

**Part 1 General**

**1.1 GENERAL REQUIREMENTS**

- .1 Read all Divisions of the building specification, Tendering Requirements, Contract Forms, and Conditions of Contract, and Division 1 which contain items affecting Mechanical Work.
- .2 If similarity or discrepancies are found between contents of Divisions 21, 22, 23, 25 and Division 1 or other documents stated above, the one with most stringent content shall be applicable.
- .3 The Mechanical Work shall consist of the supply and installation of complete and operable systems and shall include all necessary labour, plant, materials, and incidentals for the work involved.
- .4 The drawings and specifications are intended to describe complete working systems including all necessary labour and materials. Where items required to complete working system are not specified or shown on drawings, contractor shall include costs at no additional expense to Owner.
- .5 Immediately inform the Consultant, in writing, of all discrepancies, errors, omissions, contradictions and ambiguities during tender stage. The necessary Addendum or bulletin will be issued to all Bidders. Include a complete cross-checking of Drawing and Specifications for sizes and quantities to correspond correctly. Data mentioned in the Specifications and not shown on Drawings, and vice-versa, must be interpreted as part of the Work. Bring obvious discrepancies or omissions to the attention of the Consultant during the Tender Period. Where discrepancies still exist within the documents, contractors shall allow for the more demanding installation or more stringent requirement.

**1.2 SUBMITTALS**

- .1 Submittals: in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2 Shop drawings; submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.
  - .3 Shop drawings to show:
    - .1 Mounting arrangements.
    - .2 Operating and maintenance clearances.
  - .4 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.
  - .5 In addition to transmittal letter referred to in Section 01 33 00 - Shop Drawings, Product Data and Samples use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.
  - .6 Closeout Submittals:
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- .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 30 – Closeout Submittals.
  - .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 23 05 93 - Testing, Adjusting and Balancing for HVAC.
  - .6 Approvals:
    - .1 Submit four copies of draft Operation and Maintenance Manual to Consultant for approval. Submission of individual data will not be accepted unless directed by Consultant.
    - .2 Make changes as required and re-submit as directed by Consultant.
  - .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.
    - .2 Prepare and insert into each operation and maintenance manual a CD containing electronic copy of approved O&M manual including approved AS BUILT drawings.
  - .8 Site records:
    - .1 Consultant will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur.
    - .2 Transfer information weekly to reproducibles, revising reproducibles to show work as actually installed.
    - .3 Use different colour waterproof ink for each service.
    - .4 Make available for reference purposes and inspection.
  - .9 As-built drawings:
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- .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 approval and make corrections as directed.
- .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
- .5 Submit completed reproducible as-built drawings in CADD with Operating and Maintenance Manuals.
- .10 Submit copies of as-built drawings for inclusion in final TAB report.

### 1.3 QUALITY ASSURANCE

- .1 Quality Assurance: in accordance with Section 01 45 00 – Quality Control.
- .2 Health and Safety Requirements: do construction occupational health and safety in accordance Division 1 requirements.

### 1.4 MAINTENANCE

- .1 Furnish spare parts in accordance with Section 01 78 30 – Closeout Submittals as follows:
  - .1 One set of packing for each pump.
  - .2 One casing joint gasket for each size pump.
  - .3 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 Section 01 78 30 – Closeout Submittals.
- .3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

### 1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Waste Management and Disposal:
  - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycle in accordance with Section 01 74 19 - Waste Management and Disposal.

## Part 2 Execution

### 2.1 PAINTING REPAIRS AND RESTORATION

- .1 Do painting in accordance with Division 9 - Painting.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged.

### 2.2 CLEANING

- .1 Clean interior and exterior of all systems including strainers.
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**2.3 FIELD QUALITY CONTROL**

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 - Quality Control and submit report as described in 01 33 00 – Shop Drawings, Product Data and Samples.
- .2 Manufacturer's Field Services:
  - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in 01 33 00 – Shop Drawings, Product Data and Samples.
  - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
  - .3 Schedule site visits, to review Work, as directed in Section 01 45 00 – Quality Control.

**2.4 DEMONSTRATION**

- .1 Consultant will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Trial usage to apply to following equipment and systems:
  - .1 HVAC Systems
- .3 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.
- .4 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .5 Instruction duration time requirements as specified in appropriate sections.
- .6 Contractor will record these demonstrations on video tape for future reference. Submit the recording media to Owner.

**2.5 PROTECTION**

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

**Part 1 EXECUTION**

**1.1 NOT USED**

- .1 Not Used.

**END OF SECTION**

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**Part 1 General**

**1.1 RELATED SECTIONS**

- .1 23 07 15 - Thermal Insulation for Piping
- .2 22 11 16 - Domestic Water Piping
- .3 23 21 13.02 – Hydronic Systems Steel

**1.2 REFERENCES**

- .1 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB-1.181 Ready-Mixed Organic Zinc-Rich Coating.
- .2 Canada Green Building Council (CaGBC)
  - .1 LEED Canada-NC Version 1.0, LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Package For New Construction and Major Renovations (including Addendum [2007]).
  - .2 LEED Canada-CI Version 1.0, LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Guide For Commercial Interiors.
- .3 Green Seal Environmental Standards (GSES)
  - .1 Standard GS-11 2008, 2nd Edition, Environmental Standard for Paints and Coatings.
- .4 National Fire Code of Canada (NFCC 2005)
- .5 South Coast Air Quality Management District (SCAQMD), California State, Regulation XI. Source Specific Standards
  - .1 SCAQMD Rule 1113-A2007, Architectural Coatings.
  - .2 SCAQMD Rule 1168-A2005, Adhesive and Sealant Applications.

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Provide manufacturer's printed product literature, specifications and datasheets for piping and equipment and include product characteristics, performance criteria, physical size, finish and limitations.

**1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with Section 01 61 10 – Common Product Requirements and with manufacturer's written instructions.
  - .2 Delivery and Acceptance Requirements:
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- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: remove for reuse and return of pallets crates padding and packaging materials in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 MATERIAL**

- .1 Paint: zinc-rich to CAN/CGSB-1.181.
  - .1 Primers Paints Coating: in accordance with manufacturer's recommendations for surface conditions.
  - .2 Primer: maximum VOC limit to Standard GS-11.
  - .3 Paints: maximum VOC limit to Standard GS-11.
- .2 Sealants: in accordance with Section 07 92 00 - Joint Sealants.
- .3 Sealants: maximum VOC limit to SCAQMD Rule 1168 to GSES GS-36.
- .4 Adhesives: maximum VOC limit to SCAQMD Rule 1168 to GSES GS-36.
- .5 Fire Stopping: in accordance with Section 07 84 00 - Fire Stopping.

**Part 3 Execution**

**3.1 APPLICATION**

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

**3.2 PIPE TYPE APPLICATIONS**

- .1 All above ground piping shall be SCH 40 black steel with welded connections. Below ground piping shall be SCH 40 PVC with SCH 80 fittings. Connections shall be by solvent cementing method per manufacturer instructions and recommendations.

**3.3 CONNECTIONS TO EQUIPMENT**

- .1 In accordance with manufacturer's instructions unless otherwise indicated.
  - .2 Use valves and either unions or flanges for isolation and ease of maintenance and assembly.
  - .3 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.
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**3.4 CLEARANCES**

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and National Fire Code of Canada.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer without interrupting operation of other system, equipment, components.

**3.5 DRAINS**

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

**3.6 AIR VENTS**

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

**3.7 DIELECTRIC COUPLINGS**

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

**3.8 PIPEWORK INSTALLATION**

- .1 Install pipework to applicable standard.
  - .2 Screwed fittings jointed with Teflon tape.
  - .3 Protect openings against entry of foreign material. Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
  - .4 Assemble piping using fittings manufactured to ANSI standards.
  - .5 Saddle type branch fittings may be used on mains if branch line is no larger than half size of main.
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- .1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.
- .6 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
- .7 Install concealed pipework to minimize furring space, maximize headroom, conserve space.
- .8 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
- .9 Install, except where indicated, to permit separate thermal insulation of each pipe.
- .10 Group piping wherever possible.
- .11 Ream pipes, remove scale and other foreign material before assembly.
- .12 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .13 Provide for thermal expansion as indicated.
- .14 Valves:
  - .1 Install in accessible locations.
  - .2 Remove interior parts before soldering.
  - .3 Install with stems above horizontal position unless indicated.
  - .4 Valves accessible for maintenance without removing adjacent piping.
  - .5 Install globe valves in bypass around control valves. Use gate or ball valves at branch take-offs for isolating purposes except where specified.
  - .6 Use chain operators on valves NPS 2 1/2 and larger where installed more than 2400 mm above floor in Mechanical Rooms.
- .15 Check Valves:
  - .1 Install silent check valves on discharge of pumps and as indicated.
  - .2 Install swing check valves in horizontal lines on discharge of pumps and as indicated.

### **3.9 SLEEVES**

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

### 3.10 ESCUTCHEONS

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

### 3.11 PREPARATION FOR FIRE STOPPING

- .1 Install firestopping within annular space between pipes, ducts, insulation and adjacent fire separation in accordance with Section 07 84 00 - Fire Stopping.
- .2 Uninsulated unheated pipes not subject to movement: no special preparation.
- .3 Uninsulated heated pipes subject to movement: wrap with non-combustible smooth material to permit pipe movement without damaging firestopping material or installation.
- .4 Insulated pipes and ducts: ensure integrity of insulation and vapour barriers.

### 3.12 FLUSHING OUT OF PIPING SYSTEMS

- .1 Flush system in accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping.
- .2 Before start-up, clean interior of piping systems in accordance with requirements of Section 01 74 11 - Cleaning.
- .3 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

### 3.13 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK

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

**3.14 CLEANING**

- .1 Remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1 General**

**1.1 SUMMARY**

- .1 Section Includes:
  - .1 Electrical motors, drives and guards for mechanical equipment and systems.
  - .2 Supplier and installer responsibility indicated in Motor, Control and Equipment Schedule on electrical drawings and related mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.
  - .3 Control wiring and conduit is specified in Division 26 except for conduit, wiring and connections below 50 V which are related to control systems specified in Division 22 and 23. Refer to Division 26 for quality of materials and workmanship.

**1.2 REFERENCES**

- .1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
  - .1 ASHRAE 90.1-[01], Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA cosponsored; ANSI approved; Continuous Maintenance Standard).
- .2 Electrical Equipment Manufacturers' Association Council (EEMAC)
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1 Material Safety Data Sheets (MSDS).

**1.3 SUBMITTALS**

- .1 Submittals: in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2 Product Data:
    - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples. Include product characteristics, performance criteria, and limitations.
      - .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
    - .2 Shop Drawings: submit drawings stamped and signed by professional engineer registered or licensed in Province of BC.
  - .3 Quality Control: in accordance with Section 01 45 00 – Quality Control.
    - .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.
  - .4 Closeout Submittals
    - .1 Provide maintenance data for motors, drives and guards for incorporation into manual specified in Section 01 78 30 – Closeout Submittals.
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**1.4 QUALITY ASSURANCE**

- .1 Regulatory Requirements: work to be performed in compliance with applicable Provincial /Territorial regulations.
- .2 Health and Safety Requirements: do construction occupational health and safety in accordance Division 1 requirements.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle in accordance with –Section 01 61 10 - Common Product Requirements..
  - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
  - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 GENERAL**

- .1 Motors: high efficiency, in accordance with local Hydro company standards, local by-laws and to ASHRAE 90.1.

**2.2 MOTORS**

- .1 Provide motors for mechanical equipment as specified.
- .2 Motors under 373 W (1/2 HP) : speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 60 Hz, 120 V, unless otherwise specified or indicated.
- .3 Motors 373 W (1/2 HP) and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 40 degrees C, 3 phase, 60Hz, 575 V, unless otherwise indicated.

**2.3 TEMPORARY MOTORS**

- .1 If delivery of specified motor will delay completion or commissioning work, install motor approved by Consultant for temporary use. Work will only be accepted when specified motor is installed.

**2.4 BELT DRIVES**

- .1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.
  - .2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise indicated.
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- .3 For motors under 7.5 kW (10 HP): standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.
- .4 For motors 7.5 kW (10 HP) and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.
- .5 Correct size of sheave determined during commissioning.
- .6 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
- .7 Motor slide rail adjustment plates to allow for centre line adjustment.
- .8 Supply one set of spare belts for each set installed in accordance with Section 01 78 30 – Closeout Submittals.

## 2.5 DRIVE GUARDS

- .1 Provide guards for unprotected drives.
- .2 Guards for belt drives:
  - .1 Expanded metal screen welded to steel frame.
  - .2 Minimum 1.2 mm thick sheet metal tops and bottoms.
  - .3 38 mm diameter holes on both shaft centres for insertion of tachometer.
  - .4 Removable for servicing.
- .3 Provide means to permit lubrication and use of test instruments with guards in place.
- .4 Install belt guards to allow movement of motors for adjusting belt tension.-
- .5 Guard for flexible coupling:
  - .1 "U" shaped, minimum 1.6 mm thick galvanized mild steel.
  - .2 Securely fasten in place.
  - .3 Removable for servicing.
- .6 Unprotected fan inlets or outlets:
  - .1 Wire or expanded metal screen, galvanized, 19 mm mesh.
  - .2 Net free area of guard: not less than 80% of fan openings.
  - .3 Securely fasten in place.
  - .4 Removable for servicing.

## 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.
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**3.2 INSTALLATION**

- .1 Fasten securely in place.
- .2 Make removable for servicing, easily returned into, and positively in position.

**3.3 FIELD QUALITY CONTROL**

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 Quality Control and submit report as described in Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Manufacturer's Field Services:
  - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
  - .3 Schedule site visits, to review Work, as directed in Section 01 45 00 Quality Control.

**3.4 CLEANING**

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1            RELATED SECTIONS**

- .1    23 21 13.02 - Hydronic Systems Steel

**1.2            REFERENCES**

- .1    American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME)
  - .1    ANSI/ASME B31.1-2007, Power Piping.
  - .2    ANSI/ASME B31.3-2006, Process Piping.
  - .3    ANSI/ASME Boiler and Pressure Vessel Code-2007:
    - .1    BPVC 2007 Section I: Power Boilers.
    - .2    BPVC 2007 Section V: Nondestructive Examination.
    - .3    BPVC 2007 Section IX: Welding and Brazing Qualifications.
- .2    American National Standards Institute/American Water Works Association (ANSI/AWWA)
  - .1    ANSI/AWWA C206-03, Field Welding of Steel Water Pipe.
- .3    American Welding Society (AWS)
  - .1    AWS C1.1M/C1.1-2000(R2006), Recommended Practices for Resistance Welding.
  - .2    AWS Z49.1-2005, Safety in Welding, Cutting and Allied Process.
  - .3    AWS W1-2000, Welding Inspection Handbook..
- .4    Canadian Standards Association (CSA International)
  - .1    CSA W47.2-M1987(R2008), Certification of Companies for Fusion Welding of Aluminum.
  - .2    CSA W48-06, Filler Metals and Allied Materials for Metal Arc Welding.
  - .3    CSA B51-03(R2007), Boiler, Pressure Vessel and Pressure Piping Code.
  - .4    CSA-W117.2-2006, Safety in Welding, Cutting and Allied Processes.
  - .5    CSA W178.1-2008, Certification of Welding Inspection Organizations.
  - .6    CSA W178.2-2008, Certification of Welding Inspectors.

**1.3            ACTION AND INFORMATIONAL SUBMITTALS**

- .1    Provide submittals in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

**1.4            QUALITY ASSURANCE**

- .1    Qualifications:
  - .1    Welders:
    - .1    Welding qualifications in accordance with CSA B51.
    - .2    Use qualified and licensed welders possessing certificate for each procedure performed from authority having jurisdiction.
    - .3    Submit welder's qualifications to Consultant and Owner.

- .4 Each welder to possess identification symbol issued by authority having jurisdiction.
- .5 Certification of companies for fusion welding of aluminum in accordance with CSA W47.2.
- .2 Inspectors:
  - .1 Inspectors qualified to CSA W178.2.
- .3 Certifications:
  - .1 Registration of welding procedures in accordance with CSA B51.
  - .2 Copy of welding procedures available for inspection.
  - .3 Safety in welding, cutting and allied processes in accordance with CSA-W117.2.

**1.5 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: remove for reuse and return in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 ELECTRODES**

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

**Part 3 Execution**

**3.1 APPLICATION**

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.
- .2 Provide welding at outside of building away from air intakes.

**3.2 QUALITY OF WORK**

- .1 Welding: in accordance with ANSI/ASME B31.1 and B31.3, ANSI/ASME Boiler and Pressure Vessel Code, Sections I and IX and ANSI/AWWA C206, using procedures conforming to AWS B3.0, AWS C1.1.

**3.3 INSTALLATION REQUIREMENTS**

- .1 Identify each weld with welder's identification symbol.
- .2 Backing rings:
  - .1 Where used, fit to minimize gaps between ring and pipe bore.
  - .2 Do not install at orifice flanges.
- .3 Fittings:



- .1 NPS 2 and smaller: install welding type sockets.
- .2 Branch connections: install welding tees or forged branch outlet fittings.

### 3.4 INSPECTION AND TESTS - GENERAL REQUIREMENTS

- .1 Review weld quality requirements and defect limits of applicable codes and standards with Consultant before work is started.
- .2 Formulate "Inspection and Test Plan" in co-operation with Owner Representative and Consultant.
- .3 Do not conceal welds until they have been inspected, tested and approved by inspector.
- .4 Provide for inspector to visually inspect welds during early stages of welding procedures in accordance with Welding Inspection Handbook. Repair or replace defects as required by codes and as specified.

### 3.5 SPECIALIST EXAMINATIONS AND TESTS

- .1 General:
  - .1 Perform examinations and tests by specialist qualified to CSA W178.1 and CSA W178.2 and approved by Consultant.
  - .2 To ANSI/ASME Boiler and Pressure Vessels Code, Section V, CSA B51 and requirements of authority having jurisdiction.
  - .3 Inspect and test 100 % of welds in accordance with "Inspection and Test Plan" by non-destructive visual examination.
- .2 Hydrostatically test welds to ANSI/ASME B31.1.
- .3 Visual examinations: include entire circumference of weld externally and wherever possible internally.
- .4 Failure of visual examinations:
  - .1 Upon failure of welds by visual examination, perform additional testing as directed by Consultant.

### 3.6 DEFECTS CAUSING REJECTION

- .1 As described in ANSI/ASME B31.1 and ANSI/ASME Boiler and Pressure Vessels Code.
- .2 In addition, chilled water systems:
  - .1 Undercutting greater than 0.8 mm adjacent to cover bead on outside of pipe.
  - .2 Undercutting greater than 0.8 mm adjacent to root bead on inside of pipe.
  - .3 Undercutting greater than 0.8 mm at combination of internal surface and external surface.
  - .4 Incomplete penetration and incomplete fusion greater than total length of 38 mm in 1500 mm length of weld depth of such defects being greater than 0.8 mm.
  - .5 Repair cracks and defects in excess of 0.8 mm in depth.
  - .6 Repair defects whose depth cannot be determined accurately on basis of visual examination tests.

### 3.7 REPAIR OF WELDS WHICH FAILED TESTS

- .1 Re-inspect and re-test repaired or re-worked welds at Contractor's expense.
-

**3.8 CLEANING**

- .1 Clean in accordance with Section 01 74 11 - Cleaning.
- .2 Waste Management: separate waste materials for recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**END OF SECTION**



## 1.1 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B40.100-2005, Pressure Gauges and Gauge Attachments.
  - .2 ASME B40.200-2008, Thermometers, Direct Reading and Remote Reading.
- .2 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB-14.4-M88, Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.
  - .2 CAN/CGSB-14.5-M88, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.
- .3 Efficiency Valuation Organization (EVO)
  - .1 International Performance Measurement and Verification Protocol (IPMVP)
    - .1 IPMVP [2007] Version.
- .4 Green Seal Environmental Standards (GS)
  - .1 GS-11-11. Standard for Paints and Coatings.
  - .2 GS-36-11. Standard for Commercial Adhesives.

## 1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for thermometers and pressure gauges and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
  - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Province of BC Canada.
- .4 Certificates:
  - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

## 1.3 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 10 - Common Product Requirements.
  - .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
  - .3 Storage and Handling Requirements:
    - .1 Store thermometers and pressure gauges indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
    - .2 Store and protect thermometers and pressure gauges from nicks, scratches, and blemishes.
-

- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 GENERAL**

- .1 Design point to be at mid-point of scale or range.

**2.2 DIRECT READING THERMOMETERS**

- .1 Industrial, variable angle type, mercury-free, liquid filled, 200 mm scale length: to CAN/CGSB-14.4, ASME B40.200.
  - .1 Resistance to shock and vibration.

**2.3 REMOTE READING THERMOMETERS**

- .1 100 mm diameter mercury-free vapour activated dial type: to CAN/CGSB-14.5 and ASME B40.200. Accuracy within one scale division, brass movement, stainless steel capillary, stainless steel spiral armour, stainless steel bulb and polished stainless steel case for wall mounting.

**2.4 THERMOMETER WELLS**

- .1 Copper pipe: copper or bronze.
- .2 Steel pipe: stainless steel.

**2.5 PRESSURE GAUGES**

- .1 112 mm, dial type: to ASME B40.100, Grade 2A, stainless steel bourdon tube having 0.5% accuracy full scale unless otherwise specified.
- .2 Provide:
  - .1 Siphon for steam service.
  - .2 Snubber for pulsating operation.
  - .3 Diaphragm assembly for corrosive service.
  - .4 Gasketed pressure relief back with solid front.
  - .5 Bronze stop cock.
  - .6 Oil filled for high vibration applications.

**Part 3 Execution**

**3.1 EXAMINATION**

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.
    - .1 Visually inspect substrate in presence of Departmental Representative.
    - .2 Inform Departmental Representative and Consultant of unacceptable conditions immediately upon discovery.
-

- .3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 GENERAL

- .1 Install thermometers and gauges so they can be easily read from floor or platform.
  - .1 If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.

### 3.3 THERMOMETERS

- .1 Install in wells on piping. Include heat conductive material inside well.
- .2 Install in locations and on inlet and outlet of:
  - .1 Heat exchangers.
  - .2 Water heating and cooling coils.
  - .3 Water boilers.
  - .4 Chillers.
  - .5 Cooling towers.
  - .6 DHW tanks.
- .3 Install wells as indicated only for balancing purposes.
- .4 Use extensions where thermometers are installed through insulation.

### 3.4 PRESSURE GAUGES

- .1 Install in locations as follows:
  - .1 Suction and discharge of pumps.
  - .2 Upstream and downstream of PRV's.
  - .3 Upstream and downstream of control valves.
  - .4 Inlet and outlet of coils.
  - .5 Inlet and outlet of liquid side of heat exchangers.
  - .6 Outlet of boilers.
  - .7 In other locations as indicated.
- .2 Install gauge cocks.
- .3 Use extensions where pressure gauges are installed through insulation.

### 3.5 NAMEPLATES

- .1 Install engraved lamicoid nameplates in accordance with Section 23 05 53.01 - Mechanical Identification section, identifying medium.

### 3.6 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 - Cleaning.
    - .1 Leave Work area clean at end of each day.
  - .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning.
  - .3 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.
-

- .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

**3.7**

**PROTECTION**

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by thermometer and gauge installation.

**END OF SECTION**



**1.1 SUMMARY**

- .1 Related Sections
  - .1 01 61 10 Common Product Requirement
  - .2 01 74 19 Waste Management and Disposal
- .2 Section Includes
  - .1 Pads, hangers and supports for mechanical piping and equipment

**1.2 REFERENCES**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B31.1-07 - Power Piping., ASME B31.3-06 - Process Piping
- .2 ASTM International
  - .1 ASTM A125-1996(2007), Standard Specification for Steel Springs, Helical, Heat-Treated.
  - .2 ASTM A307-07b, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
  - .3 ASTM A563-07a, Standard Specification for Carbon and Alloy Steel Nuts.
- .3 Factory Mutual (FM)
- .4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
  - .1 MSS SP58-2002, Pipe Hangers and Supports - Materials, Design and Manufacture.
  - .2 MSS SP69-2003, Pipe Hangers and Supports - Selection and Application.
  - .3 MSS SP89-2003, Pipe Hangers and Supports - Fabrication and Installation Practices.
- .5 Underwriter's Laboratories of Canada (ULC)

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2 Product Data:
    - .1 Provide manufacturer's printed product literature and data sheets for hangers and supports and include product characteristics, performance criteria, physical size, finish and limitations.
  - .3 Shop Drawings:
    - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.
    - .2 Submit shop drawings for:
      - .1 Bases, hangers and supports.
      - .2 Connections to equipment and structure.
      - .3 Structural assemblies.
-

- .4 Certificates:
  - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Manufacturers' Instructions:
  - .1 Provide manufacturer's installation instructions.
    - .1 Consultant will make available 1 copy of systems supplier's installation instructions.

**1.4 CLOSEOUT SUBMITTALS**

- .1 Provide maintenance data for incorporation into manual specified in Section 01 78 30 – Closeout Submittals..

**1.5 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with Section 01 61 10 – Common Product Requirements with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements:
  - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 SYSTEM DESCRIPTION**

- .1 Design Requirements:
  - .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
  - .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP58.
  - .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
  - .4 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
  - .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP58.
- .2 Performance Requirements:
  - .1 Design supports, platforms, catwalks, hangers to withstand seismic events.

**2.2 GENERAL**

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP58.
-



- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

## 2.3 PIPE HANGERS

- .1 Finishes:
    - .1 Pipe hangers and supports: galvanized after manufacture.
    - .2 Use hot dipped galvanizing process.
    - .3 Ensure steel hangers in contact with copper piping are epoxy coated.
  - .2 Upper attachment structural: suspension from lower flange of I-Beam:
    - .1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
      - .1 Rod: 13 mm FM approved.
    - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed FM approved.
  - .3 Upper attachment structural: suspension from upper flange of I-Beam:
    - .1 Cold piping NPS 2 maximum: ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed and FM approved to MSS SP69.
    - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut FM approved.
  - .4 Upper attachment to concrete:
    - .1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.
    - .2 Concrete inserts: wedge shaped body with knockout protector plate FM approved to MSS SP69.
  - .5 Shop and field-fabricated assemblies:
    - .1 Trapeze hanger assemblies
    - .2 Steel brackets
    - .3 Sway braces for seismic restraint systems
  - .6 Hanger rods: threaded rod material to MSS SP58:
    - .1 Ensure that hanger rods are subject to tensile loading only.
    - .2 Provide linkages where lateral or axial movement of pipework is anticipated.
  - .7 Pipe attachments: material to MSS SP58:
    - .1 Attachments for steel piping: carbon steel galvanized.
    - .2 Attachments for copper piping: copper plated black steel.
    - .3 Use insulation shields.
    - .4 Oversize pipe hangers and supports.
  - .8 Adjustable clevis: material to MSS SP69 FM approved, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
-

- .1 Ensure "U" has hole in bottom for rivetting to insulation shields.
- .9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP69.
- .10 U-bolts: carbon steel to MSS SP69 with 2 nuts at each end to ASTM A563.
  - .1 Finishes for steel pipework: galvanized.
  - .2 Finishes for copper, glass, brass or aluminum pipework: galvanized, with formed portion epoxy coated.
- .11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP69.

## 2.4 RISER CLAMPS

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

## 2.5 INSULATION PROTECTION SHIELDS

- .1 Insulated cold piping:
  - .1 64 kg/m<sup>3</sup> density insulation plus insulation protection shield to: MSS SP69, galvanized sheet carbon steel. Length designed for maximum 3 m span.
- .2 Insulated hot piping:
  - .1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP69.

## 2.6 VARIABLE SUPPORT SPRING HANGERS

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

## 2.7 EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Section 05 12 23 - Structural Steel for Buildings. Submit calculations with shop drawings.
-

**2.8 EQUIPMENT ANCHOR BOLTS AND TEMPLATES**

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

**2.9 PLATFORMS AND CATWALKS**

- .1 None are required for HVAC equipment

**2.10 HOUSE-KEEPING PADS**

- .1 Provide 100 mm high concrete housekeeping pads for base-mounted equipment; size pads 50 mm larger than equipment; chamfer pad edges.
- .2 Concrete: to Section 03 30 00 - Cast-in-Place Concrete.

**2.11 OTHER EQUIPMENT SUPPORTS**

- .1 Fabricate equipment supports from structural grade steel meeting requirements of Section 05 12 23 - Structural Steel for Buildings.
- .2 Submit structural calculations with shop drawings.

**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 INSTALLATION**

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

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

**3.3 HANGER SPACING**

- .1 Plumbing piping: to Provincial Code and authority having jurisdiction.
- .2 Fire protection: to applicable fire code.
- .3 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.
- .4 Copper piping: up to NPS 1/2: every 1.5 m.
- .5 Flexible joint roll groove pipe: in accordance with table below for steel, but not less than one hanger at joints. Table listings for straight runs without concentrated loads and where full linear movement is not required.
- .6 Within 300 mm of each elbow.

Maximum Pipe Size : NPS	Maximum Spacing Steel	Maximum Spacing Copper
up to 1-1/4	2.4 m	1.8 m
1-1/2	3.0 m	2.4 m
2	3.0 m	2.4 m
2-1/2	3.7 m	3.0 m
3	3.7 m	3.0 m
3-1/2	3.7 m	3.3 m
4	3.7 m	3.6 m
5	4.3 m	
6	5.0 m	
8	5.0 m	
10	5.0 m	
12	5.0 m	

- .7 Pipework greater than NPS 12: to MSS SP69.

**3.4 HANGER INSTALLATION**

- .1 Install hanger so that rod is vertical under operating conditions.
- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

**3.5 HORIZONTAL MOVEMENT**

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.

- .2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

### 3.6 FINAL ADJUSTMENT

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

### 3.7 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 - Quality Control and submit report as described in Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Manufacturer's Field Services:
  - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
  - .3 Schedule site visits, to review Work, as directed in Section 01 45 00 - Quality Control.

### 3.8 CLEANING

- .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**END OF SECTION**

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**Part 1 General**

**1.1 SUMMARY**

.1 Section Includes:

.1 Heat tracing cables for pipes and tanks including controls and installation.

.2 Related Requirements

.1 Above ground chilled water piping running outside of building.

**1.2 REFERENCES**

.1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples. Include product characteristics, performance criteria, and limitations.

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.3 Instructions: submit manufacturer's installation instructions.

**1.4 QUALITY ASSURANCE**

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

**1.5 DELIVERY, STORAGE, AND HANDLING**

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycle in accordance with Section 01 74 19 - Waste Management and Disposal.

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**Part 2 Products**

**2.1 PIPE TRACING HEATING CABLES**

- .1 Self-regulating low temperature electric heater consisting of 2-16 AWG tinned-copper bus wires embedded in parallel in a polymer core that varies its power output to respond to temperature all along its length. Provide heater covered with a radiation cross-linked modified polyolefin dielectric jacket. Heat output 26 W/metre max.
- .2 Provide the heater to operate on line voltage of 120 volts, single phase, without the use of transformers. Select circuit length to suit power supply locations as shown on the electrical drawings.
- .3 Provide all power components, end seals, splice and tee components for a complete system.
- .4 Provide ambient sensing thermostats set to energize the systems when ambient temperature drops below 5 degrees Celsius.
- .5 All components shall be UL listed and CSA approved.

**2.2 CONTROLS**

- .1 Thermostat: remote bulb type. Rating as indicated.

**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 INSTALLATION**

- .1 Install heating cables in accordance with manufacturer's instructions. Co-ordinate installation with pipe insulation application.
- .2 Make power and control connections.

**3.3 FIELD QUALITY CONTROL**

- .1 Tests:
  - .1 Perform tests in accordance with Section 26 05 00 - Common Work Results for Electrical.
- .2 Use 500 V Megger to test cables for continuity and insulation value and record readings before, during and after installation.
- .3 Where resistance of 50 megohms or less is measured, stop work and advise Consultant.

**3.4 CLEANING**

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

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**Part 1 General**

**1.1 SUMMARY**

.1 Section Includes:

- .1 Vibration isolation materials and components, seismic control measures and their installation including chiller, pumps, all equipment, and piping system.

**1.2 REFERENCES**

.1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

- .1 Material Safety Data Sheets (MSDS).

.2 National Fire Protection Association (NFPA)

- .1 NFPA 13-[2002], Standard for the Installation of Sprinkler Systems.

.3 National Building Code of Canada (NBC)

**1.3 SUBMITTALS**

.1 Submittals: in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

- .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples. Include product characteristics, performance criteria, and limitations.

- .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

.2 Submit shop drawings in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

- .1 Shop drawings: submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.
- .2 Provide separate shop drawings for each isolated system complete with performance and product data.
- .3 Provide detailed drawings of seismic control measures for equipment and piping.

.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

- .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 Consultant will make available 1 copy of systems supplier's installation instructions.
- .3 Manufacturer's Field Reports: manufacturer's field reports specified.

**1.4 QUALITY ASSURANCE**

.1 Health and Safety:

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- .1 Do construction occupational health and safety in accordance with Section 01 35 33.10 - Health and Safety Requirements.

#### 1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle in accordance with Section 01 61 10 – Common Product Requirements.
  - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
  - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycle in accordance with Section 01 74 19 - Waste Management and Disposal.

#### 1.6 WORK INCLUDED

- .1 Provide vibration isolation on all motor driven equipment with motors of 0.37 kW (0.5 HP) and greater power output (as indicated on the motor nameplate) and on piping, as specified herein. For equipment less than 0.37 kW, provide neoprene grommets at the support points. Electrical grommets are not acceptable.
- .2 Provide seismic restraints for all isolated and non-isolated equipment and piping systems.
- .3 Provide seismic spring isolator mounts for chiller.
- .4 Ensure isolators and restraining devices which are factory supplied with equipment meet the requirements of this section. Provide signed and sealed Letter of Assurance as required by this section.
- .5 Ensure equipment manufacturer's provide attachment points capable of withstanding specified seismic forces.

#### 1.7 DESIGN CRITERIA

- .1 Ensure that the minimum distance between adjacent corner isolators is at least equal to the height of the centre of gravity of the equipment. Include height of centre of gravity on shop drawings. Otherwise, design for increased forces on the supports, and submit design calculations with shop drawings for approval.
  - .2 Ensure isolation systems have a vertical natural frequency no higher than one third of the lowest forcing frequency, unless otherwise specified. Use dynamic stiffness for elastomers and do not exceed 60 durometer.
  - .3 Design isolators and seismic restraints to meet the structural requirements of the Building Code.
  - .4 Where integral isolation/snubbing devices do not meet the seismic requirements provide secondary all directional snubbing devices.
  - .5 Design attachments to both the equipment and the structure to meet the specified forces involved. Have the attachment details to the structure approved by a Professional Engineer registered in British Columbia.
-

- .6 Provide seismic restraints for pipes 65 mm diameter and larger except where the pipe hanger rod length, from attachment to structure to attachment of support hardware (i.e. top of clevis hanger) is less than 305 mm.
- .7 Provide seismic restraints for all isolated piping and equipment, regardless of size.

#### 1.8 QUALIFICATIONS

- .1 Have all isolation/seismic restraint products tested and certified by an independent testing laboratory, or certified by a registered professional engineer, to demonstrate that the products meet the requirements of this section. If particular tests are carried out to represent an isolator type, the tests shall be valid for the full load range of the isolator. Submit such tests or certification on request.

#### 1.9 DESIGN PROFESSIONAL AND LETTERS OF ASSURANCE

- .1 Have the complete and functional seismic restraint system designed and certified by a British Columbia registered professional engineer.
- .2 Submit Letters of Assurance for the design Work of this Section, signed and sealed by the design professional engineer.
- .3 Have the design professional engineer undertake such field reviews as he or she determines to be necessary to confirm that the construction generally conforms with the design intent.
- .4 Submit letters of Assurance of Field Review and Compliance for the design Work of this Section, signed and sealed by the design professional engineer, upon completion of the Work of this Section.
- .5 Ensure that Letters of Assurance conform to the standard requirements of the Authority Having Jurisdiction.

#### 1.10 SUBMITTALS

- .1 Obtain all relevant equipment information and provide calculations, shop and placement drawings for all vibration isolation elements and steel bases for review before materials are ordered. Provide attachment to both the equipment and the structure meeting the specified forces involved. Have attachment details to the structure approved by a BC registered Professional Engineer.
- .2 Submit samples of materials required to complete the work of this section for inspection and review if requested.
- .3 Have the vibration isolation vendor provide a full inspection report of isolation/restraint products provided and installed, listing all deficiencies.

### Part 2 Products

#### 2.1 GENERAL

- .1 Size and shape of bases type and performance of vibration isolation as indicated.
-

## 2.2 ELASTOMERIC PADS

- .1 Type EP1 - neoprene waffle or ribbed; 9 mm minimum thick; 50 durometer; maximum loading 350 kPa.
- .2 Type EP2 - rubber waffle or ribbed; 9 mm minimum thick; 30 durometer natural rubber; maximum loading 415 kPa.
- .3 Type EP3 - neoprene-steel-neoprene; 9 mm minimum thick neoprene bonded to 1.71 mm steel plate; 50 durometer neoprene, waffle or ribbed; holes sleeved with isolation washers; maximum loading 350 kPa.
- .4 Type EP4 - rubber-steel-rubber; 9 mm minimum thick rubber bonded to 1.71 mm steel plate; 30 durometer natural rubber, waffle or ribbed; holes sleeved with isolation washers; maximum loading 415 kPa.

## 2.3 ELASTOMERIC MOUNTS

- .1 Type M1 - colour coded; neoprene in shear; maximum durometer of 60; threaded insert and two bolt-down holes; ribbed top and bottom surfaces.

## 2.4 SPRINGS

- .1 Design stable springs: ratio of lateral to axial stiffness is equal to or greater than 1.2 times ratio of static deflection to working height. Select for 50% travel beyond rated load. Units complete with levelling devices.
- .2 Ratio of height when loaded to diameter of spring between 0.8 to 1.0.
- .3 Cadmium plate for outdoor 100% relative humidity installations.
- .4 Colour code springs.

## 2.5 SPRING MOUNT

- .1 Zinc or cadmium plated hardware; housings coated with rust resistant paint.
  - .2 Type M2 - stable open spring: support on bonded 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad.
  - .3 Type M3 - stable open spring: 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad, bonded under isolator and on isolator top plate; levelling bolt for rigidly mounting to equipment.
  - .4 Type M4 - restrained stable open spring: supported on bonded 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad; built-in resilient limit stops, removable spacer plates.
  - .5 Type M5 - enclosed spring mounts with snubbers for isolation up to 950 kg maximum.
  - .6 Performance: as indicated.
-

## 2.6 HANGERS

- .1 Colour coded springs, rust resistant, painted box type hangers. Arrange to permit hanger box or rod to move through a 30 degrees arc without metal to metal contact.
- .2 Type H1 - neoprene - in-shear, moulded with rod isolation bushing which passes through hanger box.
- .3 Type H2 - stable spring, elastomeric washer, cup with moulded isolation bushing which passes through hanger box.
- .4 Type H3 - stable spring, elastomeric element, cup with moulded isolation bushing which passes through hanger box.
- .5 Type H4 - stable spring, elastomeric element with pre-compression washer and nut with deflection indicator.
- .6 Performance: as indicated.

## 2.7 ACOUSTIC BARRIERS FOR ANCHORS AND GUIDES

- .1 Acoustic barriers: between pipe and support, consisting of 25 mm minimum thick heavy duty duck and neoprene isolation material.

## 2.8 HORIZONTAL THRUST RESTRAINT

- .1 Spring and elastomeric element housed in box frame; assembly complete with rods and angle brackets for equipment and ductwork attachment; provision for adjustment to limit maximum start and stop movement to 9 mm.
- .2 Arrange restraints symmetrically on either side of unit and attach at centerline of thrust.

## 2.9 ISOLATORS

- .1 Supply all of the vibration isolation equipment from one approved supplier with the exception of isolators which are factory installed and are standard equipment with the machinery. In the latter case have the manufacturer supply certified calculations of the internal restraints as well as certified calculations for anchorage to the structure.
- .2 Provide isolators of the following types
  - .1 Pad Isolators
    - .1 Neoprene pad isolators, as defined by CAN/CSA-S6. Select pads for a 15% static deflection. Hold down equipment mounted on neoprene pad isolators using anchor bolts, nuts, washers, and hemi-grommets.
  - .2 Neoprene Floor Isolators
    - .1 Neoprene-in-shear isolators designed to meet specified seismic requirements. Select isolators for a 5 mm minimum static deflection, and bolt to structure. In the case of rubber isolators, provide protection in the design of the isolator to avoid contact of the rubber element with oil in the mechanical room.
  - .3 Spring Floor Isolators
    - .1 Spring mounts, with a minimum 25 mm deflection, complete with levelling devices, and minimum 6 mm thick ribbed neoprene sound pads with

1.3 mm minimum deflection. Design isolator to meet specified seismic requirements and bolt down using neoprene grommets.

- .4 Hanger Isolators
  - .1 Spring hangers within minimum 25 mm deflection, complete with 6 mm thick sound pads sized for 0.5 mm minimum deflection, or neoprene hangers. A neoprene element alone, without a hanger box, is acceptable provided no short-circuiting occurs and equipment rotates above 1170 rpm.
- .3 Select isolators at the supplier's optimum recommended loading, and do not load beyond the limit specified in the manufacturer's literature.
- .4 Design springs with stiffeners ratio of  $k_x/k_y = 1.0$  to 1.5 with a working deflection between 0.3 and 0.6 of solid deflection.
- .5 Provide hot-dipped galvanized housings and neoprene coated springs, or other acceptable weather protection, for all isolation equipment located out-of-doors or in areas where moisture may cause corrosion.

## 2.10 FLEXIBLE PIPE CONNECTORS

- .1 Install Neoprene or EPDM flexible connectors between vibrating equipment and piping over 65 mm, except those pumps handling domestic water.

## 2.11 SEISMIC ROD CLAMP

- .1 Use seismic rod clamps where the length of the threaded support rod for equipment/pipe/ductwork is over 50 times the rod diameter.
- .2 Use 25 mm x 25 mm x 6.4 mm angle for threaded rod size 9.5 to 15.9 mm diameter.
- .3 Use 38 mm x 38 mm x 6.4 mm angle for threaded rod size 19 to 32 mm diameter.
- .4 Provide rod clamps complete with locking bolt.

## 2.12 SEISMIC SOLID BRACE FOR NON-ISOLATED EQUIPMENT/PIPING/DUCTWORK

- .1 Provide two solid braces at 90° to each other at attachment point, for non-isolated hung equipment, piping, and ductwork.
- .2 Use braces complete with formed steel solid brace anchors with two bolts holds for the solid brace and swivel hinge on a support bracket on each end of the brace.

## 2.13 MECHANICAL EQUIPMENT ANCHORS

- .1 Anchors shall be provided by vibration isolation/seismic restraint supplier. The responsibility for the seismic restraint of resiliently mounted equipment, from attachment to structure to point of attachment to equipment, is that of the vibration isolation/seismic restraint supplier.

## 2.14 EPOXY PUTTY

- .1 Steel reinforced epoxy putty with an ultimate compressive strength of 82,700 kPa.
-

**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 INSTALLATION**

- .1 Seismic control measures to meet requirements of NBC.
- .2 Install vibration isolation equipment in accordance with manufacturer's instructions and adjust mountings to level equipment.
- .3 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping, conduit and ducting passage through walls and floors do not transmit vibrations.
- .4 Unless indicated otherwise, support piping connected to isolated equipment with spring mounts or spring hangers with 25 mm minimum static deflection as follows:
  - .1 Up to NPS4: first 3 points of support. NPS5 to NPS8: first 4 points of support. NPS10 and Over: first 6 points of support.
  - .2 First point of support: static deflection of twice deflection of isolated equipment, but not more than 50 mm.
- .5 Where isolation is bolted to floor use vibration isolation rubber washers.
- .6 Block and shim level bases so that ductwork and piping connections can be made to rigid system at operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.
- .7 Chiller CH-1 is to be mounted on seismic spring isolators with 65 mm static deflection.

**3.3 ISOLATORS**

- .1 Execute the work in accordance with the specifications, and where applicable, in accordance with the manufacturer's instructions and only use workmen experienced in this type of work.
  - .2 For all equipment mounted on vibration isolators, provide a minimum clearance of 50 mm to other structures, piping, equipment, and similar items.
  - .3 Isolate all floor or pier mounted equipment on spring floor isolators, unless otherwise specified.
  - .4 Isolate pumps and axial fans rotating at more than 1170 RPM on neoprene floor isolators. Use the lowest RPM scheduled for two speed equipment in determining isolator deflection.
  - .5 Before bolting isolators to the structure, start equipment and balance the systems so that the isolators can be adjusted to the correct operating position before installing seismically rated drilled inserts.
-

- .6 For equipment mounted on a slab on grade, chillers and in-line pumps, mount on neoprene floor isolators, unless otherwise specified.
- .7 For all electrical connections to isolated equipment, provide a 90° bend of flexible conduit for 25 mm conduit and smaller or 90° Crouse-Hind EC couplings for larger conduit. Use connections long enough so that the conduit will remain intact if the equipment moves laterally 300 mm from the installed position, and flexible enough to transmit less vibration to the structure than is transmitted through the springs.
- .8 Select Spring Hangers for a minimum static deflection of 25 mm for all ceiling hung fans, and air handling units, and any other vibrating sources.
- .9 Provide Spring Hangers on all piping, tanks, etc. connected to a vibrating source, if the piping is in excess of 40 mm dia. Provide the hangers for a distance of 6.5 m for a 50 mm pipe and 11.5 m for a 250 mm pipe. Isolate other pipe sizes for a proportionate distance. Isolate all piping in mechanical rooms. If neoprene hangers are proposed for non-critical spaces, change to spring hangers at no additional cost in the event that the isolation proves inadequate.
- .10 Where piping connected to noise generating equipment is routed from the mechanical room through walls and plumbing chases, position piping to avoid contact with the concrete structure, future framing, drywall and other finishes which may radiate noise.

### 3.4 EQUIPMENT INSTALLATION

- .1 Bolt all equipment to the supporting structure. Do not bridge isolation elements.

### 3.5 NON-ISOLATED HANGING SYSTEM

- .1 Follow the Seismic Restraint manual Guidelines for Mechanical systems published by SMACNA in the selection of the appropriate diameter of threaded rod for the associated load at each attachment point. Use the next largest size of rod if any doubt exists.
- .2 Wherever possible keep piping, ducting and equipment within 300 mm of the structure (i.e. top of pipe/duct or equipment to the attachment point at underside of structure). Intermediate points may exceed this 300 mm rule but a consecutive 300 mm attachment must occur with 9 m for ducting and 12 m for piping. No further seismic restraint is required if these parameters are met and all threaded rods at restraint points exceed 6.3 mm diameter.
- .3 Piping/ducting may be attached to walls and require no further restraint as long as it is attached within 300 mm of that wall.
- .4 Use pipe riser clamps wherever possible on piping without thermal expansion, instead of clevis hangers.
- .5 Trapeze parallel runs of piping/ducting except those pipes where thermal expansion is expected. Attach pipes to trapeze with "U" bolts. Where pipes are of different diameter, set the bottom of all pipes on the same horizontal plane, to accommodate attachment to the trapeze.
- .6 Anchor ducts to trapezes at flange locations.

- .7 Anchor pipes without thermal expansion penetrating structural walls to the wall at the point of penetration.
- .8 Anchor ducts penetrating walls to the wall at the point of penetration.
- .9 Place piping closer to the structural ceiling than ductwork, except where maintenance prone valves or other devices are installed in the piping.
- .10 Set the minimum distance from drill holes to the edge of the concrete or adjacent drill holes as recommended by the manufacturer of the drill inserts.
- .11 Place seismic bracing or cables for ductwork within 600 mm, in both directions from every turn on jog, then:
  - .1 space the transverse bracing at 9 m intervals;
  - .2 space the longitudinal bracing at 18 m intervals.
- .12 Place seismic bracing or cables for pipes within 600 mm, in both directions from every turn or jog, then:
  - .1 space the transverse bracing at 12 m intervals;
  - .2 space the longitudinal bracing at 24 m intervals.
- .13 Include anchored wall penetrations when calculating the 9/18 and 12/24 bracing spacings to determine the number of transverse and axial restraints required.
- .14 Install the required restraints equidistantly between corner and penetration anchor points.

### 3.6 ANCHORING RIGIDITY

- .1 Maximum air gap between anchor bolt and restraint housing anchor hole shall not exceed 3 mm.
- .2 If the air gap exceeded 3 mm, the clearance must be reduced by hemi-grommets (where the bolt is concentric with the hole) or epoxy putty.
- .3 Follow manufacturer's instructions to hand knead the 0.5 fast epoxy putty and fill the entire gap between the bolt hole and the anchor bolt.

### 3.7 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
  - .1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract Documents.
  - .2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:
    - .1 After delivery and storage of Products.
    - .2 After preparatory work is complete but before installation commences.
    - .3 Twice during the installation, at 25% and 60% completion stages.
    - .4 Upon completion of installation.
  - .3 Submit manufacturer's reports to Consultant within 3 days of manufacturer representative's review.
  - .4 Make adjustments and corrections in accordance with written report.



.2 Inspection and Certification:


- .1 Experienced and competent sound and vibration testing professional engineer to take vibration measurement for HVAC systems after start up and TAB of systems to Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .2 Provide Consultant with notice 24 h in advance of commencement of tests.
- .3 Establish adequacy of equipment isolation and acceptability of noise levels in occupied areas and where appropriate, remedial recommendations (including sound curves).
- .4 Submit complete report of test results including sound curves.

**3.8**

**CLEANING**

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**



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**Part 1 General**

**1.1 SUMMARY**

.1 Section Includes:

- .1 Seismic restraint systems for statically supported and vibration isolated equipment and systems; including mechanical equipment, kitchen equipment, fire protection, equipment and systems, both vibration isolated and statically supported.

.2 Related Sections:

- .1 23 05 48 - Vibration and Seismic Control for HVAC Piping and Equipment

**1.2 REFERENCES**

.1 Canadian Standards Association (CSA International)

- .1 CSA G40.20/G40.21-[04], General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

- .1 Material Safety Data Sheets (MSDS).

.3 National Building Code of Canada (NBC) - 1995

**1.3 DEFINITIONS**

- .1 SRS: acronym for Seismic Restraint System.

**1.4 SYSTEM DESCRIPTION**

.1 SRS fully integrated into, and compatible with:

- .1 Noise and vibration controls specified elsewhere.
- .2 Structural, mechanical, electrical design of project.

.2 Systems, equipment not required to be operational during and after seismic event.

.3 During seismic event, SRS to prevent systems and equipment from causing personal injury and from moving from normal position.

.4 Designed by Professional Engineer specializing in design of SRS and registered in Province of BC.

**1.5 SUBMITTALS**

.1 Submittals: in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

.2 Shop drawings: submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.

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- .3 Submit design data including:
  - .1 Full details of design criteria.
  - .2 Working drawings (prepared to same standard of quality and size as documents forming these tender documents), materials lists, schematics, full specifications for components of each SRS to be provided.
  - .3 Design calculations (including restraint loads resulting from seismic forces in accordance with National Building Code, detailed work sheets, tables).
  - .4 Separate shop drawings for each SRS and devices for each system, equipment.
  - .5 Identification of location of devices.
  - .6 Schedules of types of SRS equipment and devices.
  - .7 Details of fasteners and attachments to structure, anchorage loadings, attachment methods.
  - .8 Installation procedures and instructions.
  - .9 Design calculations including restraint loads to NBC and Supplement.
  - .10 Detailed work sheets, tables Simplified, Detailed work sheets, tables, Simplified, conservative assumptions are acceptable.
  - .11 Detailed design of SRS including complete working drawings prepared to same standard of quality and size as Contract Documents, materials lists, design calculations, schematics, specifications.
- .4 Submit additional copy of shop drawings and product data to Structural Engineer for review of connection points to building structure.
- .5 Quality assurance submittals: submit following in accordance with 01 33 00 - Shop Drawings, Product Data and Samples..
  - .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.
- .6 Closeout Submittals:
  - .1 Provide maintenance data including monitoring requirements for incorporation into manuals specified in Section 01 78 30 – Closeout Submittals..

## 1.6 QUALITY ASSURANCE

- .1 Health and Safety:
  - .1 Do construction occupational health and safety in accordance with Section 01 61 10 – Common Product Requirements.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
    - .1 Deliver, store and handle in accordance with Section 01 61 10 – Common Product Requirements.
    - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
  - .2 Waste Management and Disposal:
-

- .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 SRS MANUFACTURER**

- .1 SRS from one manufacturer regularly engaged in SRS production.

**2.2 GENERAL**

- .1 SRS to provide gentle and steady cushioning action and avoid high impact loads.
- .2 SRS to restrain seismic forces in every direction.
- .3 Fasteners and attachment points to resist same load as seismic restraints.
- .4 SRS of Piping systems compatible with:
  - .1 Expansion, anchoring and guiding requirements.
  - .2 Equipment vibration isolation and equipment SRS.
- .5 SRS utilizing cast iron, threaded pipe, other brittle materials not permitted.
- .6 Attachments to RC structure:
  - .1 Use high strength mechanical expansion anchors.
  - .2 Drilled or power driven anchors not permitted.
- .7 Seismic control measures not to interfere with integrity of firestopping.

**2.3 SRS FOR STATIC EQUIPMENT, SYSTEMS**

- .1 Floor-mounted equipment, systems:
  - .1 Anchor equipment to equipment supports.
  - .2 Anchor equipment supports to structure.
  - .3 Use size of bolts scheduled in approved shop drawings.
- .2 Suspended equipment, systems:
  - .1 Use one or combination of following methods:
    - .1 Install tight to structure.
    - .2 Cross-brace in every direction.
    - .3 Brace back to structure.
    - .4 Slack cable restraint system.
  - .2 SCS to prevent sway in horizontal plane, "rocking" in vertical plane, sliding and buckling in axial direction.
  - .3 Hanger rods to withstand compressive loading and buckling.

**2.4 SRS FOR VIBRATION ISOLATED EQUIPMENT**

- .1 Floor mounted equipment, systems:
-

- .1 Use one or combination of following methods:
    - .1 Vibration isolators with built-in snubbers.
    - .2 Vibration isolators and separate snubbers.
    - .3 Built-up snubber system approved by Consultant, consisting of structural elements and elastomeric layer.
  - .2 SRS to resist complete isolator unloading.
  - .3 SRS not to jeopardize noise and vibration isolation systems. Provide 4-8 mm clearance between seismic restraint snubbers and equipment during normal operation of equipment and systems.
  - .4 Cushioning action: gentle and steady by utilizing elastomeric material or other means in order to avoid high impact loads.
- .2 Suspended equipment, systems:
- .1 Use one or combination of following methods:
    - .1 Slack cable restraint system.
    - .2 Brace back to structure via vibration isolators and snubbers.

## 2.5 SLACK CABLE RESTRAINT SYSTEM (SCS)

- .1 Use elastomer materials or similar to avoid high impact loads and provide gentle and steady cushioning action.
- .2 SCS to prevent sway in horizontal plane, "rocking" in vertical plane, sliding and buckling in axial direction.
- .3 Hanger rods to withstand compressive loading and buckling.

## 2.6 SERVICE UTILITIES ENTRANCE INTO BUILDING

- .1 Provide flexibility to prevent breakage in the event of earthquake activity.

## 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 INSTALLATION

- .1 Attachment points and fasteners:
    - .1 To withstand same maximum load that seismic restraint is to resist and in every direction.
  - .2 Slack Cable Systems (SCS):
    - .1 Connect to suspended equipment so that axial projection of wire passes through centre of gravity of equipment.
    - .2 Use appropriate grommets, shackles, other hardware to ensure alignment of restraints and to avoid bending of cables at connection points.
-

- .3 Piping systems: provide transverse SCS at 10 m spacing maximum, longitudinal SCS at 20 m maximum or as limited by anchor/slack cable performance.
- .4 Small pipes may be rigidly secured to larger pipes for restraint purposes, but not reverse.
- .5 Orient restraint wires on ceiling hung equipment at approximately 90 degrees to each other (in plan), tie back to structure at maximum of 45 degrees to structure.
- .6 Adjust restraint cables so that they are not visibly slack but permit vibration isolation system to function normally.
- .7 Tighten cable to reduce slack to 40 mm under thumb pressure. Cable not to support weight during normal operation.
- .3 Install SRS at least 25 mm from equipment, systems, services.
- .4 Miscellaneous equipment not vibration-isolated:
  - .1 Bolt through house-keeping pad to structure.
- .5 Co-ordinate connections with other disciplines.
- .6 Vertical tanks:
  - .1 Anchor through house-keeping pad to structure.
  - .2 Provide steel bands above centre of gravity.
- .7 Horizontal tanks:
  - .1 Provide at least two straps with anchor bolts fastened to structure.

### 3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
  - .1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract Documents.
  - .2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:
    - .1 After delivery and storage of Products.
    - .2 After preparatory work is complete but before installation commences.
    - .3 Twice during the installation, at 25% and 60% completion stages.
    - .4 Upon completion of installation.
  - .3 Submit manufacturer's reports to Consultant within 3 days of manufacturer representative's review.
- .2 Inspection and Certification:
  - .1 SRS: inspected and certified by Seismic Engineer upon completion of installation.
  - .2 Provide written report to Consultant with certificate of compliance.
- .3 Commissioning Documentation:
  - .1 Upon completion and acceptance of certification, hand over to Consultant 1 complete set of construction documents, revised to show "as-built" conditions.

**3.4**

**CLEANING**

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1 General**

**1.1 SUMMARY**

.1 Section Includes:

- .1 Materials and requirements for the identification of piping systems, duct work, valves and controllers, including the installation and location of identification systems.

**1.2 REFERENCES**

.1 Canadian Gas Association (CGA)

- .1 CSA/CGA B149.1-05, Natural Gas and Propane Installation Code.

.2 Canadian General Standards Board (CGSB)

- .1 CAN/CGSB-1.60-97, Interior Alkyd Gloss Enamel.
- .2 CAN/CGSB-24.3-92, Identification of Piping Systems.

**1.3 SUBMITTALS**

.1 Product Data:

- .1 Submittals: in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product data to include paint colour chips, other products specified in this section.

.2 Samples:

- .1 Submit samples in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Samples to include nameplates, labels, tags, lists of proposed legends.

**1.4 QUALITY ASSURANCE**

- .1 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.

**1.5 DELIVERY, STORAGE, AND HANDLING**

.1 Packing, shipping, handling and unloading:

- .1 Deliver, store and handle in accordance with Section 01 61 10 - Common Product Requirements.
- .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

- .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 11 Waste Management and Disposal.
  - .2 Dispose of unused paint coating material at official hazardous material collections site approved by Consultant.
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- .3 Do not dispose of unused paint material into sewer system, into streams, lakes, onto ground or in locations where it will pose health or environmental hazard.

**Part 2 Products**

**2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES**

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

**2.2 SYSTEM NAMEPLATES**

- .1 Colours:
  - .1 Hazardous: red letters, white background.
  - .2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).
- .2 Construction:
  - .1 3 mm thick laminated plastic, matte finish, with square corners, letters accurately aligned and machine engraved into core.
- .3 Sizes:
  - .1 Conform to following table:

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20
  - .2 Use maximum of 25 letters/numbers per line.
- .4 Locations:
  - .1 Terminal cabinets, control panels: use size # 5.
  - .2 Equipment in Mechanical Rooms: use size # 9.

**2.3 EXISTING IDENTIFICATION SYSTEMS**

- .1 Apply existing identification system to new work.
- .2 Where existing identification system does not cover for new work, use identification system specified this section.

- .3 Before starting work, obtain written approval of identification system from Consultant.

**2.4 PIPING SYSTEMS GOVERNED BY CODES**

- .1 Identification:
  - .1 Natural gas: to CSA/CGA B149.1 and authority having jurisdiction.
  - .2 Sprinklers: to NFPA 13.
  - .3 Standpipe and hose systems: to NFPA 14.

**2.5 IDENTIFICATION OF PIPING SYSTEMS**

- .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
- .2 Pictograms:
  - .1 Where required: Workplace Hazardous Materials Information System (WHMIS) regulations.
- .3 Legend:
  - .1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.
- .4 Arrows showing direction of flow:
  - .1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.
  - .2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.
  - .3 Use double-headed arrows where flow is reversible.
- .5 Extent of background colour marking:
  - .1 To full circumference of pipe or insulation.
  - .2 Length to accommodate pictogram, full length of legend and arrows.
- .6 Materials for background colour marking, legend, arrows:
  - .1 Pipes and tubing 20 mm and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.
  - .2 Other pipes: pressure sensitive [plastic-coated cloth] [vinyl] with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150 degrees C and intermittent temperature of 200 degrees C.
- .7 Colours and Legends:
  - .1 Where not listed, obtain direction from Consultant.
  - .2 Colours for legends, arrows: to following table:

Background colour:	Legend, arrows:
Yellow	BLACK
Green	WHITE
Red	WHITE
  - .3 Background colour marking and legends for piping systems:

Contents	Background colour marking	Legend
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** Add design temperature		
++ Add design temperature and pressure		
City water	Green	CITY WATER
Treated water	Green	TREATED WATER
Condenser water loop supply	Green	COND. WTR. LOOP SUPPLY
Condenser water loop return	Green	COND. WTR. LOOP RETURN
Chilled water supply	Green	CH. WTR. SUPPLY
Chilled water return	Green	CH. WTR. RETURN
Hot water heating supply	Yellow	HEATING SUPPLY
Hot water heating return	Yellow	HEATING RETURN
Exhaust coil heating supply	Yellow	EXHAUST COIL SUPPLY
Exhaust coil heating return	Yellow	EXHAUST COIL RETURN
Fluid cooler supply	Green	FC SUPPLY
Fluid cooler return	Green	FC RETURN
Air handling unit supply	Yellow	AHU SUPPLY
Air handling unit return	Yellow	AHU RETURN
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Waste water	Green	WASTE WATER
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT
Natural gas	to Codes	
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS

2.6

**VALVES, CONTROLLERS**

- .1 Brass tags with 12 mm stamped identification data filled with black paint.
- .2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

**2.7 CONTROLS COMPONENTS IDENTIFICATION**

- .1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section.
- .2 Inscriptions to include function and (where appropriate) fail-safe position.

**2.8 LANGUAGE**

- .1 Identification in English.
- .2 Use one nameplate and label.

**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 TIMING**

- .1 Provide identification only after painting specified Division 9 - Painting has been completed.

**3.3 INSTALLATION**

- .1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.
- .2 Provide ULC and CSA registration plates as required by respective agency.

**3.4 NAMEPLATES**

- .1 Locations:
  - .1 In conspicuous location to facilitate easy reading and identification from operating floor.
- .2 Standoffs:
  - .1 Provide for nameplates on hot and/or insulated surfaces.
- .3 Protection:
  - .1 Do not paint, insulate or cover.

**3.5 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS**

- .1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: at not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.
  - .2 Adjacent to each change in direction.
  - .3 At least once in each small room through which piping or ductwork passes.
-

- .4 On both sides of visual obstruction or where run is difficult to follow.
- .5 On both sides of separations such as walls, floors, partitions.
- .6 Where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.
- .7 At beginning and end points of each run and at each piece of equipment in run.
- .8 At point immediately upstream of major manually operated or automatically controlled valves, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.
- .9 Identification easily and accurately readable from usual operating areas and from access points.
  - .1 Position of identification approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

### 3.6 VALVES, CONTROLLERS

- .1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.
- .2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Consultant. Provide one copy reduced in size if required in each operating and maintenance manual.
- .3 Number valves in each system consecutively.

### 3.7 CLEANING

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

**Part 1 General**

**1.1 SUMMARY**

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

**1.2 QUALIFICATIONS OF TAB PERSONNEL**

- .1 Submit names of personnel to perform TAB to Consultant within 30 days of award of contract.
- .2 Provide documentation confirming qualifications, successful experience.
- .3 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
  - .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1 2002.
  - .2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems-1998.
  - .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing-2002.
- .4 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- .5 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .6 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- .7 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .8 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
  - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by TAB Specialist.
  - .2 Where new procedures, and requirements, are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or TABB), requirements and recommendations contained in these procedures and requirements are mandatory.

**1.3 PURPOSE OF TAB**

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads
-

- .2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

**1.4 EXCEPTIONS**

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

**1.5 CO-ORDINATION**

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

**1.6 PRE-TAB REVIEW**

- .1 Review contract documents before project construction is started and confirm in writing to Consultant adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.
- .2 Review specified standards and report to Consultant in writing proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

**1.7 START-UP**

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- .2 Follow special start-up procedures specified elsewhere in Division 23.

**1.8 OPERATION OF SYSTEMS DURING TAB**

- .1 Operate systems for length of time required for TAB and as required by Consultant for verification of TAB reports.

**1.9 START OF TAB**

- .1 Notify Consultant 7 days prior to start of TAB.
  - .2 Start TAB when building is essentially completed, including:
  - .3 Installation of ceilings, doors, windows, other construction affecting TAB.
  - .4 Application of weatherstripping, sealing, and caulking.
  - .5 Pressure, leakage, other tests specified elsewhere Division 23.
-

- .6 Provisions for TAB installed and operational.
- .7 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
  - .1 Proper thermal overload protection in place for electrical equipment.
  - .2 Liquid systems:
    - .1 Flushed, filled, vented.
    - .2 Correct pump rotation.
    - .3 Strainers in place, baskets clean.
    - .4 Isolating and balancing valves installed, open.
    - .5 Calibrated balancing valves installed, at factory settings.
    - .6 Chemical treatment systems complete, operational.

**1.10 APPLICATION TOLERANCES**

- .1 Do TAB to following tolerances of design values:
  - .1 Hydronic systems: plus or minus 5 %.

**1.11 ACCURACY TOLERANCES**

- .1 Measured values accurate to within plus or minus 2 % of actual values.

**1.12 INSTRUMENTS**

- .1 Prior to TAB, submit to Consultant list of instruments used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .3 Calibrate within 3 months of TAB. Provide certificate of calibration to Consultant.

**1.13 SUBMITTALS**

- .1 Submit, prior to commencement of TAB:
- .2 Proposed methodology and procedures for performing TAB if different from referenced standard.

**1.14 PRELIMINARY TAB REPORT**

- .1 Submit for checking and approval of Consultant, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
  - .1 Details of instruments used.
  - .2 Details of TAB procedures employed.
  - .3 Calculations procedures.
  - .4 Summaries.

**1.15 TAB REPORT**

- .1 Format in accordance with referenced standard.
  - .2 TAB report to show results in SI units and to include:
-



- .1 Project record drawings.
- .2 System schematics.
- .3 Submit 6 copies of TAB Report to Consultant for verification and approval, in English in D-ring binders, complete with index tabs.

**1.16 VERIFICATION**

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

**1.17 SETTINGS**

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

**1.18 COMPLETION OF TAB**

- .1 TAB considered complete when final TAB Report received and approved by Consultant.

**1.19 AIR / WATER SYSTEMS**

- .1 Standard: TAB to most stringent of this section or TAB standards of AABC SMACNA and ASHRAE.
  - .2 Do TAB of systems, equipment, components, controls specified Division 23 including the following systems, equipment, components, controls:
    - .1 HVAC Systems
  - .3 Qualifications: personnel performing TAB current member in good standing of AABC qualified to standards of AABC.
  - .4 Quality assurance: perform TAB under direction of supervisor qualified to standards of AABC.
  - .5 Measurements: to include as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop, temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.
  - .6 Locations of equipment measurements: to include as appropriate:
    - .1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
    - .2 At controllers, controlled device.
  - .7 Locations of systems measurements to include as appropriate.
-

**1.20 OTHER TAB REQUIREMENTS**

- .1 General requirements applicable to work specified this paragraph:
  - .1 Qualifications of TAB personnel: as for air systems specified this section.
  - .2 Quality assurance: as for air systems specified this section.
- .2 Measurement of noise and vibration from equipment specified in Division 23.

**1.21 POST-OCCUPANCY TAB**

- .1 Participate twice in system checks during warranty period 3 months after acceptance and within 1 month of termination of warranty period.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not used.

**END OF SECTION**

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**Part 1            General**

**1.1                RELATED SECTIONS**

- .1    23 21 14 - Hydronic Specialties
- .2    22 11 16 - Domestic Water Piping
- .3    23 21 13.02 – Hydronic Systems Steel
- .4    23 21 23 - Hydronic pumps

**1.2                REFERENCES**

- .1    American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
    - .1    ANSI/ASHRAE 90.1-10-SI Edition, Energy Standard for Buildings Except Low-Rise Residential Buildings.
  - .2    ASTM International Inc.
    - .1    ASTM C335-05ae1, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
    - .2    ASTM C449/C449M-07, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
    - .3    ASTM C533-07, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
    - .4    ASTM C547-07, Standard Specification for Mineral Fiber Pipe Insulation.
    - .5    ASTM C553-02, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
    - .6    ASTM C612-04e1, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
    - .7    ASTM C795-03, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
    - .8    ASTM C921-03a, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
  - .3    Canadian General Standards Board (CGSB)
    - .1    CGSB 51-GP-52MA-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
    - .2    CAN/CGSB 51.53-95, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts.
  - .4    Health Canada/Workplace Hazardous Materials Information System (WHMIS)
    - .1    Material Safety Data Sheets (MSDS).
  - .5    South Coast Air Quality Management District (SCAQMD), California State
    - .1    SCAQMD Rule 1168-A2005, Adhesive and Sealant Applications.
  - .6    Thermal Insulation Association of Canada (TIAC)
    - .1    National Insulation Standards, Latest Edition..
  - .7    Underwriters Laboratories of Canada (ULC)
-

- .1 CAN/ULC-S102-07, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Provide manufacturer's printed product literature and datasheets for insulation and adhesives, include product characteristics, performance criteria, physical size, finish and limitations.
  - .2 Provide two copies WHMIS MSDS - Material Safety Data Sheets in accordance with Div. 1 - Health and Safety Requirements.
- .3 Manufacturer's Instructions:
  - .1 Include procedures to be used and installation standards to be achieved.
- .4 Qualifications:
  - .1 Installer to be specialist in performing work of this section, and have at least 3 years successful experience in this size and type of project, qualified to standards or member of TIAC.

**1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with Section 01 61 10 – Common Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Store at temperatures and conditions recommended by manufacturer.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets crates padding packaging materials in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 FIRE AND SMOKE RATING**

- .1 Fire and smoke ratings to CAN/ULC-S102:
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

**2.2 INSULATION**

- .1 Mineral fibre: includes glass fibre, rock wool, slag wool.
  - .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.
  - .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
    - .1 Mineral fibre: ASTM C547.
    - .2 Maximum "k" factor: ASTM C547.
-

- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
  - .1 Mineral fibre: ASTM C547.
  - .2 Jacket: to CGSB 51-GP-52MA.
  - .3 Maximum "k" factor: ASTM C547.
- .5 TIAC Code C-1: rigid mineral fibre board, unfaced.
  - .1 Mineral fibre: ASTM C612.
  - .2 Maximum "k" factor: ASTM C612.
- .6 TIAC Code C-4: rigid mineral fibre board faced with factory applied vapour retarder jacket.
  - .1 Mineral fibre: ASTM C612.
  - .2 Jacket: to CGSB 51-GP-52MA.
  - .3 Maximum "k" factor: ASTM C612.
- .7 TIAC Code C-2: mineral fibre blanket unfaced or faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
  - .1 Mineral fibre: ASTM C553.
  - .2 Jacket: to CGSB 51-GP-52MA.
  - .3 Maximum "k" factor: ASTM C553.
- .8 TIAC Code A.6: flexible unicellular tubular elastomer.
  - .1 Insulation: with vapour retarder jacket.
  - .2 Jacket: to CGSB 51-GP-52MA.
  - .3 Maximum "k" factor.
  - .4 Certified by manufacturer free of potential stress corrosion cracking corrodents.
- .9 TIAC Code A-2: rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
  - .1 Insulation: ASTM C533.
  - .2 Maximum "k" factor: ASTM C533.
  - .3 Design to permit periodic removal and re-installation.

### 2.3 CEMENT

- .1 Thermal insulating and finish
  - .1 To: ASTM C449/C449M.

### 2.4 JACKETS

- .1 Polyvinyl Chloride (PVC):
    - .1 One-piece moulded type and sheet to CAN/CGSB 51.53 with pre-formed shapes as required.
    - .2 Colours: to match adjacent finish paint.
    - .3 Minimum service temperatures: -20 degrees C.
    - .4 Maximum service temperature: 65 degrees C.
    - .5 Moisture vapour transmission: 0.02 perm.
    - .6 Fastenings:
-

- .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
  - .2 Tacks.
  - .3 Pressure sensitive vinyl tape of matching colour.
  - .7 Special requirements:
    - .1 Outdoor: UV rated material at least 0.5 mm thick.
  - .8 Covering adhesive: compatible with insulation.
  - .2 ABS Plastic:
    - .1 One-piece moulded type and sheet with pre-formed shapes as required.
    - .2 Colours: to match adjacent finish paint.
    - .3 Minimum service temperatures: -40 degrees C.
    - .4 Maximum service temperature: 82 degrees C.
    - .5 Moisture vapour transmission: 0.012 perm.
    - .6 Thickness: 0.75 mm.
    - .7 Fastenings:
      - .1 Solvent weld adhesive compatible with insulation to seal laps and joints
      - .2 Tacks.
      - .3 Pressure sensitive vinyl tape of matching colour.
    - .8 Locations:
      - .1 For outdoor use ONLY.
  - .3 Canvas:
    - .1 220 gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
    - .2 Lagging adhesive: compatible with insulation.
  - .4 Aluminum:
    - .1 To ASTM B209.
    - .2 Thickness: 0.50 mm sheet.
    - .3 Finish: smooth.
    - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
    - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
    - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5mm thick at 300 mm spacing.
  - .5 Stainless steel:
    - .1 Type: 316.
    - .2 Thickness: 0.25 mm.
    - .3 Finish: smooth.
    - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
    - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
    - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5mm thick at 300 mm spacing.
-

**2.5 INSULATION SECUREMENTS**

- .1 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .2 Contact adhesive: quick setting.
- .3 Canvas adhesive: washable.
- .4 Tie wire: 1.5 mm diameter stainless steel.
- .5 Bands: Stainless steel, 19 mm wide, 0.5 mm thick.
- .6 Facing: 25 mm galvanized steel hexagonal wire mesh on both faces of insulation.
- .7 Fasteners: 2 4 mm diameter pins with 35 mm diameter square clips. Length of pin to suit thickness of insulation.

**2.6 VAPOUR RETARDER LAP ADHESIVE**

- .1 Water based, fire retardant type, compatible with insulation.

**2.7 INDOOR VAPOUR RETARDER FINISH**

- .1 Vinyl emulsion type acrylic, compatible with insulation.

**2.8 OUTDOOR VAPOUR RETARDER MASTIC**

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m<sup>2</sup>.

**Part 3 Execution**

**3.1 APPLICATION**

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

**3.2 PRE- INSTALLATION REQUIREMENTS**

- .1 Pressure testing of equipment and adjacent piping systems complete, witnessed and certified.
- .2 Surfaces clean, dry, free from foreign material.

**3.3 INSTALLATION**

- .1 Install in accordance with TIAC National Standards
    - .1 Hot equipment: To TIAC code 1503-H.
    - .2 Cold equipment: to TIAC code 1503-C.
  - .2 Elastomeric Insulation: to remain dry. Overlaps to manufacturer's instructions. Joints tight and sealed properly.
  - .3 Provide vapour retarder as recommended by manufacturer.
  - .4 Apply materials in accordance with insulation and equipment manufacturer's instructions and this specification.
  - .5 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
-

- .6 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
  - .1 Hangers, supports outside vapour retarder jacket.
- .7 Supports, Hangers:
  - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

**3.4 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES**

- .1 Application: At expansion joints, valves, primary flow measuring elements flanges and unions at equipment.
- .2 Installation to permit periodic removal and replacement without damage to adjacent insulation.

**3.5 CLEANING**

- .1 Clean in accordance with Section 01 74 11 - Cleaning.
  - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**END OF SECTION**



**Part 1 General**

**1.1 SUMMARY**

.1 Section Includes:

- .1 Thermal insulation for piping and piping accessories in commercial type applications.

**1.2 REFERENCES**

.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

- .1 ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA co-sponsored; ANSI approved; Continuous Maintenance Standard).

.2 American Society for Testing and Materials International (ASTM)

- .1 ASTM B209M, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate [Metric].
- .2 ASTM C335, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
- .3 ASTM C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
- .4 ASTM C449/C449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
- .5 ASTM C533, Calcium Silicate Block and Pipe Thermal Insulation.
- .6 ASTM C547, Mineral Fiber Pipe Insulation.
- .7 ASTM C795, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- .8 ASTM C921, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

.3 Canadian General Standards Board (CGSB)

- .1 CGSB 51-GP-52Ma, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .2 CAN/CGSB-51.53, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts

.4 Department of Justice Canada (Jus)Canadian Environmental Assessment Act (CEAA), 1995, c. 37.

- .1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
- .2 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

.5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

- .1 Material Safety Data Sheets (MSDS).

.6 Manufacturer's Trade Associations

- .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (Revised 2004).

.7 Underwriters' Laboratories of Canada (ULC)

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- .1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.
- .2 CAN/ULC-S701, Thermal Insulation, Polystyrene, Boards and Pipe Covering.
- .3 CAN/ULC-S702, Thermal Insulation, Mineral Fibre, for Buildings
- .4 CAN/ULC-S702.2, Thermal Insulation, Mineral Fibre, for Buildings, Part 2: Application Guidelines.

**1.3 DEFINITIONS**

- .1 For purposes of this section:
  - .1 "CONCEALED" - insulated mechanical services in suspended ceilings and non-accessible chases and furred-in spaces.
  - .2 "EXPOSED" - will mean "not concealed" as specified.
- .2 TIAC ss:
  - .1 CRF: Code Rectangular Finish.
  - .2 CPF: Code Piping Finish.

**1.4 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submittals: in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.. Include product characteristics, performance criteria, and limitations.
    - .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples..
- .3 Shop Drawings:
  - .1 Submit shop drawings in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
    - .1 Shop drawings: submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.
- .4 Samples:
  - .1 Submit samples in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix label beneath sample indicating service.
- .5 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .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.

**1.5 QUALITY ASSURANCE**

- .1 Qualifications:
- .2 Installer: specialist in performing work of this Section, and have at least 3 years successful experience in this size and type of project, qualified to standards
- .3 Health and Safety:
  - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 – Health and Safety.

**1.6 DELIVERY, STORAGE AND HANDLING**

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.
  - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
  - .3 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Storage and Protection:
  - .1 Protect from weather, construction traffic.
  - .2 Protect against damage.
  - .3 Store at temperatures and conditions required by manufacturer.
- .3 Waste Management and Disposal:
  - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.
  - .2 Place excess or unused insulation and insulation accessory materials in designated containers.
  - .3 Divert unused metal materials from landfill to metal recycling facility approved by Consultant.
  - .4 Dispose of unused adhesive material at official hazardous material collections site approved by Consultant.

**Part 2 Products**

**2.1 FIRE AND SMOKE RATING**

- .1 In accordance with CAN/ULC-S102.
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

**2.2 INSULATION**

- .1 Mineral fibre specified includes glass fibre, rock wool, slag wool.
  - .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.
-

- .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
  - .1 Mineral fibre: to CAN/ULC-S702.
  - .2 Maximum "k" factor: to CAN/ULC-S702.
- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
  - .1 Mineral fibre: to CAN/ULC-S702.
  - .2 Jacket: to CGSB 51-GP-52Ma.
  - .3 Maximum "k" factor: to CAN/ULC-S702.
- .5 TIAC Code C-2: mineral fibre blanket faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
  - .1 Mineral fibre: to CAN/ULC-S702.
  - .2 Jacket: to CGSB 51-GP-52Ma.
  - .3 Maximum "k" factor: to CAN/ULC-S702.

## 2.3 INSULATION SECUREMENT

- .1 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .2 Contact adhesive: quick setting.
- .3 Canvas adhesive: washable.
- .4 Tie wire: 1.5 mm diameter stainless steel.
- .5 Bands: stainless steel, 19mm wide, 0.5 mm thick.

## 2.4 CEMENT

- .1 Thermal insulating and finishing cement:
  - .1 Hydraulic setting or Air drying on mineral wool, to ASTM C449/C449M.

## 2.5 VAPOUR RETARDER LAP ADHESIVE

- .1 Water based, fire retardant type, compatible with insulation.

## 2.6 INDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.

## 2.7 OUTDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: fibrous glass, untreated 305 g/m<sup>2</sup>.

## 2.8 JACKETS

- .1 Polyvinyl Chloride (PVC):
    - .1 One-piece moulded type and sheet to CAN/CGSB-51.53 with pre-formed shapes as required.
    - .2 Colours: by consultant.
-

- .3 Minimum service temperatures: -20 degrees C.
  - .4 Maximum service temperature: 65 degrees C.
  - .5 Moisture vapour transmission: 0.02 perm.
  - .6 Thickness: 0.5 mm.
  - .7 Fastenings:
    - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
    - .2 Tacks.
    - .3 Pressure sensitive vinyl tape of matching colour.
  - .8 Special requirements:
    - .1 Outdoor: UV rated material at least 0.5 mm thick.
  - .2 ABS Plastic:
    - .1 One-piece moulded type and sheet with pre-formed shapes as required.
    - .2 Colours: by Consultant.
    - .3 Minimum service temperatures: -40 degrees C.
    - .4 Maximum service temperature: 82 degrees C.
    - .5 Moisture vapour transmission: 0.012 perm.
    - .6 Thickness: 0.75 mm.
    - .7 Fastenings:
      - .1 Solvent weld adhesive compatible with insulation to seal laps and joints.
      - .2 Tacks.
      - .3 Pressure sensitive vinyl tape of matching colour.
    - .8 Locations:
      - .1 For outdoor use ONLY.
  - .3 Canvas:
    - .1 220 gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
    - .2 Lagging adhesive: compatible with insulation.
  - .4 Aluminum:
    - .1 To ASTM B209.
    - .2 Thickness: 0.50 mm sheet.
    - .3 Finish: stucco embossed.
    - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
    - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
    - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5mm thick at 300 mm spacing.
  - .5 Stainless steel:
    - .1 Type: 316.
    - .2 Thickness: 0.25 mm.
    - .3 Finish: smooth.
    - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
-

- .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
- .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5mm thick at 300 mm spacing.

**2.9 WEATHERPROOF Membrane for Insulation INSTALLED OUTDOORS**

- .1 Prefabricated, self-adhering, sheet-type waterproofing membrane: FlexClad-400 or approved alternative.
  - .1 Description:
    - .1 Top Layer: Stucco-embossed, UV-resistant aluminum weathering surface.
    - .2 Middle Layer: Double layer of high-density polyethylene reinforcement.
    - .3 Bottom Layer: Uniform layer of rubberized Caulking to: Section 07 92 10 – Joint Sealing.
  - .2 Heat Aging, No visible blistering or deterioration.
  - .3 Tear Resistance, ASTM D 1424, Average: 660 grams.
  - .4 Elongation, ASTM D 412, Minimum: 450 percent.
  - .5 Low Temperature Flexibility, 1,000,000 cycles at -10°F, 1,200 cycles at -20°F: No cracking.
  - .6 Water Vapor Transmission, ASTM E 96: 0.009 perms.
  - .7 Flame Spread Index, ASTM E 84: 0.
  - .8 Smoke Density Index, ASTM E 84: 5.
  - .9 Wind-Driven Rain, SFBC TAS-110-95, 100 mph: No leakage or failure.
  - .10 UV Stability: Excellent.
- .2 Application: All insulated pipework exposed to outdoors.

**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 PRE-INSTALLATION REQUIREMENT**

- .1 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified.
- .2 Surfaces clean, dry, free from foreign material.

**3.3 INSTALLATION**

- .1 Install in accordance with TIAC National Standards.
  - .2 Apply materials in accordance with manufacturer's instructions and this specification. Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
  - .3 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
-

- .1 Install hangers, supports outside vapour retarder jacket.
- .4 Supports, Hangers:
  - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

**3.4 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES**

- .1 Application: at expansion joints, valve, primary flow measuring elements flanges and unions at equipment.
- .2 Design: to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.
- .3 Insulation:
  - .1 Insulation, fastenings and finishes: same as system.
  - .2 Jacket: aluminum SS PVC ABS.

**3.5 INSTALLATION OF ELASTOMERIC INSULATION**

- .1 Insulation to remain dry. Overlaps to manufacturer's instructions. Ensure tight joints.
- .2 Provide vapour retarder as recommended by manufacturer.

**3.6 PIPING INSULATION SCHEDULES**

- .1 Includés valves, valve bonnets, strainers, flanges and fittings unless otherwise specified. TIAC Code: A-1.
    - .1 Securements: bands Tape at 300 mm on centre.
    - .2 Seals: lap seal adhesive, lagging adhesive.
    - .3 Installation: TIAC Code 1501-H.
  - .2 TIAC Code: A-3.
    - .1 Securements: bands at 300 mm on centre.
    - .2 Seals: VR lap seal adhesive, VR lagging adhesive.
    - .3 Installation: TIAC Code: 1501-C.
  - .3 TIAC Code: A-6.
    - .1 Insulation securements
    - .2 Seals: lap seal adhesive, lagging adhesive.
    - .3 Installation: TIAC Code
  - .4 TIAC Code: C-2 with vapour retarder jacket.
    - .1 Insulation securements
    - .2 Seals: lap seal adhesive, lagging adhesive.
    - .3 Installation: TIAC Code: 1501-C.
  - .5 TIAC Code: A-2.
    - .1 Insulation securements:
    - .2 Seals: lap seal adhesive, lagging adhesive.
    - .3 Installation: TIAC Code: 1501-H.
-

- .6 Thickness of insulation as listed in following table.
- .1 Run-outs to individual units and equipment not exceeding 4000 mm long.
  - .2 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.

Application	Temp (C)	TIAC Code	Pipe Sizes (NPS)	Insulation Thickness (mm)
Chilled Water Indoor CHWS, CHWR	4 - 16	A-3	Run Out	25
			To 1	25
			1-1/4 to 2	25
			2-1/2 to 4	25
			5 to 6	25
			8 and over	38
Chilled Water Outdoors CHWS & CHWR	4 - 16	A-3	Run Out	25
			To 1	25
			1-1/4 to 2	25
			2-1/2 to 4	25
			5 to 6	38
			8 and over	38
Domestic CWS with vapour retarder		C-2	Run Out	25
			To 1	25
			1-1/4 to 2	25
			2-1/2 to 4	25
			5 to 6	25
			8 and over	25



.7 Finishes:

- .1 Exposed indoors: PVC jacket to match existing..
- .2 Exposed in mechanical rooms: PVC jacket to match existing.
- .3 Use vapour retarder jacket on TIAC code A-3 insulation compatible with insulation.
- .4 Outdoors: water-proof aluminum jacket.
- .5 Finish attachments: SS bands at 150 mm on centre. Seals: closed.
- .6 Installation: to appropriate TIAC code CRF/1 through CPF/5.

**3.7 CLEANING**

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1 General**

**1.1 SUMMARY**

- .1 Section Includes:
  - .1 Procedures and cleaning solutions for cleaning mechanical piping systems.

**1.2 REFERENCES**

- .1 American Society for Testing and Materials International (ASTM)
  - .1 ASTM E202-00, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
- .2 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 - Shop Drawings, Product Data and Samples Include product characteristics, performance criteria, and limitations.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .1 Instructions: submit manufacturer's installation instructions.
    - .1 Consultant will make available 1 copy of systems supplier's installation instructions.

**1.4 QUALITY ASSURANCE**

- .1 Health and Safety:
  - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 – Health and Safety requirements.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 10 – Common Product Requirements.
- .2 Waste Management and Disposal:
  - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 CLEANING SOLUTIONS**

- .1 Tri-sodium phosphate: 0.40 kg per 100 L water in system.
- .2 Sodium carbonate: 0.40 kg per 100 L water in system.
- .3 Low-foaming detergent: 0.01 kg per 100 L water in system.

**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 Contract with existing Chemical Treatment Company under existing facility maintenance contract.
  - .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:
-

- .1 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 35 kPa (does not apply to diaphragm type expansion tanks).
  - .3 Use water metre to record volume of water in system to +/- 0.5%.
  - .4 Add chemicals under direct supervision of chemical treatment supplier.
  - .5 Closed loop systems: circulate system cleaner at 60 degrees C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
  - .6 Flush 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 82 degrees C minimum. Circulate for 12 h, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 38 degrees C. Drain as quickly as possible. Refill with clean water. Circulate for 6 h at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).

### 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 Systems.
    - .7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.
    - .8 Repeat with water at design temperature.
    - .9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.
    - .10 Bring system up to design temperature and pressure slowly over a 48 hour period.
    - .11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
    - .12 Adjust pipe supports, hangers, springs as necessary.
    - .13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.
    - .14 If sliding type expansion joints bind or if bellows type expansion joints flex incorrectly, shut down system, re-align, repeat start-up procedures.
    - .15 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.
-

- .16 Check operation of drain valves.
- .17 Adjust valve stem packings as systems settle down.
- .18 Fully open balancing valves (except those that are factory-set).
- .19 Check operation of over-temperature protection devices on circulating pumps.
- .20 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

### **3.4**

#### **CLEANING**

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1 General**

**1.1 RELATED REQUIREMENTS**

- .1 23 05 00 – Common Work Results for HVAC
- .2 23 05 05 – Installation of Pipework
- .3 23 05 48 – Vibration and Seismic Control for HVAC Piping and Equipment

**1.2 REFERENCES**

- .1 American National Standards Institute/American Water Works Association (ANSI/AWWA)
    - .1 ANSI/AWWA C111/A21.11-06, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - .2 American Society of Mechanical Engineers (ASME)
    - .1 ASME B16.1-10, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
    - .2 ASME B16.3-06, Malleable Iron Threaded Fittings: Classes 150 and 300.
    - .3 ASME B16.5-09, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
    - .4 ASME B16.9-07, Factory-Made Wrought Butt Welding Fittings.
    - .5 ASME B18.2.1-10, Square Hex, Heavy Hex and Askew Head Bolts and Hex, Heavy Hex, Hex Flange. Loded Head and Lag Screws (Inch Series).
    - .6 ASME B18.2.2-10, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
  - .3 ASTM International
    - .1 ASTM A47/A47M-99(2009), Standard Specification for Ferritic Malleable Iron Castings.
    - .2 ASTM A53/A53M-10, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.
    - .3 ASTM A536-84(2009), Standard Specification for Ductile Iron Castings.
    - .4 ASTM B61-08, Standard Specification for Steam or Valve Bronze Castings.
    - .5 ASTM B62-09, Standard Specification for Composition Bronze or Ounce Metal Castings.
    - .6 ASTM E202-10, Standard Test Method for Analysis of Ethylene Glycols and Propylene Glycols.
  - .4 CSA Standards
    - .1 CSA B242-05(R2011), Groove and Shoulder Type Mechanical Pipe Couplings.
    - .2 CSA W48-06, Filler Metals and Allied Materials for Metal Arc Welding.
  - .5 Manufacturer's Standardization of the Valve and Fittings Industry (MSS)
    - .1 MSS-SP-67-2002a, Butterfly Valves.
    - .2 MSS-SP-70-06, Gray Iron Gate Valves, Flanged and Threaded Ends.
    - .3 MSS-SP-71-05, Gray Iron Swing Check Valves Flanged and Threaded Ends.
    - .4 MSS-SP-80-08, Bronze Gate, Globe, Angle and Check Valves.
-

- .5 MSS-SP-85-02, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for hydronic systems and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
  - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.
  - .2 Indicate on drawings:
    - .1 Components and accessories.
- .4 Sustainable Design Submittals:
  - .1 Construction Waste Management:
    - .1 Submit project Waste Management highlighting recycling and salvage requirements.

**1.4 CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 30 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic systems for incorporation into manual.
  - .1 Include special servicing requirements.

**1.5 EXTRA STOCK MATERIALS**

- .1 Supply spare parts as follows:
  - .1 Valve seats: 1 minimum for every ten valves, each size. Minimum one. Discs: 1 minimum for every ten valves, each size. Minimum one.
  - .2 Stem packing: 1 minimum for every ten valves, each size. Minimum one.
  - .3 Valve handles: 2 minimum of each size.
  - .4 Gaskets for flanges: 1 minimum for every ten flanges.

**1.6 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with Section 01 61 10 – Common Product Requirements and with manufacturer's written instructions.
  - .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
  - .3 Storage and Handling Requirements:
    - .1 Store materials indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
    - .2 Store and protect hydronic systems from nicks, scratches, and blemishes.
-

- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 PIPE**

- .1 Steel pipe: to ASTM A53/A53M, Grade B, as follows:
  - .1 To NPS 6: Schedule 40.
  - .2 NPS 8 and over, 10 mm wall thickness.

**2.2 PIPE JOINTS**

- .1 NPS 2 and under: screwed fittings with PTFE tape or lead-free pipe dope.
- .2 NPS 2-1/2 and over: welding fittings and flanges to CSA W48.
- .3 Flanges: plain or raised to ANSI/AWWA C111/ A21.11.
- .4 Orifice flanges: slip-on raised face, 2100 kPa.
- .5 Flange gaskets: to ANSI/AWWA C111/ A21.11.
- .6 Pipe thread: taper.
- .7 Bolts and nuts: to ASME B18.2.1 and ASME B18.2.2.
- .8 Roll grooved coupling gaskets: type EPDM.

**2.3 FITTINGS**

- .1 Screwed fittings: malleable iron, to ASME B16.3, Class 150.
- .2 Pipe flanges and flanged fittings:
  - .1 Cast iron: to ASME B16.1, Class 125.
  - .2 Steel: to ASME B16.5.
- .3 Butt-welding fittings: steel, to ASME B16.9.
- .4 Unions: malleable iron, to ASTM A47/A47M and ASME B16.3.
- .5 Fittings for roll grooved piping (if allowed in this project): malleable iron to ASTM A47/A47M and ductile iron to ASTM A536.

**2.4 VALVES**

- .1 New valves to match style of existing equipment wherever possible.
  - .2 Connections:
    - .1 NPS 2 and smaller: screwed ends.
-



- .2 NPS 2-1/2 and larger: flanged ends.
  - .3 Gate valves:
    - .1 NPS 2 and under:
      - .1 Mechanical Rooms : Class 125, rising stem, wedge disc, as specified Section 23 05 23.01 - Valves – Bronze Elsewhere: Class 125, non- rising stem, solid wedge disc Bronze.
    - .2 NPS 2-1/2 and over:
      - .1 Mechanical Rooms: rising stem, split wedge disc, lead free bronze trim, Cast Iron.
        - .1 Operators: manual.
      - .2 Elsewhere: non- rising stem, solid wedge disc, lead free bronze trim, Cast Iron.
        - .1 Operators: manual
  - .4 Butterfly valves: to MSS-SP-67 application: isolating cells or section of multiple component equipment i.e. multi-section coils, multi-cell cooling towers:
    - .1 NPS 2-1/2 and over: lug type grooved ends.
  - .5 Globe valves: to MSS-SP-80 and 85, application: throttling, flow control, emergency bypass:
    - .1 NPS 2 and under:
      - .1 Mechanical Rooms: with PTFE disc, Bronze.
      - .2 Elsewhere: globe, with composition disc, Bronze.
    - .2 NPS 2-1/2 and over:
      - .1 With lead free bronze disc, lead free bronze trim, Cast Iron.
      - .2 Operators
  - .6 Balancing, for TAB:
    - .1 Sizes: calibrated balancing valves, as specified this section.
    - .2 NPS 2 and under:
      - .1 Mechanical Rooms: globe, with plug disc Bronze.
      - .2 Elsewhere: globe, with plug disc Bronze.
  - .7 Drain valves: Gate, Class 125, non-rising stem, solid wedge disc, Bronze.
  - .8 Bypass valves: Globe, with PTFE disc Bronze.
  - .9 Swing check valves: to MSS-SP-71.
    - .1 NPS 2 and under:
      - .1 Class 125, swing, with composition disc Bronze.
    - .2 NPS 2-1/2 and over:
      - .1 Flanged ends: Cast Iron.
  - .10 Silent check valves: NPS 2 and under:
    - .1 NPS 2-1/2 and over:
      - .1 Flanged ends.
  - .11 Ball valves:
-

- .1 NPS 2 and under: Threaded.
- .12 Lubricated Plug Valves
  - .1 NPS 2 and under: Threaded
  - .2 NPS 2-1/2 and over: Flanged

**Part 3 Execution**

**3.1 PIPING INSTALLATION**

- .1 Install pipework in accordance with Section 23 05 05 - Installation of Pipe Work.
- .2 All piping shall have screwed or welded joints.
- .3 Grooved pipe system coupling is not allowed.

**3.2 CIRCUIT BALANCING VALVES**

- .1 Install flow measuring stations and flow balancing valves as indicated.
- .2 Remove handwheel after installation and when TAB is complete.
- .3 Tape joints in prefabricated insulation on valves installed in chilled water mains.

**3.3 CLEANING, FLUSHING AND START-UP**

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

**3.4 TESTING**

- .1 Test system to 1400 kPa with water for 2 hours. Provide report to Departmental Representative.

**3.5 BALANCING**

- .1 Balance water systems to within plus or minus 5 % of design output.
- .2 In accordance with Section 23 05 93 - Testing, Adjusting and Balancing for HVAC for applicable procedures.

**3.6 CLEANING**

- .1 Leave Work area clean at end of each day.
  - .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment.
  - .3 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.
    - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.
-

**3.7 PROTECTION**

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by hydronic systems installation.

**END OF SECTION**

**Part 1 General**

**1.1 RELATED REQUIREMENTS**

- .1 23 05 00 – Common Work Results for HVAC
- .2 23 05 05 – Installation of Pipework

**1.2 REFERENCES**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B16.5-09, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
  - .2 ASME B18.2.1-10, Square Hex, Heavy Hex and Askew Head Bolts and Hex, Heavy Hex, Hex Flange. Loded Head and Lag Screws (Inch Series).
  - .3 ASME B18.2.2-10, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
- .2 ASTM International
  - .1 ASTM E202-10, Standard Test Method for Analysis of Ethylene Glycols and Propylene Glycols.
  - .2 ASTM D2467 Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
  - .3 ASTM D2564-[04e1], Standard Specification for Solvent Cements for Poly(Vinyl-Chloride) (PVC) Plastic Piping Systems.
- .3 CSA Standards
  - .1 CAN/CSA-B137.3 Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications
  - .2 CSA/CSA-B137.2 Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1 Material Safety Data Sheets (MSDS).

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for hydronic systems and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
  - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.
  - .2 Indicate on drawings:
    - .1 Components and accessories.

- .4 Design Submittals:
  - .1 Construction Waste Management:
    - .1 Submit project Waste Management highlighting recycling and salvage requirements.

**1.4 CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 30 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic systems for incorporation into manual.
  - .1 Include special servicing requirements.

**1.5 EXTRA STOCK MATERIALS**

- .1 Supply spare parts as follows:
  - .1 Valve seats: 1 minimum for every ten valves, each size. Minimum one. Discs: 1 minimum for every ten valves, each size. Minimum one.
  - .2 Stem packing: 1 minimum for every ten valves, each size. Minimum one.
  - .3 Valve handles: 2 minimum of each size.
  - .4 Gaskets for flanges: 1 minimum for every ten flanges.

**1.6 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with Section 01 61 10 – Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
  - .1 Store materials indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
  - .2 Store and protect hydronic systems from nicks, scratches, and blemishes.
  - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 PIPE**

- .1 PVC pipe: to CAN/CSA-B137.3 as follows:
  - .1 Schedule 40.

**2.2 PIPE JOINTS**

- .1 Solvent weld for PVC: to ASTM D2564.
-

- .2 Flanges: plain or raised to ASTM D2467 and ASME B16.5.
- .3 Flange gaskets: to CSA/CSA-B137.2
- .4 Bolts and nuts: to ASME B18.2.1 and ASME B18.2.2.

### 2.3 FITTINGS

- .1 PVC pipe flanges and flanged fittings:
  - .1 All fittings to be Schedule 80: to ASTM D2467

## Part 3 Execution

### 3.1 PIPING INSTALLATION

- .1 Install pipework in accordance with Section 23 05 05 - Installation of Pipe Work.
- .2 All piping outside mechanical room shall have solvent weld joints.

### 3.2 CIRCUIT BALANCING VALVES

- .1 Install flow measuring stations and flow balancing valves as indicated.
- .2 Remove handwheel after installation and when TAB is complete.
- .3 Tape joints in prefabricated insulation on valves installed in chilled water mains.

### 3.3 CLEANING, FLUSHING AND START-UP

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

### 3.4 TESTING

- .1 Test system to 1000 kPa with water for 2 hours. Provide report to Departmental Representative.

### 3.5 BALANCING

- .1 Balance water systems to within plus or minus 5 % of design output.
- .2 In accordance with Section 23 05 93 - Testing, Adjusting and Balancing for HVAC for applicable procedures.

### 3.6 CLEANING

- .1 Leave Work area clean at end of each day.
  - .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment.
  - .3 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.
-

- .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

**3.7**

**PROTECTION**

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by hydronic systems installation.

**END OF SECTION**



**Part 1 General**

**1.1 REFERENCES**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME-04 (2007), Boiler and Pressure Vessel Code.
- .2 ASTM International Inc.
  - .1 ASTM A47/A47M 99 (2004), Standard Specification for Ferritic Malleable Iron Castings.
  - .2 ASTM A278/A278M-01 (2006), Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 degrees F (350 degrees C).
  - .3 ASTM A516/A516M-06, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower - Temperature Service.
  - .4 ASTM A536-84 (2004), Standard Specification for Ductile Iron Castings.
  - .5 ASTM B62-02, Standard Specification for Composition Bronze or Ounce Metal Castings.
- .3 Canadian Standards Association (CSA International)
  - .1 CSA B51-03(R2003), Boiler, Pressure Vessel, and Pressure Piping Code.
  - .2 CSA B51-03(R2005), Boiler, Pressure Vessel, and Pressure Piping Code, Supplement #1.

**1.2 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Provide manufacturer's printed product literature and datasheets for expansion tanks, air vents, separators, valves, and strainers and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
  - .1 Provide drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.

**1.3 CLOSEOUT SUBMITTALS**

- .1 Submit maintenance and operation data in accordance with Section 01 78 30 – Closeout Submittals.

**1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with Section 01 61 10 – Common Product Requirements.
  - .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
-



- .3 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials in accordance with Section 01 74 19 Waste Management and Disposal.

## Part 2 Products

### 2.1 CLOSED EXPANSION TANK

- .1 Horizontal or vertical expansion tank with threaded pipe connections.
- .2 Capacity: as shown in schedules.
- .3 Size: as shown in schedules.
- .4 Construction:
  - .1 ASME code rated welded tank to 860 kPa test pressure of ASTM A516/A516M, pressure vessel carbon steel plate with dished heads galvanized after manufacture.
  - .2 Conform to: ANSI/ASME BPVC, Section VIII and CSA B51, and provincial regulations.
  - .3 Submit certificate of registration as required by provincial authorities.
- .5 Accessories:
  - .1 Expansion pipe connection at bottom.
  - .2 Circulating pipe connection at bottom.
  - .3 NPS 1 drain connection at bottom with drain valve.
  - .4 Vent connection, NPS at top.
  - .5 Relief valve and connection at top, to manufacturer's recommendations.
  - .6 Service hole - 275 x 375 mm on end.
  - .7 12 mm sight glass connections at 1/8 and 7/8 points of height, complete with sight glass, shut-off valves with blowdown and protective guards.
  - .8 Two - 62 mm inspection tappings on centre line of sides, one near each end.
- .6 Supports: provide supports with hold down bolts and installation templates incorporating seismic restraint systems.

### 2.2 DIAPHRAGM TYPE EXPANSION TANK

- .1 Horizontal or Vertical galvanized steel pressurized diaphragm type expansion tank.
  - .2 Capacity: as shown in schedules.
  - .3 Size: as shown in schedules.
  - .4 Diaphragm sealed in EPDM suitable for 115 degrees C operating temperature.
  - .5 Working pressure: 860 kPa with ASME stamp and certification.
  - .6 Air precharged to 84 kPa (initial fill pressure of system).
  - .7 Saddles for horizontal installation Base mount for vertical installation.
-

.8 Supports: provide supports with hold down bolts and installation templates incorporating seismic restraint systems.

.9 Renewable diaphragm.

### 2.3 AUTOMATIC AIR VENT

.1 Standard float vent: brass body and NPS 1/8 connection and rated at 690 kPa working pressure.

.2 Industrial float vent: cast iron body and NPS 1/2 connection and rated at 860 kPa working pressure.

.3 Float: solid material suitable for 115 degrees C working temperature.

### 2.4 AIR SEPARATOR - BOILER MOUNTED

.1 Complete with dip tube.

.2 Working pressure: 860 kPa.

### 2.5 AIR SEPARATOR - EXPANSION TANK FITTING

.1 Complete with adjustable vent tube and built-in manual vent valve.

.2 Working pressure: 860 kPa.

### 2.6 AIR SEPARATOR - IN-LINE

.1 Working pressure: 860 kPa.

.2 Size: as indicated.

### 2.7 COMBINATION SEPARATORS/STRAINERS

.1 Steel, tested and stamped in accordance with ANSI/ASME BPVC, for 860 kPa operating pressure, with galvanized steel integral strainer with 5 mm perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

### 2.8 COMBINATION LOW PRESSURE RELIEF AND REDUCING VALVE

.1 Adjustable pressure setting: 206 kPa relief, 55 to 172 kPa reducing.

.2 Low inlet pressure check valve.

.3 Removable strainer.

### 2.9 PIPE LINE STRAINER

.1 NPS 1/2 to 2: bronze body to ASTM B62, screwed connections, Y pattern.

.2 NPS 2 1/2 to 12: cast steel body to ASTM A278/A278M, Class 30, cast iron body to ASTM A278/A278M, Class 30 flanged connections.

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- .3 NPS 2 to 12: T type with ductile iron body to ASTM A536, malleable iron body to ASTM A47M.
- .4 Blowdown connection: NPS 1.
- .5 Screen: stainless steel with 1.19 mm perforations.
- .6 Working pressure: 860 kPa.

## 2.10 SUCTION DIFFUSER

- .1 Body: cast iron with flanged connections.
- .2 Strainer: with built-in, disposable 1.19 mm mesh, low pressure drop screen and NPS 1 blowdown connection.
- .3 Permanent magnet particle trap.
- .4 Full length straightening vanes.
- .5 Pressure gauge tapings.
- .6 Adjustable support leg.

## Part 3 Execution

### 3.1 APPLICATION

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

### 3.2 GENERAL

- .1 Run drain lines and blow off connections to terminate above nearest drain.
- .2 Maintain adequate clearance to permit service and maintenance.
- .3 Should deviations beyond allowable clearances arise, request and follow Consultant's directive.
- .4 Check shop drawings for conformance of tapings for ancillaries and for equipment operating weights.

### 3.3 STRAINERS

- .1 Install in horizontal or down flow lines.
  - .2 Ensure clearance for removal of basket.
  - .3 Install ahead of each pump.
  - .4 Install ahead of each automatic control valve and also as indicated.
-

**3.4 AIR VENTS**

- .1 Install at high points of systems.
- .2 Install gate valve on automatic air vent inlet. Run discharge to nearest drain or service sink.

**3.5 EXPANSION TANKS**

- .1 Adjust expansion tank pressure to suit design criteria.
- .2 Install lockshield type valve at inlet to tank.

**3.6 PRESSURE SAFETY RELIEF VALVES**

- .1 Run discharge pipe to terminate above nearest drain.

**3.7 SUCTION DIFFUSERS**

- .1 Install on inlet to pumps having suction size greater than 50.

**3.8 CLEANING**

- .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**END OF SECTION**

**Part 1 General**

**1.1 REFERENCES**

- .1 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE)
  - .1 Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 Electrical Equipment Manufacturers Advisory Council (EEMAC)
- .3 Canadian Standards Association (CSA International)
  - .1 CSA-B214-[07], Installation Code for Hydronic Heating Systems.
- .4 National Electrical Manufacturers' Association (NEMA)
  - .1 NEMA MG 1-[2006], Motors and Generators.

**1.2 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 – Shop Drawings, Product Data and Samples.
- .2 Product Data:
  - .1 Provide manufacturer's printed product literature and datasheets for pump, circulator, and equipment, and include product characteristics, performance criteria, physical size, finish and limitations indicate point of operation, and final location in field assembly.
- .3 Shop Drawings:
  - .1 Provide drawings stamped and signed by professional engineer registered or licensed in Province, BC, Canada.
- .4 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.

**1.3 CLOSEOUT SUBMITTALS**

- .1 Provide maintenance and operation data for incorporation into manual specified in Section 01 78 30 – Closeout Submittals.

**1.4 MAINTENANCE**

- .1 Provide maintenance materials in accordance with 01 78 30 – Closeout Submittals.

**1.5 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with 01 61 10 – Common Product Requirements.
  - .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
-

- .3 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials in accordance with 01 74 19 - Waste Management and Disposal.

## Part 2 Products

### 2.1 VERTICAL IN-LINE CIRCULATORS

- .1 Volute: cast iron radially split, with tapped openings for venting, draining and gauge connections, with screwed or flanged suction and discharge connections.
- .2 Impeller: Bronze
- .3 Shaft: alloy steel with bronze sleeve bearing, integral thrust collar.
- .4 Seal assembly: mechanical for service to 135 degrees C.
- .5 Coupling: flexible self-aligning.
- .6 Motor: to NEMA MG 1 resilient mounted, TEFC, sleeve bearing, 1800 r/min.
- .7 Capacity: refer to schedule
- .8 Design pressure: 1200 kPa.

## Part 3 Execution

### 3.1 APPLICATION

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

### 3.2 INSTALLATION

- .1 Install hydronic pumps to: CSA-B214.
  - .2 In line circulators: install as indicated by flow arrows.
    - .1 Support at inlet and outlet flanges or unions.
    - .2 Install with bearing lubrication points accessible.
  - .3 Base mounted type: supply templates for anchor bolt placement.
    - .1 Include anchor bolts with sleeves. Place level, shim unit and grout.
    - .2 Align coupling in accordance with manufacturer's recommended tolerance.
    - .3 Check oil level and lubricate. After run-in, tighten glands.
  - .4 Ensure that pump body does not support piping or equipment.
    - .1 Provide stanchions or hangers for this purpose.
    - .2 Refer to manufacturer's installation instructions for details.
-

- .5 Pipe drain tapping to floor drain.
- .6 Install volute venting pet cock in accessible location.
- .7 Check rotation prior to start-up.
- .8 Install pressure gauge test cocks.

**3.3 START-UP**

- .1 General:
  - .1 In accordance with Section 01 91 00 – Commissioning.
  - .2 In accordance with manufacturer's recommendations.
- .2 Procedures:
  - .1 Before starting pump, check that cooling water system over-temperature and other protective devices are installed and operative.
  - .2 After starting pump, check for proper, safe operation.
  - .3 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.
  - .4 Check base for free-floating, no obstructions under base.
  - .5 Run-in pumps for 12 continuous hours minimum.
  - .6 Verify operation of over-temperature and other protective devices under low- and no-flow condition.
  - .7 Eliminate air from scroll casing.
  - .8 Adjust water flow rate through water-cooled bearings.
  - .9 Adjust flow rate from pump shaft stuffing boxes to manufacturer's recommendation.
  - .10 Adjust alignment of piping and conduit to ensure true flexibility.
  - .11 Eliminate cavitation, flashing and air entrainment.
  - .12 Adjust pump shaft seals, stuffing boxes, glands.
  - .13 Measure pressure drop across strainer when clean and with flow rates as finally set.
  - .14 Replace seals if pump used to degrease system or if pump used for temporary heat.
  - .15 Verify lubricating oil levels.

**3.4 PERFORMANCE VERIFICATION (PV)**

- .1 General:
    - .1 Verify performance in accordance with Section 01 91 00 – Commissioning.
  - .2 Verify that manufacturer's performance curves are accurate.
  - .3 Ensure valves on pump suction and discharge provide tight shut-off.
  - .4 Net Positive Suction Head (NPSH):
    - .1 Application: measure NPSH for pumps which operate on open systems and with water at elevated temperatures.
-

- .2 Measure using procedures prescribed in Section 01 91 00 – Commissioning
- .3 Where procedures do not exist, discontinue PV, report to Consultant and await instructions.
- .5 Multiple Pump Installations - Series and Parallel:
  - .1 Repeat PV procedures specified above for pump performance and pump BHP for combinations of pump operations.
- .6 Mark points of design and actual performance at design conditions as finally set upon completion of TAB.
- .7 Commissioning Reports: in accordance with Section 01 91 00 – Commissioning:
  - .1 Record of point(s) of actual performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.
  - .2 Use Report Forms specified in Section 01 91 00 – Commissioning.
  - .3 Pump performance curves (family of curves).

**3.5**

**CLEANING**

- .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**END OF SECTION**



**Part 1 General**

**1.1 SUMMARY**

.1 Section Includes:

- .1 Materials, components, equipment and chemicals for installation of complete HVAC water treatment system.

**1.2 REFERENCES**

.1 American Society of Mechanical Engineers (ASME)

- .1 ASME Boiler and Pressure Vessel Code, Section VII-2004.

.2 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 – Shop Drawings, Product Data and Samples. Include product characteristics, performance criteria, and limitations.

- .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 – Shop Drawings, Product Data and Samples.

.2 Shop Drawings:

- .1 Submit shop drawings in accordance with Section 01 33 00 – Shop Drawings, Product Data and Samples.

- .1 Shop drawings: submit drawings stamped and signed by professional engineer registered or licensed in Province of BC, Canada.

.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 – Shop Drawings, Product Data and Samples

- .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.4 Closeout Submittals:

- .1 Submit operation and maintenance data for incorporation into manual specified in Section 01 78 30 – Closeout Submittals.

.2 Include following:

- .1 Log sheets as recommended by Consultant.

**1.4 QUALITY ASSURANCE**

- .1 Health and Safety:
  - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 – Health and Safety Requirements.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 10 – Common Product Requirements.
- .2 Waste Management and Disposal:
  - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.

**Part 2 Products**

**2.1 MANUFACTURER**

- .1 Equipment, chemicals, service provided by one supplier.

**2.2 POT FEEDER**

- .1 Welded steel, pressure rating 860 kPa. Temperature rating: 90 degrees C.

**2.3 CHEMICAL FEED PIPING**

- .1 Resistant to chemicals employed. Pressure rating: 860 kPa.

**2.4 SHIPPING/FEEDING CHEMICAL CONTAINERS**

- .1 High density molded polyethylene, with liquid level graduations, cover.

**2.5 CONDUCTIVITY CONTROLLER**

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

**2.6 CONDUCTIVITY PROBES**

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

**2.7 WATER TREATMENT FOR HYDRONIC SYSTEMS**

- .1 Hot water heating system: pot feeder, 25 L, operating pressure 860 kPa.
  - .2 Chilled water system: pot feeder, 25 L, operating pressure 860 kPa.
-

- .3 Flow indicator for each pot feeder system
- .4 Micron side stream filter for each pot feeder:
  - .1 Capacity 2% of pump recirculating rate at operating pressure.
  - .2 Six (6) sets of filter cartridges for each type, size of micron filter.

## 2.8 CHEMICALS

- .1 Provide 1 years supply.
- .2 Obtain chemicals from manufacturer with existing valid contract with DND.

## 2.9 TEST EQUIPMENT

- .1 Provide one set of test equipment for each system to verify performance.
- .2 Complete with carrying case, reagents for chemicals, specialized or supplementary equipment.

## 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 INSTALLATION

- .1 Install HVAC water treatment systems in accordance with ASME Boiler Code Section VII, and requirements and standards of authorities having jurisdiction, except where specified otherwise.
- .2 Ensure adequate clearances to permit performance of servicing and maintenance of equipment.

### 3.3 CHEMICAL FEED PIPING

- .1 Install crosses at changes in direction. Install plugs in unused connections.

### 3.4 CLEANING OF MECHANICAL SYSTEM

- .1 Provide copy of recommended cleaning procedures and chemicals for approval by Consultant.
  - .2 Flush mechanical systems and equipment with approved cleaning chemicals designed to remove deposition from construction such as pipe dope, oils, loose mill scale and other extraneous materials. Use chemicals to inhibit corrosion of various system materials that are safe to handle and use.
  - .3 Examine and clean filters and screens, periodically during circulation of cleaning solution, and monitor changes in pressure drop across equipment.
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- .4 Drain and flush system[s] until alkalinity of rinse water is equal to make-up water. Refill with clean water treated to prevent scale and corrosion during system operation.
- .5 Disposal of cleaning solutions approved by authority having jurisdiction.

### 3.5 WATER TREATMENT SERVICES

- .1 Provide water treatment monitoring and consulting services for period of one year after system start-up. Service to include:
  - .1 Initial water analysis and treatment recommendations.
  - .2 System start-up assistance.
  - .3 Operating staff training.
  - .4 Visit plant every 30 days during period of operation and as required until system stabilizes, and advise on treatment system performance.
  - .5 Provide necessary recording charts and log sheets for one year operation.
  - .6 Provide necessary laboratory and technical assistance.
  - .7 Provide clear, concise, written instructions and advice to operating staff.

### 3.6 FIELD QUALITY CONTROL

- .1 Start-up:
  - .1 Start up water treatment systems in accordance with manufacturer's instructions.
- .2 Commissioning:
  - .1 Commissioning Agency: to be water treatment supplier.
  - .2 Timing:
    - .1 After start-up deficiencies rectified.
    - .2 After start-up and before TAB of connected systems.
  - .3 Pre-commissioning Inspections: verify:
    - .1 Presence of test equipment, reagents, chemicals, details of specific tests performed, and operating instructions.
    - .2 Suitability of log book.
    - .3 Currency and accuracy of initial water analysis.
    - .4 Required quality of treated water.
  - .4 Commissioning procedures - applicable to Water Treatment Systems:
    - .1 Establish, adjust as necessary and record automatic controls and chemical feed rates.
    - .2 Monitor performance continuously during commissioning of connected systems and until acceptance of project.
    - .3 Establish test intervals, regeneration intervals.
    - .4 Record on approved report forms commissioning procedures, test procedures, dates, times, quantities of chemicals added, raw water analysis, treated water analysis, test results, instrument readings, adjustments made, results obtained.
    - .5 Establish, monitor and adjust automatic controls and chemical feed rates as necessary.
    - .6 Visit project at specified intervals after commissioning is satisfactorily completed to verify that performance remains as set during

- commissioning (more often as required until system stabilizes at required level of performance).
- .7 Advise Consultant in writing on matters regarding installed water treatment systems.
- .5 Commissioning procedures - Closed Circuit Hydronic Systems:
  - .1 Analyze water in system.
  - .2 Based upon an assumed rate of loss approved by Consultant, establish rate of chemical feed.
  - .3 Record types, quantities of chemicals applied.
- .6 Training:
  - .1 Commission systems, perform tests in presence of, and using assistance of, assigned O&M personnel.
  - .2 Train O&M personnel in softener regeneration procedures.
- .7 Certificates:
  - .1 Upon completion, furnish certificates confirming satisfactory installation and performance.
- .8 Commissioning Reports:
  - .1 To include system schematics, test results, test certificates, raw and treated water analyses, design criteria, other data required by Consultant.
- .9 Demonstrations
- .10 Commissioning activities during Warranty Period:
  - .1 Check out water treatment systems on regular basis and submit written report to Consultant.

**3.7**

**CLEANING**

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1 General**

**1.1 Shop Drawings and Product Data**

- .1 Submit shop drawings and product data in accordance with 01 33 00 – Shop Drawings, Product Data and Samples.
- .2 Clearly show size weight, internal and external wiring connections, and applicable certifications noted within the specification.

**1.2 Closeout Submittals**

- .1 Provide maintenance data for incorporation into manual specified in 01 78 30 – Closeout Submittals.

**Part 2 Products**

**2.1 General**

- .1 Furnish complete variable frequency drives (VFD, VSD) utilizing pulse width modulated (PWM) design as specified herein for the motors for pumps P-3A and P-3B. All features shall be included within the VFD enclosure, unless otherwise specified. VFD enclosure shall be NEMA.1. The VFD shall be rated 600 volt  $\pm 10\%$  and shall operate continuously without failure when connected to a three phase supply line. The VFD shall be highly reliable and rated for 250,000 hours mean time before failure (MTBF).
- .2 The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied in both the VFD and option panel, in the case where these are not contained in one panel. When these VFD's are to be located in Canada, CSA or C-UL certifications shall apply.

**2.2 Basic Design**

- .1 The adjustable frequency drive shall produce adjustable frequency output. Drives utilizing six step technology are not acceptable. To eliminate the need for isolation transformers and/or line suppression equipment, input line reactors will be an integral part of the input section of the drive. If isolation transformers or other external suppression equipment is needed to meet this specification, the supply and additional electrical installation, shall be included as part of this work. The VFD shall have an internally mounted 5% line reactor/15% impedance reactor as a minimum to reduce input current harmonic content and provide isolation from power line transients such as utility power factor correction capacitor switching transients and to reduce RFI emissions. All associated costs for installation and wiring shall be assumed by the manufacturer for externally mounted line reactors.
  - .2 Line noise shall be no greater than 3% harmonic distortion and no more than a 16,400 volt-microsecond commutation notch area, in accordance with IEEE Standard 519-1992 for special applications.
  - .3 Manufacturer shall submit a computerized harmonics analysis of the facility electrical system based on the most recent single line diagram. Analysis shall illustrate the effect of VFD's on system harmonics. Provide input line reactors and /or line filters required to reduce the total
-

harmonic distortion (THD) to 5% at the point of common coupling or 3% at each VFD input where the analysis has shown that the incremental effect of the addition of the VFD's would cause the THD to exceed these values as per IEEE 519-1992. Submit shop drawings.

- .4 The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerating to setpoint without tripping or damaging components.
- .5 The VFD shall have five programmable critical frequency lockout ranges to prevent the VFD from operating at an unstable speed.
- .6 The VFD shall have an intelligent motor overload feature to protect the motor at different operating speeds and loads. The VFD shall provide electronic motor overload protection qualified per UL508C.
- .7 The VFD shall protect against a stalled motor. The stall frequency/time shall be programmable.
- .8 Where the unit and internal components are to be installed within a dusty environment or air plenum, the unit shall be enclosed within a NEMA 12 enclosure.
- .9 The output current rating of the VFD shall match or exceed the motor nameplate full load current rating.

### 2.3 Local/Hand Control Panel

- .1 Each VFD shall be equipped with a front mounted plug-in control panel consisting of 4 lines by 20 characters back lit alphanumeric display and a key pad. The control panel shall include the following:
    - .1 Hand/Off/Auto switch
    - .2 Local/Remote switch
    - .3 Manual speed control
    - .4 Meter function selector
  - .2 The control panel shall include a back lit LCD meter that will display % speed, % load, or output voltage. The desired display is selected by a pushbutton. The following drive status indicator displays shall be included on the control panel. Faults shall be displayed in plain English.
    - .1 Power ON
    - .2 Ready
    - .3 Run
    - .4 Running at commanded speed
    - .5 Reverse
    - .6 Fault
    - .7 Overload
    - .8 Phase loss
    - .9 Overtemperature
    - .10 Overcurrent
    - .11 Undervoltage
    - .12 Overvoltage
    - .13 Ground fault
    - .14 External fault
-

## 2.4 Internal Adjustments

- .1 All adjustments noted below should be programmable only. Potentiometers and DIP switches are not acceptable.
  - .1 Minimum speed adjustment
  - .2 Maximum speed adjustment
  - .3 Gain and offset adjustments for signal follower
  - .4 Overload
  - .5 Current limit
- .2 In addition, the drive shall be programmable to control the following functions from the local/hand control panel.
  - .1 Acceleration time - programmable from approximately 3 to 280 seconds.
  - .2 Deceleration time - programmable from approximately 3 to 280 seconds.
  - .3 Fault counter reset - to limit fault reset attempts to 7, the fault counter reset is turned on.
  - .4 Variable overload - to protect motor from excess current at low speeds.
  - .5 Individually selectable resettable fault control - automatic functioning of the fault counter reset can be allowed or denied for ground fault, overvoltage fault, undervoltage fault, overcurrent fault, and phase-loss fault.
  - .6 Follower selection.
  - .7 Deceleration control or coast-to-rest.
  - .8 Reverse rotation.
  - .9 Output frequency - 50 to 60 Hz.
  - .10 Output voltages.
  - .11 Provide at least storage for 4 parameter sets.
  - .12 Speed Control functions include:
    - .1 Adjustment min/max speed.
    - .2 Three preset speeds.
    - .3 At least two sets of critical speed lockouts.
    - .4 At least 1 PID control loop.
    - .5 Three analog inputs.
  - .13 Output control functions:
    - .1 Flux optimization or automatic voltage optimization to limit audible motor noise.
    - .2 Current and torque limit.
    - .3 Torque regulated operating mode.

## 2.5 Internal Indicators

- .1 The key pad is to be used for troubleshooting.

## 2.6 Service Conditions

- .1 Elevation to 3,300 ft. without derating.
  - .2 Ambient temperature 14 to 104°F.
  - .3 Humidity to 95% non-condensing.
-



## 2.7 Features

- .1 Control interface inputs/outputs. Supply as standard all independently programmable:
  - .1 Three analog inputs, one 0-10v and two 4-20ma.
  - .2 Six discrete inputs.
  - .3 Two analog outputs.
  - .4 Relay contact outputs as required.
- .2 In addition to the start/stop and variable speed features in the drive, the following protective functions shall be supplied as standard:
  - .1 A minimum of 5 most recent fault messages shall be stored in the drives fault history.
  - .2 The VFD shall include MOV's for phase to phase to ground line voltage transient protection.
  - .3 Output short circuit and ground fault protection rated for 65,000 amps per UL508C without relying on fuses.
  - .4 Electronic motor overload protection per UL508C.
  - .5 AC line or DC bus over voltage and under voltage.
  - .6 Power loss ride through.
  - .7 Stall protection shall be programmable.
  - .8 Underload protection shall be programmable.
  - .9 VFD overtemperature protection.
  - .10 Input terminals for motor thermistor (PTC type).
  - .11 Input disconnect switch.

## 2.8 Special Features

- .1 The following special features shall be included in the VFD enclosure. The unit shall maintain its UL Listing.
  - .2 Provide a manual 3-contactor bypass consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in the bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in the DRIVE or BYPASS mode. The bypass circuitry shall be mounted in a separate section of the VFD enclosure. Motor overload protection shall be provided in both drive and bypass modes.
  - .3 The design shall provide for short circuit and locked rotor protection for the motor in both the line and drive position.
  - .4 Provide interlock feature to a thermistor installed in the motor.
  - .5 Long motor leads can produce high peak voltages at the motor contributing to motor stress. This should be avoided. If it is not possible to avoid long motor leads, a motor which meets NEMA MG-1, part 31, and an LC filters should be used. In addition, if the motor lead length is longer than 500' and LC filter shall be used. For multiple motor installations, the length of all
-

the motor leads must be added. The LC filter is necessary to reduce the capacitive earth leakage currents as well as the peak voltage as the motor.

## 2.9 BAS Interface

- .1 Provide the following BAS interface capability:
  - .1 System ON/OFF.
  - .2 System Status.
  - .3 4 - 20 mA input for speed signal.
- .2 All diagnostic warning and fault information shall be transmitted over the communications bus and be available for alarm reporting at the operator's workstation.

## Part 3 Execution

### 3.1 Installation

- .1 Mount drive so that operating controls/display are at about 1500mm" above floor, unless otherwise approved by the Consultant.

### 3.2 Start-up Service

- .1 The manufacturer shall provide start-up commissioning of the variable frequency drive and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the customer's site. Sales personnel and other agents who are not factory certified technicians for drive field repair shall not be acceptable as commissioning agents.
- .2 Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Included in this service shall be (as a minimum):
- .3 Verification of contractor wire terminations to the VFD and its operational circuitry.
- .4 Installation verification for proper operation and reliability of the VFD, the motor being driven, and the building automation system.
- .5 Up to eight hours of customer operator training on operation and service diagnostics at the time of the equipment commissioning. This is a requirement for substantial completion.
  - .1 Motor voltage and frequency. Verification of proper motor operation.
  - .2 Control input for proper building automation system interface and control calibration.
  - .3 Calibration check for the following setpoints (and adjustment as necessary) (1) minimum speed, (2) maximum speed, (3) acceleration and deceleration rates.

### 3.3 Warranty

- .1 The VFD shall be warranted by the manufacturer for a period of 36 months from date of shipment. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service.
-

- .2 The motor(s) which are directly connected to the VFD shall be warranted by the VFD manufacturer against insulation breakdown which is directly attributed to the VFD for the same 36 month period. The motor should be rated inverter duty as per NEMA MG1 part 31.

**3.4 Examination**

- .1 Contractor to verify that job site conditions for installation meet factory recommended and code required conditions for VFD installation prior to start-up. These shall include as a minimum:
  - .1 Clearance spacing.
  - .2 Temperature, contamination, dust, and moisture of the environment.
  - .3 Separate conduit installation of the motor wiring, power wiring, and control wiring.
  - .4 Installation per the manufacturer's recommendations.
- .2 The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

**3.5 Commissioning**

- .1 Submit the start-up report to the Commissioning Agent. Assist the Commissioning Agent in performing verification testing. Include all time required in the tendered price to assist the commissioning agent.

**END OF SECTION**

**Part 1            General**

**1.1                RELATED REQUIREMENTS**

- .1    23 05 00 – Common Work Results for HVAC
- .2    23 05 05 – Installation of Pipework
- .3    23 05 48 – Vibration and Seismic Control for HVAC Piping and Equipment
- .4    Mechanical Appendix D

**1.2                REFERENCES**

- .1    Air-Conditioning, Heating and Refrigeration Institute (AHRI)
  - .1    AHRI-550/590-03, Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle.
- .2    ANSI/ASME UL/ ASTM
  - .1    ANSI/ASHRAE 90.1 - Energy Efficient Design of New Buildings.
  - .2    ANSI/ASME SEC 8 - Boiler and Pressure Vessel Code
  - .3    ANSI/NEMA MG 1 - Motors and Generators.
  - .4    ANSI/UL 1995 - Central Cooling Air Conditioners.
  - .5    ANSI/UL 984 - Safety Standard for Hermetic Motor Compressors.
  - .6    ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings.
  - .7    ASTM B117 - Standard Method of Salt Spray (Fog) Testing
  - .8    ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
  - .9    ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products
  - .10   ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments
- .3    CSA International
  - .1    CSA B52-[05 SMART], Mechanical Refrigeration Code.
- .4    Environment Canada, (EC)/Environmental Protection Services (EPS)
  - .1    EPS 1/RA/2-[1996], Environmental Code of Practice for Elimination of Fluorocarbons Emissions from Refrigeration and Air Conditioning Systems.
- .5    ISO9001 Quality Program
  - .1    Chiller must be built in an ISO 9001 classified facility.
- .6    Federal Halocarbon Regulations (2003)
  - .1    Installation works to be undertaken in accordance with Federal Halocarbon Regulations (2003)

**1.3                ACTION AND INFORMATIONAL SUBMITTALS**

- .1    Submit submittals in accordance with Section 01 33 00 - Shop Drawings, Product Data and Samples.
  - .2    Product Data:
-

- .1 Submit manufacturer's instructions, printed product literature and data sheets for rotary-screw water chillers and include product characteristics, performance criteria, physical size, finish and limitations.
  - .3 Shop Drawings:
    - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Province of BC Canada.
    - .2 Indicate:
      - .1 Equipment including connections, piping and fittings, valves, strainers, control assemblies and ancillaries, identifying factory and field assembled.
      - .2 Wiring as assembled and schematics.
      - .3 Dimensions, construction details, recommended installation and support, mounting bolt hole sizes and locations and point loads.
      - .4 Type of refrigerant used.
  - 1.4 **CLOSEOUT SUBMITTALS**
    - .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
    - .2 Operation and Maintenance Data: submit operation and maintenance data for rotary-screw water chillers for incorporation into manual.
    - .3 Data to include:
      - .1 Description of equipment giving manufacturers name, model type and year, capacity and serial numbers.
      - .2 Provide part load performance curves.
      - .3 Details on operation, servicing and maintenance.
      - .4 Recommended spare parts list.
  - 1.5 **MAINTENANCE MATERIAL SUBMITTALS**
    - .1 Supply recommended spare parts list with pricing with maintenance manual information.
  - 1.6 **DELIVERY, STORAGE AND HANDLING**
    - .1 Deliver, store and handle materials in accordance with Section with manufacturer's written instructions.
    - .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
    - .3 Storage and Handling Requirements:
      - .1 Comply with manufacturer's installation instructions for rigging, unloading, and transporting units
      - .2 Store materials off ground and in accordance with manufacturer's recommendations in secure outdoor area
      - .3 Store and protect rotary-screw water chillers from nicks, scratches, and blemishes.
      - .4 Replace defective or damaged materials with new.
    - .4 Waste Management and Disposal in accordance with Section 07 74 19 - Waste Management and Disposal.
-

**Part 2 Products**

**2.1 GENERAL**

- .1 Provide complete high efficiency air cooled screw type chiller package including: compressor; evaporator; condenser, motor and motor starter; controls; control centre; piping; wiring; refrigeration and oil change; ready for connection to chilled water circuit, interlocks, and electric power source, installed in welded steel frame with heavy gauge panels finished to manufacturers standard.

**2.2 PROPOSED CHILLER**

- .1 For consideration of proposed chiller, the contractor shall provide for review and acceptance:
  - .1 Complete shop drawing submittal, including performance, wiring drawings, dimensional data
  - .2 Control submittal, including control interface points available to owners DCS control system
  - .3 Details on local service capability of chiller supplier, including number of technicians on staff, proximity to jobsite, and years of experience of each technician.
  - .4 Proposed chiller performance shall comply with, or be better than, the performance set force in this specification.
  - .5 The chiller shown on the drawings has been coordinated with architectural and structural elements, and with electrical service requirements. If the configuration of the proposed chiller does not conform to the space allocated on the drawings, then all costs required to modified the layout to suit shall be borne by the contractor.

**2.3 CAPACITY**

- .1 Certified ratings based on AHRI 550/590:
  - .1 672 kW, when cooling 28.84 L/s of water from 15.6 degrees C to 10.0 degrees C.
  - .2 Air cooled condenser supplied with 35 degrees C entering air design ambient temperature and minimum ambient temperature of -4 degrees C entering air
  - .3 Power input, including electrical components: 205.8 kW.
  - .4 Fouling resistance coefficient: 0.000018 m<sup>2</sup>K/W
  - .5 Refrigerant: HFC-134a

**2.4 VERIFICATION OF CAPACITY AND EFFICIENCY**

- .1 The chiller shall be factory performance tested under full load conditions in an ambient controlled, AHRI 550/590-2003 approved test facility. The manufacturer shall supply a certified test report to confirm performance as specified. The performance test shall be conducted in accordance with AHRI Standard 550/590-2003 procedures and tolerances.
- .2 The performance test shall be run with clean tubes in accordance with AHRI 550/590-2003 to include the following:
  - .1 A downward temperature adjustment shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.
- .3 The factory test instrumentation shall be per AHRI 550/590-2003, and the calibration of all instrumentation shall be traceable to the National Institute of Technology.

- .4 A certified test report of all data shall be submitted to the Contracting Officer prior to completion of the project. The factory certified test report shall be signed by an officer of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.

## 2.5 COMPRESSOR

- .1 Construct chiller using two independently circuited semi-hermetic helical rotary screw compressors.
- .2 Statically and dynamically balance rotating parts.
- .3 Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation.
- .4 Provide compressor with automatic capacity reduction equipment consisting of capacity control slide valve. Compressor must start unloaded for soft start on motors.
- .5 Provide constant speed 3600 rpm for 60Hz compressor motor, suction gas cooled with robust construction and system design protection, designed for soft start. Furnish with starter (soft start).
- .6 Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.
- .7 Provide sound absorbing panels to attenuate compressor noise.
- .8 Hermetic screw design operating at 3600 r/min.
- .9 Unloaded start with capacity modulation by continuous linear modulation of slide valve in response to load change.
- .10 Compressor to include suction and discharge shut-off valves; oil sight glass; separate circuit crankcase heater; and cylinder unloading device.
- .11 Provide nameplate to show capacity at design temperature, type of refrigerant used and total weight in system.

## 2.6 REFRIGERANT CIRCUIT

- .1 The unit shall have 2 refrigeration circuits to provide redundancy, each with one compressor on each circuit. Single refrigerant circuit chillers are not acceptable.
  - .2 Provide for each refrigerant circuit:
    - .1 Liquid line shutoff valve.
    - .2 Suction Service Valve
    - .3 Filter (replaceable core type).
    - .4 Liquid line sight glass.
    - .5 Electronic or thermal expansion valve sized for maximum operating pressure.
    - .6 Charging valve.
    - .7 Discharge and oil line check valves.
    - .8 High side pressure relief valve.
    - .9 Full operating charge of HFC-134a and oil for packaged units only
  - .3 Capacity Modulation: Provide capacity modulation that includes linear unloading to maintain close leaving water temperature control. Unit shall be capable of operation down to 20%.
-

**2.7 EVAPORATOR**

- .1 The evaporator shall be designed, tested, and stamped in accordance with ASME code and CSA B52 for a refrigerant side working pressure of 200 psig. Waterside working pressure shall be 150 psig.
- .2 Insulate the evaporator and water boxes with a minimum of 3/4 inch (K=0.26) insulation. If field installed the additional money to cover this in the field should be included in the bid.
- .3 Evaporator heat tape shall be factory installed and shall protect unit down to -29C. Contractor shall wire separate power to energize heat tape and protect cooler while chiller is disconnected from the main power..
- .4 Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally and externally finned copper tubes, roller expanded into tube sheets.
- .5 Provide ability to remove evaporator tubes from either end of the heat exchanger.
- .6 Provide water drain connection, vent and fittings for factory installed leaving water temperature control and low temperature cutout sensors.
- .7 Water connections shall be grooved pipe. Evaporator shall have only one entering and one leaving connection. If manufacturer provides 2 separate evaporators, contractor shall provide manifold and pressure gauges to ensure equal flow is provided to each evaporator.
- .8 Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.
- .9 The chilled water evaporators must be selected by the chiller manufacturer to allow trouble free chiller operation with a reduced chilled water flow rate of 55 % of the design chilled water flow rate per minute. The manufacturer shall submit certified selections showing this capability.

**2.8 CONDENSERS AND FANS**

- .1 Provide vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Entire fan assembly shall be statically and dynamically balanced and fan assembly shall be either painted or zinc coated steel. Fan guard shall be either PVC, chrome, or zinc coated.
  - .2 Provide TEAO (Totally Enclosed Air Over) fan motors with permanently lubricated ball bearings. Fans shall be low noise design. Complete fan assembly combining ultra quiet seven blade fans to provide sound reductions with no performance degradation to the unit. The fan blades shall be heavy-duty molded plastic with wavy edges to reduce airflow turbulence.
  - .3 Chiller shall be able to operate in ambient conditions down to (-17.8 °C). The chiller shall include variable frequency drive control on the final condenser fan stage to accomplish low ambient cooling.
  - .4 Construct condenser coils of aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 506 psig.
  - .5 Provide coil protection for shipping. Entire condenser coil shall be covered with heavy plastic to prevent inadvertent damage to coil during shipment or rigging.
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## 2.9 ENCLOSURES / STARTERS

- .1 House components in a galvanized steel frame and mounted on welded structural steel base. Hot-dip galvanized steel frame coating shall be Underwriters Laboratories Inc. (UL) recognized as G90-U, UL guide number DTHW2.
- .2 Unit panels and control panels shall be finished with a baked on powder paint. Control panel doors shall have door stays. Paint system shall meet the requirements for outdoor equipment of Federal Government Agencies.
- .3 Mount starters and Terminal Blocks in weatherproof panel provided with full opening access doors. Disconnect should be a lockable, through-the-door type with an operating handle and be clearly visible from outside of unit indicating if power is on or off.
- .4 Casings fabricated from steel that do not have a Zinc coating conforming to ASTM A123 or ASTM A525 shall be treated for the prevention of corrosion with a factory coating or paint system. The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B 117. Each specimen shall have a standard scribe mark as defined in ASTM D 1654. Upon completion of exposure, the coating or paint system shall be evaluated and rated in accordance with procedures A and B of ASTM D 1654. The rating of failure at the scribe mark shall be not less than six (average creepage not greater than 1/8 inch). The rating of the unscribed area shall not be less than ten (no failure). Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry-film thickness.

## 2.10 CONTROLS

- .1 Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with the chiller by the chiller manufacturer. Controls shall include the following readouts and diagnostics:
  - .1 Phase reversal/unbalance/single phasing and over/under voltage protection.
  - .2 Low chilled water temperature protection.
  - .3 High and low refrigerant pressure protection.
  - .4 Load limit thermostat to limit compressor loading on high return water temperature.
  - .5 Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize unit efficiency.
  - .6 Display diagnostics.
  - .7 Oil pressure control based off of maintaining system differential pressure.
  - .8 Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.
- .2 On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer and a single 115 volt 60 Hz single phase connection for evaporator freeze protection heaters.
- .3 The unit controller shall utilize the following components to automatically take action to prevent unit shut down due to abnormal operating conditions which will perform as follows:
  - .1 High pressure switch that is set 20 PSIG lower than factory pressure switch that will automatically unload the compressor to help prevent a high pressure

- condenser control trip. One switch is required for each compressor and indicating light shall also be provided.
  - .2 Motor surge protector that is set at 95% of compressor RLA that will automatically unload the compressor to help prevent an over current trip. One protector is required for each compressor and indicating light shall also be provided.
  - .3 Low pressure switch that is set at 5 PSIG above the factory low pressure switch that will automatically unload the compressor to help prevent a low evaporator temperature trip. One switch is required for each compressor and indicating light shall also be provided.
  - .4 The microprocessor and capacity control algorithms must handle a maximum of 30% change in water flow rate per minute and maintain leaving evaporator temperature control to within +/- 2°C and stable chiller operation.
  - .4 In the above case, the chiller will continue to run in an unloaded state, and will continue to produce some chilled water in an attempt to meet the cooling load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset will be required. Once the "near-trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.
  - .5 Provide the following safety controls with indicating lights or diagnostic readouts.
    - .1 Low chilled water temperature protection.
    - .2 High refrigerant pressure.
    - .3 Low oil flow protection.
    - .4 Loss of chilled water flow.
    - .5 Contact for remote emergency shutdown.
    - .6 Motor current overload.
    - .7 Phase reversal/unbalance/single phasing.
    - .8 Over/under voltage.
    - .9 Failure of water temperature sensor used by controller.
    - .10 Compressor status (on or off).
  - .6 Provide the following operating controls:
    - .1 Modulating leaving chilled water temperature controller which cycles compressors and activates slide valve based on PI algorithms. If manufacturer is unable to provide unloading, providing hot gas bypass shall be required.
    - .2 Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start, or greater than 2 minute stop-to-start timer is included, hot gas bypass shall be provided to insure accurate chilled water temperature control in light load applications.
    - .3 Chilled water pump output relay that closes when the chiller is given a signal to start.
    - .4 Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance trip outs.
    - .5 High ambient unloader pressure controller that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
    - .6 Compressor current sensing unloader unit that unloads compressors to help prevent current overload nuisance tripouts.
-

- .7 Auto lead-lag functions that constantly even out run hours and compressor starts automatically. If contractor cannot provide this function then cycle counter and hour meter shall be provided for each compressor so owner can be instructed by the contractor on how to manually change lead-lag on compressors and even out compressor starts and running hours.
- .8 Low ambient lockout control with adjustable setpoint.
- .9 Condenser fan sequencing which automatically cycles fans in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing unit efficiency.
- .7 Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:
  - .1 Leaving chilled water setpoint adjustment from LCD input
  - .2 Entering and leaving chilled water temperature output
  - .3 Percent RLA output for each compressor
  - .4 Pressure output of condenser for circuits one and two
  - .5 Pressure output of evaporator for circuits one and two
  - .6 Ambient temperature output
  - .7 Voltage output
  - .8 Current limit setpoint adjustment from LCD input.
  - .9 Remote leaving water temperature setpoint.
  - .10 Alarm indicating light and relay
- .8 Digital Communications to BAS system shall consist of a BACnet interface.
- .9 The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.
- .10 The chiller control panel shall provide input for leaving chilled water temperature setpoint based upon a 2-10VDC or 4-20mA signal from a building automation system.
- .11 The chiller control panel shall provide input for chiller current limit setpoint based upon a 2-10VDC or 4-20mA signal from a building automation system.
- .12 BACnet list is provided in Appendix D.

**2.11 WARRANTY**

- .1 Provide a full parts warranty for 30 months from start-up.
  - .2 Provide whole unit labor and refrigerant warranty for 18 months from start-up.
  - .3. A 5-year motor/transmission/compressor warranty shall be provided based upon the RPM of the compressor as follows:
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Compressor RPM	Warranty Term
0 - 5000	2.5 year from start-up
5001 - 10,000	5 years from start-up
10,001 and above	5 years plus annual oil analysis

**2.12 MANUFACTURER'S FIELD SERVICES**

- .1 OEM Startup is performed by factory trained and authorized servicing technicians confirming equipment has been correctly installed and passes specification checklist prior to equipment becoming operational and covered under OEM warranty.
- .2 Chiller supplier to maintain parts store and 24 hour service capabilities within 150 km of the jobsite.
- .3 Manufacturer to approve installation, to supervise startup and to instruct operators. Include 3 days per unit, as follows:
  - .1 2 days start-up and ½ day training
  - .2 ½ day training after 60 days from start-up or summer whichever occurs first.

**2.13 ACOUSTICAL PERFORMANCE**

- .1 The chiller sound power performance shall be Octave Band Sound Power Levels, dB ref, 1 pw measured in accordance with ARI Standard 370 and meet the maximum values in the table below. Units must have compressor attenuation formed as a box around the compressor and covered with a vinyl jacket. The acoustical wrap shall cover piping portion and wrap around suction lines, discharge lines and oil separators and attach by means of Velcro. Sound blanket consists of .50" foam absorber/decoupler and 2lb/square ft vinyl barrier. The sound attenuator wrap shall be barium sulfate impregnated rubber material with a foam backing. The foam and barrier to be bonded with a layer of scrim in between. Composite material to be 5/8" +/- 1/8, velcro to be sewn to composite. The materials of the attenuation shall be 11.2% PVC Resin, 77% Barium Sulfate, 2.7% Fire Retardant in compliance with UL 94-5V rating. Low noise fans used on the comprehensive acoustic package must be 7 blade fan with a TEAO motor operating at 860 rpm @ 60 Hz maximum for reduced fan noise.

Octave Band & Center Frequency, Hz Overall								
63	125	250	500	1000	2000	4000	8000	A' Wtd
88	97	97	95	92	91	83	78	98

**Part 3 Execution**

**3.1 EXAMINATION**

- .1 Verification of Conditions: verify conditions of substrates previously installed under other Sections or Contracts are acceptable for rotary-screw water chiller installation in accordance with manufacturer's written instructions.
  - .1 Visually inspect substrate in presence of Departmental Representative.
  - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
  - .3 Proceed with installation only after unacceptable conditions have been remedied.

**3.2 APPLICATION**

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, product catalogue installation instructions, product carton installation instructions, and data sheets.

**3.3 GENERAL**

- .1 Provide appropriate protection apparatus.
- .2 Install unit as indicated, to manufacturers recommendations, and in accordance with EPS 1/RA/2 and Federal Halocarbon Regulations (2003).
- .3 Ensure adequate clearances for servicing and maintenance.

**3.4 CLEANING**

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 - Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal.
  - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

**3.5 PROTECTION**

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by rotary-screw water chiller installation.

**END OF SECTION**

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