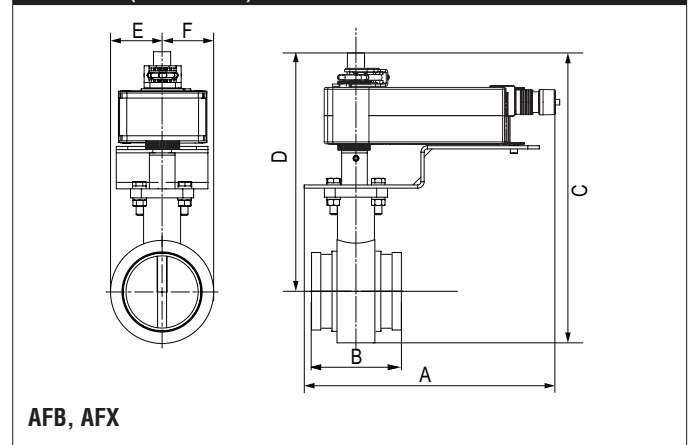
Valve assembly should be stored in a weather protected area prior to installation. Reference the butterfly valve installation instruction for additional information.

Flow/Cv					
Cv 30°	Cv 40°	Cv 50°	Cv 60°	Cv 70°	Cv 90°
7	14	23	36	60	115

Suitable Actuators

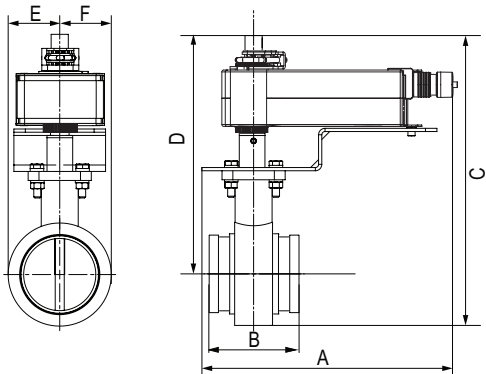
	Non-Spring	Spring
F650VIC	AMB(X), GRB(X)	AF

Dimensions (Inches [mm])



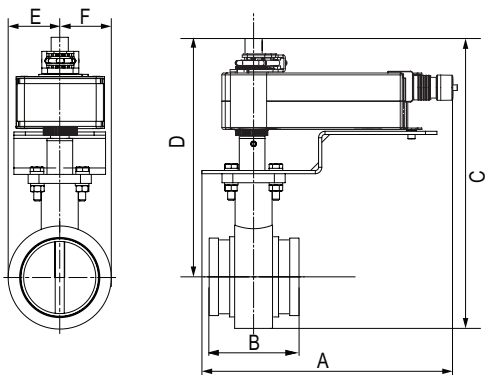
A	B	C	D	E	F
10.6" [270]	3.23" [82]	11.75" [298.5]	10.12" [257]	1.6" [41]	

Dimensions (Inches [mm])



AFB, AFX

Dimensions (Inches [mm])

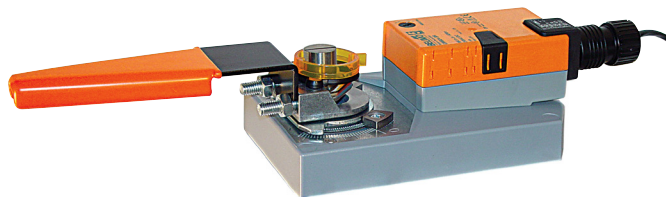


AFB, AFX

A
11.8" [300]

AMX24-MFT-X1

Modulating, Non-Spring Return, 24 V, Multi-Function Technology®



Technical Data	
Power Supply	24 VAC, ±20%, 50/60 Hz, 24 VDC, ±10%
Power consumption in operation	3.5 W
Power consumption in rest position	1.3 W
Transformer sizing	6 VA
Electrical Connection	3ft [1m], 18 GA plenum rated cable with 1/2" conduit connector (10ft [3m] and 15ft [5m] avail.)
Overload Protection	electronic throughout 0° to 95° rotation
Operating Range	DC 2...10 V (default), 4 to 20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor), variable (VDC, PWM, floating point, on/off)
Operating range Y variable	starting point DC 0.5...30 V end point DC 2.5...32 V
Input Impedance	100 kΩ for 2 to 10 VDC (0.1 mA), 500 Ω for 4 to 20 mA, 1500 Ω for PWM, floating point and On/Off
Position Feedback	DC 2...10 V, Max. 0.5 mA, VDC variable
Angle of rotation	Max. 95°, adjustable with mechanical stop
direction of rotation motor	reversible with built-in switch
Position indication	handle
Manual override	external push button
Running time motor	default 150 sec, variable 90...350 sec
Ambient humidity	5 to 95% RH non condensing (EN 60730-1)
Ambient temperature	-22...150 °F [-30...65 °C]
Non-operating temperature	-40...176 °F [-40...80 °C]
Degree of Protection	IP54, NEMA 2, UL Enclosure Type 2
Housing material	UL94-5VA
Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2004/108/EC and 2006/95/EC
Noise level, motor	<45 dB (A)
Maintenance	maintenance free
Quality Standard	ISO 9001
Weight	4.9 lbs (2.00 kg)

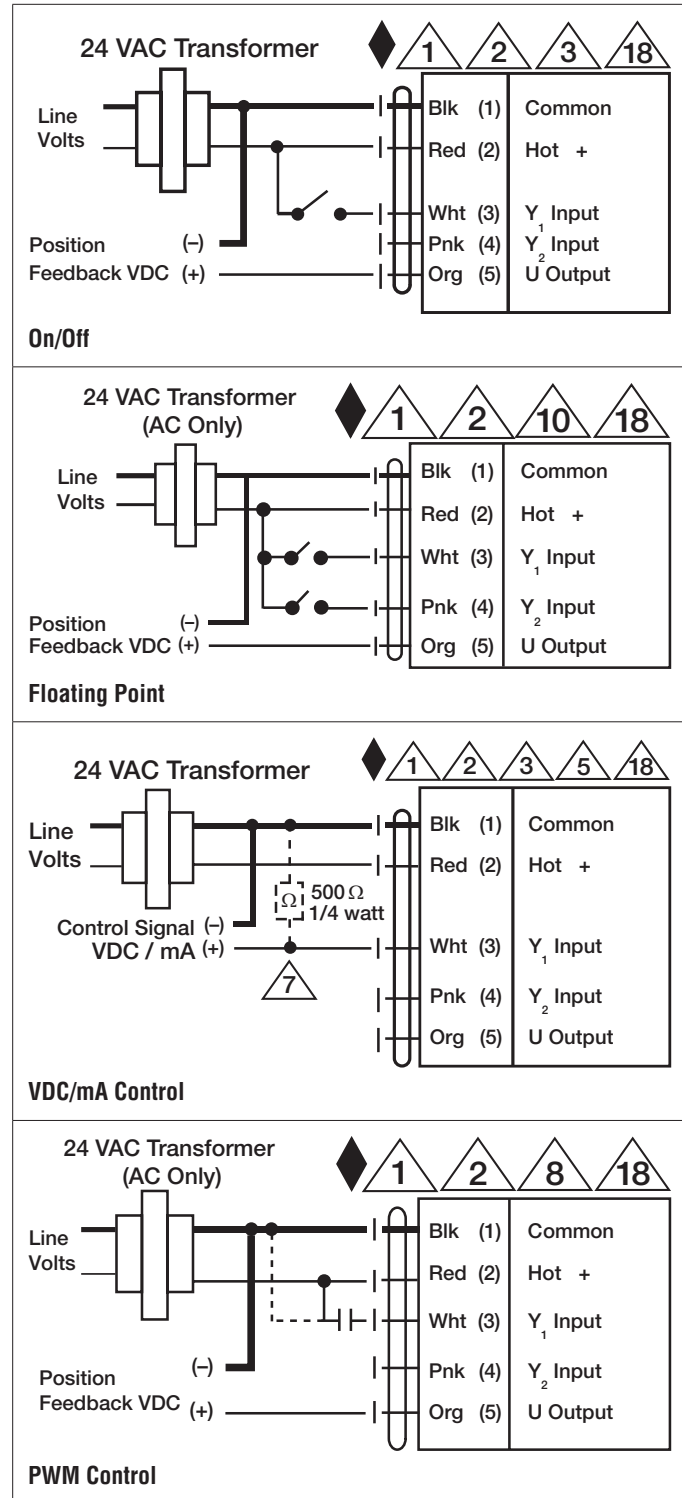
†Rated Impulse Voltage 800V, Type action 1, Control Pollution Degree 3.

Wiring Diagrams
INSTALLATION NOTES

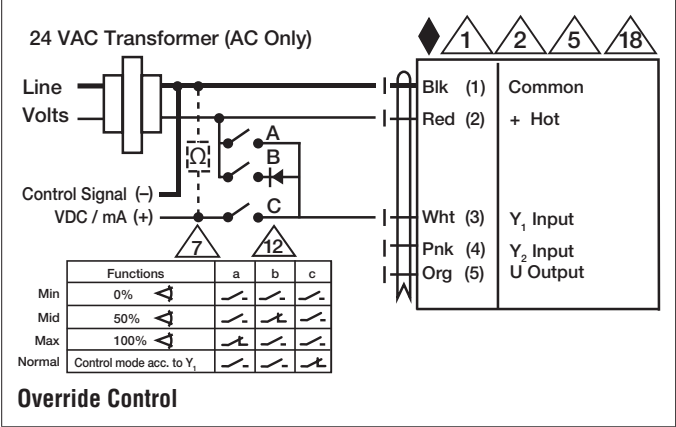
- (A)** Actuators with appliance cables are numbered.
- 1** Provide overload protection and disconnect as required.
- 3** Actuators may also be powered by 24 VDC.
- 5** Only connect common to negative (-) leg of control circuits.
- 7** A 500 Ω resistor (ZG-R01) converts the 4 to 20 mA control signal to 2 to 10 VDC.
- 8** Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 VAC line.
- 10** For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.
- 11** Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.
- 12** IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).
- ◆** Meets cULus requirements without the need of an electrical ground connection.


WARNING! LIVE ELECTRICAL COMPONENTS!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



AMX24-MFT-X1
Modulating, Non-Spring Return, 24 V, Multi-Function Technology®



Pump and Tank Module Information

Job/Project:	Representative: James M. Pleasants Company		
ESP-Systemwize: WIZE-EAC1CE	Created On: 01/28/2020	Phone: (336) 378-9911	
Location/Tag:	Email: info@jmpco.com		
Engineer:	Submitted By:	Date:	
Contractor:	Approved By:	Date:	

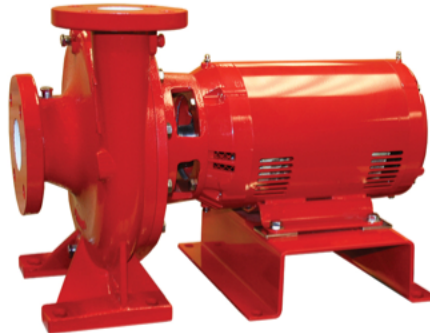
Close Coupled Foot Mounted End Suction Pump

Series: e-1532

Model: 2AD

Features & Design

- "Best in Class" hydraulic performance
- Best choice for lowest life cycle cost
- Internally self-flushing mechanical seals
- Hydrostatic testing of each pump standard



*The Bell & Gossett Series e-1532 is available in 26 sizes and a variety of configuration options that enables customization and flexibility to fit a broad range of operating conditions.

Pump Selection Summary

Duty Point Flow	168 US gpm
Duty Point Head	105 ft
Control Head	31.5 ft
Duty Point Pump Efficiency	65.6 %
Part Load Efficiency Value (PLEV)	58.8 %
Impeller Diameter	5.625 in
Motor Power	10 hp
Duty Point Power	7.02 bhp
Motor Speed	3600 rpm
RPM @ Duty Point	3396 rpm
NPSHr	8.95 ft
Minimum Shutoff Head	118 ft
Minimum Flow at RPM	38.9 US gpm
Flow @ BEP	194 US gpm
Fluid Temperature	45 °F
Fluid Type	50% Propylene glycol
Weight (approx. - consult rep for exact)	216 lbs
Pump Floor Space Calculation	2.31 ft²

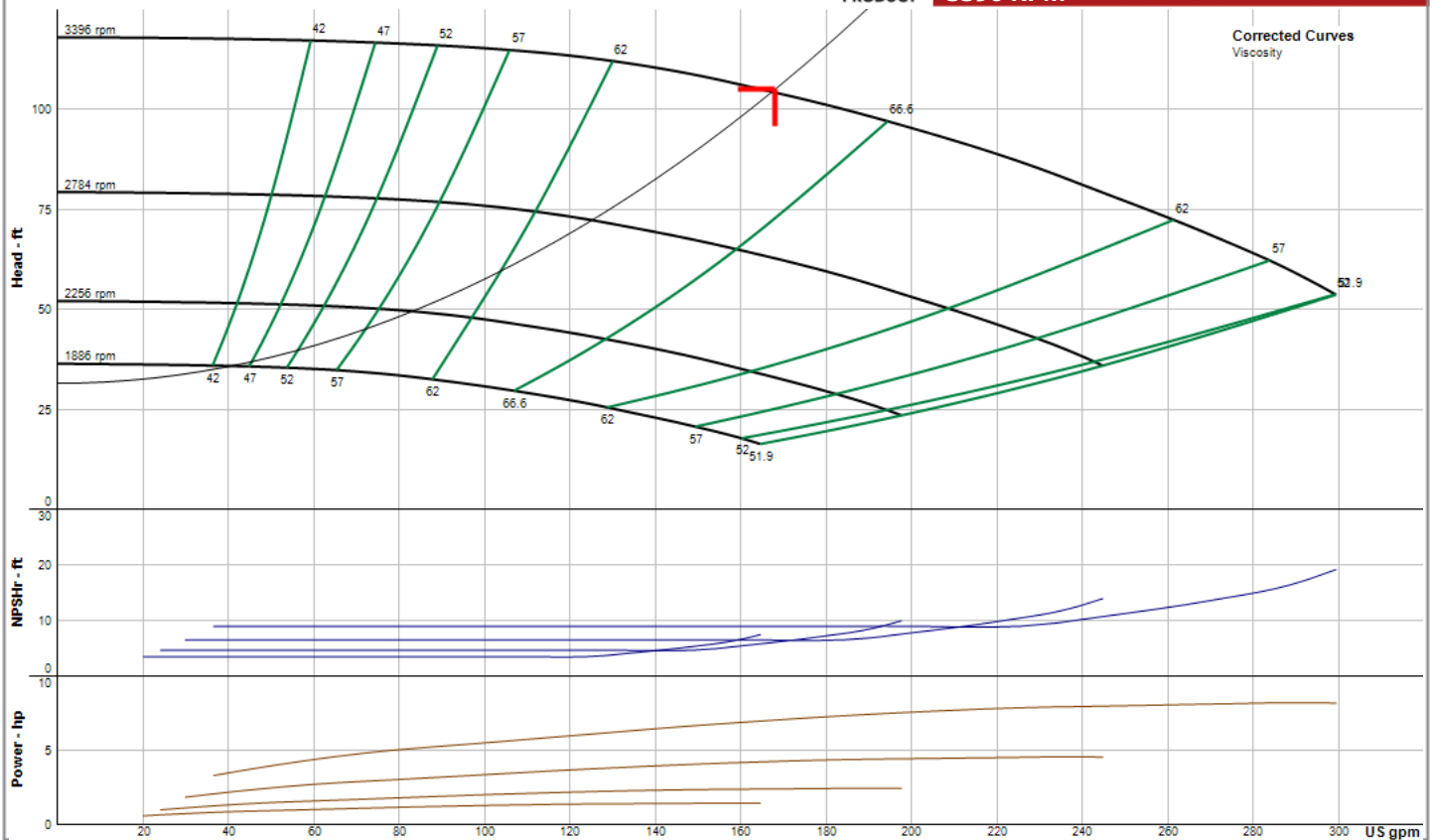
Performance Curve

Energy Efficiency Ratings:

Pump & Motor PEIc: 0.92 ERcI: 8
Pump, Motor & Drive: PEIv: 0.47 ERvI: 53



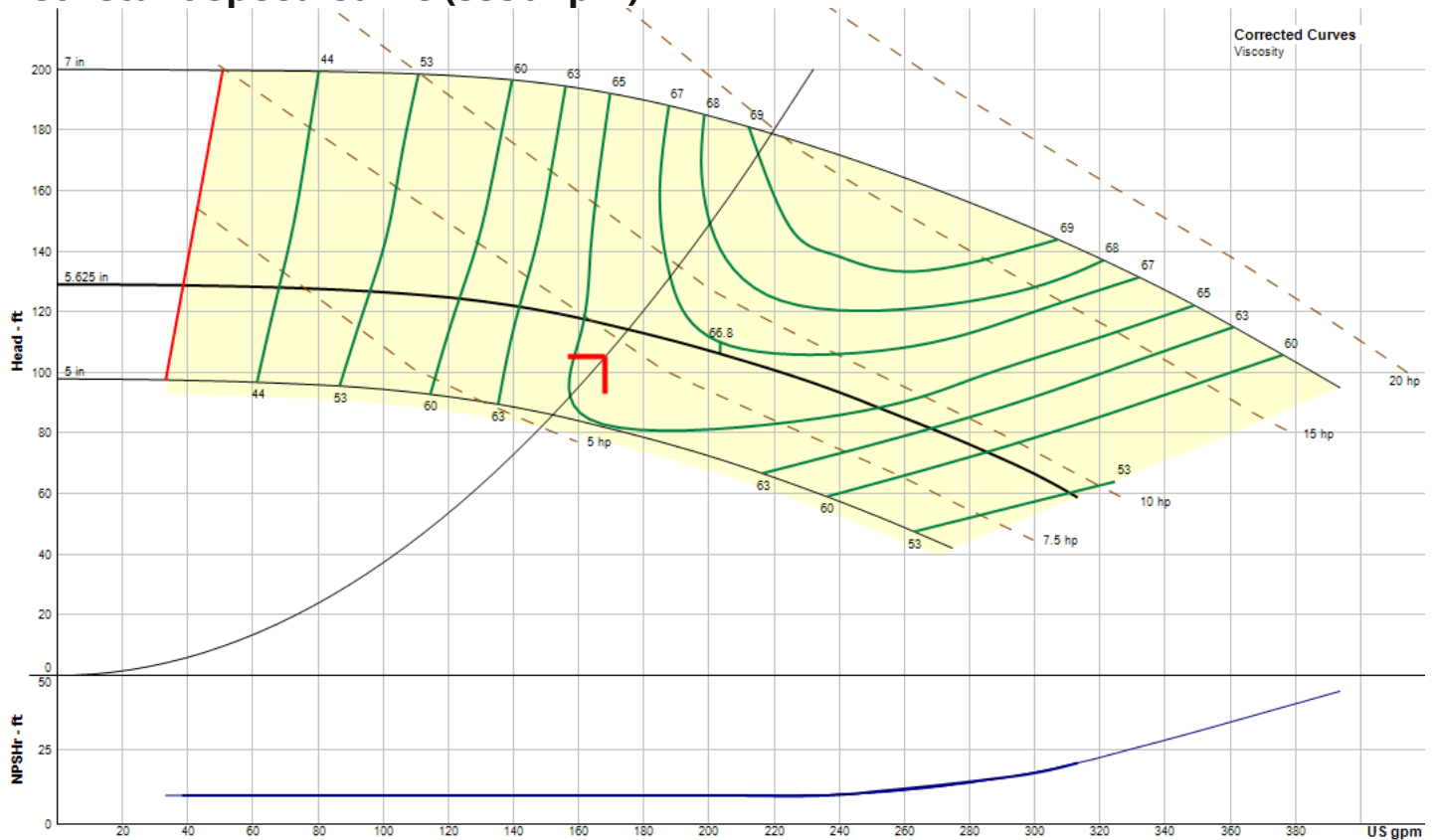
e-1532
2AD
3396 RPM



Performance curve meets 14.6 / ISO 9906 acceptance criteria

WIZE-EAC1CE

Constant Speed Curve (3550 rpm)

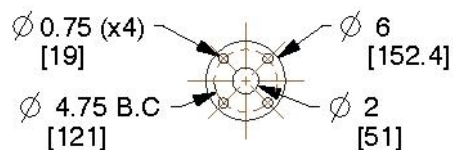


Operating Point

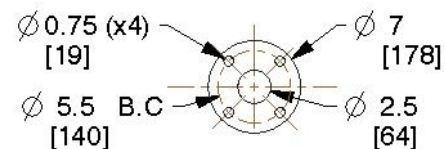
Flow: 167 US gpm **Head:** 104 ft **Speed:** 3396 **Efficiency:** 65.6% **Point BHP:** 7.02 **End Of Curve:** 55.9%

Maximum Duty Point (at rated motor speed)

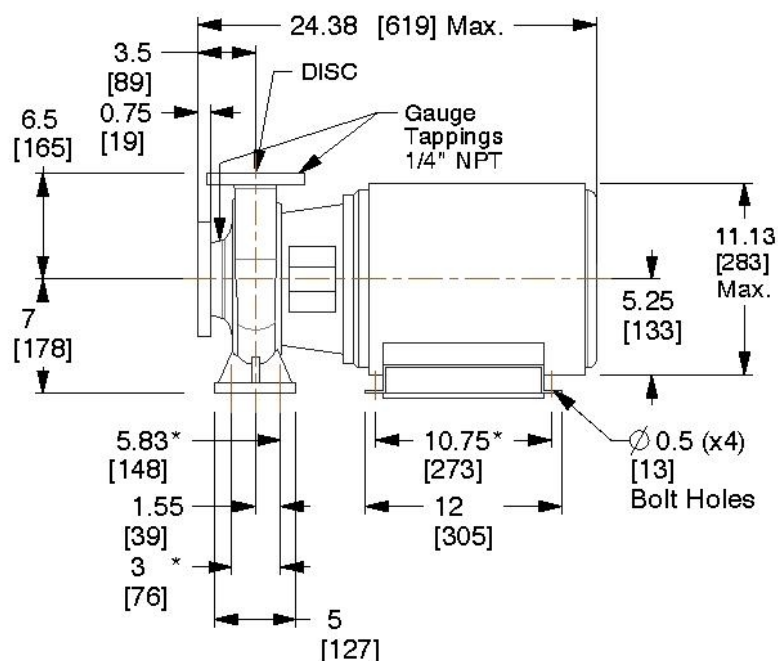
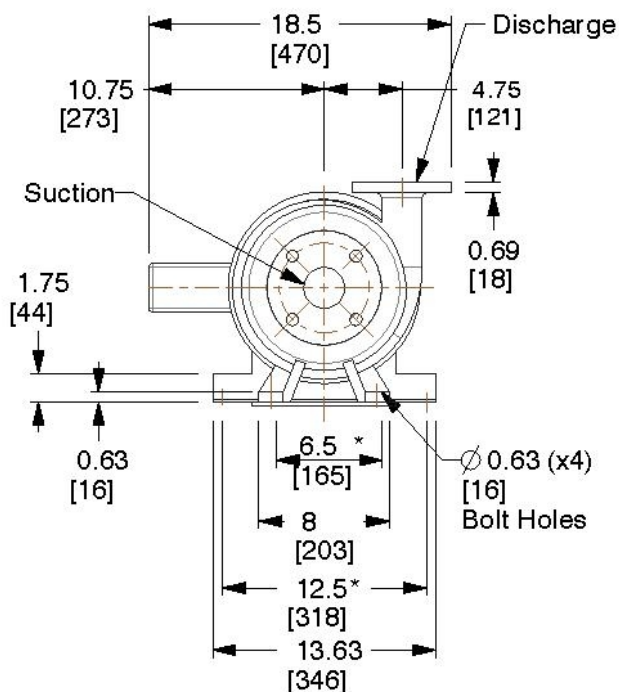
Flow: 175 US gpm **Head:** 114 ft **Speed:** 3550 **Efficiency:** 65.9% **Point BHP:** 8.01 **NOL Flow:** 302 US gpm **Runout Flow:** 313 US gpm **NOL (BHP):** 9.36



**1" DISCHARGE FLANGE
ANSI 125#**



**2.5" SUCTION FLANGE
ANSI 125#**



* Dist. Between Bolt Holes



Bell & Gossett
a xylem brand

8200 N. Austin Ave.
Morton Grove, IL 60053, USA

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Dimensions are subject to change
Not to be used for construction unless certified

BG-E1532-200AD-213-SS

Series e-1532 Close Coupled Foot Mounted Centrifugal Pump

Motor Frame:213JM | Seal Type:Standard Seal | Flange:ANSI 125#

Dimensions : IN (mm)

Scale : N.T.S.

Submittal # : B-881.4D

Standard Materials of Construction *contact your local rep for optional ES Bearing Frame

Construction:	Stainless Steel Fitted
1 Shaft:	Carbon Steel Grade per Motor Manufacturer
2 Volute:	Cast Iron ASTM A48 Class 30B
3 Impeller:	ASTM A743 Grade CF8 - 304 Stainless Steel
4 Shaft Sleeve:	ASTM 312 Grade TP304 - 304 Stainless Steel
5 Impeller Key:	#304 Stainless Steel
6 Impeller Washer:	Steel
7 Impeller Lock Washer:	#304 Stainless Steel
8 Impeller Cap Screw:	#304 Stainless Steel
9 Volute Gasket:	Cellulose Fiber

Pump Options *contact your local rep to configure

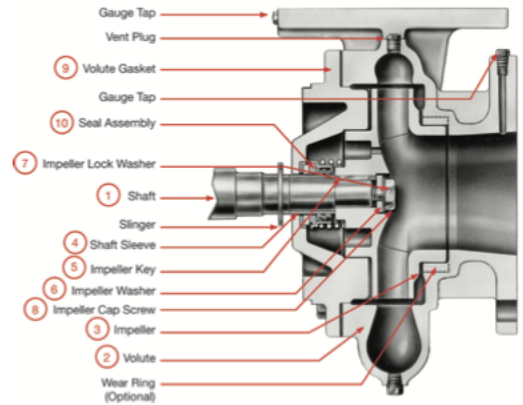
Stainless Steel Volute Wear Ring	Stuffing Box Configuration
External Flush Line	Epoxy Coated Internal Cast Iron Components
Certified Performance Tests (Per HI Standard 14.6)	Special Impeller Balancing (ISO 1940 G2.5 or G1.0)
Heavy Duty Baseplate	Galvanized Steel Drip Pan

10 Standard Mechanical Seal Assembly

Elastomer:	Buna
Rotating Face:	Carbon
Stationary Face:	Ceramic
Hardware	Stainless Steel/Brass

Maximum Working Pressure

Max Working Pressure (standard) 175 psi (12 bar) W..P.





INDUSTRIES LTD.

MODEL MF300 'PRESSURE PAL' MINI SYSTEM FEEDER

The 'PRESSURE PAL' is ideal for feeding and pressurizing closed hydronic systems that do not require cold static fill pressures higher than 170 kPa (25 psig). It is compatible with both water and glycol/water solutions. Perfect for small boiler/chiller systems, snow/ice melt circuits, outside air heating/cooling glycol coils, solar heating systems.



FEATURES and BENEFITS

- 65 litre (17 US gallon) tank for storage and mixing
- Power supply plugs into any standard 115 VAC outlet
- Diaphragm pump can run dry without damage
- No direct connection to potable water supply eliminates need for backflow prevention
- Make-up fluid stored in the feeder tank can be pre-treated
- Diverter valve allows easy purging of air on initial start-up, and manual agitation of solution
- Prevents major floods - in the event of system rupture, only the contents of the tank will be pumped into the system
- Provides leak detection - dropping fluid level provides immediate notice that the system has developed a leak
- Fluid drained for service can easily be put back into the system
- Fluid level switch shuts the pump off if the storage tank level gets too low
- Auxiliary dry contact included for remote low pressure alarm (alarm optional or by others)

Represented By:

AXIOM INDUSTRIES LIMITED 2615 WENTZ AVENUE SASKATOON, SK S7K 5J1
TOLL FREE : (877) 651-1815 **PHONE :** (306) 651-1815 **FAX :** (306) 242-3373

www.axiomind.com



INDUSTRIES LIMITED

MF300 HYDRONIC SYSTEM FEEDER TECHNICAL INFORMATION

WEIGHT - 6.8 kg, 15 lbs.

ELECTRICAL

Fused Power supply adapter
115/60/1 to 24 VDC
Rated 50 watts AC
LED Power Light

PUMP PERFORMANCE

0.04 l/s (0.7 gpm) @ free flow
Self-priming up to 1.2 m (4 feet)

SPECIFICATION

Hydronic system feeder shall be AXIOM INDUSTRIES LTD. Model MF300. System shall include 65 litre (17 U.S. gallon) storage/mixing tank with molded-in level gauge, 125 mm (5") fill/access opening and cover; pump suction hose with inlet strainer and check valve; pressure pump with fuse protection; low fluid level pump cut-out float switch; manual diverter valve for purging air and agitating contents of storage tank; pressure switch with snubber and two sets of SPST dry contacts, each individually adjustable from 70 kPa (10 psig) to 170 kPa (25 psig) cut-out pressure; factory cut-out pressure set to 104 kPa (15psig); and liquid filled pressure gauge. Unit to be c/w fused power supply adapter with LED power indicator light, 115/60/1 to 24 VDC 50 watts AC, supplied loose for field installation.

Feeder shall be compatible with glycol solutions of up to 50% concentration. Pump shall be capable of running dry without damage. The second set of contacts in the pressure switch shall be wired to a terminal strip for use as low pressure alarm contacts for remote alarm circuit supplied by others. Unit shall be completely assembled.

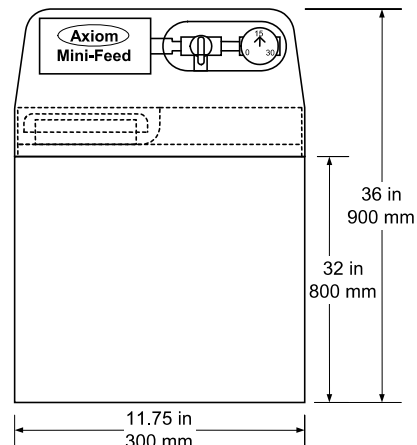
ACCESSORIES

☐ **RIA10-1-SAA** – Low Pressure Alarm Panel c/w Remote Monitoring Dry Contacts and Selectable Audible Alarm

LIMITED WARRANTY

The MF300 is warranted against defects in materials and workmanship for one year.

Project _____	Location _____
Consultant _____	Contractor _____
Unit Tag _____	Sales Agent _____



Depth - 11.75 in 300 mm
Clearances - Sides and Top - 12 in 305 mm
Discharge 1/2" FPT

Controls Information

Installation Instructions for Microprocessor Interface Panel

Purpose

The panel located herein is designed to provide a remote diagnostic display and allows the user to interface with the microprocessor located within the chiller. The display permits the user to modify the temperature set points of the chiller, as well as make adjustments to the alarm set points. In addition, the unit displays the chiller status, refrigeration pressures, pump pressures (if chiller equipped), current alarms, provides alarm logging, and compressor and pump run hours. See page 5 of these instructions for further details. The panel is also equipped with an On/Off button that permits the user to shutdown the chiller remotely. Note: The On/Off button must be illuminated by pressing the button to the 'On' position in order for the chiller to operate.

Installing the Terminal

The terminal is designed for panel or wall mounting. The mounting plate provided with the unit is designed to be installed around a standard switch box. The switch box must be mounted horizontally (sideways) in order for the bracket to be properly mounted. This will permit the 6-conductor phone cable to be easily connected to the display. When installing the mounting plate, pay careful attention to the orientation of the mounting-hole slots and the chamfered edges around the perimeter. The chamfered edge must be installed so that the taller edge extends out from the wall. See the Fig. 1 below. In this position, the vertical slotted hole is on the left, the horizontal slotted hole is on the right, and the notched groove is on the bottom. See Fig. 2 below. Installing the mounting plate in this configuration prevents the terminal from being fastened on the "latch" on back of the display, and permits easier installation and removal of the unit from the wall. Fasten the mounting plate to the wall using the screws provided.

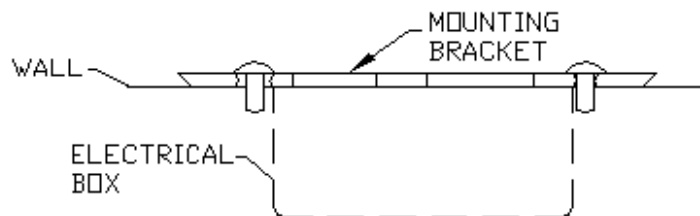


FIGURE 1

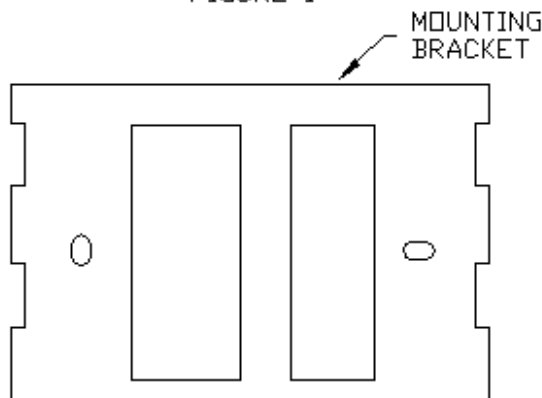


FIGURE 2

Connecting the Wires

Next, connect the RJ-12 connector to the panel. The RJ-12 connector on the opposite end of the cable attaches to the port labeled 'J10' on the microprocessor. **WARNING:** Prior to connecting the 6-conductor power cable, verify that the cable has straight-through connections. If a tester is not available, check the two RJ-12 connections. The depressor on one of connectors must face one side of the cable, and the depressor on the other connector must face the opposite side. This is usually easily distinguishable since most common 6-conductor cables have a ribbed side, and a flat side. In addition, the two ends can be held side-by-side with the depressors on each connector facing the same direction. In this position, the wire colors should match identically from left to right. If further clarification is needed, check the connectors on the 2 ft. cable that was included with the interface panel. **NOTE:** **The power supply to the interface panel is polarity sensitive. Failure to properly orient the connectors will cause damage to the panel and will void the warranty!**

If the cable length from the microprocessor to the interface panel exceeds 150 ft., the interface panel must be connected via 22 AWG or larger shielded cable with 3 twisted pairs and the shield. This wiring allows the interface panel to be installed up to 1600 ft. from the microprocessor.

Two "T-connectors" must be purchased separately when this installation option is required. One of the connectors may be installed in the switch box, while one is installed in the chiller electrical enclosure. This connector acts as a junction between the 3 twisted pair cable and the 6-conductor phone cable that must be used to connect directly to the microprocessor and the interface panel. See the wiring schematic on the following page for further details. **Warning:** The interface panel receives its power from the microprocessor. The cable can be plugged into the interface panel without turning power off of the microprocessor. However, it must not be connected and disconnected without first waiting 5 seconds before powering up the interface panel again.

Remote Interface Panel To Be Mounted Indoors. Typical installation is at constantly attended location at owner's discretion. Connect with 6-conductor cable as indicated. (2ft cable provided with chiller).

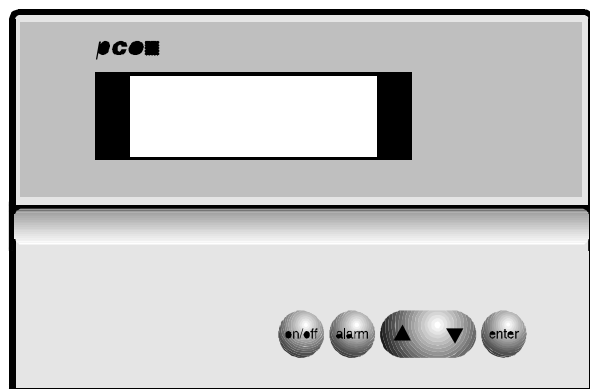
Tab. 5.5.2.1

TERMINAL USER

Contrast control in LCD Display

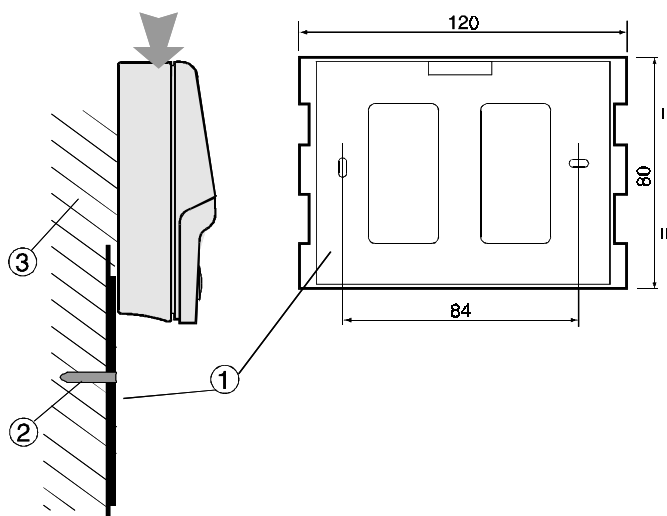
4x20 LCD display models have a trimmer for adjusting the display contrast. The trimmer can be accessed using a flat-head screwdriver through the hole located on the top right corner of the rear cover (PCOT* models) or by removing the rear cover (PCOI* models); in the latter case the potentiometer is located on the top right corner of the main board itself.

Display LCD 4x20 for wall or panel mounting



code	PCOT00*CB*
features	
Number of rows	4
Number of columns	20
Font height (mm)	5















Wall mounting



Wall mounting requires the use of a special mounting racket and a standard 3-module switchbox for the passage of the cable. With reference to Fig., fasten the bracket (1) to the wall (3) using the screws (2); clip the rear of the instrument onto the bracket.

Installation

The remote interface panel must be connected to the chiller with 6 -wire straight thru cable! This is not standard phone wire cable. Standard phone cable is cross -wired. Use of this type of cable will damage the microprocessor and void the warranty! The chiller is shipped with 2 feet of 6 -wire cable to assist the technician at start -up. A 6-wire straight thru cable of the necessary length may be purchased from ArctiChill. Contact the local representative for pricing details. Specify required cable length when the order is placed. Note that the maximum distance between the interface panel and the microprocessor is 150 ft when installing the 6-wire cable.

						
Water Temps	Set Points	Refrigeration Pressure	Pump Pressure	Clock	Alarm Log	Flow Rate
						
Hand-Off-Auto	Program	Info Key				



Water Temps

Displays the system status or demand, which compressors are currently energized, and the entering and leaving fluid temperatures of the master controller



Set Points

Displays the chiller set point and allows adjustment to the set point; high and low temperature alarm set points can be modified as well



Refrigeration Pressure

Displays the refrigeration pressures of each chiller module



Pump

If the chiller includes a tank and pump module, this key displays the pump discharge pressure (Pump suction pressure is optional)



Clock

Displays the actual time and allows the operator to energize or de-energize the chiller at set times for weekday and weekend operation



Alarm Log

Displays up to the previous 100 logged alarms along with the time they occurred and the chiller temperatures at the time of the alarm



Flow Rate

This optional feature is designed for smaller chillers due to the current flow limitation of the flow meter (approximately 50 gpm max.)



Hand-Off-Auto

This optional feature is designed for redundant chillers so that they can be controlled either manually or automatically



Program

This button contains all of the factory installed setup for the microprocessor. It is password protected by the level 2 password, and is not intended to be accessed by the operator



Info Key

Displays the total number of chiller modules, the rotation status, and the compressor run hours

ARTICHILL 2M BMS POINTS LIST AS OF 03/26/2014

BACNET MSTP/IP/ETH	BACNET GATEWAY	MODBUS	CAREL	LON	LON			
T	BV instance	Coil	Digital	Name	Type	R/W	DESCRIPTION	VALUE RANGE
1	1	10002	1			R/W	Enter water temperature sensor enable	1=Enabled
2	2	10003	2			R	Enter water temperature sensor out of range	1=Failed
3	3	10004	3			R/W	Panel temperature (B8) sensor enable	1=Enabled
4	4	10005	4			R	Panel temperature sensor (B8) out of range	1=Failed
5	5	10006	5			R/W	Leaving water temperature sensor enable	1=Enabled
6	6	10007	6			R	Leaving water temperature sensor out of range	1=Failed
7	7	10008	7	nvoLwtHighAlm	95	R	Leaving water temperature high alarm	1=Alarm
8	8	10009	8	nvoLwtLowAlm	95	R	Leaving water temperature low alarm	1=Alarm
9	9	10010	9			R/W	Control type P or P+I	1=P+I
10	10	10011	10			R	Ambient temperature (B7) sensor enable	1=Enabled
11	11	10012	11			R	Ambient temperature sensor (B7) out of range	1=Alarm
12	12	10013	12			R/W	C1 low pressure sensor enable	1=Enabled
13	13	10014	13			R	C1 low pressure sensor out of range	1=Alarm
14	14	10015	14			R/W	C2 low pressure sensor enable	1=Enabled
15	15	10016	15			R	C2 low pressure sensor out of range	1=Alarm
16	16	10017	16			R/W	C1 high pressure sensor enable	1=Enabled
17	17	10018	17			R	C1 high pressure sensor out of range	1=Alarm
18	18	10019	18			R/W	C2 high pressure sensor enable	1=Enabled
19	19	10020	19			R	C2 high pressure sensor out of range	1=Alarm
20	20	10021	20			R	Alarm Present	1=Alarm
21	21	10022	21			R/W	Display buzzer enable	1=Enabled
22	22	10023	22			R	C1 high pressure switch alarm	1=Alarm
23	23	10024	23			R	C1 low pressure switch alarm	1=Alarm
24	24	10025	24			R	C2 high pressure switch alarm	1=Alarm
25	25	10026	25			R	C2 low pressure switch alarm	1=Alarm
26	26	10027	26			R/W	Temperature units	1=degrees C
27	27	10028	27			R/W	Compressor rotation enable	1=Enabled
28	28	10029	28			R	Digital input 1 position	1=open
29	29	10030	29			R	Digital input 10 position	1=open
30	30	10031	30			R	Digital input 11 position	1=open
31	31	10032	31			R	Digital input 12 position	1=open
32	32	10033	32			R	Digital input 13 position	1=open
33	33	10034	33			R	Digital input 14 position	1=open
34	34	10035	34			R	Digital input 2 position	1=open
35	35	10036	35			R	Digital input 3 position	1=open
36	36	10037	36			R	Digital input 4 position	1=open
37	37	10038	37			R	Digital input 5 position	1=open
38	38	10039	38			R	Digital input 6 position	1=open
39	39	10040	39			R	Digital input 7 position	1=open
40	40	10041	40			R	Digital input 8 position	1=open
41	41	10042	41			R	Digital input 9 position	1=open
42	42	10043	42	nvoC1Out	95	R	Compressor 1 status	1=ON
43	43	10044	43	nvoC2Out	95	R	Compressor 2 status	1=ON
44	44	10045	44			R	Evap flow alarm	1=Alarm
45	45	10046	45			R	Not used	N/A
46	46	10047	46			R	phase alarm	1=alarm
47	47	10048	47			R/W	Cooling or Heating Mode Selection	0=Cool, 1=Heat
48	48	10049	48			R	Not used	N/A
49	49	10050	49			R	pumps alarm	1=alarm
50	50	10051	50	nvo/nviAlarmRst	95	R/W	reset alarms	1=reset
51	51	10052	51	nvoGlobalAlm	95	R	Global alarm	1=alarm
52	52	10053	52			R	Not used	N/A
53	53	10054	53			R	Not used	N/A
54	54	10055	54	nvo/nviSysOnOff	95	R/W	system on/off	1=Enabled
55	55	10056	55			R	Tank low alarm	1=alarm
56	56	10057	56			R	Status of Master DO 17 (hot/cold split valve)	1=ON

57	57	10058	57			R	slave 1 alarm	1=alarm
58	58	10059	58			R	slave 2 alarm	1=alarm
59	59	10060	59			R	slave 3 alarm	1=alarm
60	60	10061	60			R	slave 4 alarm	1=alarm
61	61	10062	61			R	slave 5 alarm	1=alarm
62	62	10063	62			R	slave 6 alarm	1=alarm
63	63	10064	63			R	slave 7 alarm	1=alarm
64	64	10065	64			R	slave 8 alarm	1=alarm
65	65	10066	65			R	slave 9 alarm	1=alarm
66	66	10067	66			R	slave 10 alarm	1=alarm
67	67	10068	67			R	slave 11 alarm	1=alarm
68	68	10069	68			R	slave 12 alarm	1=alarm
69	69	10070	69			R	slave 13 alarm	1=alarm
70	70	10071	70			R	slave 14 alarm	1=alarm
71	71	10072	71			R	slave 15 alarm	1=alarm
72	72	10073	72			R	Flow detected from digital input	1=flow
73	73	10074	73			R	Low tank level detected on pump module	1=low
74	74	10075	74			R	Phase error	1=alarm
75	75	10076	75			R	Pump 1 overload alarm	1=alarm
76	76	10077	76			R	Pump 2 overload alarm	1=alarm
77	77	10078	77			R	Panel heat on	1=on
78	78	10079	78			R	Pumps alarm (pumps switched but still have no flow)	1=alarm
79	79	10080	79			R	Panel temp sensor out of range	1=alarm
80	80	10081	80			R	Pump suction diff sensor out of range	1=alarm
81	81	10082	81			R	Pump discharge diff sensor out of range	1=alarm
82	82	10083	82			R	Pump suction pressure out of range	1=alarm
83	83	10084	83			R	Pump discharge sensor out of range	1=alarm
84	84	10085	84			R	Pump flow sensor out of range	1=alarm
85	85	10086	85			R/W	Reset alarms of all modules	1=reset
86	86	10087	86			R	Pump has switched without confirmation	1=alarm
87	87	10088	87			R	Pump module is in alarm	1=alarm
88	88	10089	88			R	Low tank alarm on pump module (latched)	1=alarm
89	89	10090	89			R	Phase alarm on pump module (latched)	1=alarm
90	90	10091	90			R	Pump 1 overload alarm (latched)	1=alarm
91	91	10092	91			R	Pump 2 overload alarm (latched)	1=alarm
92	92	10093	92			R	Geothermal entering water temp sensor out of range	1=alarm
93	93	10094	93			R	Geothermal leaving water temp sensor out of range	1=alarm
94	94	10095	94			R	Not used	1=alarm
95	95	10096	95			R	Not used	1=alarm
96	96	10097	96			R	Not used	1=alarm
97	97	10098	97			R	Not used	N/A
98	98	10099	98			R	Status of Slave1 DO 17 (hot/cold split valve)	N/A
99	99	10100	99			R	Status of Slave2 DO 17 (hot/cold split valve)	N/A
100	100	10101	100			R	Status of Slave3 DO 17 (hot/cold split valve)	N/A
101	101	10102	101			R	Status of Slave4 DO 17 (hot/cold split valve)	N/A
102	102	10103	102			R	Status of Slave5 DO 17 (hot/cold split valve)	N/A
103	103	10104	103			R	Status of Slave6 DO 17 (hot/cold split valve)	N/A
104	104	10105	104			R	Status of Slave7 DO 17 (hot/cold split valve)	N/A
105	105	10106	105			R	Status of Slave8 DO 17 (hot/cold split valve)	N/A
106	106	10107	106			R	Status of Slave9 DO 17 (hot/cold split valve)	N/A
107	107	10108	107			R	Status of Slave10 DO 17 (hot/cold split valve)	N/A
108	108	10109	108			R	Status of Slave11 DO 17 (hot/cold split valve)	N/A
109	109	10110	109			R	Status of Slave12 DO 17 (hot/cold split valve)	N/A
110	110	10111	110			R	Status of Slave13 DO 17 (hot/cold split valve)	N/A
111	111	10112	111	nvoPUMP1_ON	95	R	Pump 1 status	1=on
112	112	10113	112	nvoPUMP2_ON	95	R	Pump 2 status	1=on
113	113	10114	113			R	Pumps switched alarm	1=alarm
114	114	10115	114			R	Pump phase alarm	1=alarm

115	115	10116	115			R	Pump 1 overload alarm	1=alarm
116	116	10117	116			R	Pump 2 overload alarm	1=alarm
117	117	10118	117			R	slave 1 compressor 1 status	1=on
118	118	10119	118			R	slave 1 compressor 2 status	1=on
119	119	10120	119			R	slave 2 compressor 1 status	1=on
120	120	10121	120			R	slave 2 compressor 2 status	1=on
121	121	10122	121			R	slave 3 compressor 1 status	1=on
122	122	10123	122			R	slave 3 compressor 2 status	1=on
123	123	10124	123			R	slave 4 compressor 1 status	1=on
124	124	10125	124			R	slave 4 compressor 2 status	1=on
125	125	10126	125			R	slave 5 compressor 1 status	1=on
126	126	10127	126			R	slave 5 compressor 2 status	1=on
127	127	10128	127			R	slave 6 compressor 1 status	1=on
128	128	10129	128			R	slave 6 compressor 2 status	1=on
129	129	10130	129			R	slave 7 compressor 1 status	1=on
130	130	10131	130			R	slave 7 compressor 2 status	1=on
131	131	10132	131			R	slave 8 compressor 1 status	1=on
132	132	10133	132			R	slave 8 compressor 2 status	1=on
133	133	10134	133			R	slave 9 compressor 1 status	1=on
134	134	10135	134			R	slave 9 compressor 2 status	1=on
135	135	10136	135			R	slave 10 compressor 1 status	1=on
136	136	10137	136			R	slave 10 compressor 2 status	1=on
137	137	10138	137			R	slave 11 compressor 1 status	1=on
138	138	10139	138			R	slave 11 compressor 2 status	1=on
139	139	10140	139			R	slave 12 compressor 1 status	1=on
140	140	10141	140			R	slave 12 compressor 2 status	1=on
141	141	10142	141			R	slave 13 compressor 1 status	1=on
142	142	10143	142			R	slave 13 compressor 2 status	1=on
143	143	10144	143			R	slave 14 compressor 1 status	1=on
144	144	10145	144			R	slave 14 compressor 2 status	1=on
145	145	10146	145			R	slave 15 compressor 1 status	1=on
146	146	10147	146			R	slave 15 compressor 2 status	1=on
147	147	10148	147			R	Status of Slave14 DO 17 (hot/cold split valve)	N/A
148	148	10149	148			R	Status of Slave15 DO 17 (hot/cold split valve)	N/A
149	149	10150	149			R	Status of Slave16 DO 17 (hot/cold split valve)	N/A
AV instance	AV instance	ANALOG	ANALOG					
1	1	40002	1	nvoM_EWT_DISP	105	R	System Entering water temperature	-450 to 1850
2	2	40003	2			R	Panel / Condenser temperature (B8)	-450 to 1850
3	3	40004	3	nvoM_LWT_DISP	105	R	System Leaving water temperature	-450 to 1850
4	4	40005	4			R	Ambient / Condenser temperature or Remote Setpoint (B7)	-450 to 1850
5	5	40006	5		105	R	Low pressure c1	psi
6	6	40007	6		105	R	Low pressure c2	psi
7	7	40008	7	nvo/nviControlSet	105	R	High pressure c1	psi
8	8	40009	8			R	High pressure c2	psi
9	9	40010	9		105	R	Leaving water temperature of Master	
10	10	40011	10		105	R	Entering water temperature of Master	
11	11	40012	11			R	pump differential pressure 1	
12	12	40013	12			R	pump differential pressure 2	
13	13	40014	13			R	pump flow in GPM	
14	14	40015	14			R	pump suction pressure	
15	15	40016	15			R	pump discharge pressure	
16	16	40017	16			R	Flow demand in %	0 to 100
17	17	40018	17			R/W	Cooling setpoint	
18	18	40019	18			R/W	Heating setpoint	
19	19	40020	19			R	Hot water loop (from U2) entering temperature in H&C modes	
20	20	40021	20			R	Hot water loop (from U2) leaving temperature in H&C modes	
21	21	40022	21			R	Heating demand in H&C modes	
22	22	40023	22			R	Geothermal entering water temperature	

23	23	40024	23			R	Geothermal leaving water temperature	
24	24	40025	24			R	Panel temp of pump module	
25	25	40026	25			R/W	Low limit alarm for HW leaving temperature	
26	26	40027	26			R	Entering water temperature of Slave 1	
27	27	40028	27			R	Entering water temperature of Slave 2	
28	28	40029	28			R	Entering water temperature of Slave 3	
29	29	40030	29			R	Entering water temperature of Slave 4	
30	30	40031	30			R	Entering water temperature of Slave 5	
31	31	40032	31			R	Entering water temperature of Slave 6	
32	32	40033	32			R	Entering water temperature of Slave 7	
33	33	40034	33			R	Entering water temperature of Slave 8	
34	34	40035	34			R	Entering water temperature of Slave 9	
35	35	40036	35			R	Entering water temperature of Slave 10	
36	36	40037	36			R	Entering water temperature of Slave 11	
37	37	40038	37			R	Entering water temperature of Slave 12	
38	38	40039	38			R	Entering water temperature of Slave 13	
39	39	40040	39			R	Entering water temperature of Slave 14	
40	40	40041	40			R	Entering water temperature of Slave 15	
41	41	40042	41			R	Leaving water temperature of Slave 1	
42	42	40043	42			R	Leaving water temperature of Slave 2	
43	43	40044	43			R	Leaving water temperature of Slave 3	
44	44	40045	44			R	Leaving water temperature of Slave 4	
45	45	40046	45			R	Leaving water temperature of Slave 5	
46	46	40047	46			R	Leaving water temperature of Slave 6	
47	47	40048	47			R	Leaving water temperature of Slave 7	
48	48	40049	48			R	Leaving water temperature of Slave 8	
49	49	40050	49			R	Leaving water temperature of Slave 9	
50	50	40051	50			R	Leaving water temperature of Slave 10	
51	51	40052	51			R	Leaving water temperature of Slave 11	
52	52	40053	52			R	Leaving water temperature of Slave 12	
53	53	40054	53			R	Leaving water temperature of Slave 13	
54	54	40055	54			R	Leaving water temperature of Slave 14	
55	55	40056	55			R	Leaving water temperature of Slave 15	
56	56	40057	56			R	Condenser entering water temperature of Slave 1	
57	57	40058	57			R	Condenser entering water temperature of Slave 2	
58	58	40059	58			R	Condenser entering water temperature of Slave 3	
59	59	40060	59			R	Condenser entering water temperature of Slave 4	
60	60	40061	60			R	Condenser entering water temperature of Slave 5	
61	61	40062	61			R	Condenser entering water temperature of Slave 6	
62	62	40063	62			R	Condenser entering water temperature of Slave 7	
63	63	40064	63			R	Condenser entering water temperature of Slave 8	
64	64	40065	64			R	Condenser entering water temperature of Slave 9	
65	65	40066	65			R	Condenser entering water temperature of Slave 10	
66	66	40067	66			R	Condenser entering water temperature of Slave 11	
67	67	40068	67			R	Condenser entering water temperature of Slave 12	
68	68	40069	68			R	Condenser entering water temperature of Slave 13	
69	69	40070	69			R	Condenser entering water temperature of Slave 14	
70	70	40071	70			R	Condenser entering water temperature of Slave 15	
71	71	40072	71			R	Condenser leaving water temperature of Slave 1	
72	72	40073	72			R	Condenser leaving water temperature of Slave 2	
73	73	40074	73			R	Condenser leaving water temperature of Slave 3	
74	74	40075	74			R	Condenser leaving water temperature of Slave 4	
75	75	40076	75			R	Condenser leaving water temperature of Slave 5	
76	76	40077	76			R	Condenser leaving water temperature of Slave 6	
77	77	40078	77			R	Condenser leaving water temperature of Slave 7	
78	78	40079	78			R	Condenser leaving water temperature of Slave 8	
79	79	40080	79			R	Condenser leaving water temperature of Slave 9	
80	80	40081	80			R	Condenser leaving water temperature of Slave 10	

81	81	40082	81			R	Condenser leaving water temperature of Slave 11	
82	82	40083	82			R	Condenser leaving water temperature of Slave 12	
83	83	40084	83			R	Condenser leaving water temperature of Slave 13	
84	84	40085	84			R	Condenser leaving water temperature of Slave 14	
85	85	40086	85			R	Condenser leaving water temperature of Slave 15	
AV instance	AV instance	ANALOG	INTEGER					
1001	129	40210	1			R/W	Panel temperature set point	
1002	130	40211	2			R/W	Temperature control band	
1003	131	40212	3			R/W	Priority select: 0=BMS, 1=Cool, 2=Heat, 3=none, 4=set by term	0 to 4
1004	132	40213	4			R/W	BMS setting for units heating (priority must be set to BMS)	0 to 16
1005	133	40214	5	nvo/nviLwtHighSet		R/W	Leaving temperature high alarm set point	
1006	134	40215	6	nvo/nviLwtLowSet		R/W	Leaving temperature low alarm set point	
1007	135	40216	7			R/W	Pump diff pressure setpoint	
1008	136	40217	8			R/W	compressor minimum off	
1009	137	40218	9			R/W	compressor minimum on	
1010	138	40219	10			R/W	hot gas 1 off set point	0 to 999
1011	139	40220	11			R/W	temperature control integration time	
1012	140	40221	12			R/W	hot gas 2 off set point	0 to 999
1013	141	40222	13			R/W	hot gas 2 on set point	0 to 999
1014	142	40223	14			R/W	Initial start-up delay	0 to 999
1015	143	40224	15			R/W	Mode: 0=chl, 1=Cond, 2=Heat Rec, 3=HPmp, 4=H&C, 5=H&Crvs, 6=H&Cgeo, 7=H&CgeoRvs	0 to 5
1016	144	40225	16			R/W	Number of units reserved for the non priority mode	
1017	145	40226	17			R/W	Units heating	
1018	146	40227	18			R/W	Units cooling	
1019	147	40228	19			R/W	Entering water temperature sensor offset	N/A
1020	148	40229	20			R/W	Panel temperature (B8) sensor offset	0 to 999
1021	149	40230	21			R/W	Leaving water temperature sensor offset	N/A
1022	150	40231	22			R/W	Ambient temperature (B7) sensor offset	0 to 999
1023	151	40232	23			R/W	Low pressure c1 sensor offset	N/A
1024	152	40233	24			R/W	Low pressure c2 sensor offset	0 to 999
1025	153	40234	25			R/W	High pressure c1 sensor offset	N/A
1026	154	40235	26			R/W	High pressure c2 sensor offset	0 to 999
1027	155	40236	27			R/W	Hot gas 1 on set point	N/A
1028	156	40237	28			R/W	Pump diff pressure band	N/A
1029	157	40238	29			R	Pump diff pressure	N/A
1030	158	40239	30	nvoFlow_Demand		R	Flow demand	N/A
1031	159	40240	31			R/W	password 1 (Service)	0-9999
1032	160	40241	32			R/W	password 2 (Factory)	0-9999
1033	161	40242	33			R/W	Time setting for rotation by time	0-32767
1034	162	40243	34			R/W	Rotation index	
1035	163	40244	35			R/W	Geothermal entering water temp sensor offset	
1036	164	40245	36			R/W	Stage up time between compressors	0-999
1037	165	40246	37		8	R	compressor 1 run hours	0-32767
1038	166	40247	38		8	R	compressor 2 run hours	0-32767
1039	167	40248	39	nvoNUM_UNITS_CL		R	Number of units in the cooling mode	0 to 16
1040	168	40249	40	nvoNUM_UNITS_HT		R	Number of units in the heating mode	0 to 16
1041	169	40250	41			R	Software version day	
1042	170	40251	42			R	Software version month	
1043	171	40252	43			R	Software version year	
1044	172	40253	44			R/W	Geothermal leaving water temp sensor offset	
1045	173	40254	45			R	Hours of Pump 1 run time	
1046	174	40255	46			R	Hours of Pump 2 run time	
1047	175	40256	47	nvoLP_C1		R	master compressor 1 low pressure	0-650
1048	176	40257	48	nvoHP_C1		R	master compressor 1 high pressure	0-650
1049	177	40258	49	nvoLP_C2		R	master compressor 2 low pressure	0-650
1050	178	40259	50	nvoHP_C2		R	master compressor 2 high pressure	0-650
1051	179	40260	51	nvoLP_C3		R	slave 1 compressor 1 low pressure	0-650
1052	180	40261	52	nvoHP_C3		R	slave 1 compressor 1 high pressure	0-650

1053	181	40262	53	nvoLP_C4		R	slave 1 compressor 2 low pressure	0-650
1054	182	40263	54	nvoHP_C4		R	slave 1 compressor 2 high pressure	0-650
1055	183	40264	55	nvoLP_C5		R	slave 2 compressor 1 low pressure	0-650
1056	184	40265	56	nvoHP_C5		R	slave 2 compressor 1 high pressure	0-650
1057	185	40266	57	nvoLP_C6		R	slave 2 compressor 2 low pressure	0-650
1058	186	40267	58	nvoHP_C6		R	slave 2 compressor 2 high pressure	0-650
1059	187	40268	59	nvoLP_C7		R	slave 3 compressor 1 low pressure	0-650
1060	188	40269	60	nvoHP_C7		R	slave 3 compressor 1 high pressure	0-650
1061	189	40270	61	nvoLP_C8		R	slave 3 compressor 2 low pressure	0-650
1062	190	40271	62	nvoHP_C8		R	slave 3 compressor 2 high pressure	0-650
1063	191	40272	63	nvoLP_C9		R	slave 4 compressor 1 low pressure	0-650
1064	192	40273	64	nvoHP_C9		R	slave 4 compressor 1 high pressure	0-650
1065	193	40274	65	nvoLP_C10		R	slave 4 compressor 2 low pressure	0-650
1066	194	40275	66	nvoHP_C10		R	slave 4 compressor 2 high pressure	0-650
1067	195	40276	67	nvoLP_C11		R	slave 5 compressor 1 low pressure	0-650
1068	196	40277	68	nvoHP_C11		R	slave 5 compressor 1 high pressure	0-650
1069	197	40278	69	nvoLP_C12		R	slave 5 compressor 2 low pressure	0-650
1070	198	40279	70	nvoHP_C12		R	slave 5 compressor 2 high pressure	0-650
1071	199	40280	71	nvoLP_C13		R	slave 6 compressor 1 low pressure	0-650
1072	200	40281	72	nvoHP_C13		R	slave 6 compressor 1 high pressure	0-650
1073	201	40282	73	nvoLP_C14		R	slave 6 compressor 2 low pressure	0-650
1074	202	40283	74	nvoHP_C14		R	slave 6 compressor 2 high pressure	0-650
1075	203	40284	75	nvoLP_C15		R	slave7 compressor 1 low pressure	0-650
1076	204	40285	76	nvoHP_C15		R	slave 7 compressor 1 high pressure	0-650
1077	205	40286	77	nvoLP_C16		R	slave 7 compressor 2 low pressure	0-650
1078	206	40287	78			R	slave 7 compressor 2 high pressure	0-650
1079	207	40288	79			R	slave 8 compressor 1 low pressure	0-650
1080	208	40289	80			R	slave 8 compressor 1 high pressure	0-650
1081	209	40290	81			R	slave 8 compressor 2 low pressure	0-650
1082	210	40291	82			R	slave 8 compressor 2 high pressure	0-650
1083	211	40292	83			R	slave 9 compressor 1 low pressure	0-650
1084	212	40293	84			R	slave 9 compressor 1 high pressure	0-650
1085	213	40294	85			R	slave 9 compressor 2 low pressure	0-650
1086	214	40295	86			R	slave 9 compressor 2 high pressure	0-650
1087	215	40296	87			R	slave 10 compressor 1 low pressure	0-650
1088	216	40297	88			R	slave 10 compressor 1 high pressure	0-650
1089	217	40298	89			R	slave 10 compressor 2 low pressure	0-650
1090	218	40299	90			R	slave 10 compressor 2 high pressure	0-650
1091	219	40300	91			R	slave 11 compressor 1 low pressure	0-650
1092	220	40301	92			R	slave 11 compressor 1 high pressure	0-650
1093	221	40302	93			R	slave 11 compressor 2 low pressure	0-650
1094	222	40303	94			R	slave 11 compressor 2 high pressure	0-650
1095	223	40304	95			R	slave 12 compressor 1 low pressure	0-650
1096	224	40305	96			R	slave 12 compressor 1 high pressure	0-650
1097	225	40306	97			R	slave 12 compressor 2 low pressure	0-650
1098	226	40307	98			R	slave 12 compressor 2 high pressure	0-650
1099	227	40308	99			R	slave 13 compressor 1 low pressure	0-650
1100	228	40309	100			R	slave 13 compressor 1 high pressure	0-650
1101	229	40310	101			R	slave 13 compressor 2 low pressure	0-650
1102	230	40311	102			R	slave 13 compressor 2 high pressure	0-650
1103	231	40312	103			R	slave 14 compressor 1 low pressure	0-650
1104	232	40313	104			R	slave 14 compressor 1 high pressure	0-650
1105	233	40314	105			R	slave 14 compressor 2 low pressure	0-650
1106	234	40315	106			R	slave 14 compressor 2 high pressure	0-650
1107	235	40316	107			R	slave 15 compressor 1 low pressure	0-650
1108	236	40317	108			R	slave 15 compressor 1 high pressure	0-650
1109	237	40318	109			R	slave 15 compressor 2 low pressure	0-650
1110	238	40319	110			R	slave 15 compressor 2 high pressure	0-650

1111	239	40320	111			R	Isolation valve modulation in % of the master	0-100
1112	240	40321	112			R	Condensor fan vfd modulation in % of the master	0-100
1113	241	40322	113			R	Isolation valve modulation in % of slave 1	
1114	242	40323	114			R	Condensor fan vfd modulation in % of slave 1	
1115	243	40324	115			R	Isolation valve modulation in % of slave 2	
1116	244	40325	116			R	Condensor fan vfd modulation in % of slave 2	
1117	245	40326	117			R	Isolation valve modulation in % of slave 3	
1118	246	40327	118			R	Condensor fan vfd modulation in % of slave 3	
1119	247	40328	119			R/W	Bit mask of compressor disable (c1 to c16)	1=disable
1120	248	40329	120			R/W	Bit mask of compressor disable (c17 to c32)	1=disable
1121	249	40330	121			R	Bit mask#1 of alarms in U2	
1122	250	40331	122			R	Bit mask#1 of alarms in U3	
1123	251	40332	123			R	Bit mask#1 of alarms in U4	
1124	252	40333	124			R	Bit mask#1 of alarms in U5	
1125	253	40334	125			R	Bit mask#1 of alarms in U6	
1126	254	40335	126			R	Number of compressors running in cooling	
1127	255	40336	127			R	Number of compressors running in heating	
1128	256	40337	128	nvoStatus_Line		R	Status of the unit	
1129	257	40338	129	nvo_Cool_Demand		R	Cooling demand	
1130	258	40339	130			R	Isolation valve modulation in % of slave 4	
1131	259	40340	131			R	Isolation valve modulation in % of slave 5	
1132	260	40341	132			R	Isolation valve modulation in % of slave 6	
1133	261	40342	133			R	Isolation valve modulation in % of slave 7	
1134	262	40343	134			R	Isolation valve modulation in % of slave 8	
1135	263	40344	135			R	Isolation valve modulation in % of slave 9	
1136	264	40345	136			R	Isolation valve modulation in % of slave 10	
1137	265	40346	137			R	Isolation valve modulation in % of slave 11	
1138	266	40347	138			R	Isolation valve modulation in % of slave 12	
1139	267	40348	139			R	Isolation valve modulation in % of slave 13	
1140	268	40349	140			R	Isolation valve modulation in % of slave 14	
1141	269	40350	141			R	Isolation valve modulation in % of slave 15	
1142	270	40351	142			R	Condensor fan vfd modulation in % of slave 4	
1143	271	40352	143			R	Condensor fan vfd modulation in % of slave 5	
1144	272	40353	144			R	Condensor fan vfd modulation in % of slave 6	
1145	273	40354	145			R	Condensor fan vfd modulation in % of slave 7	
1146	274	40355	146			R	Condensor fan vfd modulation in % of slave 8	
1147	275	40356	147			R	Condensor fan vfd modulation in % of slave 9	
1148	276	40357	148			R	Condensor fan vfd modulation in % of slave 10	
1149	277	40358	149			R	Condensor fan vfd modulation in % of slave 11	
1150	278	40359	150			R	Condensor fan vfd modulation in % of slave 12	
1151	279	40360	151			R	Condensor fan vfd modulation in % of slave 13	
1152	280	40361	152			R	Condensor fan vfd modulation in % of slave 14	
1153	281	40362	153			R	Condensor fan vfd modulation in % of slave 15	
1154	282	40363	154				Unused	
1155	283	40364	155				Unused	
1156	284	40365	156				Unused	
1157	285	40366	157				Unused	
1158	286	40367	158				Unused	
1159	287	40368	159				Unused	
1160	288	40369	160				Unused	
1161	289	40370	161				Unused	
1162	290	40371	162				Unused	
1163	291	40372	163				Unused	
1164	292	40373	164				Unused	
1165	293	40374	165				Unused	
1166	294	40375	166			R	Bit mask#1 of alarms in U7	1=alarm
1167	295	40376	167			R	Bit mask#1 of alarms in U8	1=alarm
1168	296	40377	168			R	Bit mask#1 of alarms in U9	1=alarm

1169	297	40378	169			R	Bit mask#1 of alarms in U10	1=alarm
1170	298	40379	170			R	Bit mask#1 of alarms in U11	1=alarm
1171	299	40380	171			R	Bit mask#1 of alarms in U12	1=alarm
1172	300	40381	172			R	Bit mask#1 of alarms in U13	1=alarm
1173	301	40382	173			R	Bit mask#1 of alarms in U14	1=alarm
1174	302	40383	174			R	Bit mask#1 of alarms in U15	1=alarm
1175	303	40384	175			R	Bit mask#1 of alarms in U16	1=alarm
1176	304	40385	176			R	Bit mask#2 of alarms in U2	1=alarm
1177	305	40386	177			R	Bit mask#2 of alarms in U3	1=alarm
1178	306	40387	178			R	Bit mask#2 of alarms in U4	1=alarm
1179	307	40388	179			R	Bit mask#2 of alarms in U5	1=alarm
1180	308	40389	180			R	Bit mask#2 of alarms in U6	1=alarm
1181	309	40390	181			R	Bit mask#2 of alarms in U7	1=alarm
1182	310	40391	182			R	Bit mask#2 of alarms in U8	1=alarm
1183	311	40392	183			R	Bit mask#2 of alarms in U9	1=alarm
1184	312	40393	184			R	Bit mask#2 of alarms in U10	1=alarm
1185	313	40394	185			R	Bit mask#2 of alarms in U11	1=alarm
1186	314	40395	186			R	Bit mask#2 of alarms in U12	1=alarm
1187	315	40396	187			R	Bit mask#2 of alarms in U13	1=alarm
1188	316	40397	188			R	Bit mask#2 of alarms in U14	1=alarm
1189	317	40398	189			R	Bit mask#2 of alarms in U15	1=alarm
1190	318	40399	190			R	Bit mask#2 of alarms in U16	1=alarm
1191	319	40400	191			R	C1_Status (bit mapped)	1=On
1192	320	40401	192			R	C2_Status (bit mapped)	1=On

BMS INTEGER INDEXES 121-135 are the bit maps of alarms present in each slave

Bit 0 = Entering Water temperature sensor failure
 Bit 1 = Leaving Water temperature sensor failure
 Bit 2 = Analog input B8 sensor failure
 Bit 3 = Analog input B7 sensor failure
 Bit 4 = Circuit 1 Low Pressure sensor failure
 Bit 5 = Circuit 1 High Pressure sensor failure
 Bit 6 = Circuit 2 Low Pressure sensor failure
 Bit 7 = Circuit 2 High Pressure sensor failure
 Bit 8 = High Leaving Water temperature
 Bit 9 = Low Leaving Water temperature
 Bit 10 = Circuit 1 High Pressure
 Bit 11 = Circuit 1 Low Pressure
 Bit 12 = Circuit 2 High Pressure
 Bit 13 = Circuit 2 Low Pressure
 Bit 14 = Compressor 1 Overload
 Bit 15 = Compressor 2 Overload

BMS INTEGER INDEXES 176-190 are the bit maps of alarms present in each slave

Bit 0 = Evaporator flow alarm
 Bit 1 = Condenser flow alarm
 Bit 2 = Phase Detector
 Bit 3 = Low Oil Pressure Comp 1
 Bit 4 = Low Oil Pressure Comp 2
 Bit 5 = Compressor 1 Local switch is turned off
 Bit 6 = Compressor 2 Local switch is turned off
 Bit 7 = Not used
 Bit 8 = Not used
 Bit 9 = Not used
 Bit 10 = Not used
 Bit 11 = Not used
 Bit 12 = Not used
 Bit 13 = Not used
 Bit 14 = Not used
 Bit 15 = Not used

BMS INTEGER INDEX 191 is a bit map of Compressor #1 in all modules
Bit 0 = C1 of Master, Bit 1 = C1 of slave 1 ----- Bit 15 = C1 of slave 15

BMS INTEGER INDEX 192 is a bit map of Compressor #2 in all modules
Bit 0 = C2 of Master, Bit 1 = C2 of slave 1 ----- Bit 15 = C2 of slave 15