



WESBURN MANOR LTC AHU COOLING

Mechanical Specifications

Issued for Tender

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END OF SECTION

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PART 1 - GENERAL

1.1 References

- .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.
- .2 The Specification is generally prepared in accordance with the format of the CSI/CSC Master Format 2004 edition.

1.2 Application

- .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.
- .2 Perform All Work specified herein by experienced and licensed personnel.
- .3 Be responsible for advising product vendors of requirements of this Section.

1.3 Related Work

- .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.
- .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.
- .3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- .4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- .5 Where used, word "provide" shall mean supply and install as each is described above.
- .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.
- .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.
- .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.
- .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.
- .10 Where used, words "Drawings" and "Specifications" are referred to; it means the "Contract Documents".

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- .11 Where used, words "Prime Mechanical Contractor" shall mean the supervisory Mechanical Contractor of all Mechanical Sub-Contractors.
- .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.
- .13 The term "concealed" means, not exposed, hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
- .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.
- .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.
- .16 The term "approved", "approvals", etc., means, approved by Authorities having jurisdiction as conforming to the requirements of the Contract Documents.
- .17 The term "acceptable" or "acceptance", etc., means, acceptable to the Consultant as conforming to the requirements of the Contract Documents.
- .18 The term "submit for review" or "submit notice", etc., means, submit to the Consultant.
- .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.
- .20 The term "accessible" used alone means, readily accessible by a person using tools as required without cutting or breaking out materials.
- .21 The term "noted" means, notes on the drawings, the detail drawings and on the Schedules.
- .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.
- .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.
- .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.
- .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.
- .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.
- .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

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- .1 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.
- .2 Specification is arranged in accordance with CSI/CSC 50 Division Sections MasterFormat.
- .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.
- .4 Review Drawings and Specifications in conjunction with documents of other Divisions and, where applicable, Code Consultant's report.
- .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.
- .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.
- .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.
- .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.
- .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.
- .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.
- .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.
- .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 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,

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make accurate measurements onsite. Where significant discrepancies are found, immediately notify Consultant for direction.

1.6 Work Standards

- .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.
- .2 Where regulatory codes, standards and regulations are at variance with Drawings and Specification, more stringent requirement will apply unless otherwise directed by Consultant.
- .3 Supplementary mandatory specification and requirements to be used in conjunction with project include but are not limited to following:
 - .1 Air-Conditioning, Heating and Refrigeration Institute (AHRI);
 - .2 Air Movement and Control Association (AMCA);
 - .3 American Iron and Steel Institute (AISI);
 - .4 American National Standards Institute (ANSI);
 - .5 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., (ASHRAE);
 - .6 American Society of Mechanical Engineers (ASME);
 - .7 American Society of Testing and Materials (ASTM);
 - .8 American Water Works Association (AWWA);
 - .9 Associated Air Balance Council (AABC);
 - .10 Building Industry Consulting Services, International (BICSI);
 - .11 Canadian Gas Association (CGA);
 - .12 Canadian General Standards Board (CGSB);
 - .13 Canadian Standards Association (CSA);
 - .14 Electrical and Electronic Manufacturers Association of Canada (EEMAC);
 - .15 Electrical Safety Authority (ESA);
 - .16 Electronic Industries Association (EIA);
 - .17 Factory Mutual Systems (FM);
 - .18 Illuminating Engineering Society (IES);
 - .19 Institute of Electrical and Electronic Engineers (IEEE);
 - .20 International Standards Organization (ISO);
 - .21 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS);
 - .22 National Building Code of Canada (NBC);
 - .23 National Electrical Manufacturers Association (NEMA);
 - .24 National Environmental Balancing Bureau (NEBB);

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- .25 National Fire Protection Association (NFPA);
- .26 National Standards of Canada;
- .27 NSF International;
- .28 Occupational Health and Safety Act (OHSA);
- .29 Ontario Building Code (OBC);
- .30 Ontario Electrical Safety Code (OESC);
- .31 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA);
- .32 Technical Standards and Safety Authority (TSSA);
- .33 Thermal Insulation Association of Canada (TIAC);
- .34 Underwriters' Laboratories of Canada (ULC);
- .35 Workplace Hazardous Materials Information System (WHMIS);
- .36 Material Safety Data Sheets by product manufacturers;
- .37 local utility inspection permits;
- .38 Codes, standards, and regulations of local governing authorities having jurisdiction;
- .39 additional codes and standards listed in Trade Sections;
- .40 Owner's standards.
- .4 Provide applicable requirements for barrier free access in accordance with latest edition of local governing building code.
- .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.
- .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.
- .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.
- .8 Journeyperson tradesmen are to have a copy of valid trade certificates available at site for review by Consultant at any time.
- .9 Experienced and qualified superintendent is to be on-site at times when work is being performed.
- .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.
- .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.

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- .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.
- .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 Permits, Certificates, Approvals and Fees

- .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.
- .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.
- .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.
- .4 Include in each copy of operating and maintenance instruction manuals, copies of approvals and inspection certificates issued by regulatory authorities.

1.8 Requirements for Contractor Retained Engineers

- .1 Professional engineers retained to perform consulting services with regard to Project work, i.e. seismic engineer, fire protection engineer or structural engineer, are to be members in good standing with local Association of Professional Engineers and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of governing authorities in Place of the Work.
- .2 Retained engineer's professional liability insurance is to protect Contractor's consultants and their respective servants, agents, and employees against any loss or damage resulting from professional services rendered by aforementioned consultants and their respective servants, agents, and employees in regards to the Work of this Contract.
- .3 Unless otherwise specified in Division 00 or 01, liability insurance requirements are as follows:
 - .1 coverage is to be a minimum of \$1,000,000.00 CDN inclusive of any one occurrence;
 - .2 insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;
 - .3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work;
 - .4 retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above;
 - .5 evidence of the required liability insurance in such form as may be required is to be issued to Owner, Owner's Consultant, and Municipal Authorities as required prior to commencement of aforementioned consultant's services.

1.9 Interpretation of Drawings

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- .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.
- .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.
- .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.

1.10 Existing Services

- .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.
- .2 Before commencing work, establish location and extent of service lines in area of work and notify Consultant of finding.
- .3 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .4 Remove abandoned service lines. Cap or otherwise seal lines at cut-off points, in manner approved by authorities having jurisdiction over service.
- .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.
- .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.
- .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.

1.11 Discrepancies & Omissions

- .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.

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- .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.
- .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.

1.12 Workplace Safety

- .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.
- .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.
- .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.

1.13 Planning and Layout of Work

- .1 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings.
- .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 piping requiring uniform pitch;
 - .2 piping 100 mm (4") dia. and larger;
 - .3 large ducts (main runs);
 - .4 cable tray and bus duct;
 - .5 conduit 100 mm (4") dia. and larger;
 - .6 piping less than 100 mm (4") dia.;
 - .7 smaller branch ductwork;
 - .8 conduit less than 100 mm (4") dia..
- .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.
- .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

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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.

- .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.
- .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.
- .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.
- .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.

1.14 Phasing

- .1 Include for scheduling, coordination, and construction phasing to suit project as specified in Division 01 and on drawings. Confirm exact phasing requirements with Consultant prior to start of Work.
- .2 Phasing and scheduling of Work is required in order to maintain existing building operations. Include costs (including costs for "off hours" work) for scheduling, coordination, and construction phasing to suit this project as specified in Division 01 and on drawings. Coordinate phasing requirements with Consultant prior to start of Work.
- .3 Protect existing areas above, below and adjacent areas of Work from any debris, noise, or interruptions to existing services to satisfaction of Owner and Consultant. Maintain in operation existing services to these areas to allow Owner to continue use of these areas. If services that are required to be maintained run through areas of renovations, provide necessary protection to services or reroute, in coordination with Owner and Consultant. Include for required premium time work to meet these requirements.
- .4 Work being performed within occupied spaces and work affecting surfaces adjacent to occupied spaces may need to be performed after regular business hours. For areas where spaces are used by Owner on a 24 hours basis or over various hours, coordinate hours of work with Owner on a regular basis to suit Owner's schedule. Execute work at times confirmed with and agreed to by Consultant and Owner, so as not to inconvenience Owner's occupation or in any way hinder Owner's use of building. Include for required premium timework to meet these requirements.

1.15 Coordination of Work

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- .1 Review Contract Documents and coordinate work with work of each trade. Coordination requirements are to include but not be limited to following:
 - .1 requirements for openings, sleeves, inserts and other hardware necessary for installation of work;
 - .2 concrete work such as housekeeping pads, sumps, bases, etc., required for work, and including required dimensions, operating weight of equipment, location, etc.;
 - .3 depth and routing of excavation required for work, and requirements for bedding and backfill;
 - .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.
- .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.
- .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.
- .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.
- .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 Provisions for Systems/Equipment Used During Construction

- .1 Permanent building mechanical systems are not to be used for temporary heating or cooling purposes during construction.
- .2 Confirm with Consultant what equipment can be used during construction.
- .3 Any system or piece of equipment that is specified to be provided under requirements of Documents and is required to be used during construction stages of work prior to issuing of Certificate of Substantial Performance of the Work, are to be provided with special interim maintenance and service to cover systems/equipment during time of use during construction period of project until project has been certified as substantially performed and such systems/equipment are turned over to Owner.
- .4 During this period of construction, such systems/equipment to not become property of Owner or be Owner's responsibility for maintenance or service. Systems/equipment are to remain property of respective manufacturers/suppliers or Contractor, who are responsible for full maintenance and servicing of systems/equipment in order to maintain validity of warranties after turn over to Owner.
- .5 Prior to application for a Certificate of Substantial Performance of the Work and turn over to Owner, such systems/equipment to be cleaned, restored to "new" condition, paint finishes "touched-up", filters cleaned or replaced, etc.

1.17 Openings

- .1 Supply opening sizes and locations to Consultant to allow verification of their effect on design, and for inclusion on structural drawings where appropriate.

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- .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.
- .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.

1.18 Equipment Loads

- .1 Supply equipment loads (self-weight, operating weight, housekeeping pad, inertia pads, etc.) to Consultant, via shop drawing submissions, prior to construction.
- .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.
- .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.

1.19 Products

- .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.
- .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.
- .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.
- .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.
- .5 Documents have been prepared based on product available at time of Bidding. If, after

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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.

- .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.
- .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.
- .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 Indicate in Supplementary Mechanical Bid Form, names of manufacturers for proposed products to be supplied, and which were based specified or scheduled with a manufacturer's name. Names of proposed manufacturers on list must be one of names stated as acceptable for particular products, unless prior written permission from Consultant has been given for use of products by other manufacturers. Submit as directed.
- .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,

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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.

- .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.
- .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.
- .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.
- .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.

1.20 Material Substitution

- .1 The following requirements are aimed to establish a certain quality of materials to be used.
- .2 Besides, the objective is not to eliminate the loyal competition in the tender process applied to materials and substitute products.
- .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.
- .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.
- .5 The equivalences will be accepted only on the following conditions:
 - .1 Equivalence must be submitted before the contract;
 - .2 Proofs of equivalences will be required and this at the Supplier's fees;
 - .3 Samples of the proposed material or equipment and the specified material or equipment may be required;
 - .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.
- .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.
- .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

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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.

- .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.

1.21 Access Panels & Doors

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

- .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.
- .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 tapping bend with pre-punched holes. Drywall compound is applied over the beading at the same time as the drywall joints are finished
- .3 Door to be 16 gauge prime-coated steel with 14 gauge steel frame and screwdriver operated can latch.
- .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.

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

- .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.
- .2 Door and frame to be 16 gauge prime-coated steel with concealed hinges and positive locking and self-opening screwdriver lock.
- .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.

.3 Fire-Rated Separations:

- .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.
- .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.
- .3 ULC rating 1-1/2 hours, temperature rise maximum 250°F (120°C) in thirty (30) minutes.
- .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.

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- .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.
- .5 Size access panel doors to provide adequate access and correspond with the type of structural and architectural finish.
- .6 Ensure proper fire resistance rating of doors/panels in fire separations.
- .7 Provide the following:
 - .1 Type RW recessed for "SG" board in wet areas.
 - .2 Type TM flush mount for tile and masonry.
 - .3 Type WB flush for wall board.
- .8 Materials & Finish:
 - .1 Galvanized bonderized steel, phosphate-dipped with baked-on rust inhibitive grey prime finish.
 - .2 Stainless steel with No. 4 finish in Shower, Wet Washrooms and Drying Areas.
- .9 Acceptable Products:
 - .1 Le Hage
 - .2 Milcor
 - .3 Acudor
 - .4 Nystrom
 - .5 Access Panel Solutions Inc. (Bauco - Plus II) for Drywall

1.22 Concrete Work & Supports

- .1 Installation of concrete bases for all mechanical equipment shall be by this Division.
- .2 Prime Mechanical Contractor shall construct the bases. Provide accurate templates for the concrete trade to pour the bases.
- .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.
- .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.

1.23 Flashing

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

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1.24 Painting

- .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.
- .2 Equipment exposed to the exterior weather conditions are to be shop finished with rust-resistant paint or as specified in equipment specification.
- .3 Leave all work in a clean, paintable condition.
- .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.
- .5 Paint pipe sleeves one (1) coat primer.
- .6 Paint all relief and drain pipes serving Mechanical equipment, flat black.

1.25 Cutting & Patching

- .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.
- .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.
- .3 Where pipes and ducts pass through walls in the existing building, the cutting and patching is by the Prime Mechanical Contractor.
- .4 Co-ordinate work with Division 01 for Firestopping and Smoke Seals.

1.26 Sleeves

- .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.
- .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.
- .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.
- .4 Terminate sleeves flush with surface of concrete and masonry and 2" (50 mm) above floors. Not applicable to concrete floors on grade.
- .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.
- .6 Fill voids around pipes.
 - .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.

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- .2 Ensure no contact between copper pipe and ferrous sleeve.
- .7 Co-ordinate work with Division 01 for Firestopping and Smoke Seals.

1.27 Escutcheons & Plates

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

1.28 Dielectric Couplings

- .1 Provide wherever pipes of dissimilar metals are joined.
- .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.
- .3 Provide an isolating separation wherever piping may touch dissimilar metal studs, joists, concrete, etc.

1.29 Fire Stopping

- .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.

1.30 Impeller, Sheave & Belt Changes

- .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.

1.31 Non-Ferrous Materials

- .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.

1.32 Scaffolding, Hoisting and Rigging

- .1 Unless otherwise specified or directed, supply, erect and operate scaffolding, rigging, hoisting equipment and associated hardware required for work, and subject to review by and coordination with Consultant. Include for the cost of dismantling and reassembling equipment, where required, to the manufacturer's approval.
- .2 Direct this work by qualified people normally engaged in rigging, hoisting and handling of equipment.
- .3 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.
- .4 Do not place major scaffolding/hoisting equipment loads on any portion of structure

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without approval from Consultant.

1.33 Protection

- .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.
- .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.

1.34 Rights Reserved

- .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.

1.35 Superintendence

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

1.36 Co-Ordination

- .1 The Prime Mechanical Contractor is responsible for co-ordinating the mechanical work herein to suit Project Phasing Schedule.
- .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.
- .3 Failure to co-ordinate will result in installed work being removed and new work put in place without cost to the Owner.

1.37 Maintenance

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

1.38 Delivery, Storage & Handling

- .1 Transport, store and handle the materials in conformance with the manufacturer's instructions.
- .2 Delivery and receipt:

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- .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.
- .3 Storage and protection:
 - .1 Store the materials in a dry environment.
 - .2 Store the materials in the temperature and humidity conditions recommended by the manufacturer, and protect them from exposure to extreme weather conditions.
- .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.

1.39 Tendering Instructions

- .1 Refer to the General Conditions for the Instructions to Bidders.
- .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.
- .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.
- .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.
- .5 The Prime Mechanical Contractor shall not be required to employ as a subcontractor, a firm to whom he may reasonably object.
- .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.

1.40 Changes in the Work

- .1 Whenever Consultant proposes in writing to make a change or revision to design, arrangement, quantity or type of work from that required by Contract Documents, prepare and submit to Consultant for approval, a quotation being proposed cost for executing change or revision.
- .2 Quotation is to be a detailed and itemized estimate of product, labour, and equipment costs associated with change or revision, plus overhead and profit percentages and applicable taxes and duties.
- .3 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.
- .4 Unless otherwise specified in Divisions 00 or 01, following additional requirements apply to all quotations submitted:
 - .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;
 - .2 material costs are not to exceed those published in local estimating price guides;
 - .3 mechanical material labour unit costs are to be in accordance with Mechanical

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- Contractors Association of America Labor Estimating Manual, less 25%;
- .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%;
 - .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;
 - .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;
 - .7 costs for rental tools and/or equipment are not to exceed local rental costs;
 - .8 overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals;
 - .9 quotations, including those for deleted work, to include a figure for any required change to Contract time.
- .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.
- .6 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- .7 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.41 Progress Payment Breakdown

- .1 Prior to submittal of first progress payment draw, submit a detailed breakdown of work cost to assist Consultant in reviewing and approving progress payment claims.
- .2 Payment breakdown is subject to 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.
- .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.

1.42 Notice for Required Field Reviews

- .2 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.
- .3 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- .4 Do not conceal work until Consultant advises that it may be concealed.
- .5 When Consultant is requested to perform a field review and work is not ready to be reviewed, reimburse Consultant for time and travel expenses.

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1.43 Submittals

- .1 Submittals: in accordance with Division 01.
- .2 Shop drawings to show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
- .3 Shop drawings and product data accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification of compliance to applicable codes.
- .4 In addition to transmittal letter referred to in Division 01: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.
- .5 Closeout Submittals:
 - .1 Provide operation and maintenance data for incorporation into manual specified in Division 01.
 - .2 Operation and maintenance manual approved by, and final copies deposited with, Consultant before final inspection.
 - .3 Operation data to include:
 - .1 Control schematics for systems including environmental controls.
 - .2 Description of systems and their controls.
 - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
 - .4 Operation instruction for systems and component.
 - .5 Description of actions to be taken in event of equipment failure.
 - .6 Valves schedule and flow diagram.
 - .7 Colour coding chart.
 - .4 Maintenance data to include:
 - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
 - .5 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
 - .4 Testing, adjusting and balancing reports as specified in Section 20 05 50 - Testing, Adjusting and Balancing.
- .6 Approvals:

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- .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.
- .2 Make changes as required and re-submit as directed by Consultant.
- .7 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .8 As-built drawings:
 - .1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.
 - .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).
 - .3 Submit to Consultant for review and make corrections as directed.
 - .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
 - .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.
- .10 Site records:
 - .1 Engineer will provide one set of mechanical drawings. Mark changes as work progresses and as changes occur.
 - .2 Transfer information to reproducible, revising reproducible to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.

1.44 Record Drawings

- .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.
- .2 Record drawings shall locate all concealed shut-off valves, dampers, control valves and concealed air vents.
- .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.

1.45 Interference Drawings

- .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.

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- .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.
- .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.
- .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.
- .5 As a minimum, interference drawings shall be made for all areas of mechanical equipment rooms, duct shafts and corridor ceiling spaces.
- .6 Work that has been installed before review of interference drawings, and has been determine 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.

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

- .1 Provide materials and equipment in accordance with Division 01.
- .2 Equipment and material to be CSA certified and manufactured to standards specified herein.
- .3 Factory assemble control panels and component assemblies.
- .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".
- .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.
- .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.
- .7 The Owner reserves the right to accept or reject any or all "Approved Alternates".

1.47 Manufacturers, Shop Drawings & Submittals

- .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.
- .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.
- .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.

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- .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.
- .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.
- .6 The shop drawings must apply to the equipment under consideration. Advertising literature and comprehensive data sheets are not acceptable.
- .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.
- .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.
- .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.
- .10 Shop drawings will be returned "No Exception Taken", "Revise & Resubmit", "Make Corrections Noted, Resubmission Not Required" or "Rejected, Submit Compliant Product/System".
 - .1 "No Exception Taken" Drawings shall be considered as conforming with the design concept.
 - .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.
 - .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.
 - .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.
- .11 All shop drawings must be submitted promptly.

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[illegible]

STATUS LEGEND

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

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

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1.48 Operation & Maintenance Manuals

- .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.
- .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).
- .3 Not later than three (3) weeks prior to application for inspection by Consultant for Substantial Performance, submit records and maintenance manuals to Consultant.
- .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.
- .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.
- .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.

1.49 Temporary or Trial Usage

- .1 Do not use any permanent Mechanical Systems during construction unless specific written approval is obtained from the Consultant.
- .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.
- .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.
- .4 The use of permanent systems shall not invalidate the guarantee or warranty.
- .5 Prior to final acceptance, return all equipment to as new condition and provide supplier certification of same.

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1.50 Time for Completion

- .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 Advise the Consultant if materials and equipment involves longer delivery times than indicated in the schedule.
 - .2 Monitor and expedite delivery of equipment and materials. If necessary, inspect at source of manufacture.
- .2 Be responsible for failure of, or delay in, the delivery of specified equipment.

1.51 Preliminary Testing

- .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.
- .2 When, in Consultant's opinion, tests are required to be performed by a certified testing laboratory, arrange and pay for such tests.
- .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.
- .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.

1.52 Testing & Adjusting

- .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.
- .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.
- .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.
- .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.
- .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.
- .6 All tests must be witnessed by the Owner's Authorized Representative. Failure to do so will result in a re-test.
- .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.

Common Work Results for Mechanical

1.53 Start-Up & Instruction

- .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.
- .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.
- .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.

1.54 Operate & Adjust Systems

- .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.
- .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.
- .3 Test for both heating and cooling days. Refer to Section 23 08 01 - Performance Verification Mechanical Piping Systems

1.55 Commissioning

- .1 After successful start-up and prior to Substantial Performance of the Work, commission the mechanical work. Commissioning work is the process of Contractor demonstrating to Owner and Consultant, for purpose of final acceptance, by means of successful and documented functional performance testing, that systems and/or subsystems are capable of being operated and maintained to perform in accordance with requirements of Contract Documents, as further described below.
 - .1 Retain services of a testing, adjusting, and balancing agency to perform testing and balancing of mechanical system air/fluid flows and capacities, prior to operational performance testing. Refer to Section entitled Testing, Adjusting and Balancing.
 - .2 Test, adjust and operate equipment and systems after start-up but before functional performance testing, to confirm operations are in accordance with requirements of Contract Documents. Verify modes and sequences of control and monitoring, interlocks, and responses to emergency conditions. Complete commissioning data sheets to document successful operational performance testing.
 - .3 Repeat successful operational performance testing with completed commissioning data sheet documentation in the presence of Consultant and Owner to validate and verify equipment and systems are complete in all respects, function correctly, and are ready for acceptance.
 - .4 Submit final commissioning data sheets, TAB reports as specified in Section entitled Testing, Adjusting and Balancing, project closeout documents, and other

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required submittals.

- .2 Where commissioning specifications are included as part of Division 01, requirements of Section entitled Mechanical Work Commissioning are to supplement commissioning requirements of Division 01. Where variances or contradictions exist, more stringent requirement will apply unless otherwise directed by Consultant.

1.56 Completion

- .1 Keep the premises in a clean and orderly condition during construction. All waste and unusable materials shall be promptly removed from the site.
- .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.
- .3 Before final payment is made, the following items must be completed:
 - .1 Present to the Consultant "Maintenance Manuals" complete with air and water balancing reports, wiring diagrams and certified equipment prints.
 - .2 Present to the Consultant an as-built record set of drawings and CAD disk.
 - .3 Instruction of Owner's personnel in the maintenance and operation of all new equipment.
 - .4 Present to the Consultant completed Equipment Start-up and Acceptance Checklist.
 - .5 Present to the Consultant Test Certificates and results.
 - .6 Present to the Consultant Valve Tag Charts.
 - .7 Spare filters and frames, labelled and located where directed by the Owner.
 - .8 Present to the Consultant start-up report for fan coil units.
 - .9 Present to the Consultant start-up report for air handling unit.
 - .10 Present to the Consultant Medical Gas Certification
 - .11 Present to the Consultant complete controls commissioning report.
 - .12 Present to the Consultant as-built drawings on CAD diskette.
 - .13 Maintain a set of approved drawings on site available for review by authorities.
 - .14 Perform the above work in a timely manner so as not to interfere with the progress of the project.
- .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.

1.57 Warranty

- .1 Unless otherwise specified in Divisions 00 and 01, warrant mechanical work to be in accordance with Contract Documents and free from defects for a period of 1 year from date of issue of a Certificate of Substantial Performance of the Work.
- .2 Where equipment includes extended warranty period, e.g., 5 years, first year of warranty period is to be governed by terms and conditions of warranty in Contract Documents, and remaining years of warranty are to be direct from equipment manufacturer and/or supplier to Owner. Submit signed and dated copies of extended warranties to Consultant.
- .3 Warranty to include parts, labour, travel costs and living expenses incurred by

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manufacturer's authorized technician to provide factory authorized on-site service.

- .4 Repair and/or replace any defects that appear in Work within warranty period without additional expense to Owner. Be responsible for costs incurred in making defective work good, including repair or replacement of building finishes, other materials, and damage to other equipment. Ordinary wear and tear and damage caused wilfully or due to carelessness of Owner's staff or agents is exempted.
- .5 Do not include Owner deductible amounts in warranties.
- .6 Visit building during warranty period with Owner representatives. Owner to organize these visits. At these meetings, Owner representatives are to review performance of systems. If performance is satisfactory, then no further action needs to be taken. If unsatisfactory, then correct deficiencies, as directed by Owner representatives, to satisfaction of Owner's representatives. These site visits to occur:
 - .1 once during 1st month of building operation;
 - .2 once during 3rd month of building operation;
 - .3 once between 4th and 10th month in a season opposite to 1st and 3rd month visits.

1.58 Liability

- .1 Each Section and Trade shall:
 - .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.
 - .2 Be responsible for prompt installation of work in advance of concrete pouring, ceiling installation or similar work.
 - .3 Protect finished and unfinished work of this Division and work of other Sections from damage due to work of this Division.
 - .4 Be responsible for condition of material and equipment supplied. Be responsible for protection and maintenance of work completed until termination and acceptance.

PART 2 - PRODUCTS

2.1 Materials

- .1 Not used

PART 3 - EXECUTION

3.1 Painting Repairs & Restoration

- .1 Prime and touch up marred finished paintwork to match original.
- .2 Restore to new condition, finishes which have been damaged.

3.2 Cleaning

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

3.3 Demonstration

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

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- .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 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4 Instruction duration time requirements as specified in appropriate sections.

3.4 Protection

- .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 _____

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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 #																			
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ACCEPTED BY	OWNER'S REP	DATE																		
ACCEPTED BY	CONSULTANT	DATE																		

END OF SECTION

Basic Mechanical Materials and Methods

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies products, common criteria and characteristics, and methods and execution that are common to one or more 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 Submit the following for review:
 - .1 shop drawings/product data sheets: submit for:
 - .1 pressure gauges and thermometers;
 - .2 electric motors (submit with equipment they are associated with).
 - .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;
 - .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;
 - .4 **list of equipment nameplates:** submit a list of equipment identification nameplates indicating proposed wording and sizes;
 - .5 **pipe & duct identification:** submit a list of pipe and duct identification colour coding and wording;
 - .6 **valve tag chart:** submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording;
 - .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;
 - .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;
 - .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

- .1 Galvanized Sheet Steel: Minimum #16 gauge galvanized steel with an integral flange at one end to secure the sleeve to formwork construction.
- .2 Polyethylene: Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.
- .3 Galvanized Steel Pipe – Waterproof: Schedule 40 mild galvanized steel pipe with a

Basic Mechanical Materials and Methods

welded-on square steel anchor and water stop plate at the sleeve midpoint.

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

2.2 Fire Stopping and Smoke Seal Materials

- .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 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.
- .3 Provide seals to form draft tight barriers to retard the passage of flame, smoke, gas and firefighter's hose stream.
- .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.
- .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.
- .6 Firestop sealant: single component, low modulus, silicone rubber, moisture curing, ULC labelled to ULC-S115.
- .7 Firestop insulation: to CAN/ULC-S702, Type 2; mineral fibre manufactured from rock or slag, suitable for manual application.
- .8 Density: 81 kg/m³ when tested to ASTM C303.
- .9 Combustibility: Non-combustible to CAN/ULC S114.
- .10 Melt temperature: >1175 degrees C.
- .11 Surface burning characteristics: to CAN/ULC S102, maximum flame spread of 0, smoke developed of 0.
- .12 Moisture Absorption: 0.04 percent when tested to ASTM C1104.
- .13 Smoulder Resistance: 0.01 percent when tested to CAN/ULC S129.
- .14 Damming, back-up, supports, and anchorage: In accordance with manufacturer's fire rated systems and to acceptance of authorities having jurisdiction.
- .15 Primer: As recommended by firestop sealant manufacturer.
- .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.
- .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

Basic Mechanical Materials and Methods

- .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:

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

2.4 Pipe Escutcheon Plates

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

2.5 Piping Hangers and Supports

- .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:
 - .1 unless otherwise specified, all ferrous hanger and support products are to be electro-galvanized;
 - .2 hangers and supports for insulated piping are to be sized to fit around the insulation and the insulation jacket.
- .2 Horizontal Suspended Piping: Hangers and supports are to be:
 - .1 adjustable steel clevis hanger – Anvil Fig. 260 – MSS Type 1;
 - .2 adjustable swivel ring band type hanger – Anvil Fig. 69 – MSS Type 10;
- .3 Horizontal Pipe On Vertical Surfaces: Epoxy coated steel pipe stays are not permitted. Supports are to be:
 - .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
 - .2 heavy-duty steel pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26;
 - .3 single steel pipe hook - Myatt Fig. 156;
- .4 Floor Supports For Vertical Risers: Supports are to be:
 - .1 copper tubing riser clamp – Anvil Fig. CT-121, Anvil Fig. CT-121C (plastic coated), or Myatt Fig. 150CT – MSS Type 8;
 - .2 heavy-duty steel riser clamp – Anvil Fig. 261, or Myatt Fig's. 182, 183, 190 and 191 – MSS Type 8.
- .5 Vertical Piping on Vertical Surfaces: Epoxy coated steel pipe stays are not permitted. Supports are to be:

Basic Mechanical Materials and Methods

- .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
- .2 heavy-duty steel pipe bracket or soil pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26;
- .3 extension split pipe clamp – Anvil Fig's. 138R or Myatt Fig. 129 – MSS Type 12;
- .6 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.
- .7 Special Hangers and Supports: Special hangers and supports for various applications are as follows:
 - .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 **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;
 - .3 **for sections of piping connected to vibration isolated equipment** – hangers and supports as specified above but complete with MSS Type 48 spring cushions;
 - .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;
 - .5 **for piping on new roofs** – Lexcor "Flash-Tite" or Thaler Roofing Specialties Products Inc. "MERS" Series insulated aluminum support risers with diameter, height, securement method and flashing to suit the application, all required accessories, channel type aluminum cross members, and galvanized steel pipe hangers and/or supports conforming to MSS Type SP-58, complete with all required accessories;
 - .6 **for plastic piping** – generally as specified above but in accordance with the pipe manufacturer's printed recommendations;
 - .7 **for bare horizontal copper piping** – generally as above but factory vinyl coated to prevent direct copper/steel contact;
 - .8 **for bare copper vertical piping** – corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate the pipe from the clamp;
 - .9 **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.
- .8 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.

Basic Mechanical Materials and Methods

.9 Acceptable Manufacturers: Acceptable hanger and support material manufacturers are:

- .1 E. Myatt & Co. Inc.;
- .2 Anvil International Inc.;
- .3 Empire Tool & Mfg. Co. Inc.;
- .4 Hunt Manufacturing Ltd.;
- .5 Unistrut Canada Ltd.;
- .6 Nibco Inc. "Tolco";
- .7 Taylor Pipe Supports.

2.6 Access Doors

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

2.7 Pressure Gauges and Thermometers

- .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:
 - .1 H. O. Trerice Co. Model 700 LFSS-40;
 - .2 Weiss Instruments Model LF4S-2;
 - .3 Ashcroft #35-1009 SWL-26.
- .2 **Pressure Gauge Accessories & Additional Requirements:** Accessories and additional requirements are as follows:
 - .1 a bronze ball type shut-off valve is to be provided in the piping to each pressure gauge;
 - .2 each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber.

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- .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, 1/2" NPT connection with 1/4" diameter stainless steel stem, and a suitable thermowell. Acceptable products are:

- .1 H.O. Trerice Co. B85600 Series;
- .2 Weiss Instruments Model 5VBM25;
- .3 Ashcroft #50EI60E-040-0/250.

2.8 Equipment Belt Drives

- .1 ANSI/RMA Standard V-belt type rated at minimum 1.5 times the motor nameplate rating, and in accordance with the following requirements:
- .1 belts are to be reinforced cord and rubber, and multiple belts are to be matched sets;
 - .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;
 - .3 motor slide rail adjustment plates are to allow for centre line adjustment.
- .2 Supply a spare belt set (tagged and identified) for each belt drive and hand to the Owner upon Substantial Performance of the work.

2.9 Equipment Drive Guards and Accessories

- .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 1 1/2" diameter tachometer openings at each shaft location.
- .2 **For flexible couplings** - removable "U" shaped galvanized steel guards to OSHA Standards with a 3/32" thick frame and expanded mesh face.
- .3 **For unprotected fan inlets & outlets** - unless otherwise specified, removable 3/4" galvanized steel wire mesh with galvanized steel frames, all to OSHA Standards.

2.10 Electric Motors

- .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 Vertically mounted and submersible motors are to be purposely designed for mounting in

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this attitude.

- .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.
- .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.
- .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.
- .6 **Thermistor Protection:** Unless otherwise indicated, motors 30 HP and larger are to be complete with a heat sensing PTC thermistor in the end turn of the stator winding for each phase and connected in series inside the motor with two marked leads brought out to the motor conduit box.
- .7 **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.
- .8 **Acceptable Manufacturers:** Acceptable motor manufacturers are:
 - .1 Westinghouse Canada Inc.;
 - .2 Canadian General Electric;
 - .3 Baldor Electric Co.;
 - .4 U.S. Electrical Motors;
 - .5 Weg Electric Corp.;
 - .6 Marathon Electric;
 - .7 Magna-Tech Canada;
 - .8 Toshiba Corp.;
 - .9 Leeson Canada.

2.11 Motor Starters and Accessories

- .1 **General:** All motor starters must be capable of starting the associated motors under the

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- imposed loads. Confirm that starter voltage matches the motor prior to ordering.
- .2 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.
 - .3 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.
 - .4 Motor Starter Enclosures: Unless otherwise specified, motor starter enclosures are to be in accordance with the following NEMA/EEMAC ratings:
 - .1 all enclosures located in sprinklered areas – Type 2;
 - .2 all enclosures exposed to the elements – Type 3R, constructed of stainless steel;
 - .3 all enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;
 - .4 all enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;
 - .5 all enclosures except as noted above – Type 1;
 - .6 all enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.
 - .5 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.
 - .6 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.
 - .7 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.
 - .8 Acceptable Manufacturers: Acceptable manufacturers are:
 - .1 Rockwell Automation Inc. - Allen-Bradley;
 - .2 Eaton Corp. – Cutler-Hammer;

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- .3 Eaton Corp. – Moeller Electric;
- .4 Siemens Canada;
- .5 Schneider Electric.

2.12 Mechanical Work Identification Materials

- .1 Equipment Nameplates: Minimum 1/16" thick 2-ply laminated coloured plastic plates, minimum 1/2" x 2" for smaller items such as damper motors and control valves, minimum 1" x 2 1/2" for equipment, and minimum 2" x 4" for control panels and similar items. Additional requirements are as follows:
 - .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 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;
 - .3 supply stainless steel screws for securing nameplates in place;
 - .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 Valve Tags: Coloured, 1 1/2" 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.:
 - .1 Valve V12
 - .2 8"
 - .3 Chill. Water
 - .4 Normally Open
- .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:
 - .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 for pipe larger than 6" diameter, saddle type strap-on markers with 2 opposite identification locations and complete with nylon cable ties.
- .4 Standard Pipe Identification Wording and Colours: Identification wording and colours for pipe identification materials are to be as follows:

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic cold water	green	DOM. COLD WATER

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PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic hot water supply	green	DOM. HW SUPPLY
domestic hot water recirculation	green	DOM. HW RECIRC.
heating water supply	yellow	HTG. WTR. SUPPLY
heating water return	yellow	HTG. WTR. RETURN
chilled water supply	green	CH. WTR. SUPPLY
chilled water return	green	CH. WTR. RETURN

- .5 Colours For Legends & Arrows: Colours for pipe identification legends and directional arrows are to be as follows:

IDENTIFICATION COLOUR	LEGEND & ARROW COLOUR
red	white
orange	black
yellow	black
brown	white
green	white
blue	white

- .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.

2.13 Flexible Connectors

- .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:
- .1 Hyspan Precision Products Inc.;
 - .2 Senior Flexonics Ltd.;
 - .3 The Metraflex Co.

PART 3 - EXECUTION

3.1 General Piping and Ductwork Installation Requirements

- .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

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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.

- .2 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 Install all pipes and ducts parallel to building lines and to each other.
- .4 Neatly group and arrange all exposed work.
- .5 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.
- .6 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.
- .7 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.
- .8 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.
- .9 Insulation Clearance: Install piping and ductwork which are to be insulated so that they have sufficient clearance to permit insulation and finish to be applied continuously and unbroken around the pipe or duct, except for ductwork at fire barriers, in which case the insulation will be terminated at each side of the duct fire damper.
- .10 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.
- .11 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.
- .12 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.
- .13 Unions and Flanges: Whether shown or specified on the drawings or not, provide

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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.

- .14 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

- .1 Do not make pipe joints in walls or slabs.
- .2 Ream all piping ends prior to making joints.
- .3 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.
- .4 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.
- .5 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.
- .6 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.
- .7 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.
- .8 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.
- .9 Mechanical Joints: Install mechanical joint fittings and couplings in accordance with the

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manufacturer's instructions.

- .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.
- .11 Pressure Crimped Piping Joints: If pressure crimped couplings and fittings are used, ensure that gaskets are fully compatible with the piping fluid, and that all valves and piping accessories are suitable. Use only fitting manufacturer supplied crimping equipment. Comply with the manufacturer's latest published specification, instructions, and recommendations with respect to pipe, coupling, and fitting preparation and installation, and support, anchoring and guiding of the piping system.
- .12 PVC Piping Solvent Weld Joints: Solvent weld PVC piping in two parts, primer stage and cementing stage, in accordance with the manufacturer's recommendations, ASTM D2855, and CSA requirements.
- .13 PVC Piping Gasketed Joints: Install PVC piping with gasketed joints in accordance with the manufacturer's current published specifications, instructions and recommendations, and CSA requirements.

3.3 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;
 - .2 in concrete or masonry walls: Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.
- .2 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.
- .3 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.
- .4 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

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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;
- .5 Where sleeves are required in masonry work, accurately locate and mark the sleeve location, and hand the sleeves to the mason for installation.
- .6 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.
- .7 "Gang" type sleeving will not be permitted.
- .8 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.

3.4 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.

3.5 Duct Openings

- .1 Duct openings, air inlet and outlet openings, fire damper and similar openings will be provided in new poured concrete work, masonry, drywall and other building surfaces by the trade responsible for the particular construction in which the opening is required.
- .2 Ensure that openings for fire dampers to 24" high are sized to suit the damper arrangement with the folding blade out of the air stream.
- .3 For all duct openings except where fire dampers are required, pack and seal the space between the duct or duct insulation and the duct opening as specified above for pipe openings in non-fire rated construction.

3.6 Sleeve and Formed Opening Location Drawings

- .1 Prepare and submit for review, white print drawings indicating the size and location of all required sleeves, recesses and formed openings in poured or precast concrete work.
- .2 Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs
- .3 Begin to prepare such drawings immediately upon notification of acceptance of bid and

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award of Contract.

3.7 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.
- .2 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.

3.8 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.
- .5 Do not attach fasteners to steel deck without written consent from the Consultant.

3.9 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

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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')
3½"	3.6 (12')	3.6 (12')
4"	4.2 (14')	3.6 (12')
10"	6.0 (20')	
12"	6.6 (22')	

- .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

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- 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;
 - .2 on new roof - supply manufactured roof supports as per Part 2 of this Section to accommodate the piping involved and support spacing specified above, and hand the supports to the roofing trade on the roof for installation as part of the roofing work, then secure piping in place on the 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.

3.10 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.

3.11 Installation of Valves

- .1 Generally, valve locations are indicated or specified on drawings or specified in Sections

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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.

3.12 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 main mechanical plant equipment such as boilers, chillers, heat exchangers, main coils, etc.;
 - .3 in expansion tank(s);
 - .4 in separate domestic hot water instantaneous heater;
 - .5 at the top most outlet in each standpipe fire protection system riser;
 - .6 in piping at each side of a pressure reducing valve;
 - .7 in potable water service piping downstream of the meter;
 - .8 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 main mechanical plant equipment such as boilers, chillers, cooling towers, 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:

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- .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.

3.13 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.

3.14 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,

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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 Electrical Tracing: For all new electrically traced mechanical work, identification wording is to include "ELECTRICALLY TRACED".
- .6 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.
- .7 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

3.15 Finish Painting of Mechanical Work

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

3.16 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 Heat Transfer (HVAC) System Piping: Test piping with cold water at a pressure of 150 psi (1035 kPa) for a minimum of two hours.
- .7 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 hydrostatic 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;

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- .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.

3.17 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 Three Phase Motor Starters on Motor Starter Panels: Where three phase starters are indicated and/or scheduled to be mounted on a motor starter panel, the starters will be mounted and connected, complete with the panels and splitter trough, as part of the electrical work. Hand the starters to the electrical trade at the site when they are required.
- .5 Disconnect Switches on Motor Starter Panels: 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 starter panel, a disconnect switch will be provided on the motor starter panel as part of the electrical work
- .6 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.

3.18 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

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- 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.

3.19 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

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hydronic piping, it is to be assumed that pipe freezing will be required.

3.20 Equipment Bases and Supports

- .1 Concrete Housekeeping Pads: Unless otherwise specified or required, set all floor mounted equipment on minimum 4" high reinforced concrete housekeeping pads 8" clear of the equipment on each side and end, or a minimum of 8" from the centreline of equipment anchor bolts to the edge of the base, whichever is larger. Conform to the following requirements:
 - .1 supply dimensioned drawings and equipment base templates, and provide anchor bolts for proper setting and securing of equipment on pads;
 - .2 place anchor bolts during the concrete pour and be responsible for all required levelling, alignment, and grouting of the equipment;
 - .3 as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details.
- .2 Structural Steel Stands/Supports: For equipment not designed for base mounting, where required, provide welded, cleaned and prime coat painted structural steel stands or supports conforming to the following requirements:
 - .1 all stands and supports, except those for small equipment, are to be designed by a structural engineer registered in the jurisdiction of the work, and stamped and signed design drawings with calculations are to be submitted as shop drawings for review;
 - .2 all steel stands are to be flange bolted to concrete housekeeping pads;

3.21 Concrete Work for Mechanical Equipment Bases/Pads

- .1 Provide all poured concrete work, including reinforcing and formwork, required for mechanical equipment bases/pads. Perform concrete work in accordance with requirements specified in Division 03.
- .2 Concrete is to be minimum 20,700 kPa ready-mix concrete in accordance with CAN/CSA-A23.1 and the Building Code.
- .3 Submit for review, dimensioned shop drawings for all concrete pads or bases for support of large, heavy equipment. Indicate on the shop drawings the total weight of the pad or base as well as the equipment it is provided for, and concrete reinforcing. Shop drawings are to be prepared and stamped by a professional structural engineer registered in the place of the work.
- .4 Ensure that bases and pads are keyed into the structure to meet seismic restraint requirements.

3.22 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

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defined renovation and scope of work areas indicated on the architectural drawings.

- .2 Patch surfaces, where required, to exactly match existing finishes using tradesmen skilled in the particular trade or application worked on.
- .3 Where new pipes pass through existing construction, core drill an opening. Size openings to leave ½" clearance around the pipes or pipe insulation.
- .4 Prior to drilling or cutting an opening in poured concrete construction, determine the location, if any, of existing services concealed in the construction to be drilled or cut. Ferro Scan Test the walls or slabs if required.
- .5 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.

3.23 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.

3.24 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;
 - .2 duration of instruction;
 - .3 names of persons instructed;
 - .4 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.

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3.25 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.

3.26 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.

3.27 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.

3.28 Installation of Flexible Connectors

- .1 Provide flexible connectors in all piping connections to vibration isolated equipment.

3.29 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.

3.30 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

Mechanical Vibration Control

PART 1 - GENERAL

1.1 Application

- .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 **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 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment, if needed or required. Include auxiliary motor slides and rails, base weights, equipment static loads.
 - .2 Vibration 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 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 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

- .1 Vibration isolation products are to be in accordance with the drawing schedule and details, and as specified below.
- .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.
- .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.

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- .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.
- .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

- .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:
 - .1 Kinetics Noise Control Vibron Products Group Type NGS/NGD;
 - .2 Vibro-Acoustics Ltd. Type NSN;
 - .3 Mason Industries Inc. Type SW/S/SW with HG Bolt Insertion Washers;

2.3 Rubber Floor Isolators

- .1 Captive, bridge bearing quality neoprene mount selected for a minimum 4 mm (0.15") static deflection unless otherwise specified, with an integral ductile iron housing and integral equipment anchor bolt. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type RQ;
 - .2 Vibro-Acoustics Ltd. Type R;
 - .3 Mason Industries Inc. Type BR;

2.4 Spring Floor Isolators

- .1 Seismically rated captive spring mount isolator complete with levelling bolts, upper and lower neoprene spring cups, neoprene cushion, ductile iron housing, neoprene sound pads, and neoprene isolation grommets for securing bolts. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type FLSS;
 - .2 Vibro-Acoustics Ltd. Type SFS;
 - .3 Mason Industries Inc. Type SSLFH;

2.5 Open Spring Mounts

- .1 Base mount free-standing assemblies, each complete with a stable colour coded steel spring welded in place, drilled mild steel mounting plate bonded to a ribbed rubber or neoprene acoustical pad, and an external 16 mm ($\frac{5}{8}$ ") diameter level adjustment bolt. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type FDS;
 - .2 Vibro-Acoustics Ltd. Type FS;
 - .3 Mason Industries Inc. Type SLFH.

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2.6 Closed Spring Mounts

- .1 Base mount free-standing enclosed assemblies, each complete with stable colour coded spring(s), two piece cast housing, non-binding rubber horizontal stabilizers, a ribbed rubber or neoprene acoustical pad bonded to the base of the closed housing, and an external level adjustment bolt. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type FLS;
 - .2 Vibro-Acoustics Ltd. Type CM;
 - .3 Mason Industries Inc. Type C.

2.7 Totally Retained Spring Mounts

- .1 Base mount free-standing enclosed and retained assemblies to limit both vertical and lateral movement of the mounted equipment, each complete with stable colour coded spring(s), drilled welded steel housing and top plate, ribbed rubber or neoprene acoustical pad bonded to the bottom of the housing, vertical limit adjusting hardware, and a level adjustment bolt. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type SM;
 - .2 Vibro-Acoustics Ltd. Type CSR;
 - .3 Mason Industries Inc. Type SLRSO.

2.8 Spring Hangers

- .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:
 - .1 Kinetics Noise Control Vibron Products Group. Type SRH;
 - .2 Vibro-Acoustics Ltd. Type SHR-SN;
 - .3 Mason Industries Inc. Type 30N.

2.9 Neoprene Hanger Isolators

- .1 Neoprene double deflection rod isolators with steel housing and hanger rod bushing, selected for a minimum 4 mm (0.15") static deflection unless otherwise specified. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type RH;
 - .2 Vibro-Acoustics Ltd. Type NH;
 - .3 Mason Industries Inc. Type HD or WHD.

2.10 Concrete Inertia Type Equipment Base

- .1 Welded steel bases, each complete with a structural black steel channel frame, concrete reinforcing rods, and brackets for spring mounts welded to the frame. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group. Type CIB;
 - .2 Vibro-Acoustics Ltd. Type CIB;

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- .3 Mason Industries Inc. Type KSL.

2.11 Steel Equipment Base

- .1 Fully welded structural steel equipment and motor support bases, each complete with a wide flange steel frame, full depth cross members, brackets for spring mounts, and adjustable motor slide rails. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type SFB;
 - .2 Vibro-Acoustics Ltd. Type SB;
 - .3 Mason Industries Inc. Type WFSL.

2.12 Combination Steel /Concrete Inertia Equipment Base

- .1 Welded steel bases with a structural black steel channel frame, concrete reinforcing rods, bottom sheet steel pan, brackets for spring mounts welded to the frame and adjustable motor slide rails. Acceptable products are:
 - .1 Vibro-Acoustics Ltd. Type CIB (with motor slide rails);
 - .2 Kinetics Noise Control Vibron Products Group Type CIB (with motor slide rails);
 - .3 Mason Industries Inc. Type BMK or K.

2.13 Slung Steel Base

- .1 Slung steel bases of structural members with gusset plates welded to the ends and complete with adjustable motor slide rails and vertical section size to suit equipment's motor power output. Acceptable products are:
 - .1 Vibro-Acoustics Ltd. Type SS;
 - .2 Kinetics Noise Control Vibron Products Group Type CIB-H;
 - .3 Mason Industries Inc. Type MSL.

2.14 Curb-Mounted Spring Rail for Roof Mounted Equipment

- .1 Full-perimeter rail type isolator, spring components shall be free-standing, un-housed, laterally stable steel springs. Springs shall be colour coded to indicate load capacity.
- .2 Rails shall provide continuous support for the rooftop equipment and shall be designed to provide isolation against casing-radiated vibration in the rooftop equipment housing and structure-borne vibration from rotating and mechanical equipment in the rooftop package.
- .3 Rail assembly shall consist of extruded aluminum top and bottom members connected by spring isolators and a continuous air- and water-tight seal. The seal shall be a beaded elastomeric material retained in a keyway along the top extrusion. The weather strip shall be sealed along the bottom with an aluminum fascia strip.
- .4 Rail assemblies shall incorporate means for attachment to the building and the supported equipment and shall incorporate additional stiffening members if necessary to assure stability.

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- .5 Continuous rooftop isolation shipped completely assembled, consisting of galvanized steel sections formed to fit roof curb and associated equipment with a flexible air and weather seal joining upper and lower rail sections and:
 - .1 stable springs which are cadmium plated and selected to provide minimum deflection with 50% additional travel to solid;
 - .2 springs shall have a lateral stiffness greater than 1.0 times the rated vertical stiffness and shall be designed for 50% overload to solid
 - .3 rails shall be fitted with wind restraint devices suitable for prevailing wind conditions that will not impose loads on the curb walls at 90 degrees to their long axis allowing 6 mm (1/4") movement before engaging and resisting wind loads in any lateral direction.
- .6 Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type KSR;
 - .2 Vibro-Acoustics Ltd.. Vibro-Acoustics Type RTR;
 - .3 Mason Industries Inc. Type RSC.

PART 3 - EXECUTION

3.1 Installation of Vibration Isolation Materials

- .1 Provide vibration isolation products for mechanical work in accordance and requirements specified herein and/or on the drawings.
- .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 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.
- .4 Unless otherwise specified, all vibration isolation products are to be the product of one manufacturer.
- .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.
- .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:
 - .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;
 - .2 all steel bases are to clear the sub-base by 25 mm (1");
 - .3 all concrete bases are to clear the sub-base by 50 mm (2").

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- .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:
- .1 for pipe to and including 100 mm (4") dia. – first three points of support;
 - .2 for pipe 125 mm (5") to 200 mm (8") dia. – first four points of support;
 - .3 for pipe 250 mm (10") dia. and larger – first six points of support;
 - .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");
 - .5 secure the top of the spring hanger frame rigidly to the structure, and do not install spring hangers in concealed locations;
 - .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.
- .8 **Piping Risers:** Isolate designated piping risers at floor support points in accordance with the drawing detail.
- .9 **Roof Curb Isolation:** Erect roof curb vibration isolation in accordance with instructions shipped with the assembly. Match vibration isolation with the associated roof top unit and orient the isolation as identified by manufacturer to ensure proper loading and optimum performance. Caulk the top of the roof curb with two beads of caulking provided and centre the isolation assembly onto roof curb and, unless otherwise noted, screw in place with 50 mm (2") lag screws at 900 mm (36") O.C. Position gasket on top rail or alternatively, caulk with two beads of caulking provided and orient and lower roof top unit onto the isolation rails and, unless otherwise noted, screw unit into top rail with 25 mm (1") lag screws at 900 mm (36") O.C. After roof top unit is secured in place, but before damageable work is installed, spray each isolated equipment assembly with water and correct any water leaks.
- .10 **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.
- .11 **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.

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- .12 **Seismic Restraint Isolation:** Refer to the mechanical work Section entitled Seismic Control and Restraint for requirements pertaining to seismically restrained vibration isolation.

END OF SECTION

Mechanical Insulation

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:

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- .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:

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- .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:

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- .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.

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- .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".

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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.

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- .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.

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- .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

- .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 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;
 - .4 chilled glycol solution piping, supply and return, to and including 100 mm (4") dia. – 25 mm (1") thick;
 - .5 chilled glycol solution piping, supply and return, larger than 100 mm (4") dia. – 40 mm (1½") thick;

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- .6 hot water heating piping, supply and return, to 40 mm (1½") dia. – 40 mm (1½") thick;
- .7 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];
- .8 all piping as above located inside building in unheated areas and indicated to be traced with electric heating cable – minimum 50 mm (2") 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.

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)

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- .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 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 Chilled water 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.

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- .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.

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- .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.

Mechanical Insulation

- .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

Mechanical Insulation

- .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.

Mechanical Insulation

- .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

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PART 1 - GENERAL

1.3 Description

- .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.

1.4 Quality Assurance

- .1 VFDs are to comply with following codes, regulations and standards (as applicable):
 - .1 applicable local codes and regulations;
 - .2 IEEE-519-1992
 - .3 NEMA MG-1 Motors and Generators
 - .4 Canadian Electrical Code (CSA 22.1-12)
 - .5 EN50082-1/2
 - .6 IEC 61800-3

1.5 Submittals

- .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.
- .2 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.
- .3 Certification Letter: Submit a start-up and installation certification letter from supplier of VFDs as specified in Part 3 of this Section;
- .4 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.
- .5 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.
- .6 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.

1.6 Coordination with Electrical Divisions

- .1 This Section specifies VFD requirements for motors. Ensure that VFDs packaged with various system equipment, complies with specifications of this Section.
- .2 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.

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- .3 Coordinate and review with Electrical Divisions, responsibility requirements for supply of VFDs, harmonic filters and requirements for control and power conductors and connections.
- .4 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.
- .5 Additionally, review and confirm responsibilities with Consultant and Prime Contractor.

PART 2 - MATERIALS AND PRODUCTS

2.1 Manufacturers

- .1 VFD Manufacturers may include the following:

- .1 Danfoss;
- .2 ABB;
- .3 Schneider Electric (Square D);
- .4 Rockwell Automation;
- .5 Eaton Cutler Hammer;
- .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.

- .2 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

- .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 Frequency stability of +/-0.05% for 24 hours with voltage regulation of +/-1% of maximum rated output voltage.
- .3 Speed regulation of +/- 0.5% of base speed.
- .4 Insensitive to input line rotation.
- .5 Humidity: 0 to 95% (non-condensing and non-corrosive).
- .6 Altitude: 0 to 3,300 feet (1000 meters) above sea level.
- .7 Ambient Temperature: 0 to 50 °C.
- .8 Storage Temperature: -40 to 60 °C.

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2.3 Power Requirements

- .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 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.
- .3 Drive output voltage shall vary with frequency to maintain a constant volt per hertz ratio up to motor base speed (typically 60 Hz).
- .4 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.
- .5 Normal Overload Capacity (Variable Torque) rated drives shall have a 1 minute overload rating equal to 120% of their continuous output current rating.
- .6 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.
- .7 The VFD shall maintain the line side displacement power factor at no less than 0.96, regardless of speed and load.

2.4 Enclosure

- .1 VFDs shall be provided in the following enclosures
 - .1 in climate controlled areas – NEMA 12;
 - .2 in non-climate controlled areas – NEMA 3R.
- .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.
- .3 All user serviceable parts shall be accessible from the front such that no rear access will be required.

2.5 Electronics

- .1 The VFD must pass the following standards for noise immunity and voltage transient protection:
 - .1 IEEE C62.41-1991 Category B (Voltage Transients up to 6000V)
 - .2 IEC EN50082-1/2 (Generic Immunity Standard)
 - .3 VFDs that have not been tested to these standards are not acceptable.
- .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.
- .3 All VFD circuit boards shall be conformal coated for maximum protection in harsh

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environments.

- .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.
- .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 Electronic Bypass

- .1 Electronic bypass system to be a fully operational horsepower rated manual and automatic system for full speed operation without VFD, with following components and features:
 - .1 factory wired and tested microprocessor controlled bypass system consisting of an output contactor and bypass contactor, service (isolation) switch and VFD input fuses; (bypass designs, which have no VFD only fuses, or that incorporate fuses common to both VFD and bypass will not be accepted);
 - .2 bypass enclosure door and VFD enclosure to be interlocked such that input power is turned off before either enclosure can be opened;
 - .3 door interlocked padlockable disconnect switch that disconnects all input power from drive and all internally mounted devices;
 - .4 following operators:
 - .1 bypass Hand-Off-Auto;
 - .2 drive mode selector and light;
 - .3 bypass mode selector and light;
 - .4 bypass fault reset;
 - .5 bypass LCD display, 2 lines for programming and status / fault / warning indications.
 - .5 motor protection from single phase power conditions; bypass system to detect a single phase input power condition while running in bypass, disengage motor in a controlled fashion, and give a single phase input power indication;
 - .6 bypass system does not depend on VFD for bypass operation; bypass to be completely functional in both Hand and Automatic modes even if VFD is removed from enclosure for repair / replacement;
 - .7 run permissive circuit - for damper or valve control; dry contact closure that will signal damper to open (VFD motor does not operate); when damper is fully open, a normally open dry contact (end-switch) closes; closed end-switch is wired to a VFD digital input and allows motor operation; two separate safety interlock inputs, when either is opened, motor to coast to stop, and damper to close;
 - .8 bypass control to monitor status of VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil; this failed contactor operation to be indicated on Bypass LCD display as well as over serial communications protocol;
 - .9 bypass control to include a programmable time delay for bypass start and control panel indication that this time delay is in process; this allows VAV boxes to be

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- driven open before motor operates at full speed in bypass mode; time delay to be field programmable from 0 - 120 seconds;
- .10 bypass control to be programmable for manual or automatic transfer to bypass; user to be able to select via control panel programming which drive faults will generate an automatic transfer to bypass and which faults require a manual transfer to bypass;
 - .11 adjustable motor current sensing circuit for bypass and VFD mode to provide proof of flow indication; condition is indicated on control panel display, transmitted over building automation protocol and on a relay output contact closure;
 - .12 programmable digital inputs, and programmable Form-C relay outputs;
 - .13 relay outputs from bypass to be programmable for any of following indications:
 - .1 system started;
 - .2 system running;
 - .3 bypass override enabled;
 - .4 drive fault;
 - .5 bypass fault;
 - .6 bypass H-O-A position;
 - .7 motor proof of flow (broken belt);
 - .8 overload;
 - .9 bypass selected;
 - .10 bypass run;
 - .11 system started (damper opening);
 - .12 bypass alarm;
 - .13 over temperature.
 - .14 digital inputs for system accept 24VAC or 24VDC; bypass incorporates internally sourced power supply and does not require an external control power source; bypass power board to supply 250 ma of 24 VDC for use by others to power external devices;
 - .15 interlock terminal strip: provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command; external safety interlocks to remain fully functional whether system is in VFD or bypass mode; remote start/stop contact to operate in VFD and bypass modes; terminal strip allows for independent connection of up to four (4) unique safety inputs;
 - .16 User is able to select text to be displayed on keypad when safety opens; example text display indications include "Firestat", "Freezestat", "Over pressure" and "Low pressure"; user is able to determine which of four (4) safety contacts is open over serial communications connection;
 - .17 Class 10, 20, or 30 (selectable) electronic motor overload protection is included as required for specific applications.

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2.7 Control Features

- .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 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
- .3 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).
 - .1 The VFD's PID regulator shall allow a pressure or flow signal to be connected for closed loop control.
- .4 The PID set point shall be adjustable from the terminal, by analog input or through communication network.
- .5 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.
- .6 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.
- .7 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.
- .8 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.
- .9 Password: The VFD shall include password protection to prevent parameter changes by unauthorized personnel.
- .10 Drive shall be capable of providing control for hardwired interlocks.
- .11 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.
- .12 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.

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- .13 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.

2.8 VFD Protective Features

- .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 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.
- .3 The VFD main PCB shall include isolated control circuitry.
- .4 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.
- .5 The VFD shall not require any additional external impedance (dc bus reactor or ac line reactor) to protect itself.
- .6 The VFD shall protect itself from the following through a normal shut down with no component damage or blown fuses.
 - .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 Damage due to a single phase condition on the input ac power line and/or the complete loss of input power
 - .3 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
- .7 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.
- .8 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.
- .9 The VFD shall include heat sink thermal protection to protect itself against excessively high ambient temperature conditions.
- .10 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.
- .11 The VFD shall be provided with Metal Oxide Varistors (MOVs) for transient voltage

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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.

- .12 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.
- .13 The VFD shall be capable of protecting the motor against damage during stall conditions.
- .14 The VFD shall include electronic thermal motor overload protection

2.9 VFD Operator Interface

- .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 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.
- .3 The VFD shall include a bright LED to indicate that voltage is present on the DC Bus.
- .4 The VFD main PCB shall have LED indicators to indicate: Drive in Current Limit and Microprocessor Active.
- .5 The Operator Interface Keypad shall:
 - .1 Allow frequently accessed VFD programmable parameters to be adjusted from the digital operator keypad located on the front of the VFD.
 - .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.
 - .3 Include adjustable contrast with large characters easily visible in normal ambient light.
 - .4 Include the ability to start and stop the drive, reset VFD faults, and manually adjust the VFD's speed reference.
- .6 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.
- .7 The Operator Interface shall be removable and remote mountable.
- .8 The display shall include the following status indicators (or equivalent) at a minimum:
 - .1 Run,
 - .2 Forward,
 - .3 Reverse,

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- .4 Stop,
 - .5 Ready,
 - .6 Alarm,
 - .7 Fault,
 - .8 Local,
 - .9 Panel,
 - .10 Remote,
 - .11 Hand,
 - .12 Auto,
 - .13 Test
 - .14 Bypass
 - .15 Off
- .9 The operator shall be able to scroll through the keypad menu to choose between the following (or equivalent):
- .1 Monitor
 - .2 Operate
 - .3 Parameter setup
 - .4 Actual parameter values
 - .5 Active faults
 - .6 Fault history
 - .7 LCD contrast adjustment
- .10 The following setups and adjustments, at a minimum, are to be available through the interface:
- .1 Start command from keypad, remote or communications port
 - .2 Speed command from keypad, remote or communications port
 - .3 Motor direction selection
 - .4 Maximum and minimum speed limits
 - .5 Acceleration and deceleration times, two settable ranges
 - .6 Critical frequency avoidance (minimum 3 with bandwidth control)
 - .7 Torque limit
 - .8 Multiple attempt restart function
 - .9 Multiple preset speeds adjustment
 - .10 Catch a spinning motor start or normal start selection
 - .11 Programmable analog output

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- .12 DC brake current magnitude and time
- .13 Proportional/Integral/Differential (PID) process controller
- .11 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:
 - .1 Output Speed (%)
 - .2 Motor RPM
 - .3 Motor Power (kW)
 - .4 Motor Current
- .12 The VFD interface shall be capable is displaying any monitored parameters.

2.10 Monitoring & Alarms

- .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:
 - .1 Output frequency
 - .2 Output speed (%)
 - .3 Motor current
 - .4 Motor torque
 - .5 Motor power (kW)
 - .6 Motor voltage (Output voltage)
 - .7 Motor RPM
 - .8 DC-link voltage
 - .9 Heatsink temperature
 - .10 Total operating days counter
 - .11 Total operating hours
 - .12 Operating hours (with reset function)
 - .13 Total megawatt hours
 - .14 Megawatt hours (with reset function)
- .2 Cost of electricity consumed by the drive for a given period (based on internal calculations and with reset function)
 - .1 Voltage level of analog input
 - .2 Current level of analog input
 - .3 Digital inputs status
 - .4 Digital and relay outputs status
 - .5 Motor temperature rise, percentage of allowable.

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- .6 Information to indicate the standard software and optional features software loaded.
- .3 The VFD shall transmit alarms to the BAS.
- .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.
- .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:
 - .1 Time of alarm
 - .2 Alarm Code
 - .3 Amperage at alarm
 - .4 Frequency at alarm
 - .5 DC Bus Voltage at alarm

2.11 Communications

- .1 The VFD shall be capable of communicating with the existing Building Automation System.
- .2 VFD shall be capable of digital communications through RS-232/422/485, USB,
- .3 The following protocols shall be embedded in the VFD and selectable via a parameter without any field programming to download software prior to operation:
 - .1 BacNet.
 - .2 ModBus RTU
 - .3 Metasys N2
 - .4 Optional adapters shall be available for Ethernet/IP, LonWorks, etc
- .4 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.
- .5 Digital Inputs
 - .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 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.
- .6 Analog Inputs
 - .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,

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- 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 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.
- .7 Digital Outputs
- .3 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.
- .4 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.
- .8 Analog Outputs
- .1 The VFD shall have two (2) analog output signals.
- .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.
- .9 Defined Parameters
- .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 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.
- .10 Provide communication cards and output signal conditioner card(s) as required to meet VFD communication requirements with the existing BAS system.
- .11 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

- .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.

Variable Frequency Drives

3.1 Training

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

3.2 Documentation & Warranty

- .1 The VFD manufacturer shall provide one (or more) copies of the VFD Operation and Maintenance Manual as part of the final documentation package.
- .2 The VFD manufacturer shall provide one (or more) copies of its list of recommended spare parts as part of the final documentation package.
- .3 The VFD manufacturer shall provide digital and physical copies of the start up reports for each unit.
- .4 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

Demolition and Revision Work

PART 1 - GENERAL

1.1 Application

- .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 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

- .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.
- .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 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.
- .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.
- .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.
- .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:
 - .1 Plumbing fixtures and fittings in good condition.

Demolition and Revision Work

3.2 Hazardous Waste

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

- .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 contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner in writing 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.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .5 **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".

3.4 Decommissioning or Alterations to Refrigeration Equipment

- .1 Remove and reclaim refrigerant from all applicable equipment to be decommissioned and/or altered. All refrigerant reclaim and recycling work is to be in accordance with Refrigerant Management Canada guidelines, and governing codes and regulations. Do not under any circumstances vent refrigerant from existing equipment to atmosphere.
- .2 Use refrigerant recovery equipment designed specifically to reclaim and recycle refrigerant, and use only skilled refrigeration mechanics to perform the reclaim and recycle work.
- .3 Provide approved, properly sized and sealable refrigerant containers for reclaimed refrigerant.
- .4 Hand the containers of refrigerant to the Owner at the site.
- .5 Dispose of reclaimed refrigerant by engaging the services of a licensed firm specializing in recycling of reclaimed refrigerant. Submit documentation to confirm that the refrigerant has been properly removed from the site and recycled or disposed of.

Demolition and Revision Work

3.5 Roofing Work

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

END OF SECTION

Testing, Adjusting and Balancing

PART 1 - GENERAL

1.1 Application

- .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 **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.
- .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.
- .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.
- .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.
- .5 **Draft Report:** Submit a draft report, as specified in Part 3 of this Section.
- .6 **Final Report:** Submit a final report, as specified in Part 3 of this Section.
- .7 **Warranty:** Submit a testing and balancing warranty as specified in Part 3 of this Section.
- .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 The following are definitions of words used in this Section:
 - .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.;
 - .2 "hydronic systems" – includes heating water, chilled water, glycol-water solution, condenser water, and any similar system;
 - .3 "air systems" – includes all outside air, supply air, return air, exhaust air, and relief air systems;
 - .4 "flow rate tolerance" – means the allowable percentage variation, minus to plus, of actual flow rate values in the Contract Documents;
 - .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

Testing, Adjusting and Balancing

accepted, should also form the permanent record to be used as the basis for required future testing, adjusting and balancing;

- .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;
- .7 “main” – means the duct or pipe containing the system’s major or entire fluid flow;
- .8 “submain” – means the duct or pipe containing part of the systems’ capacity and serving two or more branch mains;
- .9 “branch main” – means duct or pipe servicing two or more terminals;
- .10 “branch” – means duct or pipe serving a single terminal.

1.4 Quality Assurance

- .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 AABC - Associated Air Balance Council;
 - .2 NEBB - National Environmental Balancing Bureau;
- .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 National Standards For A Total System Balance published by the Associated Air Balance Council;
 - .2 Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems published by the National Environmental Balancing Bureau;
 - .3 Chapter 39, Testing, Adjusting, and Balancing of ASHRAE Handbook HVAC Applications.

1.5 Acceptable list of TAB firms:

- .1 Air Adjustments & Balancing Inc.;
- .2 Designtest & Balancing Co Ltd.;
- .3 Dynanic Flow Balancing;
- .4 Enviro Balance Inc.;

PART 2 - PRODUCTS

Testing, Adjusting and Balancing

Not Applicable

PART 3 - EXECUTION

3.1 Scope of Work

- .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.
- .2 Mechanical systems to be tested, adjusted and balanced include:
 - .1 **Domestic Water Systems:** TAB of domestic water systems (all piping extended from the Municipal main) is to include:
 - .1 domestic hot water recirculation piping;
 - .2 tempered water piping flows.
 - .2 **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 **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".
 - .4 **Air Handling Systems:** TAB of air handling systems is to include all equipment and ductwork air temperatures, capacities and flows.
 - .5 **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

- .1 **General Requirements:** Conform to the following requirements:
 - .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;
 - .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 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;

Testing, Adjusting and Balancing

- .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;
- .5 testing, adjusting and balancing is not to begin until:
 - .1 building construction work is substantially complete and doors have been installed;
 - .2 mechanical systems are complete in all respects, and have been checked, started, adjusted, and then successfully performance tested.
- .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;
- .7 obtain copies of reviewed shop drawings of all applicable mechanical plant equipment and terminals, and temperature control diagrams and sequences;
- .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;
- .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;
- .10 wherever possible, the Agency is to lock all balancing devices in place at the proper setting, and permanently mark settings on all devices;
- .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;
- .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;
- .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;
- .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;
- .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

Testing, Adjusting and Balancing

instruments with minimum accuracy which are within plus or minus 2% of required values;

- .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;

- .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.

.2 **Preparation of Reports:** Prepare reports as indicated below.

- .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.

- .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 **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:

- .1 General Information and Summary;
- .2 Air Systems;
- .3 Hydronic Systems;

- .4 **Report Contents:** The Agency is to provide the following minimum information, forms and data:

- .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;
- .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 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

Testing, Adjusting and Balancing

equipment, terminals, and accessories;

- .4 the Agency is to include report sheets indicating building comfort test readings for all rooms.
- .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.
- .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.

END OF SECTION

Performance Verification Mechanical Piping Systems

PART 1 - GENERAL

1.1 Summary

.1 Related Sections:

- .1 Section 20 05 05 - Common Work Results for Mechanical
- .2 Section 20 05 40 – Mechanical Work Commissioning
- .3 Section 20 05 50 - Testing, Adjusting and Balancing

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.

1.3 Cleaning & Start-Up of Mechanical Piping Systems

- .1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

1.4 Hydronic Systems - Performance Verification (PV)

- .1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.
- .2 When systems are operational, perform following tests:
 - .1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.
 - .2 Verify performance of hydronic system as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.
 - .1 Maximum cooling demand.
 - .2 Maximum heating demand.

1.5 Hydronic System Capacity Test

- .1 Perform hydronic system capacity tests after:
 - .1 TAB has been completed
 - .2 Verification of operating, limit, safety controls.
 - .3 Verification of primary and secondary pump flow rates.
 - .4 Verification of accuracy of temperature and pressure sensors and gauges.
- .2 Calculate system capacity at test conditions.
- .3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.
- .4 When capacity test is completed, return controls and equipment status to normal operating conditions.
- .5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.

Performance Verification Mechanical Piping Systems

- .6 Heating system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures to ensure that coils are not subjected to freezing conditions) or
 - .2 Reducing space temperature by turning of heating system for sufficient period of time before starting testing.
 - .2 Test procedures:
 - .1 Open fully heat exchanger, heating coil and radiation control valves.
 - .2 With hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.
- .7 Chilled water system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Adding heat from building heating system or;
 - .2 Raising space temperature by turning off cooling and air systems for sufficient period of time before starting testing and pre-heating building to summer design space temperature (occupied) or above. Set OAD and RAD for minimum outside air if OAT is near outside design temperature or to maximum recirculation if RAT is greater that OAT. RAT to be at least 23 degrees C minimum.
 - .2 Test procedures:
 - .1 Open fully cooling coil control valves.
 - .2 Set thermostats on associated AHU's for maximum cooling.
 - .3 Set AHU's for design maximum air flow rates.
 - .4 Set load or demand limiters on chillers to 100%.
 - .5 After system has stabilized, record chilled water, and condenser water flow rates and supply and return temperatures simultaneously.

1.6 Reports

- .1 In accordance with Section 20 05 40 - Mechanical Work Commissioning, supplemented as specified herein.

1.7 Training

- .1 In accordance with Section 20 05 40 - Mechanical Work Commissioning, supplemented as specified herein.
 - .1 Include following:
 - .1 Humidifier operation.
 - .2 Air vent operation.
 - .3 Control valve operation.

Performance Verification Mechanical Piping Systems

PART 2 - PRODUCTS

2.1 Not Used

PART 3 - EXECUTION

3.1 Not Used

END OF SECTION

Cleaning and Start-up of Mechanical Piping Systems

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.

Cleaning and Start-up of Mechanical Piping Systems

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.

Cleaning and Start-up of Mechanical Piping Systems

- .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).

Cleaning and Start-up of Mechanical Piping Systems

- .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

Hydronic Piping and Valves

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 piping and unions.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .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 **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.
- .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

- .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 **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

- .1 Ball Type: 1034KPA (150 psi) / 600 WOG Rating, brass or bronze body, full port, PTFE seats, double O-ring design, or PTFE packing, chrome plated solid ball, lever handle. Acceptable manufacturers are:
 - .1 Kitz Corporation;
 - .2 Crane;
 - .3 Toyo Valve Co.;
 - .4 Apollo Valves;
 - .5 Red-White Valve;
 - .6 M.A. Stewart & Sons Ltd.

2.4 Swing Check Valves

Hydronic Piping and Valves

- .1 **Bronze - Screwed:** 860KPA (125 psi) / 200 WOG rating, bronze body to ASTM B62, bronze trim, and Y-pattern. Acceptable manufacturers are:
 - .1 Kitz Corporation;
 - .2 Crane;
 - .3 Toyo Valve Co.;
 - .4 Red-White Valve;
 - .5 M.A. Stewart & Sons Ltd.
- .2 Gate Valves: 860KPA (125 psi) / 200 WOG rating cast or ductile iron body to ASTM A126 class B, bronze trim, OS & Y, flanged. Acceptable manufacturers are:
 - .1 Kitz Corporation;
 - .2 Toyo Valve Co.;
 - .3 M.A. Stewart & Sons Ltd.

2.5 Drain Valves

- .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 manufacturers are:
 - .1 Kitz Corporation;
 - .2 Toyo Valve Co.;
 - .3 Red-White Valve;
 - .4 M.A. Stewart & Sons Ltd.

2.6 Circuit Balancing Valves

- .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 manufacturers are:
 - .1 Tour and Andersson;
 - .2 Red-White Valve;
 - .3 Armstrong Fluid Technology;
 - .4 Victaulic.

PART 3 - EXECUTION

3.1 Demolition

- .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.

Hydronic Piping and Valves

3.2 Piping Installation Requirements

- .1 Provide all required hydronic piping. Pipe, unless otherwise specified, is to be:
 - .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;
 - .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 for short branch connections to heating equipment where structural obstructions occur and site bending of pipe is advantageous, a single length of type "L" soft copper.
- .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 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.
- .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.
- .5 Where steel piping is required to be buried, apply two coats of Densopaste (Denso of Canada Ltd.) primer to all buried surfaces after assembly and testing. Hot or cold applied tape as manufactured by Tapecoat, selected for the application and applied to manufacturer's instructions, is also acceptable.
- .6 **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.
- .7 **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.
- .8 **Check Valves:** Provide a check valve in the discharge piping of every pump, and elsewhere in piping where shown on the drawings. Where check valves are required in vertical piping, ensure that they are suitable in all respects for the application. Note that check valves for vertical in-line and/or base mounted circulating pumps are integral with the discharge accessory.

Hydronic Piping and Valves

- .9 **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.
- .10 **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

- .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

- .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

Hydronic Piping Specialties

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/product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 Pressure Relief Valves

- .1 ASME tested, rated, and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each capable of relieving 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:
 - .1 Bell & Gossett 3301/4100, or 790/1170;
 - .2 Dresser Industries "CONSOLIDATED";
 - .3 Spirax Sarco Ltd. SVI Series;
 - .4 McDonnell & Miller Models 250 and 260;
 - .5 Conbraco 10-600 Series;
 - .6 Watts Industries (Canada) Inc. 174A or 740.

2.2 Air Vents

- .1 **Automatic Air Vents:** Float actuated air vents, each complete with a semi-steel body and a cap, a stainless steel float assembly and seat, and a neoprene head. Acceptable products are:
 - .1 Spirax Sarco Ltd., Type 13 W for system working pressures to 1035 kPa (150 psi), 13 WH for system working pressures greater than 1035 kPa (150 psi);
 - .2 Armstrong International Inc. No. 1-AV.

2.3 Strainers

- .1 Cast iron wye shaped strainers, minimum 890 kPa (125 psi) rated and complete with a removable type 304 stainless steel screen with perforations sized to suit the application, and, for strainers 50 mm (2") diameter and larger, a blowdown pipe connection tapping. Acceptable products are:
 - .1 Spirax Sarco Ltd. Type IF-125 screwed or Type AF-250 flanged;
 - .2 Toyo Valve Co. Ltd. Fig. 380A screwed or Fig. 381 flanged;
 - .3 Victaulic Co. of Canada Style 732 or W732 "Vic-Strainer";
 - .4 Armstrong International Inc. A1 Series;
 - .5 Watts Industries (Canada) Inc. #77SCI;
 - .6 Mueller Steam Specialty Products Model 11M screwed or Model 758 flanged.

Hydronic Piping Specialties

2.4 Piping Alignment Guides

- .1 Prime coat painted black carbon steel pipe alignment guides sized and fabricated to suit the pipe size and the pipe insulation thickness. Acceptable products are:
 - .1 Senior Flexonics Ltd. Series PGT;
 - .2 E. Myatt & Co. Ltd. Fig. 1267;
 - .3 Empire Tool & Mfg. Inc. Fig 256;
 - .4 The Metraflex Co. Style IV.

2.5 Flexible Pump Connections

- .1 Flexible metal hose assemblies, each complete with annular corrugated unbraided type 321 stainless steel inner core, braided type 321 stainless steel hose, and a collar and flange at each end, all suitable for twice the working pressure of the system. Acceptable products are:
 - .1 Senior Flexonics Inc. A1 and A6 Series;
 - .2 The Metraflex Co. Model SST and "METRA-MINI".

2.6 Air Separator

- .1 Vortex type vertical air separator with side tangential inlet and outlet connections, a top air outlet connection, and bottom drain connection. The separator is to be constructed of cast iron or fabricated steel for a pressure of 1105 kPa (160 psi) at 180°C (350°F) in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.
- .2 Acceptable products are:
 - .1 Armstrong Fluid Technology Model "VA";
 - .2 Bell & Gossett "Rolairtrol";
 - .3 Taco Canada Ltd. "Vortech".

2.7 Expansion Tank

- .1 Replaceable bladder type, factory pressurized expansion tank with permanent separation of air and water, as per the drawing schedule and complete with:
 - .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 a heavy-duty butyl rubber (EDPM) bladder;
 - .3 a tapping for installation of a pressure gauge;
 - .4 for horizontal tanks only, mounting saddles supplied loose;
 - .5 Acceptable products are:
 - .1 Armstrong Fluid Technology Series "AX-V" Series "L";
 - .2 Bell & Gossett Series "B" (ASME);

Hydronic Piping Specialties

- .3 Taco Canada Ltd.;
- .4 Amtrol "Extrol".

2.8 Glycol Solution Mixing and Storage Tank

- .1 Package type glycol solution mixing, storage and automatic feed assembly designed to maintain minimum system pressure levels and complete with:
 - .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 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;
 - .3 a tank pressure relief valve with discharge piped back into the tank;
 - .4 a tank low level switch;
 - .5 a pressure gauge;
 - .6 a Honeywell #L404A "Pressurtrol" or equal pipe mounting differential pressure switch with a 100-1000 kPa (15-150 psi) range;
 - .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:
 - .1 terminal blocks for power and control wiring connections;
 - .2 a H-O-A switch with green "Power On" indicator light;
 - .3 a 120 volt/12 volt control transformer;
 - .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;
 - .5 dry contacts for building automation system alarm annunciation.
- .2 Acceptable products are:
 - .1 Ashland Water Technologies Model 5800;
 - .2 Bell & Gossett Series GMU;
 - .3 Armstrong Fluid Technology GLA Standard Series.

2.9 Glycol

- .1 Propylene glycol blended with Nitrite based corrosion inhibitors.

Hydronic Piping Specialties

PART 3 - EXECUTION

3.1 Installation of Pressure Relief Valves

- .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.
- .2 Pipe the discharge of each glycol solution piping relief valve back to the system expansion tank or return piping.
- .3 Confirm relief valve settings.

3.2 Installation of Air Vents

- .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.
- .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

- .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 Air Separator

- .1 Provide an air separator in piping where shown and connect with valved inlet and outlet piping.
- .2 Extend valved blowdown piping from the bottom pipe connection tapping to the nearest floor drain location.
- .3 Equip the top pipe connection tapping with an automatic air vent and piping as detailed.

3.5 Installation of Expansion Tank

- .1 Provide an expansion tank where shown.
- .2 Secure the tank stand to a concrete housekeeping pad by means of machine bolts. Connect the tank with system piping as indicated.
- .3 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.
- .4 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.
- .5 Check the tank air charge and adjust to suit the system.

3.6 Installation of Glycol Solution Mixing – Storage Tank

Hydronic Piping Specialties

- .1 Provide a mixing - storage tank and feed assembly for each glycol solution circulating system as shown.
- .2 Secure the tank stand to a concrete housekeeping pad. Connect with system piping. Refer to the drawing detail.
- .3 Fill the tank with, unless otherwise specified, a solution of 50% water, 50% propylene glycol, and test the solution to confirm proper concentrations.
- .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.

3.7 Installation of Flexible Piping Connections

- .1 Provide flexible connections in piping connections to equipment where shown and/or as required to prevent vibration transmission to the piping distribution system.
- .2 Install in accordance with the manufacturer's instructions.

END OF SECTION

HVAC Water Treatment

PART 1 - GENERAL

1.1 Submittals

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

- .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 Chemicals must be approved by governing authorities for release into Municipal sewer system.
- .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 Manufacturers/Suppliers of Chemicals and Feed Equipment

- .1 Acceptable manufacturers/suppliers are:
 - .1 Solenis;
 - .2 Klenzoid Inc.;
 - .3 Magnus Canada;
 - .4 Chem-Aqua Inc.;
 - .5 Cleaver-Brooks Inc.;
 - .6 Suez Water Technologies;
 - .7 Excalibur Water Systems;
 - .8 For open heat transfer system treatment only:
 - .1 Drew Chemical Canada;
 - .2 Lakos Filtration Solutions;
 - .3 Tower-Flo;
 - .4 Excalibur Water Systems;

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2.3 Existing Treatment Systems

- .1 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.

2.4 Piping System Flushing and Cleaning Chemical

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

2.5 Closed Heat Transfer System Treatment

- .1 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 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 tappings, and a screw-on cast iron cap with "Buna N" "O" ring seal.
- .3 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.
- .4 Piping tee mounting coupon holders, each complete with 25 mm (1") diameter NPT plugs with a minimum of one coupon for copper and one coupon for steel.
- .5 Chromate free, nitrite/borate type corrosion inhibitor suitable for use with both ferrous and non-ferrous metals.
- .6 Test kit for measuring inhibitor level.

PART 3 – EXECUTION

3.1 Piping System Flushing and Cleaning

- .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.
- .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 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.

HVAC Water Treatment

- .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.
- .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

- .1 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.
- .2 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

- .1 For all water treatment equipment include for on-site certification, start-up supervision, and system training by treatment chemical manufacturer's representative as follows:
 - .1 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements;
 - .2 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements;
 - .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

HVAC Air Distribution

PART 1 -GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all products specified in this Section except shop fabricated ductwork and fittings.

1.2 Quality Assurance

- .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

- .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 Rectangular
 - .1 Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum #26 gauge.
- .3 Round
 - .1 Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.

2.2 Flexible Connection Material

- .1 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:
 - .1 Duro Dyne Canada Inc. "DUROLON";
 - .2 Dyn Air Inc. "HYPALON".

2.3 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 tested maximum flame spread rating of 5 and smoke developed rating of 0.
- .2 Acceptable manufacturers are:
 - .1 Johns Manville;
 - .2 Manson Insulation;
 - .3 Knauf Insulation.

2.4 Casing And Plenum Material and Accessories

- .1 Unless otherwise specified, casing and plenum material is to be same as connecting

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duct material.

- .2 Accessories such as access doors and drain pans are to be constructed of same material as casing and plenum and are to be in accordance with Chapter 6 of SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.5 Plenum Access Doors

- .1 Factory fabricated, double wall insulated access doors, sized as indicated on drawings, and constructed of same material as connecting ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit operating pressure of the system.

2.6 Backdraft Dampers

- .1 Nailor Industries Model 1370CB counterbalanced backdraft dampers, vertical or horizontal mounting, 50 mm (2") wide, sized as shown and complete with:
 - .1 extruded 6063-T5 aluminum frame, 2.3 mm (0.090") nominal wall thickness, with mitred corners;
 - .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;
 - .3 corrosion-resistant synthetic bearings;
 - .4 adjustable plated steel counterweights mounted internally in the airstream;
 - .5 concealed blade linkage located out of the airstream.
- .2 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 T.A. Morrison & Co. Inc. "TAMCO";
 - .3 Pottorff;
 - .4 Greenheck Fan Corp.;
 - .5 Ruskin Co.

2.7 Duct Access Doors

- .1 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.

PART 3 - EXECUTION

3.1 Cleanliness Requirements for Handling and Installation of Ductwork

- .1 Handle and install ductwork in accordance with SMACNA's Duct Cleanliness for New Construction Guidelines at the Advanced Level.

3.2 Fabrication and Installation of Galvanized Steel Ductwork

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- .1 Provide required ductwork, rectangular, round and/or flat oval. Where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.
- .2 It is to be understood that all duct dimensions shown on drawings are clear internal dimensions.
- .3 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.
- .4 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.
- .5 Clean exterior exposed (uninsulated) ducts and coat with a heavy full coverage of Bakor #410-02 black metal paint.
- .6 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material.

3.3 Installation of Casing and Plenum Access Doors

- .1 Provide access doors into all site or shop fabricated casings and plenums requiring access, and wherever shown.
- .2 Construct access doors to open in or out to suit positive and negative pressures of system.
- .3 Provide pitot tube openings in access doors where required for system air quantity balancing purposes.
- .4 Provide suitably sized, engraved, red-white laminated Lamacoid warning nameplates on access doors into casings and plenums where equipment is located, i.e. fans.

3.4 Installation of Backdraft Dampers

- .1 Provide backdraft dampers.
- .2 Install and secure dampers so they cannot move or rattle.

3.5 Installation of Flexible Connection Material

- .1 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.
- .2 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.

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3.6 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 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 ductwork to suit access door installed.

3.7 Duct System Protection, Cleaning and Start-Up

- .1 Temporarily cover all open ends of ducts during construction.
- .2 Remove all dirt and foreign matter from entire duct systems and clean duct system terminals and interior of air handling units prior to operating fans.
- .3 Prior to starting any supply air handling system provide 50 mm (2") thick glass fibre construction filters at fan equipment in place of permanent filters.
- .4 Provide cheesecloth over duct system inlets and outlets and run system for 24 hours, after which remove cheesecloth and construction filters, and install new permanent filters.
- .5 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

Ductwork - Standard

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.

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 Flexible Metallic Ductwork

- .1 **Bare:** Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, SMACNA Form "M-UN", ULC-S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, and supplied in 3 m (10') lengths.
- .2 **Insulated:** Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, SMACNA Form "M-I", ULC-S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, supplied in 3 m (10') lengths and factory covered with 40 mm (1½") thick, 12 kg/m³ (0.75 lb/ft³) density fibreglass insulation with a vinyl jacket meeting flame spread and smoke developed requirements of CAN/ULC-S102.

2.3 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.

2.4 Acoustic Lining

- .1 Minimum 25 mm (1") thick acoustic lining material meeting NFPA 90A requirements and flame spread and smoke developed fire hazard ratings of CAN/ULC-S102, flexible for round ducts, board type for rectangular ducts, consisting of a bonded fiberglass mat coated on the inside (airside) face with a black fire-resistant coating.

PART 3 - EXECUTION

Ductwork - Standard

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** 500 Pa (2.0" w.c.) positive or negative as applicable, a maximum 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 **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.
- .4 **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.
- .5 **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.
- .6 **Automatic Control Components:** Install (but do not connect) all duct system mounted automatic control components supplied as part of the automatic control work.
- .7 **Heat Transfer Equipment Connections:** Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.
- .8 **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.
- .9 **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").
- .10 **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.

Ductwork - Standard

- .11 **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.**
- .12 **Support of Roof Mounted Ducts:** As specified in the mechanical work Section entitled Duct System Dampers and Accessories.
- .13 **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.
- .14 **Protective Coating for Exposed Exterior Ducts:** Clean exterior exposed (uninsulated) ducts with a heavy full coverage of Bakor #410-02 black metal paint.

3.2 Installation Of Flexible Ductwork

- .1 Provide maximum 3 m (10') long lengths of flexible ductwork for connections between galvanized steel duct mains and branches, and necks of ceiling grilles and diffusers. Do not install flexible ductwork through walls, even if shown on the drawings.
- .2 At rectangular galvanized steel duct, accurately cut holes and provide flanged or "Spin-in" round flexible duct connection collars. Seal joints with duct sealer.
- .3 Install flexible ducts as straight as possible and support in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, and secure at each end with nylon or stainless steel gear type clamps, and seal joints. Provide long radius duct bends where they are required.
- .4 Do not penetrate fire barriers with flexible duct.

3.3 Installation Of Acoustic Lining

- .1 Provide acoustic lining in ductwork in locations as follows:
 - .1 wherever shown and/or specified on the drawings;
- .2 Install lining in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, however, for all installations regardless of velocity, at leading and trailing edges of duct liner sections, provide galvanized steel nosing channel as per the detail entitled Flexible Duct Liner Installation found in the ANSI/SMACNA manual referred to above.

3.4 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.

Ductwork - Standard

- .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

Duct Dampers & Accessories

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.

2.3 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.

Duct Dampers & Accessories

.5 Acceptable manufacturers are:

- .1 Nailor Industries Inc.;
- .2 T.A. Morrison & Co. Inc. "TAMCO";
- .3 Pottorff;
- .4 Price Industries Ltd.;
- .5 Ruskin Co.

2.4 Backdraft Dampers

.1 T. A. Morrison & Co. Inc. "TAMCO" counterbalanced backdraft dampers, Series 7000 WT for vertical mounting, Series 7000 CW for down (horizontal) mounting, 65 mm (2½") deep, sized as shown and complete with:

- .1 extruded aluminum frame and blades, minimum 1.58 mm (1/16") thick, with captive extruded silicone blade gaskets and side seals in slots integral with the aluminum extrusions;
- .2 damper blade counterweights internal to the frame and consisting of adjustable weights fastened to brackets which are riveted to the blades;
- .3 dual PVC linkage tracks at each end of the blades, and non-corrosive linkage with hard alloy aluminum pivot arm and Ticona "Celcon" acetal copolymer bearings.

.2 Acceptable manufacturers are:

- .1 T.A. Morrison & Co. Inc. "TAMCO";
- .2 Nailor Industries Inc.;
- .3 Pottorff;
- .4 Price Industries Ltd.;
- .5 Ruskin Co.

2.5 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 74°C (165°F) rated standard fusible link [100°C (212°F) high temperature 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 Acceptable fusible link damper manufacturers are:

- .1 Nailor Industries Inc.;
- .2 Price Industries Ltd.;

Duct Dampers & Accessories

- .3 Pottorff;
- .4 Ruskin Co.

2.6 Flexible Connection Material

- .1 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:
 - .1 Duro Dyne Canada Inc. "DUROLON";
 - .2 Dyn Air Inc. "HYPALON".

2.7 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.

2.8 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.

2.9 Instrument Test Ports

- .1 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.

2.10 Wire Mesh (Birdscreen)

- .1 Heavy-gauge galvanized steel or aluminum mesh, 12 mm x 12 mm ($\frac{1}{2}$ " x $\frac{1}{2}$ ") secured in a rigid galvanized steel or aluminum framework, sized as indicated on the drawings, and constructed so as to be removable.

2.11 Louvres

- .1 Price Industries Inc. DE439 or DE635 100 mm (4") or 150 mm (6") deep (to suit wall thickness) factory assembled stationary, drainable, storm-proof louvres sized as indicated on the drawings, each AMCA water penetration and air performance certified, constructed of welded, extruded, alloy 6063-T5 aluminum with drainable blades, mounting and securing hardware to suit the application, and 12 mm ($\frac{1}{2}$ ") mesh aluminum birdscreen in an aluminum frame.
- .2 Louvres are to be factory finished with a finish equal to PPG Industries "Duranar" fluoropolymer powder coating over primer with colour as selected from the manufacturer's standard colour chart or match the colour sample as per architect's direction.
- .3 Acceptable manufacturers are:

Duct Dampers & Accessories

- .1 Price Industries Inc.;
- .2 Ventex Inc.;
- .3 Construction Specialities;
- .4 Nailor Industries Inc.;
- .5 Greenheck Fan Corp.

2.12 Motorized Control Dampers

- .1 T.A. Morrison & Co. Inc. "TAMCO", 100 mm (4") deep, flanged aluminum control dampers with AMCA certified maximum leakage through a 1.2 m x 1.2 m (4' x 4') damper of 52 L/s/m² (110 ft³/min) against 1 kPa (0.145 psi) differential static pressure. Control dampers for mixing applications are to be parallel blade type. Control dampers for open-shut service are to be opposed blade type.
- .2 **Standard Damper:** Series 1000 dampers complete with:
 - .1 extruded 6063T5 aluminum frame and blades, each with an integral slot to receive a gasket;
 - .2 extruded silicone frame gaskets and extruded EPDM blade gaskets;
 - .3 slip-proof aluminum and corrosion resistant plated steel linkage concealed in the frame, equipped with self-sealing and self-lubricating bearings consisting of a Ticona "Celcon" inner bearing fixed on the hexagonal blade pin and rotating in a polycarbonate outer bearing inserted in the frame.
- .3 **Insulated Damper:** As specified for standard dampers but with all four sides of the frames insulated with injected polyurethane foam, and with the blades thermally broken and insulated with expanded polyurethane foam.
- .4 **Damper Motor:** Equal to Belimo CSA certified, spring return, direct coupled electric motor damper actuator, 120 volt or 24 volt as required, electronic overload protected, complete with position indicator, a housing to suit the mounting location, and additional features as required to suit the application and control sequence.

2.13 Thermostats

- .1 Equal to Johnson Controls surface wall mounting thermostats, line voltage or low voltage and single or double stage as required, each complete with a factory set 0.55 to 1°C (1 to 1.8°F) dead band, locking cover, tamper-proof concealed adjustment set point dial, and a thermometer.

Duct Dampers & Accessories

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.

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 Backdraft Dampers

- .1 Provide backdraft dampers where shown.
- .2 Install and secure the dampers so that they cannot move or rattle.

3.5 Installation of Fusible Link Dampers

- .1 Provide fusible link dampers where shown and/or specified on the drawings. Ensure that the damper rating (1½ 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.

Duct Dampers & Accessories

- .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.

3.6 Installation of Flexible Connection Material

- .1 Provide a minimum of 100 mm (4") of flexible connection material where ducts, plenums, and/or easings connect to fans, air handlers and wherever else shown or specified.
- .2 Rigidly secure a minimum of 75 mm (3") of duct material (minimum #24 gauge) to each edge of the flexible fabric and to the fan, duct, plenum, etc., in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Ensure that connections to the flexible fabric material are arranged and supported so as to not impose any external forces on the fabric.

3.7 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.

3.8 Installation of Instruments Test Ports

- .1 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.
- .2 Locate test ports where recommended by personnel performing air quantity testing and balancing work.

3.9 Installation of Wire Mesh (Birdscreen)

- .1 Provide framed, removable wire mesh panels over openings in ducts and/or walls where shown and/or specified on the drawings. Rigidly secure in place but ensure the panels are removable.
- .2 Provide wire mesh panels for open-end return air ducts in ceiling spaces whether shown on the drawings or not.

3.10 Installation of Louvres

- .1 Provide louvres for wall openings where shown.

Duct Dampers & Accessories

- .2 Install louvre assemblies and secure in place in accordance with the manufacturer's instructions and details.
- .3 Confirm exact louvre sizes and finish prior to ordering.

3.11 Installation of Motorized Control Dampers

- .1 Provide motorized control dampers where shown. Secure in place to prevent movement or rattle, and to prevent air bypass around the damper.
- .2 Provide insulated dampers in fresh air intake ductwork or openings, and for exhaust air service at exterior walls.
- .3 Equip each damper with an electric motor actuator, 120 volt or 24 volt as required. Ensure that each actuator is equipped with all required features to suit the application.

3.12 Installation Of Thermostats

- .1 Supply thermostats for control systems and mount on an outlet box approximately 1.6 m (5') above the floor where shown.
- .2 Connect thermostats with control wiring in accordance with the drawings and the wiring requirements specified below in this Section.
- .3 Check thermostat operation and adjust to design requirements.

3.13 Control Wiring

- .1 Provide all required power wiring for controls from 15A-1P circuits terminated in junction boxes adjacent to the control work and do all control wiring to connect control components.
- .2 Install wiring in conduit in accordance with electrical work wiring material and installation requirements.

END OF SECTION

Air Filters and Accessories

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 Document.
- .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

- .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 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.
- .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.
- .4 Acceptable filter manufacturers are:
 - .1 AAF International;
 - .2 Camfil Farr Inc.;
 - .3 Modern Air Filter Corp.;
 - .4 Daeco.

2.2 Construction Filters

- .1 Roll type, disposable, MERV 7 to 9 woven glass fibre media, UL Class 2.

2.3 Dial Type Air Filter Gauge

- .1 Dwyer Instruments Inc. Series 2000 "Magnehelic" differential dial type filter gauge, accurate to within $\pm 2\%$ of full scale and complete with a die-cast aluminum housing and bezel, acrylic cover, over-pressure relief plug, a pair of 3.2 mm (1/8") dia. female NPT pressure taps at both the side and back of the gauge, two pressure tap plugs, flexible vinyl tubing, a scale overlay or marker to indicate dirty filters, and all other required mounting and connection accessories.
- .2 Each filter gauge is to be complete with contacts suitable for connection into the building automation system.

PART 3 - EXECUTION

Air Filters and Accessories

3.1 Installation of Construction Filters

- .1 Provide roll type medium efficiency disposable media filter(s) across the entire filter bank of each supply air handling unit, either at the factory where the fan is produced or at the site as soon as the fan is installed. Secure the media in place so it will not be dislodged by fan operation. Replace the roll media periodically if it becomes loaded and clogged.
- .2 For exhaust systems, secure the filter media across exhaust air openings and ductwork to prevent construction dirt and dust from fouling the fan
- .3 Leave the media in place until fan start-up, at which time remove and dispose of the construction media.

3.2 Installation of Filters

- .1 Provide all required filter media when fan equipment is ready for start-up and performance testing. Provide any required filter framing/racks.
- .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.

3.3 Installation of Dial Type Filter Gauges

- .1 Provide dial type filter gauges for air handling system filter banks.
- .2 Secure gauge to filter section casing and install differential pressure tubing and accessories. Set gauges to suit fresh clean filter media and mark scales at point where filter media requires replacement.

END OF SECTION

Air Cooled Water Chillers

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit chiller shop drawings/product data sheets, complete with piping and power and control wiring schematics, accessories, rated capacities, weights, and all other data to confirm that the chiller proposed meets all requirement of the Contract Documents.
- .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.
- .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 **Extended Compressor and Motor Warranty:** Submit a signed copy of the chiller manufacturer's extended four year parts and on-site labour warranty, in the name of the Owner, for the compressor and motor. The terms and conditions of the warranty are to be the same as the Contract warranty.
- .5 **Manufacturer's Local Service Agency:** Submit the name and address of the chiller manufacturer's local (to project) service representative.

1.2 Quality Assurance

- .1 **Codes and Regulations:** Chillers and installation of chillers are to be in accordance with requirements of the following:
 - .1 all applicable Provincial Codes and Standards;
 - .2 CSA-B52, Mechanical Refrigeration Code;
 - .3 ANSI/ASHRAE 15, Safety Code for Mechanical Refrigeration;
 - .4 ARI Standard 550/590, Standard for Water Chilling Packages Using the Vapor Compression Cycle.
- .2 **Installation Tradesmen:** Chiller installation tradesmen are to be journeyman tradesmen licensed to install chiller equipment.
- .3 **Manufacturer's Local Service Representation:** The chiller manufacturer is to be represented in the locale of the Project by an experienced, factory trained service agency with a fully stocked parts department and personnel available seven days a week. Submit the name of the agency with shop drawings/product data.

PART 2 - PRODUCTS

2.1 Air Cooled Packaged Water Chiller

Air Cooled Water Chillers

- .1 Factory assembled, factory run performance tested, package type, water cooled chiller as per the drawing schedule, designed to operate with R-32 refrigerant only, ULC listed, CSA approved, performance efficiency rated and shipped on a structural steel base with a full operating charge of refrigerant and oil. Unless otherwise specified, capacities are to be based on a 0.0001 fouling factor allowance on the evaporator and based on a 0.00025 fouling factor allowance on the condenser tube. The chiller is to be factory finished with alkyd equipment enamel applied to cleaned surfaces.
- .2 **Evaporator and Condenser:** Cleanable shell and removable finned tube type, 1035 kPa (150 psi) rated, complete with:
 - .1 removable flanged and gasketed water heads suitable for grooved end pipe and mechanical coupling joint type field connections;
 - .2 vent and drain taps, liquid shut-off valve, purge valve, and reseatable spring loaded relief valves;
 - .3 a CRN on each shell;
 - .4 a pilot operated thermal expansion valve to meter refrigerant flow from 100% to 10%, with superheat maintained at or below -17°C (1°F) under all load conditions;
 - .5 vapour-proof flow switches equal to McDonnell & Miller Series FS7-4, CSA certified flow switches supplied loose for site installation in chilled and condenser water piping;
- .3 **Purge or Pump-Out System:** Chillers are to be complete with a separate refrigerant purge system that operates independently of the unit and can be operated while the chiller is shut-down, or, have the capability of storing the entire refrigerant charge in the condenser, or have a refrigerant pump-out system with transfer pump and storage tank.
- .4 **Compressor and Motor:** Centrifugal compressor(s) with a fully shrouded and dynamically balanced aluminium impeller over-speed tested at 1.25 times impeller shaft speed, mounted to a high grade steel alloy shaft and complete with:
 - .1 aluminum insert, hydrodynamic, sleeve type or equal bearings with an infinite life rating;
 - .2 a factory mounted, positive displacement submerged oil pump with oil cooled by an external factory mounted water cooled heat exchanger, and equipped with all necessary controls and piping to operate the oil pump and cooler capacity control accomplished by the use of hydraulically operated inlet guide vanes and moveable discharge diffuser, with capacity controls designed to allow modulation from 100% to 10% of scheduled conditions without the use of hot gas bypass, and no linkage penetrations through the castings;
 - .4 a hermetic or semi-hermetic refrigerant cooled, high efficiency type motor conforming to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods and UL 984, with thermistors in the three windings factory wired to the control panel to stop the compressor if excessive temperature is sensed;
 - .5 an integral crankcase heater and controls.

Air Cooled Water Chillers

- .5 **Factory Applied Insulation:** Minimum 20 mm ($\frac{3}{4}$ ") thick closed cell sheet foam insulation factory applied to all low temperature surfaces including the evaporator and water boxes, suction line, motor housing, and accessories, with fire hazard ratings for flame spread and smoke developed in accordance with requirements of CAN/ULC-S102, and equal to Armacell "AP/Armaflex" insulation with Armacell #520 contact adhesive and a finish coat of Armacell "WB Armaflex" latex enamel.
- .6 **Refrigerant Circuits:** Each compressor is to be complete with a separate independent refrigerant circuit, and each circuit is to be complete with:
 - .1 isolating valves to permit the total refrigerant charge to be isolated in either the high or low pressure side shell during service;
 - .2 liquid line and discharge line service valves, filter dryer, combination moisture indicator-sight glass, charging port and valve, liquid line solenoid valve, and electronically controlled expansion valve;
 - .3 factory installed suction and discharge pressure gauges conforming to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods;
 - .4 an automatic resetting pressure relief valve (rupture discs are not acceptable).
- .7 **Motor Starter:** The chiller is to be equipped with a factory mounted and wired solid state motor starter in accordance with UL 508 requirements and installed in a ventilated EEMAC 2 enclosure with hinged door and locking type retaining latches. The starter mode is to be closed loop current control and is to provide a smooth acceleration of the motor without current transitions or transients. The starter is to be complete with:
 - .1 copper mechanical type incoming line lugs, and a terminal block for control wiring connections;
 - .2 a properly sized control power transformer with fused primary and secondary, and current transformers of the proper size, ratio and burden capacity to provide a signal to the control panel and optional devices;
 - .3 control relays and associated hardware to interface with the control panel for conditions that include:
 - .1 current phase loss;
 - .2 current phase unbalance;
 - .3 current phase reversal;
 - .4 over/under line voltage;
 - .5 motor current overload during start-up and running;
 - .6 momentary power loss protection with auto restart consisting of three-phase current sensing devices that monitor the status of the current;
 - .7 starter contactor fault protection;
 - .8 starter transition failure;
 - .9 transient voltage protection to the SCR's through RC snubbers and MOV's connected line-to-line and line-to-ground;

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- .10 high heat sink temperature protection;
- .11 motor thermistor high winding temperature.
- .4 a non-fused door interlock disconnect switch or circuit breaker.
- .8 **Factory Installed Pump Packages**
 - .1 Provide a factory mounted and wired pump package for each chiller as scheduled. The chiller controller shall provide a pump start/stop signal when operation is required. On dual pump systems, the chiller shall incorporate automatic alternating of pump starts and duty/standby functionality.
 - .2 **Single Pump:** Supply as scheduled, a vertical in-line, radially split-case pump. The motor and pump rotating assembly shall be serviceable without removing the pump casing from the line.
 - .3 Pump package shall also be equipped with "Y" type inlet strainer; combination triple-duty outlet valve having a drip-tight discharge shutoff valve; non-slam check valve and flow throttling valve; combination suction guide with flow stabilizing outlet vanes and stainless steel strainer with a disposable fine-mesh strainer for start-up; flow switch; interconnecting schedule 40 piping with Victaulic couplings and insulation of all cold surfaces.
 - .4 Provide water pressure gauges on the suction and discharge side of the pump.
 - .5 VFD software shall provide automatic speed control in variable volume systems without the need for pump mounted (internal/external) or remotely mounted differential pressure system feedback sensor(s). Control mode setting and minimum / maximum head and flow set-points shall be set at the factory and be user adjustable via the inbuilt programming interface.
- .9 **Control Panel:** Unit mounted, factory wired control panel with DDC microprocessor based control system with super VGA colour monitor with touch screen data entry requiring password security to prevent unauthorized access. All required pressure and temperature sensors are to be factory mounted. The control system is to be completed with Bacnet interface for integration with the building automation system and is to be complete with the following features:
 - .1 operating data display for:
 - .1 entering and leaving, chilled and condenser (and heat recovery if applicable) water temperatures;
 - .2 evaporator, suction, discharge, condensing and liquid refrigerant temperatures;
 - .3 evaporator, condenser and lift pressure;
 - .4 actual motor amps and motor amps as a percent of RLA;
 - .5 oil feed and sump temperature, and oil pressure;
 - .6 total hours of operation and number of starts;
 - .7 hours since last start;

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- .8 unit status including start-up and shut-down sequence, and operational status;
- .9 entering water reset Off/On;
- .10 remote reset Off/On;
- .11 soft loading Off/On;
- .12 low pressure unloading Off/On;
- .13 maximum ampere limit Off/On;
- .14 remote ampere limit Off/On;
- .15 manual ampere limit;
- .16 leaving evaporator set-point;
- .17 reset leaving set-point;
- .18 remote reset signal;
- .19 fault history (last 25 faults) with time and related operating conditions;
- .20 critical sensor values at time of fault;
- .21 trend log data in graphic format.
- .2 monitoring and display of the alarm conditions as follows:
 - .1 no starter transition;
 - .2 low/high oil sump temperature;
 - .3 low evaporator pressure;
 - .4 high discharge pressure/temperature;
 - .5 compressor surge;
 - .6 low refrigerant charge;
 - .7 no evp/cds flow;
 - .8 low oil pressure;
 - .9 high motor current;
 - .10 sensor failure.
- .3 microprocessor features as follows:
 - .1 the microprocessor is to employ P.I. control algorithms to ensure precise leaving water temperature control without hunting, drooping or overshooting the setpoint;
 - .2 the microprocessor is to have the option of limiting and the amp draw to a user selected value from 30 to 100% of rated load amps and the controller is to use a softload function to prevent the chiller from operating at full load during initial pull down;

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- .3 the microprocessor is to have the option of resetting the chilled water setpoint and demand limiting from 4-20 mA remote signals from the building automation system, and, in addition, the chilled water set-point is to be resettable by return water temperature if so programmed, and the control panel is to be capable of starting the chiller from a remote signal;
 - .4 the microprocessor is to include Surge Guard protection, and upon recognition of a surge situation the controller is to shutdown the chiller and announce an alarm condition;
 - .5 the microprocessor is to include output contacts for operating the chilled water and condenser water pumps;
 - .6 the microprocessor is to include a time clock for chiller operation including programmable holiday schedule to override a weekly schedule, and a manual override time period;
 - .7 auto-restart after a power failure is to be provided, and microprocessor memory is to be non-volatile requiring no battery back-up while maintaining programmed data during an extended shut down or power failure;
 - .8 input/output boards are to be optically isolated to prevent transients or incorrect voltage from entering the microprocessors, and all field wiring is to terminate at a separate terminal strip;
 - .9 the microprocessor is to have an auto-logging feature that will automatically log chiller functions at a time of daily peak load or at present time and store up to six weeks of accumulated data, and is to be downloadable via on board CD drive;
 - .10 the microprocessor is to have pre-alarm logic for high and low pressure controls, and logic is to take corrective action to avoid an alarm trip, and the unit is to display pre-alarm warnings for low and high superheat, low oil temperature and high oil temperature;
 - .11 the microprocessor is to inhibit loading and activate unloading to control low evaporator pressure conditions;
 - .12 the microprocessor is to contain four digital outputs for control of cooling tower fans and an analog output for control of a cooling tower fan or bypass valve control, and digital and analog outputs are to be programmable.
- .10 **Vibration Isolation:** Closed spring mounts, supplied loose with the chiller for field installation, suitable in all respects for the application, and conforming to requirements specified in the mechanical work Section entitled Mechanical Vibration Control.
- .11 **Start-Up and Commissioning:** A factory trained member of the chiller manufacturer's/supplier's personnel is to be available on-site for the length of time required during initial examination and certification of the installation, start-up and commissioning procedures, and for O & M training, all as specified in Part 3 of this Section.
- .12 **Acceptable Manufacturers:** Acceptable chiller manufacturers are:
- .1 Daikin-McQuay;

Air Cooled Water Chillers

- .2 Trane Canada Inc.;
- .3 Carrier Enterprise Canada;
- .4 Johnson Controls York.

PART 3 - EXECUTION

3.1 Installation of Chiller

- .1 Provide water chiller(s) where shown. Comply with the chiller manufacturer's instructions for rigging, unloading, and transporting the equipment.
- .2 Secure the chiller in place, level, and plumb, on vibration isolation on a concrete housekeeping pad.
- .3 Install flow switches and other accessories supplied loose with the chiller. Install flow switches in accordance with the manufacturer's instructions in horizontal piping with a minimum of five pipe diameters spacing from any elbow, valve, or pipe restriction on each side of the switch.
- .4 Provide drain valves and vent cocks for each water box. Provide piping for the compressor oil cooler as per the chiller manufacturer's instructions. Connect to shut-down the chiller upon sensing loss of flow.
- .5 Provide all required refrigerant and oil.
- .6 Provide Schedule 40 black steel piping from each refrigerant circuit relief valve to atmosphere. Ensure that the piping is securely braced and anchored. Terminate piping with a bronze screened turn-down elbow.
- .7 Do all required control wiring (except the building automation system connection) in conduit in accordance with the manufacturer's control wiring schematics and wiring standards of the electrical work.
- .8 Locate the refrigerant sensor(s) adjacent to the chiller. Wall mount the alarm system controller panel in the Chiller Room adjacent to the door, and wall mount the remote alarm panel outside the Chiller Room adjacent to the door. Do all required alarm wiring in conduit from the sensor(s) to the controller, from the controller to the remote panel, and from the controller and remote panel to the Chiller Room exhaust fan starter and to the chiller control panel. Wiring to the exhaust fan starter is to operate the fan at high speed when an alarm condition occurs. Alarm wiring is to be in accordance with the manufacturer's certified wiring diagrams and electrical work wiring requirements.
- .9 Provide self-contained breathing apparatus and wall mount adjacent to the alarm panel outside the Chiller Room door. Confirm the exact location prior to installation.
- .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.
- .11 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.

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- .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 one eight hour day 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

Air Handling Units – Modular Indoor

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all 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 computer generated and certified fan performance curves;
 - .2 computer generated psychometric chart for each cooling coil;
 - .3 certified sound power data for discharge, radiated, and return positions by octave band;
 - .4 hardware for section-to-section site connections as applicable;
 - .5 dimensioned layouts;
 - .6 product data sheets for fan motors.
- .2 **Spare Air Filters:** Submit spare air filters as specified in Part 2 of this Section.
- .3 **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.
- .4 **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 Indoor modular 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 ANSI/ARI 410, Forced-Circulation Air-Cooling and Heating Coils;
 - .2 ANSI/ARI 430, Central Station Air-Handling Units;
 - .3 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - .4 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.
- .2 Indoor modular air handling equipment is also to be in accordance with requirement of the following Codes, Standards, and Regulations:
 - .1 CAN/CSA-C22.2 No. 236/UL 1995, Heating and Cooling Units;
 - .2 ANSI/ASHRAE 90.1, Energy Standard for Buildings Except Low Rise Residential Buildings;
 - .3 CSA or ETL certification and labelling for all electrical components;
 - .4 governing local Codes and Regulations.
- .3 Acceptable manufacturers are:

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- .1 Daikin Industries Ltd.;
- .2 Trane Canada Inc.;
- .3 Johnson Controls York;
- .4 Engineered Air.

PART 2 - PRODUCTS

2.1 Indoor Modular Air Handling Units

- .1 Daikin "Vision" factory made, indoor, sectional, modular, air handling units as per the drawing schedule with dimensions and arrangements as shown and detailed on the drawings. Where required, air handling units are to be shipped in sections suitable for entry into the building through existing openings.
- .2 **Unit Construction:** Unit construction is to produce an assembly designed for 1.5 kPa (6" w.c.) positive pressure and 1 kPa (4" w.c.) negative pressure with an air leakage rate less than 1% of total capacity. Each unit is to be constructed with #16 gauge galvanized steel channel posts and 50 mm (2") thick, thermally broken, double wall sandwich type removable panels and access doors insulated with injected foam for a R-value not less than R-13, with all panels, access doors, and shipping sections (as applicable) sealed with permanently applied bulb type gaskets. Additional construction features are as follows:
 - .1 **base rail and frame:** a full perimeter #10 gauge structural galvanized steel base rail with a height to permit proper trapped condensate drainage, and removable cross-member frame channels;
 - .2 **inner panels:** #18 gauge G90 galvanized sheet steel, except for cooling coil modules which are to be complete with type 304 stainless steel panels;
 - .3 **outer panels:** G60 galvanized steel, #18 gauge for units up to size #30, #16 gauge for larger size units, each cleaned, primed, and finished with acrylic equipment enamel with colour as selected by the Consultant;
 - .4 **module to module assembly:** overlapping, full perimeter, insulated, internal splice joints sealed with bulb gaskets on both mating modules;
 - .5 **access doors:** full size flush access doors arranged to swing outward for modules under negative pressure, inward for modules under positive pressure with a secondary latch to relieve pressure upon access, all with a minimum of two 150 mm (6") piano hinges, Ventlok 202 latch and minimum 115 mm (4½") handle assembly operable from both inside and outside the module, and, for fan modules, a safety glass or Lexan framed viewing window;
 - .6 **cooling coil module drain pans:** stainless steel drain pans, each constructed with a cross-break and a double slope pitch to the extended 32 mm (1¼") diameter drain connection located with a centreline a minimum of 75 mm (3") above the base rail, and complete with 50 mm (2") of insulation meeting flame spread and smoke developed ratings of CAN/ULC-S102;

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- .3 **Centrifugal Fans:** DWDI forward curved design or airfoil design, or SWSI airfoil design plenum fans as per the drawing schedule, each dynamically balanced as an assembly on all three planes and at all bearing supports, and capable of operating over the complete pressure class limits as specified in AMCA Standard 99-2408. Each fan is to be complete with:
- .1 **wheel:** continuously welded, stable, non-overloading wheel with die-formed steel blades and, unless otherwise required, a cast iron hub;
 - .2 **fan shaft and bearings:** solid hot rolled steel shaft, accurately turned, ground, polished, ring gauged for accuracy, with maximum 0.0076 mm (0.003") lateral static deflection per 300 mm (12") of shaft length, and sized for a first critical speed of at least 1.25 times the maximum rated speed for the fan, and heavy-duty, grease lubricated, ball or roller, self-aligning pillow block type bearings selected for an AFBMA L-50 minimum average bearing life in excess of 400,000 hours, and equipped with extended copper lubrication lines terminated in lubrication fittings immediately inside the fan section access door;
 - .3 **motor, drive, and guard:** TEFC motor and, unless otherwise specified, an adjustable V-belt drive selected for 40% service factor based on the motor nameplate data, and an OSHA guard, all in accordance with requirements of the mechanical work Section entitled Basic Mechanical Materials and Methods;
 - .4 **fan and motor support base:** rigid, welded structural steel, vibration isolated base with steel cross members, factory cleaned, deburred, and finished with epoxy enamel, and complete with a slide type motor base and stable, colour coded 50 mm (2") deflection spring mounts with seismic snubbers and sound pads, selected to suit the maximum equipment load and to operate at not greater than 2/3 solid load, and shipping restraints;
 - .5 **flexible connection:** Duro Dyne Canada Inc. "DURALON" or DynAir Inc. "HYPOLON" waterproof, indoor-outdoor woven fibreglass fabric coated on both sides with a synthetic rubber compound and factory secured to galvanized steel plates at both ends, installed between the fan discharge and the fan module discharge opening, with spring thrust restraints secured to welded brackets on the fan housing and by steel rods through the fan casing with a steel back-up plate.
- .4 **Hydronic Heat Transfer Coils:** Drainable coils designed and constructed to meet requirements of the ASME Code Category "H" as a registered fitting, and complete with a TSSA CRN. Coil data, performance, and specific features not specified below are to be in accordance with the drawing schedule and details. Each coil is to be accessible for removal and complete with:
- .1 a slide in-slide-out type 304 stainless steel mounting framework with blank-off plates to prevent air bypass;
 - .2 seamless copper tube headers enclosed within the coil module, return bend 16 mm (5/8") O.D. seamless copper tubes mechanically expanded into 0.24 mm (3/32") thick aluminium fins with full drawn collars;

Air Handling Units – Modular Indoor

- .3 NPT Schedule 40 ASTM A53 seamless steel pipe or OD sweat copper pipe (as applicable) supply and return connections extended and capped a minimum of 125 mm (5") beyond the module outer panel through a sealed opening and equipped with an air vent and a drain valve;
- .4 a formed, flanged # 14 gauge type 304 stainless steel casing designed to drain off standing water, and stainless steel intermediate tube support sheets as required.
- .5 **Filter Framing and Racks:** Rigid, reinforced galvanized steel frame and side load rack assembly constructed to suit the number, type and size of individual filters comprising the filter bank, complete with top and bottom channels for sliding filters in and out, galvanized steel blank-off sheets to prevent air bypass, and galvanized steel wire grid members to prevent loaded filters from being sucked out of the filter rack.
- .6 **Filters:** Filters are to be factory supplied with each unit as follows:
 - .1 **construction filter:** equal to Camfil Farr Canada Inc. CS-5 25 mm (1") thick white, synthetic roll media factory secured in place in the filter section prior to shipping;
 - .2 **pre-filters and final filters:** disposable, extended surface glass fibre media as per the drawing schedule, ULC listed and labelled Class 1, supplied in sealed filter manufacturer's shipping cartons in quantities sufficient for an initial loading at fan start-up, and two complete sets of spare filters;
- .7 **Filter Gauges:** Unless otherwise specified, Dwyer Instruments Inc. Series 605 "Magnehelic", 24 volt DC differential pressure gauges, one for each pre-filter bank, one for each final filter bank, each with $\pm 3\%$ accuracy with a range to suit the application, an indicating transmitter with 4-20 mA output, and a mounting bracket.
- .8 **Motorized Dampers:** Equal to T. A. Morrison & Co. Inc. "TAMCO" 100 mm (4") deep flanged aluminium dampers, parallel blade type for mixing applications, opposed blade type for open-shut service, each complete with an extruded 6063T5 aluminum frame and blades, each blade with an integral slot to receive a gasket, and slip-proof aluminium and corrosion resistant zinc-plated steel linkage concealed in the frame and equipped with self-sealing and self-lubricating bearings consisting of a Celcon inner bearing fixed on the hexagonal blade pin and rotating in a polycarbonate outer bearing inserted in the frame. Dampers leakage is to be maximum 15 L/s/m² (3 CFM/ft²) against 0.25 kPa (1" w.c.) differential static pressure, and dampers are to be as follows:
 - .1 **standard dampers:** Series 1500, with aluminium end caps press-fitted to blade ends, and extruded silicone frame and blade gaskets secured in an integral slot within the aluminium extrusions;
 - .2 **insulated dampers:** Series 9000, with thermally broken blades internally insulated with expanded polyurethane foam, and non-metallic side seals and extruded blade gaskets secured in an integral slot within the aluminium extrusions;

Air Handling Units – Modular Indoor

- .3 **damper motors:** Belimo or Johnson Controls CSA certified, spring return, direct coupled electric motor damper actuator, 120 volt or 24 volt as required, electronic overload protected, complete with position indicator, a housing to suit the mounting location, and additional features as required to suit the application and control sequence.
- .9 **Controls:** Refer to drawing control diagrams and sequences. All control system components required for installation within air handling unit modules are to be provided with the air handling unit with identified wiring terminated in identified junction boxes on the outside of the module casings for site connections as part of the automatic control work and electrical work. Unless otherwise specified all air handling unit control components are to be of the same manufacturer as the building automatic control system component manufacturer.
- .10 **Electrical Items:** Factory installed and wired items terminated for "load" side site connection as part of the electrical work. Electrical items are to be as follows:
 - .1 **marine lights:** Equal to Cooper Crouse-Hinds TP Series surface mounting, aluminium construction, vapour-proof marine lights, CSA certified, complete with clear polycarbonate globe with die-cast housing and guard, and an 18 watt compact fluorescent lamp, and wall or ceiling mounted inside modules where indicated;
 - .2 **switches:** Hubbell Canada Inc. #HBL1297 single pole, CSA certified, 20 ampere, 120 volt "PRESSWITCH" with red nylon actuator and pilot light and #HBL1795 clear bubble silicone rubber cover plate, and located on module exterior casings where indicated;
 - .3 **disconnect switches:** un-fused, heavy-duty, front operated, quick make and break door interlock safety switches in accordance with CSA Standard C22.2 No. 4, complete with an EEMAC 2 enclosure and located on module exterior casings where indicated;
 - .4 **duplex receptacles:** CSA certified, Specification Grade, 15 ampere, 125 volt, duplex GFI receptacles with nylon cover plates located on module exterior casings where indicated;
 - .5 **variable frequency drives:** variable frequency drives with motors to suit, suitable in all respects for the application, in accordance with requirements of the mechanical work Section entitled Variable Frequency Drives, located on the fan module casing, and factory connected to the motor;
 - .6 **motor starters:** full voltage, non-reversing, three phase, 60 Hz , combination starter in accordance with requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods;
 - .7 **factory wiring:** wiring and electrical work factory installed by the unit manufacturer is to be in accordance with the Project electrical work Specification and is to include:
 - .1 provision of a casing mounted 120 volt single phase disconnect switch for receptacles and lighting fixtures;

Air Handling Units – Modular Indoor

- .2 a switch, located a maximum of 1.2 m (5') above the bottom of the unit exterior casing where shown (or as high as possible if casing is less than 1.2 m (5')), connected with "line" side power wiring to the 120 volt disconnect switch and with "load" side power wiring to control all lighting fixtures;
- .3 receptacles installed on unit exterior casings approximately 450 mm (18") above the bottom of the casing where shown and connected to the 120 volt disconnect switch;
- .4 a motor starter for each fan motor, secured to the exterior of the fan section casing and prewired to the fan motor;
- .5 a disconnect switch for fan motors as indicated, secured to the exterior of the fan module casing and prewired to the fan motor;
- .6 a variable frequency drive for fan motors as indicated, secured to the exterior of the fan module casing and prewired to the fan motor;
- .7 identified wiring for control devices, terminated in identified junction boxes on the exterior of the unit casing.

PART 3 - EXECUTION

3.1 Installation Of Indoor Modular Air Handling Units

- .1 Provide indoor modular air handling units where shown.
- .2 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 Secure base mounting units in place, level, and plumb, on a concrete pad.
- .4 Remove fan base hold-down clamps and all other shipping restraints and protective packaging.
- .5 Carefully coordinate the installation of each unit with all other trades making connections to the unit, in particular, control connections.
- .6 **Equipment and System Start-Up:** Refer to requirements of the article entitled Equipment and System Start-Up in the mechanical work Section entitled Mechanical Work General Instructions.
- .7 **Manufacturer's Certification:** Refer to requirements of the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions. Submit a copy of the letter prior to Substantial Performance.
- .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 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.

Air Handling Units – Modular Indoor

END OF SECTION

Humidifiers – Steam Injection Manifold

PART 1 - GENERAL

1.1 Submittals

- .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.
- .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

- .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:
 - .1 an inlet strainer;
 - .2 a stainless steel steam jacketed manifold, a dispersing tube, and a stainless steel noise attenuator;
 - .3 a stainless steel separator;
 - .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;
 - .5 a cast iron float and thermostatic drip trap with stainless steel internal components for each manifold.
- .2 . Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd.;
 - .2 Armstrong International Ltd.;
 - .3 DRI-STEEM Corp.

PART 3 - EXECUTION

3.1 Installation Of Steam Injection Humidifier Manifold

- .1 Provide steam injection humidifier manifold assemblies where shown.
- .2 Install each manifold assembly in accordance with the manufacturer's instructions. Coordinate installation with the sheet metal trade.
- .3 Connect with valved steam and condensate piping.
- .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.

Humidifiers – Steam Injection Manifold

- .5 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- .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