AME Group
consulting mechanical engineers

CITY OF SURREY, RCMP COOLING TOWER REPLACEMENT

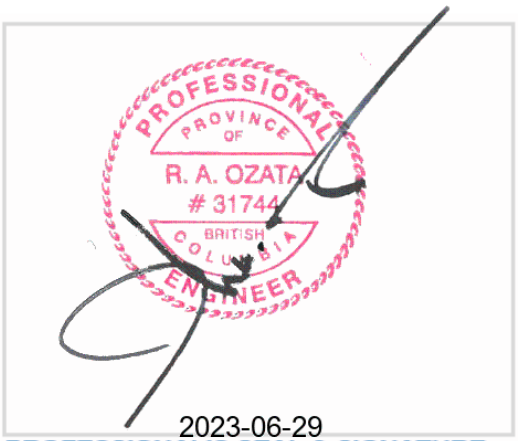
PROJECT NO.: 085b-075-03

MECHANICAL SPECIFICATION

Issued for RFQ
June 29, 2023

200-638 Smithe Street, Vancouver, BC V6B 1E3
T 604-684-5995

Permit to Practice No: 1000236



2023-06-29
PROFESSIONAL'S SEAL & SIGNATURE

Section No.	Section Title
Division 21	
21 05 01	Common Works Results for Mechanical
Division 22	
22 11 16	Domestic Water Piping
Division 23	
23 05 01	Acceptable Manufacturers
23 05 14	Variable Frequency Drives
23 05 16	Expansion Fittings and Loops for Mechanical Piping
23 05 29	Hangers and Supports for Mechanical Piping and Equipment
23 05 33	Heat Tracing for Mechanical Piping and Tanks
23 05 48	Vibration and Seismic Control for Mechanical
23 05 53	Identification for Mechanical Piping and Equipment
23 05 93	Testing, Adjusting, and Balancing for HVAC
23 07 19	HVAC Piping Insulation
23 08 00	Commissioning of Mechanical Systems
23 08 01	Performance Verification of Mechanical Piping Systems
23 09 33	Electric and Electronic Control System for HVAC
23 65 10	Condensers, Coolers and Cooling Towers
Division 25	
25 90 00	Integrated Automation Control Sequences

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Drawings and General Provisions of the Contract apply to work specified in this section.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise. Apply the greater requirement called for between the National and British Columbia codes.

.2 National Codes:

.1 National Building Code of Canada 2015 (NBC).

.2 National Energy Code of Canada for Buildings 2015.

.3 National Fire Code of Canada 2015.

.4 National Plumbing Code of Canada 2015.

.3 British Columbia Codes:

.1 British Columbia Fire Code 2018.

.2 Technical Safety BC regulations and regulatory notices.

.3 British Columbia Building Code 2018.

.4 British Columbia Plumbing Code 2018.

.4 American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE):

.1 ASHRAE 90.1- 16, Energy Standard for Buildings except Low-Rise Residential Buildings.

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

.1 Material Safety Data Sheets (MSDS).

.6 Electrical Equipment Manufacturers' Association Council (EEMAC):

1.4 Definitions

.1 "concealed" – means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.

.2 "exposed" – means work normally visible, including work in equipment rooms, service tunnels, and similar spaces.

.3 "finished" - means when in description of any area or part of an area or a product which receives a finish such as paint, or in case of a product may be factory finished.

.4 “provision” or "provide" (and tenses of "provide") – means supply and install complete.

.5 "install" (and tenses of "install") – means secure in position, connect complete, test, adjust, verify and certify.

.6 "supply" – means to procure, arrange for delivery to site, inspect, accept delivery and administer supply of products; distribute to areas; and include manufacturer's supply of any special materials, standard on site testing, initial start-up, programming, basic commissioning, warranties and manufacturers' assistance to Contractor.

.7 "delete" or "remove" (and tenses of "delete" or "remove") – means to disconnect, make safe, and remove obsolete materials; patch and repair/finish surfaces to match adjoining similar construction; include for associated re-programming of systems and/or change of documentation identifications to suit deletions, and properly dispose of deleted products off site unless otherwise instructed by Owner and reviewed with Consultant.

.8 "BAS" – means building automation system; "BMS" – means building management system; "FMS" – means facility management system; and "DDC" means direct digital controls; references to "BAS", "BMS", "FMS", and "DDC" generally mean same.

.9 "governing authority" and/or "authority having jurisdiction" and/or "regulatory authority" and/or "Municipal authority" – means government departments, agencies, standards, rules and regulations that apply to and govern work and to which work must adhere.

.10 "OSHA" and "OHSA" – stands for Occupational Safety and Health Administration and Occupational Health and Safety Act, and wherever either one is used, they are to be read to mean local governing occupational health and safety regulations that apply to and govern work and to which work must adhere, regardless if Project falls within either authority's jurisdiction.

.11 "Mechanical Divisions" – refers to Divisions 20, 21, 22, 23, 25 and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Mechanical Contractor, unless otherwise noted.

.12 "Electrical Divisions" – refers to Divisions 26, 27, 28 and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Electrical Contractor, unless otherwise noted.

.13 "Consultant" – means person, firm, corporation identified as such in Agreement, or Documents, and is licensed to practice in Place of the Work, and has been appointed by Owner to act for Owner in a professional capacity in relation to the Work.

.14 Wherever words "indicated", "shown", "noted", "listed", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean product referred to is "indicated", "shown", "listed", or "noted" on Contract Documents.

.15 Wherever words "reviewed", "satisfactory", "as directed", "submit", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean that work or product referred to is "reviewed by", "to the satisfaction of", "submitted to", etc., Consultant.

1.5 General Scope

.1 The scope of Section 21 Common Work Results for Mechanical, Section 22 Plumbing, Section 23 HVAC, and Section 25 Control is for building services within the project structure and 1m from the building.

.2 Provide complete, fully tested, and operational systems to meet the requirements described herein and in complete accord with applicable codes and ordinances.

.3 Contract documents and drawings of this Division are diagrammatic and approximately, to scale unless detailed otherwise. They establish scope, material, and installation quality but are not detailed installation instructions.

.4 Follow manufacturers' recommended installation instructions, details, and procedures for equipment, supplemented by requirements of the Contract Documents.

.5 Install equipment generally in locations and routes indicated. Run piping and ductwork close to building structure, parallel to building lines, maximize headroom and maintain minimum interference with other services and free space. Remove and replace improperly installed equipment to satisfaction of the Consultant at no extra cost.

.6 For work within existing facilities, confirm locations and elevations of existing piping and equipment prior to commencement of new work.

.7 Install equipment to provide service access, maintain service clearances and for ease of maintenance.

.8 Connect to equipment specified in other Sections and to equipment supplied and installed by other Contractors or by the Owner. Uncrate equipment, move in place and install complete; start up and test.

.9 Install control valves, control dampers, thermal wells, and other devices on piping, furnished by Division 25.

1.6 Coordination of Work

.1 Cooperate and coordinate with other trades on the project.

.2 Make reference to electrical and mechanical drawings when setting out work. Consult with respective Divisions in setting out locations for equipment and piping, so that conflicts are avoided and symmetrical even spacing is maintained. Jointly work out all conflicts on site before fabricating or installing any materials or equipment.

.3 Where dimensional details are required, work with the applicable architectural and structural drawings.

.4 Full size and detailed drawings shall take precedence over scale measurements from drawings.

.5 Any areas indicated as space for future materials or equipment shall be left clear.

1.7 Permits and Fees

.1 All work shall comply with provincial, municipal, bylaws and authorities having jurisdiction.

.2 Obtain all permits and pay all fees applicable to the scope of work.

.3 Contractor shall arrange for inspections of the work by the authorities having jurisdiction and shall provide certificates indicating Final Approval.

1.8 Examination of Site

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

1.9 Quotation Price Breakdown

.1 Submit a quotation price breakdown within thirty (30) days of quotation closing and before first progress claim, in a format agreed to with the Consultant.

.2 As a minimum, include the following in the quotation price breakdown:

.1	Site Services:	Materials, labour
.2	Mechanical:	Equipment, materials, labour
.3	Plumbing:	Equipment, materials, labour
.4	Controls:	Equipment, materials, labour

1.10 Submittals

.1 Submittals shall be in accordance with the following:

.1 Installed materials and equipment shall meet specified requirements regardless of whether or not shop drawings are reviewed by the Consultant.

.2 No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent.

.3 Shop drawings shall be reviewed by the Prime Contractor and Mechanical Sub-Contractor indicating that the shop drawings have been reviewed, coordinated with the work and that the shop drawings are submitted without qualifications. Shop drawings shall bear the 'reviewed' stamp dated and initialled by the General Contractor and Mechanical Sub-Contractor prior to submitting the shop drawings to the consultant. Shop drawings, which do not bear the contractors and sub-trades 'reviewed' stamp, initials and date will be rejected and sent back as 'not reviewed'.

.4 Submit samples, in addition to drawings, of all items, which in the Consultant's judgment, can be better examined for capacity, quality, finish or detail by sample rather than by drawings. Samples shall be submitted before equipment or material is ordered.

.5 If shop drawings are rejected technically after 3 submissions, the Contractor at no additional expense to the Owner shall revert to the specified product and manufacturer for this project.

.2 Contractor shall provide and submit to the Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.

.3 Requirements for Contractor Retained Engineers

.1 Professional engineers retained to perform consulting services with regard to Project work, i.e. seismic engineer, fire protection engineer or structural engineer, are to be members in good standing with local Association of Professional Engineers, and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of governing authorities in Place of the Work.

.2 Retained engineer's professional liability insurance is to protect Contractor's consultants and their respective servants, agents, and employees against any loss or damage resulting from professional services rendered by aforementioned consultants and their respective servants, agents, and employees in regards to the Work of this Contract.

.3 Unless otherwise specified in Division 00 or 01, liability insurance requirements are as follows:

.1 Coverage is to be a minimum of $1,000,000.00 CDN inclusive of any one occurrence;

.2 Insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;

.3 Liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work.

.4 Retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above.

.5 Evidence of the required liability insurance in such form as may be required is to be issued to Owner, Owner's Consultant, and Municipal Authorities as required prior to commencement of aforementioned consultant's services.

.4 Submit shop drawings for all products identified in the relevant specification sections of Divisions 21, 22, 23 and 25. Provide drawings as electronic files (file format: .dwg, .dxf, pdf, or comparable). When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall include a complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data.

.5 Submit the following shop drawings stamped and signed by professional engineer registered or licensed in Province of British Columbia.

.1 Fastening details for Seismic restraints.

.2 Mounting details for spring isolation of equipment.

.3 Structural steel supports

.6 Shop drawings and product data shall be accompanied by:

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

.2 Acoustical sound power data, where applicable.

.3 Capacity and performance characteristics indicated on performance curves.

.4 Manufacturer to certify current model production.

.5 Certification for compliance to applicable codes.

.7 Shop drawings to indicate:

.1 Material Specification including CSA or ULC reference numbers.

.2 Clearly mark submittal material using arrows, underlining or circling to show differences from specified ratings, capabilities and options being proposed. Cross out non-applicable material. Specifically note on the submittal specified features such as special tank linings, pumps, seals, material, or painting.

.3 Dimensioned construction drawings with plans and sections showing size, arrangement and necessary clearances, with mounting point loads.

.4 Weights of all major equipment for review by the appropriate Consultant.

.5 Mounting arrangements and installation details to suit the applications on this project.

.6 Motor efficiencies on motors 1H.P. and larger.

.7 List of the manufacturers and figure numbers for all valves, traps and strainers.

.8 Control explanation and internal wiring diagrams for packaged equipment.

.9 Control system drawings including a written description of control sequences relating to the schematic diagrams. Refer to additional requirements in controls sections.

.10 Operating and maintenance requirements.

.11 Submit as a shop drawing, an electrical equipment list for any equipment supplied by the mechanical contractor or his subtrades. The list is to be submitted in a timely fashion so that the electrical contractor can utilize the list as a final check prior to ordering motor control centres, starters, or disconnects. The list is to indicate the following:

.1 The horsepower size and number of motors.

.2 The minimum circuit amps (MCA) for packaged equipment such as roof top units.

.3 The voltage and phase of the motors.

.4 Whether or not a starter or a disconnect is included as part of the package.

.8 Material Safety Data Sheets (MSDS):

.1 Submit Material Safety Data Sheets (MSDS) in accordance with Division 01 - Submittal Procedures for the following products. Indicate VOC emissions, prior to installation or use:

.1 Adhesives.

.2 Caulking compounds.

.3 Sealants.

.4 Insulating materials.

.5 Fireproofing or fire stopping materials.

.9 Closeout Submittals:

.1 Provide mechanical operation and maintenance data in compliance with Division 01 - Closeout Submittals and the following:

.1 The Contractor shall furnish and pay for three (3) complete sets of operating and maintenance manuals for the complete mechanical installation plus two (2) copies of the digital version of the manuals on USB type flash drive.

.2 Supply indexed copies of equipment manufacturers' operating and maintenance (O&M) instruction data manuals. Consolidate each copy of data in an identified hard cover three "D" ring binder. Each binder to include:

.1 Front cover: project name; wording – "Mechanical Systems Operating and Maintenance Manual"; and date;

.2 Introduction sheet listing Consultant, Contractor, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses;

.3 Equipment manufacturer's authorized contact person name, telephone number and company website;

.4 Table of Contents sheet, and corresponding index tab sheets;

.5 Copy of each "REVIEWED" or clean, updated "REVIEWED AS NOTED" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, company website address, and email address for local source of parts and service; when shop drawings are returned marked "Reviewed As Noted" with revisions marked on shop drawing copies, they are to be revised by equipment supplier to incorporate comments marked on "Reviewed" shop drawings and a clean updated copy is to be included in operating and maintenance manuals;

.3 Operation and maintenance manual approved by, and final copies deposited with the Consultant a minimum of 7-days before final inspection.

.4 Operation data to include but not limited to:

.1 Pressure test reports, and certificates issued by governing authorities

.2 Control schematics for systems including environmental controls.

.3 Wiring and connection diagrams.

.4 A description of the systems and associated controls.

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

.6 Operational instructions for systems and associated components.

.7 A description of actions to be taken in the event of equipment failure.

.8 Valves schedule and flow diagrams.

.9 Colour coding chart.

.5 Maintenance data to include:

.1 Servicing, maintenance, operation, and trouble-shooting instructions for each item of equipment.

.2 Data to include schedules of tasks, frequency, tools required and task time.

.3 Recommended maintenance practices and precautions.

.4 Complete parts lists with numbers.

.6 Performance data to include:

.1 Equipment manufacturer's performance datasheets indicating point of operation as left after commissioning is complete.

.2 Equipment performance verification test results and final commissioning report.

.3 Special performance data as specified.

.4 Testing, adjusting, and balancing.

.7 Digital Version of Manuals

.1 The digital version of the manuals and the hard copy version shall be prepared by the same company.

.2 Utilize latest version of Adobe Acrobat, Portable Document Format (pdf).

.3 The digital manual shall be enhanced with the following features: Bookmarks, Internet Links, Internal Documents Links and Optical Character Recognition (OCR).

.4 All shop drawings shall be scanned to a minimum 8.5" x 11" size. If the original page is 11" x 17", the digital copy shall also be 11" x 17".

.5 Provide a minimum 300 DPI for all scanned pages.

.6 All scanned material may be searched for text with minimum 60% Optical Character Recognition (OCR).

.7 Rotation of scanned page images/texts shall be displayed within +/- 20 degrees.

.8 Digital manual shall be organized in the same manner as the hard copy manual. Bookmark all major tabs and sub-sections and each set of shop drawings. Link the Table of Contents to the referenced section. Insert Internet Links to the Mechanical Equipment Manufacturers/Suppliers/Contractors official websites

.8 Approvals:

.1 Submit 1 copy of draft Operation and Maintenance Manual to Consultant for approval. Submission of individual data will not be accepted unless directed by Consultant.

.2 Make changes as required and re-submit as directed by Consultant.

.9 Warranties

.1 Include copy of all equipment warranty and extended warranty certificates into the Operation and Maintenance Manual.

.10 Additional data:

.1 Prepare and insert into operation and maintenance manual additional data when need as it becomes apparent during demonstrations and instructions.

.2 Chemical treatment reports.

.3 Back-flow preventer test certificates.

.4 Results of Owner's Orientation (demonstrations).

.5 List of spare parts turned over to owner's forces.

.2 Site records:

.1 Contractor shall maintain 1 set of white prints at contractors cost to mark changes as work progresses and as changes occur.

.2 Use different colour waterproof ink for each service. Do not use pencil or black ink.

.3 Transfer information weekly to show work as actually installed.

.4 Make available for reference purposes and review.

.3 Record drawings:

.1 Prior to start of Testing, Adjusting and Balancing for Mechanical, finalize production of record drawings.

.2 Use site record set to electronically produce CAD/Revit files and pdfs of drawings thus forming reproducible "Record Drawings" set.

.3 Identify each drawing in lower right-hand corner in letters at least 12 mm high as follows: - "RECORD DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (date).

.4 Submit Record drawings, to consultant for approval and make corrections as directed.

.5 Provide digital copies of final record drawings reviewed by Consultant onto USB type flash drive, or method as directed by owner. Provide 2 complete sets of "Record Drawings" on separate USBs. Submit "Record Drawings" sets of white prints and USBs to Consultant

.6 Perform testing, adjusting, and balancing for HVAC using record drawings.

.7 Submit completed reproducible record drawings with Operating and Maintenance Manuals.

.8 Cost to transfer record information onto reproducible media & Auto-CAD or Revit are this contractor's responsibility. Consultant will release drawings to contractor after signing a copyright form.

.9 Should the Contractor choose to utilize this consultant for transferring site records (Set with marked changes) information to record drawings, allow $400 / sheet for all drawings in the construction set. This will cover costs for drafting time & printing costs.

.10 Submitted drawings are to be of same quality as original Contract Drawings. CAD/Revit drawing files are to be compatible with AutoCAD/Revit software release version confirmed with consultant.

1.11 Quality of Work

.1 All work shall be by qualified tradesmen with valid Provincial Trade Qualification Certificates. Spot checks will be made by the Consultant.

.2 Work, which does not conform to standards accepted by the Consultant and the trade, may be rejected by the Consultant. The Contractor shall redo rejected work to the accepted standard at no cost to the Owner.

1.12 Metric Conversion

.1 All units in this division are expressed in SI units.

.2 Submit all shop drawings and maintenance manuals in SI units.

.3 On all submittals (shop drawings etc.), use the same SI units as stated in the specification.

.4 Equivalent Nominal Diameters of Pipes - Metric and Imperial:

.1 Where pipes are specified with metric dimensions and Imperial sized pipes are available, provide equivalent nominal Imperial sized pipe as indicated in the table, and provide at no extra cost adapters to ensure compatible connections to all metric sized fittings, equipment, and piping.

.2 When CSA approved SI Metric pipes are provided, the Contractor shall provide at no extra cost adapters to ensure compatible connections between the SI Metric pipes and all new and existing pipes, fittings, and equipment.

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

.5 Metric Duct Sizes:

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

1.13 Drawings and Specifications

.1 Drawings and specifications are complementary to each other, and what is called for by one shall be binding as if called for by both.

.2 Should any discrepancy appear between drawings and specifications, which leaves the Contractor in doubt as to the true intent and meaning of the plans, and specifications, obtain written clarification from the Consultant during the quotation period. Without a written clarification, the better quality and/or greater quantity of work or materials shall be estimated, performed and furnished within the quoted price.

.3 Examine all contract documents, including all drawings and specifications, and work of other trades to ensure that work is satisfactorily carried out without changes to building.

1.14 Cutting, Patching and Coring

.1 Provide holes and sleeves, cutting and fitting required for mechanical work. Relocate improperly located holes and sleeves.

.2 Drill for expansion bolts, hanger rods, brackets, and supports.

.3 Provide openings and holes required in precast members for mechanical work. Cast holes 100 mm or larger in diameter. Field cut smaller than 100 mm.

.4 Patch building where damaged from equipment installation, improperly located holes etc. Use matching materials as specified in the respective section.

.5 Removal of any existing pipe, conduit, or ductwork within a slab core hole or slab opening through floors and roofs must be removed completely, including any associated sleeving, in a safe manner. Provisions are to be made during the removal process to protect any occupants and/or fabric of the space below. The Consultant is to be advised of all existing mechanical service penetration locations, such that site visits and field reviews can be fully co-ordinated and undertaken before and after the opening is closed in and filled.

.6 Filling of any existing slab core or opening is to be with an engineered design of concrete fill complete with doweling for adhesion and/or fire stopping system as appropriate.

1.15 Installation of Equipment

.1 Pipe all equipment drains to building drains except systems containing glycol.

.2 Unions and flanges shall be provided in piping or ductwork to permit easy removal of equipment.

.3 Maintain permanent access to equipment for maintenance.

1.16 Connections to Existing Services

.1 Maintain liaison with the Owner and provide a mutually acceptable schedule to interrupt, reroute or connect to existing building services with the minimum of interruption of those services.

.2 Major services shall not be interrupted before all preparatory work is completed and all required materials are on site. Provide a minimum of one week notice for all service shutdowns. Allow for major service interruptions outside of normal operating hours of the facility.

.3 Interruptions and shutdowns of existing services shall be by the building/plant maintenance staff. Advise building/plant maintenance staff of the duration of service interruption or shut down.

1.17 Selective Demolition

.1 Reference Standards

.1 Unless otherwise specified, carry out demolition work in accordance to CSA S350-M1980 Code of Practice for Safety in Demolition of Structures.

.2 Remove from site all equipment, ducting or piping which is no longer required because of work under this Contract.

.3 Existing Conditions

.1 Visit and examine the site and note all characteristics and irregularities affecting the work of this Section.

.4 Protection

.1 Prevent debris from blocking surface drainage inlets and all types of drainage piping systems which remain in operation.

.5 Salvageable Materials

.1 Except as otherwise stated, salvageable materials from area of demolition shall become the property of the Owner at his discretion. All material not taken over by the Owner or removed from the building under this contract shall be removed from this site and disposed of as required by any applicable disposal regulations.

.2 Turnover to and deliver to the Owner's storage area all items which have been determined to have salvage value and has been removed due to the Work.

1.18 Equipment and Materials

.1 Materials and equipment installed shall be new, CSA approved and of quality specified.

.2 Each major component of equipment shall bear manufacturer's name, address, catalog and serial number in a conspicuous place.

.3 Where two or more products of the same type are required, products shall be of the same manufacturer.

.4 Notify the Consultant in writing ten (10) days prior to the quotation close, any materials or equipment specified which is not currently available or will not be available for use as called for herein. Failing this, the contract will assume that the most expensive alternate has been included in the quotation price.

.5 All equipment supplied to the project will meet efficiencies as defined in ASHRAE Standard 90.1 and NECB (current versions).

1.19 Cleaning

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

.2 Clean equipment and devices installed as part of this project.

1.20 Delivery, Storage and Handling

.1 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

.2 Storage and Handling Requirements:

.1 Store materials and equipment in accordance with the manufacturer's recommendations in a clean, dry, well-ventilated area.

.2 Store and protect equipment from nicks, scratches, and blemishes.

.3 Replace defective or damaged materials with new.

.3 Protect equipment and materials in storage on site during and after installation until final acceptance. Leave factory covers in place. Take special precautions to prevent entry of foreign material into working parts of piping, equipment and duct systems.

.4 Protect equipment and open-end duct with polyethylene covers and maintain equipment on crates until installation.

.5 Operate, drain and flush out unsealed bearings and refill with fresh oil before final acceptance.

.6 Thoroughly clean piping, ducts and equipment of dirt, cuttings and other foreign substances.

.7 Protect bearings and shafts during installation. Grease shafts and sheaves to prevent corrosion. Supply and install necessary extended nipples for lubrication purposes.

.8 Ensure that existing equipment is carefully dismantled and not damaged or lost. Do not reuse existing materials and equipment unless specifically indicated.

1.21 Single Point Electrical Connection

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

1.22 Electrical Motors

.1 Supply mechanical equipment complete with electrical motors.

.2 Quality Assurance

.1 Provide motors designed, manufactured, and tested in accordance with the latest edition of the following codes and standards: NEMA, EEMAC, CSA, CEC Part 1, IEEE and ANSI. All motors to be UL listed and CSA labelled.

.2 All motors to be approved for use in the designated area classification by the Provincial Electrical Protection Branch.

.3 All motors intended for use with a [variable speed drive] [variable frequency drive] (VFD) shall be inverter duty rated.

.4 Motors connected to VFD(s) shall be wound using inverter spike resistant magnet wire capable of 1600V.

.5 The noise level of each motor shall comply with NEMA standards, less than 80 dBA at 1 meter.

.6 Minimum certified motor efficiency shall be as outlined in current version of ASHRAE 90.1and NECB.

.3 Unless specified otherwise, provide motors designed for full voltage starting, EEMAC Design B. Motors driving high torque or high inertia loads may be EEMAC Design C or D.

.4 Provide motors rated for continuous duty with 1.15 service factor unless specified otherwise in the driven equipment specifications. Provide all motors with thermal overload protection.

.5 Motors less than 3/4-hp shall be 120 V, 60 Hz, 1 phase. Motors 3/4-hp and larger shall be 3 phase at the indicated voltage.

.6 All motors shall be 1800 rpm unless otherwise noted.

.7 Provide motors complete with equipment except where indicated.

.8 Provide motors with grease or oil lubricated anti-friction type ball or roller bearings.

.9 Provide motors designed with Class B insulation, Class F insulation for totally enclosed motors.

.10 Motors exposed to outdoor temperature to be lubricated with lubricants suitable for operation at 6 deg. C. below the lowest temperature recorded by ASHRAE or the Climatic Information (Supplement to the National Building Code), for the location in which they are installed.

.11 All motors 10 hp and larger that are controlled by a VFD are to use a dielectric grease bearings and a grounding kit with a system of brass or stainless steel brushings.

.12 Where motor power is stated in watts or kilowatts, nominal motor horsepower multiplied by 746 or 0.746 respectively, has been used as the conversion factor.

.13 All motors used with fire pumps shall be listed for fire pump service.

.14 Submittals

.1 Submit data of test method used and motor efficiencies with shop drawings.

1.23 Motor Starters and Accessories

.1 Motor starters must be capable of starting associated motors under the imposed loads. Confirm starter voltage matches motor prior to ordering.

.2 Unless otherwise specified, starters for 1-phase motors are to be 115 volt; thermal overload protected manual starting switches with a neon pilot light, a surface or recessed enclosure to suit the application, and, where automatic operation is required, a separate H-O-A switch in an enclosure to match starter enclosure.

.3 Unless otherwise specified, starters for 3-phase motors less than 50 HP are to be combination "quick-make" and "quick-break" fused disconnects and full voltage non-reversing across-the-line starters, each complete with and overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.

.4 Starters for 2-speed double winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.

.5 Starters for 2-speed single winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.

.6 Starters for reversible motors for cooling towers are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to allow fan(s) to coast down to a stop before being operated in reverse rotation.

.7 Unless otherwise specified, motor starter enclosures are to be in accordance with following NEMA ratings:

.1 Enclosures located in sprinklered areas – Type 2;

.2 Enclosures exposed to the elements – Type 3R, constructed of stainless steel;

.3 Enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;

.4 Enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;

.5 Enclosures except as noted above – Type 1;

.6 Enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.

.8 Motor control centres are to be multi-unit, 2.28 m (9') high, NEMA Class 1, type "B", factory assembled, dead front, floor mounted, freestanding motor control centre with tin plated copper bus and an NEMA Type 1 or Type 2 enclosure as for loose starters specified above. Each motor control centre is to be complete with starters as specified above, load and control wiring terminal boards, and required facilities for line and load side power wiring connections.

.9 Disconnect switches for motor control centres are to be heavy-duty, CSA certified, front operated switches as per motor starter schedule, each complete with a handle suitable for padlocking in "off" position and arranged so that door cannot be opened with handle in "on" position and an NEMA enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.

.10 Fuses are to be, unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.

1.24 Miscellaneous Metals

.1 Provide all necessary miscellaneous to hang or support materials, equipment and provide access for work under this contract.

.2 All miscellaneous metals shall be prime painted.

.3 Miscellaneous metals shall include but not limited to:

.1 Hangers for equipment, piping and ductwork.

.2 Support for equipment.

.3 Access platforms and catwalks.

1.25 Scaffolding, Hoisting and Rigging

.1 Unless otherwise specified or directed, supply, erect and operate scaffolding, rigging, hoisting equipment and associated hardware required for work, and subject to approval from Owner.

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

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

1.26 Temporary Heat

.1 Do not use the permanent system for temporary heating purposes without written permission from the Consultant.

.2 If approved, permanent mechanical systems in building may be used for temporary heating during construction subject the following conditions:

.1 Each entire system is complete, pressure tested, cleaned, and flushed out.

.2 Specified water treatment system has been commissioned, and treatment is being continuously monitored.

.3 Thoroughly clean and overhaul permanent equipment used during the construction period, replace worn or damaged worn or damaged parts before final inspection.

.4 Use of permanent systems for temporary heat shall not modify terms of warranty.

.5 Operate heating systems under conditions, which ensure no temporary or permanent damage. Operate with proper safety devices and controls installed and fully operational. Operate systems only with treated water as specified.

.6 Air systems shall not be used for temporary heating.

.7 When permanent systems are used for temporary heat, provide alarm indicating system failure. Connect alarm to independent alarm company system.

.8 Where pumps are used for temporary heating, replace mechanical seals, regardless of condition, with new mechanical seals.

.9 Energy costs are to be paid by Contractor.

.10 During this period of construction, such systems/equipment to not become property of Owner or be Owner's responsibility for maintenance or service. Systems/equipment are to remain property of respective manufacturers/suppliers or Contractor, who are responsible for full maintenance and servicing of systems/equipment in order to maintain validity of warranties after turn over to Owner.

.11 Prior to application for a Certificate of Substantial Performance of the Work and turn over to Owner, such systems/equipment to be cleaned, restored to "new" condition, paint finishes "touched-up", filters cleaned or replaced, etc.

1.27 Progress Claim Breakdown

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

.2 Payment breakdown is subject to Owner's approval and Consultant's review. Progress payments will not be processed until an approved breakdown is in place. Breakdown is to include one-time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, adjusting and balancing, system testing and verification, and project closeout submittals.

.3 Indicate equipment, material and labour costs for site services (if applicable) and indicate work of each trade in same manner as indicated on progress draw.

.4 Progress claims will not be certified nor payment made beyond 95% on the overall Mechanical contract and beyond 70% on the Control systems contract, until commissioning and verification of the systems are complete. (The 70% limit on Controls is included in the overall fig.). This procedure is to allow for any necessary deficiency holdbacks on items, which do not become apparent until the systems are commissioned.

1.28 Notice for Required Field Reviews

.1 Whenever there is a requirement for Consultant to perform a field review prior to concealment of any work, to inspect/re-inspect work for deficiencies prior to Substantial Performance of the Work, for commissioning demonstrations, and any other such field review, give minimum 5 working days' notice in writing to Consultant.

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

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

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

1.29 Changes in the Work

.1 Whenever Consultant proposes in writing to make a change or revision to design, arrangement, quantity or type of work from that required by Contract Documents, prepare and submit to Consultant for review, a quotation being proposed cost for executing change or revision.

.2 Quotation is to be a detailed and itemized estimate of product, labour, and equipment costs associated with change or revision, plus overhead and profit percentages and applicable taxes and duties.

.3 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.

.4 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.30 Temporary or Trial Usage

.1 Temporary or trial usage by the Owner or Consultant of mechanical equipment supplied under contract shall not represent acceptance.

.2 Repair or replace permanent equipment used temporarily.

.3 Repair or otherwise rectify damage caused by defective materials or workmanship during temporary or trial usage.

.4 Avoid thermal shock to heating system by coordination with the Owner during planning, construction and operation of temporary heating system.

1.31 Guarantee / Warranty

.1 Furnish a written guarantee stating that all work executed in this contract will be free from defective workmanship and materials for a period of one (1) year from the date of Substantial Performance. The Contractor shall, at his own expense, repair and replace any work, which fails or becomes defective during the term of the guarantee/warranty, providing such work is not due to improper usage. The period of guarantee specified shall not in any way supplant any other guarantees of a longer period but shall be binding on work not otherwise covered.

.2 Use of permanent systems for temporary heat shall not modify terms of the manufacturers' warranty or the guarantee.

.3 If the equipment is used during construction, the warranty or guarantee period shall not be shortened or altered.

1.32 Substantial and Total Performance

.1 Prior to requesting an inspection for Substantial Performance, provide a complete list of items, which are deficient.

.2 A certificate of Substantial Performance will not be granted unless the following items are completed and available to the Owner's Consultant:

.1 Final Plumbing Inspection Certificate from the Authority having Jurisdiction.

.2 Commissioning checklists are completed and submitted.

.3 Seismic Letter of Assurance Schedule SB and SC.

.4 Systems have been chemically cleaned. Flushed and water treatment initiated. Provide report from manufacturer's representative to confirm status of treatment and final inspection.

.5 Potable water piping's flushing and chlorination test certificate

.6 Major equipment – suppliers start-up test sheets and letters certifying start up (Cooling tower).

.7 Draft Operating/Maintenance Manuals have been submitted for review.

.8 All mechanical systems have been commissioned and are capable of operation with alarm controls functional and automatic controls in operation.

.9 Water systems have been balanced with draft report submitted to the Consultant.

.10 Mechanical identification is complete.

.11 Warranty forms have been mailed to the manufacturer. Provide copy of the original warranty for equipment, which has a warranty period longer than one year.

.12 Operating and Maintenance demonstrations have been provided to the Owner.

.13 Written inspection report by manufacturer's representative has been submitted for noise and vibration control devices and flexible connections.

.14 Record drawings have been submitted.

.15 All previously identified deficiencies have been corrected and accepted.

.16 Heat trace megger test reports for each circuit, submitted on manufacturer's letterhead.

.3 Prior to a Total Performance Inspection, provide declaration in writing that deficiencies noted at time of substantial performance inspection have been corrected and the following items completed prior to the total performance inspection:

.1 Submit final water balance reports.

.2 Submit final operating and maintenance manuals.

.3 Complete final calibration.

.4 The Consultant shall provide one (1) visitation for the purpose of total performance inspection. Subsequent visitations if required shall be at the expense of the Contractor.

.5 The Contractor shall provide qualified personnel in appropriate numbers to operate the facility until substantial performance is declared.

1.33 Alternate Materials and Equipment

.1 The price submitted for this contract shall be based on the use of materials and equipment as specified or as contained within the Acceptable Manufacturers List.

.2 Requests for alternate equivalent materials or equipment must be submitted to the Consultant no later than seven (7) working days prior to the Mechanical trades' closing quotation date. Submit all applicable technical data, including performance curves and physical details for review. Approval of requests shall only be given by addendum.

.3 Approved equivalents and/or alternatives to specified products shall be equal to the specified product in every respect, operate as intended, and meet the space, capacity, and noise requirements outlined.

.4 The Contractor shall be fully responsible for any additional labour and materials required by any trades or other Contractors to accommodate the use of other than specified materials or equipment. The Contractor shall bear any and all costs for design/system modifications to accommodate the "alternate" equipment. Extras will not be approved to cover such work.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 Acceptable Manufacturers.

2.2 Existing Services

.1 Building Mechanical Services: Maintain activity of all building services during demolition/removal of existing services required of this contract.

2.3 Demolition

.1 Completely demolish the items scheduled and remove all materials from the premises unless otherwise requested by the Owner.

.2 Carry out demolition in a manner to cause as little inconvenience to the occupied building area as building area as possible. Co-ordinate this activity with the Owner and/or the Consultant.

.3 Carry out demolition in an orderly and careful manner.

.4 All coring, patching and removal of existing equipment, pipes, and ductwork, which may affect the operation of occupied areas of the building, shall be carried out outside of regular office hours or as scheduled with the Owner.

2.4 Asbestos

.1 The intent is for a Haz-Mat Contractor to remove all asbestos containing material prior to the proposed project work taking place. Notify the Consultant if asbestos containing material is suspected to remain on site.

.2 When new work is required to be connected to existing plumbing, piping, ductwork or equipment, which contains asbestos insulation or products the following, shall apply:

.1 Keep disruption to existing piping and equipment to a minimum

.2 Protect the site and all Contractors from the work

.3 Remove the asbestos at piping and equipment for new connections and carry out work in accordance with Work Safe BC, Workers Compensation Board, Occupational Health and Safety (OHSA) requirements for asbestos removal.

2.5 Electrical Motors

.1 All Motors, 1 H.P. motors and larger, shall be energy efficient design and have a minimum and nominal full load efficiency, which will meet or exceed the values listed in accordance CAN/CSA C390-1. The minimum efficiency shall be guaranteed.

.2 Belt Drives: Provide belt drives to the following requirements:

.1 Provide steel, cast iron or aluminum sheaves for motors less than 3/4 H.P.

.2 Provide steel or cast iron sheaves keyed to shafts, for motors 3/4 H.P. and larger.

.3 For motors less than 10 H.P. provide standard adjustable pitch drive sheaves having +/-10% range. Use mid-position of range for specified RPM.

.4 For motors 10 H.P. and larger, provide fixed pitch drive sheaves with split tapered bushing and keyway. Provide final drive sheaves of size to suit final balancing.

.5 Match drive and driven sheaves.

.6 V-belts shall conform to the American Belt Manufacturers standards. Multiple belts shall be matched sets.

.7 Not less than a 2-belt configuration is required for each drive for motors 3/4 H.P. and larger.

.8 Poly Chain GT belt drives shall be used on all motors 10HP and larger.

.9 Minimum drive rating shall be 150% of nameplate rating of motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.

.10 Motor slide rail adjustment baseplate with double draw bolt, shall allow for centre line adjustment.

.11 Tension belts to manufacturers recommendations before start up and after 100 hours of operation using calibrated belt tensioning gauge.

.12 Provide one spare set of belts for each piece of equipment with each belt separately identified for the equipment item to be served.

.3 Shaft Couplings: Shaft couplings shall be of the pin or jaw neoprene insert type, gear type, or flexing steel insert type and shall allow coupling inserts to be easily removed without disassembly of the equipment.

.4 Guards:

.1 Provide removable protective guards on all exposed V-belt drives and shaft couplings in accordance with Worker's Compensation Board requirements.

.2 Guards for drives shall have:

.1 1 mm [18ga.] expanded metal screen welded to 25 mm [1"] steel angle frame.

.2 1.5 mm [16ga.] thick galvanized sheet metal tops and bottoms.

.3 Removable side[s] for servicing.

.4 38 mm [1-1/2"] dia. holes on both shaft centres for insertion of tachometer.

.5 Sectionalize if necessary so one man can handle removal.

.3 Provide means to permit lubrication and use of test instruments with guards in place.

.4 Fabricate and install belt guards for V-belt drives to permit movement of motors for adjusting belt tension and for belt slap.

.5 Provide removable "U" shaped guards for flexible couplings with 2.5 mm [12ga.] thick galvanized frame and 1.2 mm [18ga.] thick expanded mesh face.

.6 Provide guards on all unprotected fan inlets and outlets. Guards to be provided by fan manufacturer.

.7 Prime coat guards and finish paint to match equipment.

.8 Secure guards to equipment allowing for ease of removal.

3. EXECUTION

3.1 Painting Repairs and Restoration

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

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

.3 Clean exposed bare metal surfaces supplied under Divisions 21, 22, 23 and 25. Apply at least one coat of corrosion resistant primer paint to all supports and equipment fabricated from ferrous metal.

.4 Paint all pipe hangers and exposed sleeves, in exposed areas, with a rust inhibiting primer.

3.2 System Cleaning

.1 Clean interior and exterior of all systems including strainers.

3.3 Field Quality Control

.1 Manufacturer's Field Services:

.1 Obtain written reports from manufacturers' verifying compliance of the work, in handling, installing, applying, protecting, cleaning and start-up of a product.

.2 Submit Manufacturer's Field Reports as described in PART 1 - Submittals.

.3 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

3.4 Demonstration

.1 Consultant and/or Owners representative may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.

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

.3 Where specified elsewhere in Division 21, 22, 23 or 25 manufacturers to provide demonstrations and instructions.

.4 Use operation and maintenance manual, record drawings, and audio visual aids as part of instruction materials.

.5 Instruction duration requirements shall be as specified in the appropriate sections.

.6 Contractor will record these demonstrations on digital video for future reference.

3.5 Fire Stopping and Smoke Seals

.1 Refer to Section 22 07 11.

3.6 Access Doors

.1 Installation:

.1 Provide all access doors required to access work installed by Divisions 21, 22, 23 and 25. Be responsible for coordinating locations, cutting opening and installing panels. Any secondary supports, blocking etc. will be by the ceiling or wall contractor.

.2 Access doors in mechanical equipment to be provided by this Division.

.3 Access panel requirements and locations shall be fully coordinated with all involved contractors prior to the installation of any mechanical systems or equipment.

.2 Location:

.1 Ensure that equipment is within view and accessible for operating, inspecting, adjusting, servicing without using special tools.

.3 Provide 3 sets of each type of access door key to the Owner at substantial completion. Obtain a signed receipt indicating date, quantity of keys and person receiving keys. Submit receipt to the Owner's Consultant.

3.7 Electrical Motors

.1 Manufacturer's instructions:

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

.2 Installation:

.1 Unless otherwise noted starters and protection devices will be included under Division 26 - Electrical.

.2 Co-ordinate with Division 26 Contractor to ensure proper connection, correct thermal overload protection and correct motor controls.

.3 Where starters are included in this Division as an integral part of packaged equipment, they shall contain thermal overload protection in all ungrounded lines.

.4 Equipment, which has more than one voltage rating, shall be fed from a single power source through a disconnect switch.

.5 Fasten securely in place.

.6 Make removable for servicing, easily returned into, and positively in position.

.3 Setting and Alignment:

.1 Employ a journeyman millwright to align all V-belt drives and/or shaft coupling drives. The millwright shall check that centrifugal fan wheels are properly centred on fan shafts.

.2 Align shaft couplings, using a dial indicator, to within +/-0.051 mm [0.002"] after grouting is complete and the piping system is operational.

.3 Align V-belt drives using a straight edge.

.4 Submit a certificate from the millwright employed, certifying that all shaft couplings and V-belt drives have been aligned and centrifugal fan wheels centred prior to initial start-up and checked again after final system balance adjustment.

3.8 Protection

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

END OF SECTION

1. GENERAL

1.1 Summary

.1 This section includes materials and installation for domestic cold water systems including all piping, fittings, valves and equipment inside the building to 1 m outside the building.

.2 This section does not include pumps associated with domestic water systems.

1.2 Related Sections

.1 This section of the specification forms part of the Contract Documents and shall be read interpreted and coordinated with all other parts of the Contract Documents.

.2 Section 21 05 01 Common Work Results for Mechanical.

.3 Section 23 05 29 Hangers and Supports for Mechanical Piping and Equipment.

.4 Section 23 05 33 Heat Tracing for Mechanical Piping and Tanks.

.5 Section 23 05 48 Vibration and Seismic Control for Mechanical.

.6 Section 23 05 53 Identification for Mechanical Piping and Equipment.

.7 Section 23 05 93 Testing, Adjusting and Balancing for HVAC.

.8 Section 23 07 19 HVAC Piping Insulation.

1.3 References

.1 Applicable Building and Plumbing Code - Refer to Section 21 05 01.

.2 American Society of Mechanical Engineers (ASME)

.1 ASME B1.20.1 - Pipe Threads, General Purpose, Inch.

.2 ASME B16.5 – Pipe Flanges and Flanged Fittings: NPS ½ Through NPS 24 Metric /Inch Standard.

.3 ASME B16.9 - Factory-Made Wrought Buttwelding Fittings.

.4 ASME B16.15 - Cast Bronze Threaded Fittings, Classes 125 and 250.

.5 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

.6 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

.7 ASME B31.9 – Building Services Piping.

.8 ASME B36.19M – Stainless Steel Pipe.

.3 American Society for Testing and Materials International, (ASTM).

.1 ASTM A182/A 182M - Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service

.2 ASTM A193 - Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications

.3 ASTM A269 – Seamless and Welded Austenitic Stainless Steel Tubing for General Service

.4 ASTM A312 / A312M – Seamless, Welded and Heavily Cold Worked Austenitic Stainless Steel Pipes

.5 ASTM A403/A 403M – Wrought Austenitic Stainless Steel Piping Fittings

.6 ASTM A351/A 351M – Castings, Austenitic for Pressure Containing Parts

.7 ASTM A536 – Ductile Iron Castings

.8 ASTM B88 - Standard Specification for Seamless Copper Water Tube.

.9 ASTM F876 – Standard Specification for Crosslinked Polyethylene (PEX) Tubing.

.10 ASTM F877 – Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot and Cold Water Distribution Systems.

.11 ASTM F1960 – Standard Specification for Cold Expansion Fittings With PEX Reinforcing Rings for Use With Crosslinked Polyethylene (PEX) Tubing.

.4 American Water Works Association (AWWA).

.1 AWWA C104/A21.4 – Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.

.2 AWWA C110/A21.10 – Ductile-Iron and Gray-Iron Fittings.

.3 AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings.

.4 AWWA C151/A21.51 – Ductile-Iron Pipe, Centrifugally Cast.

.5 AWWA C228 – Stainless Steel Pipe Flanges for Water Service – Sizes 2in. Through 72 in. (50mm Through 1,800mm).

.6 AWWA C606 – Standard for Grooved and Shouldered Joints.

.7 AWWA C904 – Crosslinked Polyethylene (PEX) Pressure Pipe ½ In. (12mm) through 3" (75mm) for Water Service.

.8 AWWA C651-86 – Standard for Disinfecting Water Mains

.5 Canadian Standards Association (CSA Group).

.1 CSA-B64 Series 11 (R2016), Backflow Preventers and Vacuum Breakers.

.2 CSA B64.10.1 - Selection and Installation of Backflow Preventers/Maintenance and Field Testing of Backflow Preventers.

.3 CSA B137 - Thermoplastic Pressure Piping Compendium.

.4 CSA B137.5 – Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.

.5 CSA B242- 05 (R2016) - Groove and Shoulder Type Mechanical Pipe Couplings.

.6 CSA-B356-10 (R2015), Water Pressure Reducing Valves for Domestic Water Supply Systems.

.6 Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS).

.1 MSS SP 67 - Butterfly Valves.

.2 MSS SP 70 - Cast Iron Gate Valves, Flanged and Threaded Ends.

.3 MSS SP 71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends.

.4 MSS SP 80 - Bronze Gate, Globe, Angle and Check Valves.

.7 National Sanitation Foundation (NSF):

.1 NSF/ANSI 14 Plastic Piping System Components and Related Materials

.2 NSF/ANSI/CAN 61 Drinking Water System Components – Health Effects.

.3 NSF/ANSI 372 – Drinking Water System Components – Lead Content

.8 Plumbing and Drainage Institute (PDI).

.1 PDI-WH201 (Revised 2010), Water Hammer Arrestors Standard.

.9 Underwriters' Laboratories of Canada Inc:

.1 CAN/ULC-S101 Standard Methods of Fire Endurance Tests of Building Construction and Materials.

.2 CAN/ULC-S102.2 Standard for Surface Burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies.

.3 CAN/ULC-S115 Standard Method of Fire Tests of Firestop Systems.

.10 Plastic Pipe Institute (PPI):

.1 PPI Technical Report TR-4.

1.4 Waste Management and Disposal

.1 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.2 Place materials defined as hazardous or toxic in designated containers.

.3 Fold up metal banding, flatten and place in designated area for recycling.

1.5 Quality Assurance

.1 All materials shall comply with manufacturer's specifications and referenced documents.

.2 Piping: Labeled and marked as determined by agency approved by authorities having jurisdiction.

.3 Source Limitations: Obtain piping, fittings, valves and accessory equipment from a single manufacturer where applicable.

.4 All roll grooved or cut grooved joint couplings, fittings, valves and specialties shall be manufactured by the same manufacturer including roll grooving tools used.

.5 The installer of the piping system shall be qualified, licensed within the jurisdiction and familiar with the installation of the type of pipe or tube being installed.

.6 To comply with the manufacturer's warranty requirements, confirm with the manufacturer the style or model number of couplings, dielectric connections, stainless steel bolted branch outlets, expansion compensators, valves, flange adaptors and accessories to suit pipe material and diameters.

1.6 Submittals

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheets for fixtures and equipment.

.2 Indicate dimensions, performance, construction details and materials for specified items.

.2 Shop Drawings:

.1 Submit shop drawings to indicate materials, finishes, method of anchorage, dimensions, construction and assembly details and accessories for the following:

.1 Valves

.2 Domestic Water Pipe, Fittings and Insulation

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

.4 Instructions: submit manufacturer's installation instructions.

.5 Closeout submittals: submit maintenance and engineering data for incorporation into maintenance manuals.

1.7 Pipe, Fittings and Couplings

.1 Provide for all pipe, fittings, couplings, valves, nipples, drains and all accessory pipe work for a complete installation within the base quotation price.

.2 No extra cost will be considered based on failure of the contractor to allow for pipe, fittings and pipe work as required during construction to provide offsets to avoid structural components, and to coordinate with other piping services, ductwork, cable trays, conduits or other obstacles whether indicated on the drawings or not.

1.8 Freeze Protection

.1 Provide freeze-proof hose bibbs for all exterior installations and where required due to indoor ambient temperatures.

.2 Provide heat tracing as indicated in the contract drawings and referenced in Section 23 05 33 – Heat Tracing for Mechanical Piping and Tanks.

1.9 Seismic Protection

.1 Comply with Section 23 05 48 – Vibration and Seismic Control for Mechanical.

1.10 Substantial & Total Performance

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Substantial and Total Performance.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Materials

.1 Material or equipment containing a weighted average of greater than 0.25 percent lead are prohibited in any potable water system intended for human consumption, and shall be listed and certified in accordance with NSF/ANSI/CAN 61 or NSF/ANSI 372 for domestic cold and hot water (where applicable). Endpoint devices used to dispense water for drinking shall meet the requirements of NSF 61, Section 9.

.2 Plastic pipe, fittings, and solvent cement shall meet NSF 14 and shall be NSF listed for the service intended.

2.3 Pipe Hangers and Supports

.1 Comply with Section 23 05 29 – Hangers and Supports for Mechanical Piping and Equipment.

.2 Arrange and pay for the services of a professional engineer registered in the province of the system installation to provide all required engineering services necessary for the complete design, sizing and detailing of all anchors and anchor supports to structure required for the project. Submit details for review.

.3 Vertical piping shall be supported at its base and at the floor level of alternate storeys, unless otherwise recommended by pipe manufacturer, by rests that can support the weight of the pipe that is between it and the rest above it. Maximum spacing of vertical supports shall be 7.5 m (24.6 ft.) or less if recommended by pipe manufacturer and to comply with seismic requirements.

2.4 Miscellaneous Metal Related to Domestic Water Systems

.1 All miscellaneous metal related to the facility water distribution systems including all metal back up plates, stands, brackets and supports for all roof, floor or wall supported equipment and piping systems is part of this Section of the work.

.2 Provide two coats of heavy red oxide primer to all steel components after fabrication, and touch up on site after installation.

2.5 Piping General

.1 Grooved products used on this project shall be roll grooved only unless otherwise noted. All roll grooved joint couplings, fittings, valves and specialties for this project shall be from the same manufacturer, including roll grooving tools used. Installation shall be in accordance with the manufacturer's installation instructions.

2.6 Above Ground Water Pipe Inside the Building

.1 Copper Piping Systems

.1 Pipe and fittings:

.1 Cold water:

.1 Type 'K' hard drawn seamless copper tubing to ASTM B88 or copper pipe to ASTM B42.

.2 Cast brass or wrought copper solder joint pressure fittings with 95/5 Sn/Sb or Silvabrite 100 solder joints.

.3 Press to Connect Fittings [12 mm (1/2" to 50 mm (2")]:

.1 Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of ASME B16.51 and IAPMO PS 117 (IAPMO PS 117 is not for B75).

.2 Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer.

.3 Maximum working pressure of 1,379 kPa (200 psi) and maximum temperature of 121° C (250° F).

.4 Press ends shall allow identification of an unpressed fitting during pressure testing to provide the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation.

.5 Pressing tools and jaws used shall be approved for use by the fitting manufacturer.

.1 Roll groove fittings for 2 NPS and larger, copper-tube dimensioned grooved ends. (Flaring tube or fitting ends to accommodate alternate sized couplings is not permitted.) Complying with CSA B242, ASME B16.18 or ASME B16.22. All roll grooves must be in accordance with manufacturer recommendation.

.2 Grooved couplings to be installation ready complete with pre-lubricated center leg gaskets, suitable for use with copper tube to ASTM B-88. Epoxy coated ductile iron to ASTM A536, designed with angle bolt pads to provide rigid joint at copper tubing sizes. Gasket shall be grade – P Fluoroelastomer Blend suitable for temperature from -18°C (0°F) to +82°C (+180°F). All grooved end products must be listed and certified to NSF/ANSI/CAN 61 and NSF/ANSI 372 for domestic cold and hot water.

.2 Crosslinked Polyethylene (PEX) Pipe and Fittings

.1 Pipe and fittings:

.1 High density crosslinked polyethylene (PEX-a) conforming to ASTM F876, ASTM 877, ASTM F1960 and CSA B137.5.

.2 All PEX-a tubing fittings and fitting assemblies shall be by one manufacturer.

.3 Pipe shall be rated for continuous operation of 690 kPa @ 82° C (100 psi @ 180° F), and 550 kPa @ 93° C (80 psi @ 200° F).

.4 CAN/ULC S102.2 listed for flame spread and smoke developed rating of 25/50.

.5 CAN/ULC S115 Standard Method of Fire Tests of Firestop systems.

.6 PEX-a pipe to have a UV protective coating of UV resistant material.

.7 Manufacturer's warrantry shall be twenty five (25) years on pipe and fittings.

.8 Fittings shall be in accordance with ASTM F877, ASTM F1960 and CSA B137.5 and approved by the manufacturer's PEX piping system, with applicable plumbing and mechanical code certifications. Fittings shall be lead free.

.9 Distribution manifolds shall be copper Type L, NSF 61 certified.and supplied by the piping manufacturer.

.10 Copper and/or brass outlets shall be high temperature brazed (lead free) into headers.

.2 Pre-sleeved tubing:

.1 NSF 61 certified high density polyethylene (HDPE) corrugated pre-sleeved tubing for use in PEX-a hot and cold potable water distribution systems for installation in concrete slabs or soil to allow removal and replacement of the tubing.

.2 Pre-sleeved tubing shall fit in all manufacturer's concrete floor tube brackets and be installed as recommended by the manufacturer.

.3 Application temperature continuous operation of sleeve: -15 deg. C. (5 deg. F.) to 90 deg. C. (194 deg. F.).

.3 Pipe joints:

.1 PEX-a joints shall be to ASTM F1960 Cold Expansion Fittings with PEX Reinforcing Rings for Use with Crosslinked Polyethylene (PEX-a) Tubing and as approved by the manufacturer of the PEX piping system.

.2 Provide dielectric connections between dissimilar metals. Dielectric fittings complete with thermoplastic and complying to ASTM F492.

.3 Flange adaptors for 65 mm (2½") and 75mm (3") PEX-a pipe: In compliance with ASTM F 877, ASTM F 1960 and CSA B137.5 certified, maximum operating temperarure 99° C (210° F), lead free brass including all nuts and bolts. Flange shall carry a 150 lb. rating. Suitable for transition from PEX piping to another flange connector designed to receive a 4 bolt flanged connection.

2.7 Valves

.1 Valves shall conform with NSF/ANSI/CAN 61 for domestic cold and hot water service and NSF/ANSI 372.

.2 Gate: (for shut-off and isolation)

.1 50 mm (2") and smaller, bronze body, solid wedge disc, bronze or stainless steel trim, non-rising stem, 860 kPa (125 psi) rating.

.2 65 mm (2½") and larger, flanged ends, cast iron body, solid wedge disc, bronze or stainless steel trim, rising stem, outside screw and yoke.

.3 Ball: (in lieu of gate valves or as specified)

.1 50 mm (2") and smaller, brass two piece body, blow-out proof stem, PTFE seats, brass chrome plate ball, lever handle operator, 1035 kPa (150 psi) rating.

.2 65 mm (2½") and larger, 1,380 kPa (200 psig) rating, wafer style or threaded lug style cast iron body, EPDM seat liner, bronze disc, 403 stainless steel stem, 10 position lever lock handle operator on 150 mm (6") diameter and smaller, handwheel worm gear operator on 200 mm (8") diameter and larger, for installation between Class 125 / 150 flanges.

.4 Butterfly: (in lieu of gate valves or as specified)

.1 50 mm (2") and larger, 2,065 kPa (300 psi) rating, grooved end, suitable for bi-directional and dead-end service to full rated pressure. Grooved end stainless steel body and disc. Disc shall be connected to the stem without the use of fasteners or pins and be offset from the disc centerline to provide a full 360° continuous contact with the seating surface when closed. Seat shall be pressure responsive, Grade P Fluoroelastomer. Basis of design suitable for use with ductile iron or stainless steel grooved end pipe system.

.2 65 mm (2½") and larger, 2,065 kPa (300 psi) rating, grooved end. Cast brass body complete with Aluminum bronze disc, with pressure responsive grade "P" Fluoroelastomer seat. Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating. Bubble tight, dead-end or bi-directional service. Basis of design suitable for use with copper grooved end pipe system.

.5 Globe: (for throttling, bypass and make-up applications)

.1 50 mm (2") and smaller, bronze body, bronze or stainless steel trim, 860 kPa (125 psi) rating.

.2 265 mm (2½") and larger, flanged ends, cast iron body, bronze or cast iron bevel-type disc, bronze or stainless steel trim, rising stem, outside screw and yoke.

.6 Check: (for horizontal installation)

.1 50 mm (2") and smaller, threaded joint type, bronze body, bronze or stainless steel swing disc holder with Teflon disc, 860 kPa (125 psi) rating.

.2 65 mm (2½") and larger, flanged ends, cast iron body, bronze or cast iron swing disc, bronze or stainless steel trim, 860 kPa (125 psi) rating.

.7 Drain Valves and Hose Bibbs:

.1 Hose Bibbs: Lockshield globe type with bronze body and trim suitable for maximum system operating pressure.

.2 Drain Valves: Ball type with brass body, cap & chain and chrome plated brass ball.

2.8 Pipe Joints

.1 Solders and fluxes having a lead content and self cleaning acid type fluxes shall not be used.

.2 All copper to steel or iron and flanged adaptors shall be brass, not copper.

.3 All unions or similar interconnections between dissimilar metals shall be dielectric couplings.

3. EXECUTION

3.1 Examination

.1 The installing contractor shall examine the pipe/tube and fittings for defects or cracks. There shall be no defects of the pipe/tube and fittings. Any damaged pipe/tube and fittings shall be rejected.

.2 Verify that site conditions are acceptable for installation of domestic water piping. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 General Piping Installation

.1 Provide expansion joints or flexible couplings at building expansion joints, building earthquake joints, building firewalls and other locations as required. Refer to Section 23 05 16 – Expansion Fittings and Loops for Mechanical Piping.

.2 Unless otherwise noted, pipe hangers and supports shall be as required by Section 23 05 29 – Hangers and Supports for Mechanical Piping and Equipment.

.3 Provide allowance for thermal expansion and contraction of piping passing through a wall, floor ceiling or partition.

.4 Where grooved piping systems are utilized, contractor to coordinate with manufacturer to provide piping system design services to accommodate thermal movement and/or differential settlement of the piping system, included but not limited to, risers and horizontal piping systems. The service includes a detailed schematic design locating anchors, anchor loads, guides, expansion joints and any other required manufacturer's components to accommodate movement. A calculation report showing thermal movement and accommodation shall also be provided. A design stamped by a qualified professional engineer from the jurisdiction in which the grooved piping products manufacturer is located or where the project is being constructed is required

.5 Stainless steel press connections shall be made in accordance with the manufacturer's installation instructions.

.6 Vertical stainless steel piping shall be supported at each floor or at 3 metre (10 ft.) intervals.

.7 Piping shall be installed such that it is not in contact with building members.

.8 All off site prefabrication of piping shall be at the contractor's own risk.

.9 Install piping to maximize headroom in all areas, including exposed installations. Co-ordinate space requirements with other installation Contractors.

.10 Combustible pipe shall not be installed in vertical shafts.

.11 Comply with hanger and supports requirements of the manufacturer for all combustible piping. Where the manufacturers recommendations conflict with Section 23 05 29 Hangers and Supports for Mechanical Piping and Equipment, the more stringent shall apply.

.12 Installation shall be in accordance with the applicable building and plumbing codes and local authority having jurisdiction.

.13 Tie rods shall only be used in conjunction with fittings possessing integral tie lugs.

.14 Tie rods complete with their associated nuts, bolts and washers shall be stainless steel.

.15 Install piping free of sags, bends and kinks.

.16 Remove scale, slag, dirt and debris from inside and outside of pipe and fittings before assembly.

.17 Threaded joints shall have teflon tape applied to the male threads only. Tighten joint with a wrench and backup wrench as required.

.18 Assemble piping using fittings manufactured to noted standards. Installation shall also be to the manufacturer's recommendations.

.19 Connect to fixtures and equipment shall be in accordance with manufacturer's written instructions unless otherwise indicated.

.20 Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)

.21 Provide dielectric connections between dissimilar metals. Dielectric fittings complete with thermoplastic liner and complying ASTM F492.

.22 Where a hanger or support for pipe or tube is of a dissimilar metal it shall be suitably separated and electrically insulated from the pipe or tube.

.23 Joints in copper tubes installed underground shall be made with either flared or compression fittings or be brazed using a brazing alloy within the American Welding Society's AWS-BCuP range. Compression fittings shall not be used underground under a building.

.24 For press to connect and push to connect fittings, the insertion depth and installation methods shall comply with the fitting manufacturer's recommendations. For press to connect fittings, provide to Owner one disconnect clip for each size of fitting installed.

3.3 Stainless Steel Pipe

.1 Preparation:

.1 Stainless steel shall be cut with a wheeled pipe cutter or approved stainless steel pipe cutting tool. The pipe shall be cut square to permit proper joining of the fittings.

.2 Remove scale, slag, dirt and debris from inside and outside of pipe and fittings before assembly.

.3 The pipe end shall be wiped clean and dry. The burrs on the pipe shall be reamed with a deburring or reaming tool.

.2 Installation:

.1 Stainless steel press connections shall be made in accordance with the manufacturer's installation instructions.

.2 Provide protection against abrasion where stainless steel pipe is in contact with other building members by wrapping with an approved tape, pipe insulation or otherwise suitable method of isolation.

.3 Provide allowance for thermal expansion and contraction of stainless steel pipe passing through a wall, floor, ceiling or partition.

.4 Vertical stainless steel pipe shall be supported at each floor or at 3 metre (10 ft.) intervals.

.5 Where a hanger or support for stainless steel pipe or tube is of a material other than stainless steel, it shall be suitably separated and electrically insulated from the pipe or tube.

.3 Hangers and Supports:

.1 Spacing of hangers and supports for stainless steel pipe:

.1 Size smaller than 1": Maximum spacing of 2.5 metres (8.20 ft.)

.2 Size 1" and larger: Maximum spacing of 3 metres (9.84 ft.)

.2 Spacing of hangers and supports for stainless steel tube:

.1 Size smaller than 1": Maximum spacing of 2.5 metres (8.20 ft.)

.2 Size 1" and larger: Maximum spacing of 3 metres (9.84 ft.)

3.4 Crosslinked Polyethylene (PEX) Pipe

.1 Installers shall be trained and certified by the manufacturer to install pipe and fittings according to the manufacturer's guidelines.

.2 All expansion tools used with cold expansion fittings shall be as recommended by the fitting manufacturer.

.3 Installers shall comply with the manufacturer's technical guidelines including but not limited to technical manuals installation guides, technical bulletins and product submittals.

.4 The minimum bend radius for cold bending of the pipe shall be not less than six (6) times the outside diameter. Bends with a radius of less than this shall require a bending template as suppled by the pipe manufacturer.

.5 Where fittings are encased in concrete or buried underground, fittings shall be wrapped as per manufacturer's recommendations to protect the material. Where tubing is installed in concrete slabs or soil use NSF 61 certified high density polyethylene (HDPE) corrugated pre-sleeved tubing to allow for removal and replacement of the tubing.

.6 Piping that passes through expansion joints or walls shall be covered in protective polyethylene convoluted sleeving (flexible conduit) extending 400mm (16") on each side of the joint. Secure sleeving on pipe to prevent movement during installation.

.7 Provide a protective conduit around the pipe when entering wall. Extend 150mm (6") either side of entry. For penetrations at manifolds, use rigid PVC bend guides.

.8 PEX tubing passing through metal studs shall be used with grommets or sleeves at the penetration.

.9 Manufacturer's wall penetration brackets shall be used at all wall membrane penetrations.

.10 Hangers and support spacing shall be as recommended by the pipe manufacturer and the applicable building/plumbing code.

.11 In compliance with PEX piping manufacturer's recommendations, where installation includes long piping runs, install PEX-a pipe supports as provided by the pipe manufacturer and use proper strapping as recommended by the pipe manufacturer at the pipe support.

3.5 Valve Installation

.1 Where possible, disassemble solder end joint valves before soldering. Where disassembly and reassembly of the valves is impossible, the contractor shall give special regard to solder jointing in order not to damage, melt or deform any valve parts.

.2 Shut Off Valves:

.1 Install shut-off or isolation valves whether shown on the drawings or not at the following locations:

.1 At the point where the water service first enters the building.

.2 At the base of each building riser.

.3 At each main branch supply point; provide a valve on each outlet leg from the tee or cross.

.4 At each single plumbing fixture (i.e. normally this requirement is satisfied by the provision of the angle valve specified with the specific fixture).

.5 At each single piece of equipment.

.6 At all points as indicated on the drawings.

.7 At all points where the plumbing code requires same.

.8 Close to the main on each branch and riser serving two or more plumbing fixtures or equipment connections and where indicated.

.9 On the inlet to each plumbing equipment item, on each supply to each plumbing fixture not having stops on supplies, and elsewhere as indicated.

.3 Drain Valves:

.1 Install drain valves 20 mm (3/4") minimum, or line size where the piping is smaller than 20 mm (3/4").

.2 Install a hose-end adaptor, cap and chain on the discharge side of each drain valve or pipe to drain where indicated.

.3 Install drain valves at the base of each riser, at low points of horizontal runs, and where required to drain the water distribution piping system.

3.6 Flanges, grooved couplings and Unions

.1 Provide on all connections to pumps, reducing valves, control valves, fixtures, and equipment.

.2 Connections up to and including 50 mm (2") size shall be all bronze union, 1,035 kPa (150 psi) rating with ground seat; larger connections shall be flanged.

3.7 Pipe Joints

.1 Install dielectric type couplings where copper piping and accessories connect to plumbing equipment such as steel storage tanks, pressure reducing stations and ductile iron pipe.

.2 Where the water service enters the building terminate at the edge of the building and excavation with a Smith Blair standard sleeve coupling having stainless steel nuts and bolts. Bridge the excavation with ductile iron pipe.

.3 Tie rods shall only be used in conjunction with fittings possessing integral tie lugs.

.4 Tie rods complete with their associated nuts and bolts shall be coated with two coats of asphaltic paint after installation.

.5 Provide flanges, grooved couplings or unions on all connections to pumps, reducing valves, control valves, fixtures, and equipment.

.6 Connections up to and including 2 NPS shall be all bronze union, 1,035 kPa (150 psi) rating with ground seat; larger connections shall be grooved or flanged.

.7 All roll grooves on Stainless Steel Schedule 10 pipe must be formed using manufacturer recommended rolls.

.8 All roll grooves on Copper tube must be formed using manufacturer recommended rolls.

.9 Ensure minimum coupling pressure rating is 2,065 kPa (300 psi).

3.8 Testing and Inspection

.1 Conform to the requirements of Section 21 05 01 Common Work Results for Mechanical.

.2 Use only potable water for testing of potable water systems.

.3 Test pressure shall be the greater of 1.5 times maximum system operating pressure or 860 kPa.for 8 hours.

.4 Any leaks shall be corrected and the system retested.

3.9 Pre-Start-Up Inspections

.1 Systems to be complete, prior to flushing, testing and start-up.

.2 Verify that system can be completely drained.

.3 Ensure expansion compensators are installed properly.

3.10 Start-Up

.1 Timing: Start up after:

.1 Pressure tests have been completed.

.2 Flushing & chlorination procedures have been completed.

.3 Final Plumbing inspection Certificate has been issued.

.2 Provide continuous supervision during start-up.

.3 Start-up procedures:

.1 Establish circulation and ensure that air is eliminated.

.2 Check pressurization to ensure proper operation and to prevent water hammer, flashing and/or cavitation.

.3 Bring hot water storage tank up to design temperature slowly.

.4 Monitor piping systems for freedom of movement and pipe expansion.

.5 Check control, limit, safety devices for normal and safe operation.

.4 Rectify start-up deficiencies.

3.11 Performance Verification

.1 Timing:

.1 After pressure and leakage tests and disinfection completed, and certificate of completion has been issued by authority having jurisdiction.

.2 Procedures:

.1 Verify that flow rate and pressure meet Design Criteria.

.2 Testing and balancing in accordance with Section 23 05 93 – Testing, Adjusting and Balancing for Mechanical.

.3 Adjust pressure regulating valves while withdrawal is maximum and inlet pressure is minimum.

.4 Sterilize systems for Legionella control.

.5 Verify performance of temperature controls.

.6 Verify compliance with safety and health requirements.

.7 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut off water immediately. If water hammer occurs, replace water hammer arrestor/s. Repeat for outlets and flush valves.

.8 Confirm water quality consistent with supply standards, verifying that no residuals remain as a result of flushing and/or cleaning.

.3 Reports:

.1 In accordance with Section 23 08 00 – Commissioning of Mechanical Systems.

.2 Include certificate of water flow and pressure tests conducted on incoming water service, demonstrating adequacy of flow and pressure.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 This section provides a list of acceptable Manufacturers for this project.

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 Submittals

.1 Requests for alternate equivalent materials or equipment must be submitted to the Owner's Consultant no later than seven (7) working days prior to the Mechanical trades' closing quotation date. Submit all applicable technical data, including performance curves and physical details for review. Approval of requests shall only be given by addendum.

1.4 General Requirements

.1 The price submitted for this contract shall be based on the use of materials and equipment as specified or as contained within the Acceptable Manufacturers List.

.2 Approved equivalents and/or alternatives to specified products shall be equal to the specified product in every respect, operate as intended, and meet the space, capacity, and noise requirements outlined.

.3 The Contractor shall be fully responsible for any additional labour and materials required by any trades or other Contractors to accommodate the use of other than specified materials or equipment. The Contractor shall bear any and all costs for design/system modifications to accommodate the "alternate" equipment. Extras will not be approved to cover such work.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 The following listed Manufacturers are acceptable for their ability to meet the general design intent, quality and performance characteristics of the specified product. The list does not endorse the acceptability of all products available from the listed Manufacturers/Suppliers.

.2 It remains the responsibility of the Contractor to ensure the products supplied are equal to the specified products in every respect, operate as intended, and meet the performance specifications and physical dimensions of the specified product.

.3 The contractor shall be fully responsible for any additional work or materials, to accommodate the use of equipment from the acceptable Manufacturers and Suppliers list.

.4 Any manufacturers not included on the list of acceptable manufacturers must submit a formal request to be included on this list.

.5 List of acceptable Manufacturers:

Type of Equipment Plumbing & HVAC	Approved Manufacturers
Balancing Agents (BC)	Kane Consulting
Commissioning Agents	KD Engineering, Western Mechanical Services
Controls Contractors	Ainsworth
Cooling Towers - Induced Draft - Counterflow	Baltimore Air Coil
Expansion Fittings - Flexible Hoses	Anvilstar, Griswold Controls, Metraflex, Nexus Valve, Tri-Flex Loop, Unisource Mfg.
Expansion Fittings - Joints - Bellows Type	Adsco, Anaconda, Flexonics, Hydro-Flex, Tube Turns, United Flexible, Vibra-Flo
Expansion Fittings - Joints - Grooved Type	Victaulic, Gruvlok
Expansion Fittings - Joints - Sleeve Type	Badger, Flexonics, Tube Turn, Yarway
Firestopping	Hilti (Canada) Limited, 3M Fire Protection Products, Tremco Sealants & Coatings, AD Firebarrier, Specified Technologies Inc (STI)
Grooved Mechanical Pipe Couplings / Valves / Fittings	Victaulic, Shurjoint, Gruvlok
Pipe and Valve Identification	Seton, Brady, Incom
Piping - Insulation Shields	Klo-Shure
Plumbing - Dielectric Unions	Watts, Zurn, Mifab
Thermometers	Trerice, Marsh, Ashcroft, Winters, Moeller, Weiss, Weksler, Winters
Valves – Ball	Apollo, Crane/Jenkins, KVC, Gruvlok, Kitz, NCI Canada, Nexus Valve, Red&White, Victaulic, Watts
Valves – Butterfly	Apollo, Bray, Centreline, Crane, DeZurik, Dresser, Grinnell, Jenkins, Keystone, Kitz, KVC, Locxend, Lunkenheimer, Monotight, Mueller, NCI Canada, Nexus Valve, Red & White, Toyo, Victaulic, Watts
Valves – Check – Lever and Weight	Cla-Val, Valmatic, Mueller, Kennedy

Type of Equipment Plumbing & HVAC	Approved Manufacturers
Valves – Check – Spring Loaded	Victaulic, Mueller Locxend, Moygro
Valves – Check - Swing	Bonney Forge, Crane, Hattersley, Kitz, NCI Canada, Nibco, Red-White/Toyo
Valves – Circuit Balancing	Armstrong, Bell & Gossett, Griswold, Tour & Andersson, Nexus Valve, Preso, Wheatley
Valves – Gate	Bonney Forge, Crane, Hattersley, Kitz, NCI Canada, Nibco, Red-White/Toyo
Valves – Globe	Bonney Forge, Crane, Hattersley, Kitz, NCI Canada, Nibco, Red-White/Toyo
Variable Frequency / Speed Drives	ABB, Allen-Bradley, Baldor, Danfoss, Eaton, Hitachi, Siemens, Teco-Westinghouse, Toshiba, WEG, Yaskawa
Vibration Isolation	Mason, Korfund, Vibro-Acoustics
Water Treatment Agents	Pace Chemicals, Dubois Chemicals, Enercon, Magnus Chemicals Ltd

3. EXECUTION

3.1 Post Quotation Submission Requirement

.1 Submit within 14 days of contract award a copy of the list underlining the name of the Manufacturer whose price was carried in the quotation. If no Manufacturer's names are submitted, it will be assumed that the price carried in the quotation was that of the specified Manufacturer or where the specified product is generic, the first acceptable Manufacturer listed for each item and equipment.

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical

.3 Section 23 05 01 – Acceptable Manufacturers

.4 Division 25 – Integrated Automation

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.1 Applicable Building Code - Refer to Section 21 05 01

.2 Institute of Electrical and Electronic Engineers (IEEE)

.1 IEEE 519-2014, IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.

.2 IEEE C62.41.1 – Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits.

.3 IEEE C62.41.2 – Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits.

.3 Underwriters Laboratories

.1 UL508 UL Standard for Safety Industrial Control Equipment

.2 UL508C UL Standard for Safety Power Conversion Equipment

.4 National Electrical Manufacturer's Association (NEMA)

.1 ICS 7.0, AC Adjustable Speed Drives

.5 International Electrotechnical Commission (IEC)

.1 EN/IEC 61800-3

.6 National Electric Code (NEC)

.1 NEC 430.120, Adjustable-Speed Drive Systems

.7 International Building Code (IBC)

.1 IBC 2012 Seismic – referencing ASC 7-05 and ICC AC-156

1.4 General

.1 The drive manufacturer shall supply the drive and all necessary options as herein specified.

.2 The manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years.

.3 All VFDs installed on this project shall be from the same manufacturer.

.4 All VFDs and ancillary components must be procured by one supplier in order to assure an integrated system and one point of contact for service.

1.5 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:

.1 For each VFD provide:

.1 Outline dimensions, conduit entry locations, and weight.

.2 Customer connection and power wiring diagrams.

.3 Complete technical product description include a complete list of options provided.

.4 Seismic Certification and Installation requirements.

.5 Any portions of this specification not met must be clearly indicated on a separate page and cross-referenced to the specification or the supplier and contractor shall be liable to provide all additional components required to meet this specification.

.2 Closeout submittals: submit all maintenance and test schedules and reviewed shop drawings for incorporation into manual specified in Section 21 05 01 – Common Work Results - Mechanical

1.6 Coordinating Responsible Party

.1 The contractor that supplies the VFD will be the responsible party for the coordination and installation of the drive.

.2 The contractor will be responsible for all of the VFD implementation requirements associated with the installation.

.3 The contractor shall engage the appropriate trade for the work to be performed if outside of the supplying contractor's standard installation requirements.

.4 The responsible party is to ensure that all requirements of the installation have been satisfactory provided even if not specifically indicated in other contractor's scope of work.

1.7 Supplier Spare Parts Availability

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

1.8 Warranty

.1 The VFD supplier shall provide warranty coverage for a minimum period of 3 years upon the date of project substantial completion.

.2 The warranty shall include parts, labor, travel costs, and living expenses incurred by the supplier to provide factory authorized service.

.3 The Contractor shall be responsible to bring the supplier's factory representative to site to reset, repair, and re-commission the VFD if problems arise with the normal operation of the VFD during the warranty period.

.4 Items repaired or replaced shall be warranted for an additional period of at least twelve (12) months from the date that the VFD becomes functional again.

.5 All existing motors listed on the motor schedule will be tested for motor insulation integrity. All motors which do not meet the minimum standards for motor insulation integrity would not be included as part of the warranty program with respect to motor failure. The contractor will be responsible for the testing of the motor.

.6 The VFD supplier shall be responsible to coordinate all warranty works with the Owner's forces during the warranty period.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 Product Qualifications

.1 VFD shall be UL508 listed as a complete assembly.

.2 VFD shall be ULC listed and CSA (cUL) certified.

.3 The VFD assembly and associated options and peripherals shall comply with the applicable requirements of the latest standards of ANSI, IEEE, NEMA, and the Canadian Electrical Code.

.4 The VFD, including the bypass (if specified), shall conform to the European Union Electromagnetic Compatibility directive and be CE marked.

.5 The VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with filters to bring the drive in compliance with the First Environment levels.

.6 The VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the 2012 International Building Code (IBC):

.1 Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake table test data as defined by ICC AC-156.

2.3 Variable Frequency Drives

.1 General:

.1 Furnish complete variable frequency drive(s) as specified herein for the equipment designated on the drawing schedules or control sequences with variable speed controls.

.2 Each VFD, with all standard and optional features, shall be factory packaged in a ULC rated and listed enclosure most appropriate for each application and location, completely assembled and tested by the manufacturer in an ISO9001 facility.

.3 VFDs sized less than 100 HP to be of the 6-pulse Pulse-Width Modulated (PWM) type with a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The PWM strategy shall incorporate a microprocessor to handle all logic functions as well as the complex, sine-coded PWM generating algorithms that control output stage switching.

.4 VFDs sized from 100 HP to 199 HP to be of the 12-pulse Pulse-Width Modulated (PWM) type with a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The PWM strategy shall incorporate a microprocessor to handle all logic functions as well as the complex, sine-coded PWM generating algorithms that control output stage switching. Input isolation transformers with a 30 degree phase shift complete with appropriate filtering to be provided where required.

.5 VFDs sized from 100 HP to 199 HP to be of the 6-pulse Pulse-Width Modulated (PWM) type with a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The PWM strategy shall incorporate a microprocessor to handle all logic functions as well as the complex, sine-coded PWM generating algorithms that control output stage switching. VFDs sized from 100 HP to 199 HP shall include a harmonic filter.

.6 The variable frequency drives shall convert three-phase, 60 Hz utility power to proportionally variable voltage and frequency, three-phase, AC power using the latest insulated-gate bipolar transistor (IGBT) technology for step less motor speed control of one or more three-phase induction motors. The VFD output waveform to be the PWM or Vector type waveform producing smooth torque at low frequencies and low motor current harmonics.

.7 Drives shall be capable of controlling and set up for either variable or constant torque loads, as follows:

.1 Variable torque: loads such as centrifugal fans, pumps and compressors

.2 Constant torque: loads such as positive displacement pumps and reciprocating or screw compressors

.8 The VFD shall provide full rated output from a line of ±10% of nominal voltage.

.9 The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute in every 10 minutes.

.10 VFDs shall be capable of continuous full load operation under the following environmental operating conditions:

.1 -10°C to 40°C (14 to 104°F) ambient temperature.

.2 Altitude 0 to 1015m (0 to 3300 ft) above sea level.

.3 Humidity less than 95%, non-condensing.

.11 All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating.

.12 The VFD shall have cooling fans. The fans shall be replaceable without requiring VFD removal or removal of circuit boards. The VFD cooling fans shall cycle via thermal sensing not operate continuously.

.13 Any options shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

.2 Features:

.1 Loss-of-load (broken belt / broken coupling) relay output. The drive shall be programmable to signal the loss-of-load condition via keypad warning, relay output, and / or over the serial communications bus.

.2 If the input reference is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user.

.3 The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage (flying start).

.4 The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

.5 The VFD shall also be capable of DC injection braking that can be employed to stop a free wheeling motor before starting to avoid overvoltage nuisance tripping.

.6 The VFD shall be capable of automatically extending the ramp down time to keep the drive from tripping on overvoltage caused by regeneration of power by the load.

.3 Line Conditioning and Filtering:

.1 The VFD shall have a dual 5% impedance DC link reactor (or 5% line reactor) on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable.

.2 Provide a coordinated AC transient surge protection system consisting of 4 MOVs (phase to phase and phase to ground), a capacitor clamp, 1600 PIV Diode Bridge, and internal chokes. The MOV's shall have a minimum 125 joule rating per phase across the diode bridge. VFDs that do not include coordinated AC transient surge protection shall include an external TVSS (Transient Voltage Surge Suppressor).

.3 Provide EMI / RFI filters. VFD assembly to be CE Marked and comply with product standard EN 61800-3 for the First Environment restricted level (Category C2). Second environment (Category C3, C4) is not acceptable. Submit certified test reports with the shop drawing submittal confirming compliance.

.4 Provide an additional output (load) reactor directly downstream of the inverter, for all applications where the motor wiring downstream of the inverter exceeds 30m (98ft).

.4 Adjustments:

.1 Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.

.2 Two (2) PID Set point controllers, allowing pressure, or flow signals to be connected to the VFD. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable.

.3 Two (2) programmable analog inputs with oscillation filters

.4 Two (2) programmable analog outputs (0-20ma or 4-20 ma)

.5 Six (6) programmable digital inputs

.6 Three (3) programmable, digital relay outputs

.1 Rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS

.7 The VFD shall automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.

.5 VSD Interface:

.1 Provide a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alphanumeric codes are not acceptable). All VFD faults shall be displayed in English words.

.2 The keypad shall include Hand-Off-Auto selections and manual speed control.

.3 The drive shall incorporate "bump less transfer" of speed reference when switching between "Hand" and "Auto" modes.

.4 There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with 10 years minimum life span. The clock shall date and time stamp faults and record operating parameters at the time of fault. VFD programming shall be held in non-volatile memory and is not dependent on battery power.

.5 All applicable operating values shall be capable of being displayed in engineering (user) units. Minimum display values shall be:

.1 Output Frequency

.2 Motor Speed (RPM, %, or Engineering units)

.3 Motor Current

.4 Motor Torque

.5 Motor Power (kW)

.6 DC Bus Voltage

.7 Output Voltage

.6 Provide a fireman's override input. Upon receipt of a fire panel input signal, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback while overriding all other inputs, except customer defined safety run interlocks.

.6 Serial Communications

.1 The VFD shall have a TIA-485 (RS-485) port as standard. The standard protocols shall be:

.1 Modbus

.2 Johnson Controls N2

.3 Siemens Building Technologies FLN

.4 BACnet

.2 All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet). Use of non-certified protocols is not allowed.

.3 Serial communication minimum capabilities shall include:

.1 Run-stop controls

.2 Speed set adjustment

.3 Output speed / frequency, current (in amps)

.4 % torque

.5 Power (kW), kilowatt hours (resettable),

.6 Operating hours (resettable)

.7 Drive temperature.

.8 All diagnostic warning and fault information shall be transmitted over the serial communications bus.

.9 The BAS shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values.

.10 Remote VFD fault reset.

.11 drive and bypass digital and analog outputs via the serial interface.

3. EXECUTION

3.1 Installation

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

.2 Power wiring shall be completed by Division 26.

3.2 Testing

.1 VFD assemblies are to be factory tested prior to shipment. Testing is to be performed at the factory or at the VFD OEM or integrator facility. Provide confirmation of actual tests completed and results.

.2 Provide certified copies of production test results required by CSA and EEMAC, prior to acceptance of the equipment. Test results are to be provided to the Consultant prior to shipment of the equipment.

.3 A copy of all factory production tests shall also be shipped with the drives.

.4 Field Testing

.1 The VFD supplier shall provide on-site startup, fine-tuning, field support during commissioning, provision of final setup information prior to turnover and operator training and instruction.

.2 The VFD supplier shall provide site functionality test reports indicating loading / current levels during testing as well as control point proving results. Reports shall be submitted to the commissioning agent and the Consultant.

.3 The VFD supplier shall ensure shaft-to-ground voltage does not exceed 1.5 volts at any speed or load requirement.

.5 Harmonics Testing

.1 The VFD supplier shall, with the aid of the detailed electrical power single line diagram showing all impedances in the power path to the VFDs, perform an analysis to initially demonstrate the supplied equipment will meet the IEEE 519 recommendations after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then include the cost of providing the equipment. Provide complete harmonics testing and analysis compliance with IEEE 519 after complete VFD startup.

.2 Fine tune VFD with signal from controls, inspect, verify motor load RPM at 25%, 50%, 75%, 90% and 100%. Motor RPM should match the percentage indicated.

.3 If motor RPM does not match the percentage indicated, motors/fans shall be re-sheaved. Record all measured values (minimum of RPM, frequency, current and voltage input/output).

.4 Calibrate VFD display values with Building Controls System display output.

.5 Verify motor RPM values with a calibrated tachometer. Motor RPM shall match the percentage indicated. If not motors/fans shall be re-sheaved.

.6 Conduct a minimum of four (4) samples. (Testing to be provided to 25%, 50%, 75%, 90%, and 100% of motor output RPM.)

.7 Contractor is to submit a signed copy of the completed test results, certifying proper system operation demonstrating compliance with the specification requirements.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Materials and installation for:

.1 Flexible pipe connectors.

.2 Expansion joints.

.3 Expansion compensators.

.4 Pipe anchors.

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

.3 Section 22 11 16 – Domestic Water Piping.

1.3 References

.1 American Society for Testing and Materials International, (ASTM).

.1 ASTM A53/A53M- 18, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

.2 ASTM A105/A105M- 14, Standard Specification for Carbon Steel Forgings, for Piping Applications.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:

.2 Submit data on all materials.

.3 Shop Drawings:

.1 Indicate layout of piping systems, including flexible connectors, expansion joints, expansion compensators, loops, offsets and swing joints.

.4 Product Data:

.1 Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, and braid structure.

.2 Expansion Joints: Indicate maximum temperature and pressure rating, maximum expansion compensation, materials and system compatibility.

.5 Design Data:

.1 Indicate criteria and show calculations.

.6 Manufacturer's Installation Instructions: Submit special procedures.

.7 Manufacturer's Certificate: Certify products meet or exceed specified requirements.

.8 Welders' Certificate: Provide welders' certificate.

.9 Manufacturer's Field Reports: Indicate results of inspection by manufacturer's representative.

.10 Operation and Maintenance Data:

.1 Submit adjustment instructions.

1.5 General Requirements

.1 For non-metallic piping systems comply with manufacturer's installation instructions and recommendations for expansion compensation, anchoring and guides.

.2 Provide structural work and equipment required for expansion and contraction of piping. Provide anchors, guides, and expansion joints as required to adequately protect the piping systems.

.3 Provide expansion compensation for all piping systems including but not limited to: heating water, chilled water, domestic hot, cold, hot water recirculation, steam and condensate, condenser water systems, refrigerant (supply and suction) systems, and all other piping systems that operate at varying temperatures.

.4 Equipment materials must be specifically designed and supplied for use in the systems that they are installed in. For example, specific materials and cleaning is required for expansion equipment used for refrigerants.

.5 The installation of all piping systems must follow the design requirements of the Contractor's qualified professional engineer that has designed the entire piping system to allow expansion compensation.

.6 Make provision for expansion and contraction of all pipe work. All piping shall be anchored and supported in such a manner that strain and/or weight does not come upon any apparatus and pipe branch connections. Expansion joints and compensators shall be installed and guided as per manufacturer's recommendations. All equipment shall be connected with grooved couplings, unions or flanges to provide for easy removal. Where piping passes through walls or floor slabs, the sleeves shall be of sufficient size to accommodate the expansion and the pipe insulation, without binding or crushing the insulation or preventing the expansion of the piping.

.7 All grooved joint couplings, fittings, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. All castings shall be date stamped for quality assurance and traceability.

.8 Where grooved piping systems are utilized, contractor to coordinate with manufacturer to provide piping system design services to accommodate thermal movement and/or differential settlement of the piping system, included but not limited to, risers and horizontal piping systems. The service includes a detailed schematic design locating anchors, anchor loads, guides, expansion joints and any other required manufacturer's components to accommodate movement. A calculation report showing thermal movement and accommodation shall also be provided. A design stamped by a qualified professional engineer from the jurisdiction in which the grooved piping products manufacturer is located or where the project is being constructed is required.

.9 Where grooved components are used for thermal expansion, the contractor shall use anchors from the same manufacturer.

.10 Special attention should be given to straight pipe runs, pipe riser installations and non-metallic pipe installations. As a minimum on hot piping, provide expansion compensation on every other floor of a non-metallic pipe riser in a shaft and every third floor for metallic pipe risers. All pipe take-offs from the riser must also be designed to allow vertical movement of the riser connection if needed. Take-offs with specifically designed swing joints with appropriate piping support can be used to allow movement.

.11 Unless required otherwise by the Contractor's Engineer, metallic piping expansion compensation is generally not required for

.1 Piping risers less than 12m (39 feet) in vertical height

.2 Horizontal runs with straight lengths less than 11m (36 feet) and a total floating piping system length less than 30m (98 feet). Floating systems consist of piping supports allowing movement in at least 2 directions (pipe hangers) and equipment connections with flexible hoses.

.12 Expansion Compensation Design Criteria:

.1 Installation Temperature: 10°C (50°F).

.2 Safety factor: 30%.

.13 In the absence of manufacturer's expansion data use the following criteria:

Material	Expansion Coefficients	
	10^{-6} m/m •C	10^{-6} in/in •F
Carbon Steel	11.7	6.5
Copper	16.8	9.3
HDPE High Density Polyethylene	120	67
PE Polyethylene	150	83
CPVC Chlorinated Polyvinyl Chloride	79	44
PVC Polyvinyl Chloride	50.4	28

1.6 Warranty

.1 Furnish five year manufacturer warranty for leak free performance of packed expansion joints.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Flexible Pipe Connectors

.1 Restrained Double Sphere Elastomer Type:

.1 Molded twin spherical type with integral cable or control rod restraints.

.2 Reinforced with an external ring between spheres.

.3 Safety factor for burst and flange pullout shall be a minimum of 3:1.

.4 Bridge bearing quality Neoprene or EPDM.

.5 Suitable for outdoor installation.

.6 Suitable for system operating temperatures and pressures.

.7 Joints: As specified for flanged pipe joints.

.8 Size: Use pipe-sized units.

2.3 Expansion Joints

.1 Stainless Steel Bellows Type:

.1 Corrugated, packless.

.2 Stainless steel guide sleeves.

.3 Cover over external surfaces.

.4 Suitable for system operating temperatures and pressures.

.5 Maximum Compression: 45mm (1-3/4").

.6 Maximum Extension: 6mm (1/4").

.7 Joint: As specified for piping system.

.8 Size: Use pipe sized units.

.9 Accessories: limit stops.

.10 Application: Axial or lateral movements. Steel piping 3 NPS and smaller.

.2 External Ring Controlled Stainless Steel Bellows Type:

.1 Suitable for system operating temperatures and pressures.

.2 External cast iron control rings.

.3 Maximum Compression: 24mm (15/16").

.4 Maximum Extension: 9mm (3/8").

.5 Maximum Offset: 3mm (1/8").

.6 Joint: As specified for flanged pipe joints.

.7 Size: Use pipe sized units.

.8 Accessories: Internal flow liner, external guide rods, limit stops.

.9 Application: Axial or lateral movements. Steel piping 4 NPS and larger.

.3 Copper Sleeve Type:

.1 Slip type.

.2 Allowance for repacking under full service.

.3 Suitable for system operating temperatures and pressures.

.4 Joint: As specified for piping system.

.5 Size: Use pipe sized units.

.6 Accessories: drip connections.

.7 Application: Axial movements. Copper or steel piping 2 NPS and larger.

2.4 Expansion Compensators.

.1 Steel Pipe Expansion Compensator:

.1 Bronze or stainless steel bellows in carbon steel casing.

.2 Anti-torque groove, internal pipe guides, internal liner.

.3 Suitable for system operating temperatures and pressures up to 1035 kPa (150psi)

.4 Maximum Compression: 12mm (1/2") per each linear 300mm (12") of compensator.

.5 Maximum Extension: 6mm (1/4") per each linear 300mm (12") of compensator.

.6 Joint: As specified for piping system.

.7 Size: Use pipe sized units.

.8 Application: Axial movements. Steel piping 2 NPS and under.

2.5 Pipe Anchors.

.1 Fabricate from mild steel plate and structural steel angle and channel sections, in accordance with ANSI B.31.

.2 Contractor and Engineer to confirm with the Structural Engineer that the structure is suitable for mounting of the Anchor and the load placed on the structure before level one is poured and prior to install.

.3 Riser clamps are not suitable for use as anchors.

.4 Where grooved piping systems are utilized, incorporate Victaulic Anchors A10, A11, A20, A40 or WA20 AGS as required, or equivalent

3. EXECUTION

3.1 General

.1 Install to manufacturer's instructions.

.2 Provide all piping systems with provision for expansion.

.3 Only major expansion fittings and loops have been indicated on the drawings. Provide all required additional expansion fittings and loops to accommodate system expansion and contraction.

.4 Provide flexible pipe connectors on all pipes connected to equipment supported by vibration isolation.

.5 Where grooved piping systems are used, three Victaulic flexible type couplings, or equivalent, may be used in lieu of flexible pipe connectors.

.6 Provide flexible pipe connectors at right angles to displacement. Install one end of the compensator immediately adjacent to the isolated equipment and provide an anchor at the other end.

.7 Provide expansion joints on all piping crossing building expansion joints, building seismic joints for seismic separations.

.8 Ensure that expansion joints or elbows are taken into account for refrigerant systems that are limited on pressure drops

.9 Provide a minimum of three pipe elbows in all branch pipe connections. Provide flexible metal hose connectors where space does not permit the installation of three elbows.

.10 Install compensators in the horizontal plane unless indicated otherwise.

.11 Rigidly anchor piping to the structural members. Provide pipe guides to direct movement along the pipe axis.

.12 Ensure flexible metal hose and expansion compensators, specifically low pressure units, are not damaged during pressure testing.

3.2 Flexible Metal Hose

.1 Provide a union at the hose on all screwed installations.

.2 Protect the hose from torque damage during installation.

3.3 Expansion Joints

.1 Provide 2 sets of alignment guides at each expansion joint. Spacing to manufacturer's recommendations.

.2 Provide anchors on both sides of each expansion joint. Spacing to manufacturer's recommendations.

.3 Locate expansion joints centrally between anchors.

.4 Bellows Type:

.1 Provide a union at one end of each unit with threaded connections.

.2 Remove any slippage bolts and or spacers after installation.

.5 Sleeve Type:

.1 Provide structure for base mounted units.

.2 Pack joints after installation.

3.4 Pipe Alignment Guides

.1 Alignment guides are required to maintain the pipe/tube centerline axial to expansion joints and throughout the intermediate portion of the run to prevent buckling.

.2 Expansion joints that do not include internal guides require an alignment guide to be located 4 diameters from the face of the expansion joint, and an additional guide 14 diameters from the first guide or as per manufacturer's instructions.

.3 Expansion joints with internal guides require only one alignment guide to be located 10-14 diameters from the expansion joint or as per manufacturer's instructions.

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical

.3 Section 23 05 16 – Expansion Fittings and Loops for Mechanical Piping

.4 Section 23 05 48 – Vibration and Seismic Control for Mechanical.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.2 ASTM International

.1 ASTM A125 – Standard Specification for Steel Springs, Helical, Heat-Treated.

.2 ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs and Threaded Rod, 60,000 PSI Tensile Strength.

.3 ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts.

.3 Factory Mutual (FM)

.4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)

.1 MSS SP-58 – Pipe Hangers and Supports - Materials, Design and Manufacture.

.5 Underwriter's Laboratories of Canada (ULC)

.6 Cast Iron Soil Pipe Institute

.1 CISPI Designation 301-18 - Standard Specification For Hubless Cast Iron Soil Pipe And Fittings For Sanitary And Storm Drain, Waste, And Vent Piping Applications.

.2 CISPI Designation 310-20 - Specification For Coupling For Use In Connection With Hubless Cast Iron Soil Pipe And Fittings For Sanitary And Storm Drain, Waste, And Vent Piping Applications.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:

.1 Submit shop drawings for:

.1 Bases, hangers and supports.

.2 Connections to equipment and structure.

.3 Structural assemblies.

.2 Certificates:

.1 Submit certificates from the manufacturer certifying that materials comply with specified performance characteristics and physical properties of the listed Related Standards.

.3 Manufacturers' Instructions:

.1 Provide manufacturer's installation instructions.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

.1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP-58.

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

.3 Toggle hangers and/or strap hangers shall not be used.

.4 Power actuated fasteners and “drop-in” anchors shall not be used for tension load applications such as pipe and duct hangers.

2.3 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.

2.4 Insulation Protection Shields

.1 Insulated cold piping:

.1 64 kg/m^3 (4 lb./ft^3) density insulation plus insulation protection shield, galvanized sheet carbon steel. Length designed for maximum 3 m (10 foot) span.

.2 Non-metallic support coupling, sized to suit standard and millimeter pipe O.D. UL listed, meeting 25/50 flame and smoke spread ratings. Supplied with hanger and/or strut mount as a complete support assembly.

.2 Insulated hot piping:

.1 Curved plate 300 mm (12 inch) long, with edges turned up, welded-in centre plate for pipe sizes NPS 300 mm (12 inch) and over.

.2 For piping to 60°C (140°F) Non-metallic support coupling, sized to suit standard and millimeter pipe O.D. UL listed, meeting 25/50 flame and smoke spread ratings. Supplied with hanger and/or strut mount as a complete support assembly.

2.5 Constant Support Spring Hangers

.1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report (CMTR).

.2 Load adjustability: 10 % minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.

.3 Provide upper and lower factory set travel stops.

.4 Provide load adjustment scale for field adjustments.

.5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm (1") minimum.

.6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.6 Variable Support Spring Hangers

.1 Vertical movement: 13 mm (½") minimum, 50 mm (2") maximum, use single spring pre-compressed variable spring hangers.

.2 Vertical movement greater than 50 mm (2"): use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.

.3 Variable spring hanger complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.

.4 Steel alloy springs: to ASTM A125, shot peened, magnetic particle inspected, with +/-5 % spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR

2.7 Equipment Supports

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

2.8 Equipment Anchor Bolts and Templates

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

2.9 Other Equipment Supports

.1 Fabricate equipment supports from structural grade steel meeting requirements of Division 5.

.2 Submit structural calculations with shop drawings.

3. EXECUTION

3.1 Manufacturer's Instructions

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

3.2 Installation

.1 Install in accordance with manufacturer's instructions and recommendations.

.2 Vibration Control Devices:

.1 Install on piping systems at pumps, boilers, chillers, cooling towers, and as indicated.

.3 Clamps on riser piping:

.1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.

.2 Bolt-tightening torques to industry standards.

.3 Steel pipes: install below coupling or shear lugs welded to pipe.

.4 Cast iron pipes: install below joint.

.4 Clevis plates:

.1 Attach to concrete with 4 minimum concrete inserts, one at each corner.

.5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.

.6 Use approved constant support type hangers where:

.1 Vertical movement of pipework is 13 mm (½") or more,

.2 Transfer of load to adjacent hangers or connected equipment is not permitted.

.7 Use variable support spring hangers where:

.1 Transfer of load to adjacent piping or to connected equipment is not critical.

.2 Variation in supporting effect does not exceed 25 % of total load.

.8 No-hub pipe and fitting coupling joints over 100 mm (4") in size shall receive auxiliary support by means of appropriate bracing materials, per U.S. soil pipe and fitting manufacturers' installation instructions, CISPI Designation 301-18 and 310-20, and CISPI Cast Iron Soil Pipe and Fittings Handbook. Auxiliary restraint products used shall be manufactured assemblies with thrust pressure rating adequate for the specific installation and shall be installed onto horizontal joints over 100 mm (4") in size. Field-devised methods and materials shall not be used to accomplish this application solution.

3.3 Hanger Spacing

.1 Maximum horizontal spacing of supports and additional support conditions for piping used for plumbing systems, as defined by plumbing codes, shall be compliant with the requirements of the applicable plumbing code for the pipe materials being installed for the piping systems.

.2 Flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.

.3 Within 300 mm (12") of each elbow.

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

.4 Install PEX-a pipe support vertically or horizontally for plenum and non-plenum applications or support PEX pipe at 900 mm (36") intervals with manufactured hanger fittings regardless of size. PEX installed with PEX-a pipe support shall follow the manufacturers pipe support recommendations for hanger spacing

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

3.4 Hanger Installation

.1 Install hanger so that rod is vertical under operating conditions.

.2 Adjust hangers to equalize load.

.3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

.4 Do not support from metal deck.

.5 Install hangers to provide minimum 13 mm (½") space between finished covering and adjacent work.

.6 Support vertical piping at every other floor.

.7 Where several pipes can be installed in parallel and at the same elevation, provide multiple or trapeze hangers.

.8 Support riser piping independently of connected horizontal piping.

.9 Install plastic inserts between steel studs and piping.

.10 Provide insulation protection saddles on all insulated piping.

3.5 Horizontal Movement

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

.2 Where horizontal pipe movement is less than 13 mm (½"), offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 Final Adjustment

.1 Adjust hangers and supports:

.1 Ensure that rod is vertical under operating conditions.

.2 Equalize loads.

.2 Adjustable clevis:

.1 Tighten hanger load nut securely to ensure proper hanger performance.

.2 Tighten upper nut after adjustment.

.3 C-clamps:

.1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.

.4 Beam clamps:

.1 Hammer jaw firmly against underside of beam.

3.7 Inserts

.1 Install in accordance with manufacturer's recommendations.

.2 Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practical.

.3 Set inserts in position in advance of concrete work. Use grid system in equipment rooms.

.4 Provide reinforcement rod in concrete for inserts carrying piping over 100 mm (4") or ducts over 1500 mm (60") wide.

.5 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Materials and installation for heat tracing cables, components, and controls, to prevent pipes from freezing.

1.2 Related Requirements

.1 Section 21 05 01 – Common Work Results for Mechanical.

.2 Section 23 07 19 – HVAC Piping Insulation.

.3 Section 23 08 00 – Commissioning of Mechanical Systems.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.2 Canadian Standards Association:

.1 CAN/CSA-C22.2 NO. 130-16 - Requirements for Electrical Resistance Heating Cables and Heating Device Sets.

.3 Canadian Electrical Code.

.4 Institute of Electrical and Electronics Engineers:

.1 IEEE 515 - Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Industrial Applications.

.5 International Electrotechnical Commission:

.1 IEC 62395-1 & 2 - Electrical resistance trace heating systems for industrial and commercial applications.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:

.1 Product Data: For each type of product:

.1 Include:

.1 Heating cable data sheet.

.2 System installation and operation manual.

.3 System installation details.

.4 Connection kits and accessories data sheet.

.5 Controller data sheet.

.6 Controller wiring diagram.

.2 Include rated capacities, operating characteristics, and furnished specialties and accessories.

.3 Schedule heating capacity, length of cable, and electrical power requirement for each electric heating cable required.

.4 Include heat loss calculations for each pipe including pipe and insulation characteristics, heat loss, and watts per foot supplied by the heating cable.

.2 Shop drawings:

.1 All heat tracing cables, components, layouts, and controls.

1.5 General Requirements

.1 The contractor shall be responsible for selecting the type of heating cable to be used for a given application.

.2 Provide ground fault protection to prevent runaway overheating and potential corrosion when heating cable used with copper pipe. Ground fault protection for the system used shall be as recommended by heating cable manufacturer. Coordinate with Division 26.

.3 Provide all necessary materials to provide a complete system.

.4 Coordinate cable termination locations with the Division 26 Contractor.

.5 The entire design and installation of the system shall be CSA approved and comply with the Canadian Electrical Code and the requirements of the authorities having jurisdiction.

.6 Self-regulating heating cables shall;

.1 Vary its power output relative to the temperature of the surface of the pipe or vessel.

.2 Be designed such that it can be crossed over itself and cut to length in the field.

.3 Be designed for a useful life of 20 years or more with “power on” continuously.

.4 Capable of passing a 1.6 KV dielectric test for one minute after undergoing a 10 ft-lb impact per IEEE 515.

.5 Be of parallel construction so that it can be cut to length without changing its power output per unit length.

.6 Shall be covered with a fluoropolymer, high temperature fluoropolymer, modified polyolefin, or thermoplastic elastomer outer jacket as required by the application.

.7 Have a warranty against manufacturing defects for a period of 10 years.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Low Temperature - Self-Regulating Heating Cable

.1 Heating cables shall be self-regulating, capable of maintaining temperatures up to 66°C (150°F) and a continuous exposure to temperature of 85°C (185°F) while de-energized.

.2 The heater cable assembly shall have a monolithic heating core construction consisting of two parallel 16 AWG nickel plated copper bus conductors with a semi-conductive PTC polymer extruded over and between these parallel conductors.

.3 The basic cable will be covered by a metallic braid of tinned copper bus wires embedded in a self-regulating polymetric case. The braid will provide a nominal coverage of eighty percent (80%) and will exhibit a resistance not exceeding 0.0146 ohm/m (0.0045 ohm/ft).

.4 The cable shall be covered with a corrosion resistant outer jacket of thermoplastic elastomer (for possible exposure to aqueous solutions, mild acids, or bases) or fluoropolymer (for possible exposure to organic chemicals or corrosives).

.5 For longer circuit lengths and higher heat loss requirements greater than 32 W/m @ 10°C (10 W/ft @ 50°F), the heating cable shall have 14 AWG nickel-plated copper bus conductors.

2.3 Thermostats and Contactors

.1 All freeze protection systems:

.1 Shall operate using self-regulating control and ambient air sensing thermostat.

.2 Setpoint range -18°C to 107°C (0°F to 400°F).

.3 Operating ambient range - -40°C to 71°C (-40°F to 160°F).

.2 Process temperature maintenance system:

.1 Shall operate using a pipe wall sensing bulb and capillary thermostat.

.2 Setpoint range -18°C to 204°C (0°F to 225°F).

.3 Operating ambient range - -40°C to 71°C (-40°F to 160°F).

.3 Contactor enclosure type shall be NEMA 4 for indoor installations and NEMA 4X for all outdoor installations.

2.4 Control, Monitoring and Power Distribution Systems (Other than Fire Suppression)

.1 For single loop applications:

.1 A UL listed microprocessor based temperature control, monitoring, and power distribution system shall be used. The controller shall accept universal sensor inputs.

.2 The system shall be compatible with self-regulating and mineral insulated (MI) cables.

.2 For multi-loop applications:

.1 A UL listed microprocessor based temperature control, monitoring, and power distribution system shall be used. The sensors shall be of the type resistance temperature detector and shall be wired to the panel.

.2 The system shall be compatible with self-regulating and MI cables.

.3 The systems must have ground fault alarm or ground fault and trip.

.4 The system must have load managing start-up capability.

.5 The system must have one set of dry alarm contacts.

.6 The system must have a control Loop Enable/Disable Feature.

.7 All features including temperature control, contactors, and power distribution must be contained in one enclosure.

.8 The system must be modular in-design, such that individual components can be replaced in the field if necessary.

.3 All control and monitoring systems shall be capable of communicating with a host PC for central programming, status review and alarm communication.

2.5 Heating Cable Connection Kits

.1 Provide power connections, splices/tees, and end seal kits to properly connect and terminate heating cable circuit along specified length of piping.

.2 Install splices, tees, and crosses underneath pipe insulation with service loops installed to allow for future service of piping.

.3 Connection kits shall be rated NEMA 4X to prevent water ingress and corrosion. All components shall be UV stabilized and shall not require cutting into heating-cable core to expose bus wires.

.4 Certification: UL Listed, CSA Certified, and FM approved.

.5 Locate connection kits above grade for buried applications.

2.6 Accessories

.1 Cable Installation Accessories: Fiberglass tape, cable ties, connection kits, and end seals all furnished by manufacturer or as recommended in writing by manufacturer.

.2 Identification: Provide and install "CAUTION – HEAT TRACED" labels on exterior of pipe insulation every 10 ft. (3 m) on opposite sides of pipe, and on all splices, tees, crosses, and power connections for the entire length of heat traced piping.

.3 Warning Labels: Refer to Section 23 05 53 - Identification for Mechanical Piping and Equipment.

.4 Thermal Pipe Insulation:

.1 Pipes to be thermally insulated in accordance with manufacturer's written requirements.

.2 Thermal Insulation: Refer to Section 23 07 19 – HVAC Piping Insulation.

2.7 System Approval

.1 Complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended freeze protection of metallic and non-metallic piping associated with HVAC and plumbing systems.

3. EXECUTION

3.1 General

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

.2 Distribute and fasten cable evenly on pipe using pipe strap or tape at maximum spacing 600mm (24”).

.3 Ensure that heating cables do not touch or cross each other.

.4 Install sensing bulb on side of pipe at least 1000 mm [40”] away from valves, flanges, pumps, etc.

.5 Run only cold leads in conduit and ensure sensing bulb does not touch cable.

.6 Ground shield to building ground.

.7 Coordinate cable installation with insulation application.

.8 Loop additional cable at fittings, valves, and flanges.

.9 Install ambient sensing thermostat away from sunlight.

.10 Make control connections, final power connection by Division 26.

.11 Apply permanent labels to the outside of the thermal insulation, spaced approximately every 3 m. Labels shall state "CAUTION – HEAT TRACED".

3.2 Installation

.1 All heat-tracing components including power connections, splices, tees, and crosses or end seal, must be installed above grade and protected from abuse or damage. In accordance with CEC, electrical connections are not permitted to be installed below grade.

.2 In the field, all heating cables shall be meggered with a minimum of 2,500 V dc for self-regulating cable. The following field megger readings shall be taken on each heating cable:

.1 Heating cable shall be meggered when received at Project site before installation.

.2 Heating cable shall be meggered after installation, but before insulation is installed.

.3 Heating cable shall be meggered after insulation is installed.

.4 Heating cable shall be meggered at final commissioning prior to being energized.

.5 Insulation resistance must exceed 1.000 megohms at 2,500 V dc.

.6 All results must meet manufacturer's specification.

.3 Install electric heating cables after piping has passed all hydrostatic pressure testing and before insulation is installed.

.4 Install electric heating cables in accordance with IEEE 515.1.

.5 Install insulation over piping with electric cables in accordance with Section 23 07 19 - HVAC Piping Insulation.

.6 Install warning tape on piping insulation where piping is equipped with electric heating cables.

.7 Set field-adjustable switches and circuit-breaker trip ranges.

3.3 Field Quality Control

.1 Tests:

.1 Perform tests in accordance with Division 26 - Common Work Results for Electrical.

.2 Before and after installation and before and after installing the thermal insulation, subject heating cable to testing using a 2500-Vdc Megger. Record results and submit data to Owners Consultant.

.3 Minimum insulation resistance shall be 20 megohms or greater.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 The work in this section includes, but is not limited to the following:

- .1 Vibration isolation for piping, and equipment.
- .2 Equipment isolation bases.
- .3 Flexible piping connections.
- .4 Seismic restraints for isolated equipment.
- .5 Seismic restraints for non-isolated equipment.
- .6 Certification of seismic restraint designs and installation supervision.
- .7 Certification of seismic attachment of housekeeping pads.

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.2 Applicable Building Code: Refer to Section 21 05 01 – Common Work Results for Mechanical.

.3 American Society of Heating, Refrigeration, and Air Conditioning Engineers ASHRAE):

- .1 ASHRAE HVAC Applications Handbook (Seismic Design Chapter 54).

.4 Federal Emergency Management Agency (FEMA):

- .1 FEMA – Installing Seismic Restraints for Mechanical Equipment.

.5 Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

- .1 VISCMA – Installing Seismic Restraints for Mechanical Equipment.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:

- .1 Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.
- .2 Shop drawings: submit drawings for seismic control stamped and signed by a Professional Engineer registered or licensed in Province of British Columbia.
- .3 Provide separate shop drawings for each isolated system complete with performance and product data.

1.5 General Requirements

.1 The Contractor shall retain the services of a qualified professional seismic engineer (Seismic Engineer) registered in the Province of British Columbia. The Seismic Engineer shall design and review the installation of all seismic restraints as well as mechanical equipment and mechanical system supports. The restraints and supports shall be specifically designed to fasten to the structure indicated in the contract documents and installed in the field. The complete design for these systems shall comply with all applicable building code requirements.

.2 Seismic Engineer shall provide and submit to the Owner's Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.

.3 Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

.1 Determine vibration isolation and seismic restraint sizes and locations.

.2 Provide vibration isolation and seismic restraints as scheduled or specified.

.3 Provide calculations and materials if required for restraint of non-isolated equipment.

.4 Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

.2 All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.

.3 It is the intent of the seismic portion of this specification to keep all mechanical and electrical building system components in place during a seismic event.

.4 All such systems must be installed in strict accordance with seismic codes, component manufacturer's, and building construction standards. Whenever a conflict occurs between the standards, the most stringent shall apply.

.5 Seismic restraints shall be designed in accordance with seismic force levels as indicated in the Building Code for the specific region of the project.

.6 All elastomeric components in isolation pads, mounts, and seismic snubbers shall be bridge bearing neoprene, meeting CSA Standard CAN3-S6 Section 11.10.

.7 Provide an acceptable means of corrosion protection for all equipment, attachments, and accessories supplied under this section, suitable for the conditions in which this equipment, etc. will be installed.

.8 Bolt all equipment to the structure. Do not bridge isolation elements.

.9 Use ductile materials in all vibration isolation equipment.

.10 Isolators:

.1 Provide neoprene isolators for deflections 6mm (¼") and under.

.2 Provide either neoprene or steel spring isolators for deflections between 6mm and 12mm (½").

.3 Provide steel spring isolators for deflections of 12mm (½") and over.

.4 Provide adjustable limit stops for spring isolation mounts on equipment with operating weights substantially different from the installed weights.

.5 All spring isolators shall be “open spring” unless otherwise stated. Seismically rated housed spring isolators may be used in lieu provided that they meet this project's requirements for seismic restraint.

.6 Isolators and bases which are factory supplied with equipment shall meet the requirements of this section. Where internal isolation is provided, the isolation requirements specified in the minimum static deflection table apply to all separate vibration sources in the unit. Where internal vibration isolation is not provided, the unit frame shall be rigid enough such that the isolators can be attached directly without additional stiffening.

.7 Space isolators under equipment so that the minimum distance between adjacent corner isolators is at least equal to the height of the center of gravity of the equipment. Include height of center of gravity on shop drawings. Otherwise, provide suitable horizontal restraint isolators.

.8 Select isolators in accordance with equipment weight distribution to allow for an average deflection meeting or exceeding the specified deflection requirements and so that no isolator has a deflection less than 80% of the static deflection specified. A minimum of 4 isolators are required for each piece of equipment, unless specified otherwise. Number and colour code each isolator to show location. Mark code number and colour on shop drawings, on each isolator and on each base to ensure proper placement. Clearly tag all springs to show undeflected height and static deflection.

.9 Refer to the minimum static deflection table contained in this Section.

.11 Bases:

.1 Other than equipment requiring concrete inertia bases, provide structural steel bases for all vibration isolated equipment, unless the equipment manufacturer certifies direct attachment capabilities.

.2 Co-ordinate with Division 03 for the provision of housekeeping pads at least 100 mm (4”) high under all isolated equipment. Provide at least 175 mm (7”) clearance between drilled inserts and edge of housekeeping pads and follow structural consultant’s instructions for drilled inserts.

.12 Piping Hangers:

.1 Provide resilient hangers on all piping, etc., rigidly connected to vibration isolated equipment. Provide the hangers for a distance of 3.0m (9.75’) for a 1 NPS pipe and 13.5m (44’) for a 10 NPS pipe. Isolate other pipe sizes for a proportionate distance (both interpolation and extrapolation may be required). Select the three closest hangers to the vibration source for the lesser of 25mm (1”) static deflection or the static deflection of the isolated equipment. Select the remaining isolators for the lesser of 25mm (1”) static deflection or one-half the static deflection of the isolated equipment.

.2 Where resilient hangers cannot be provided for piping rigidly connected to vibration isolated equipment (such as a rigid fire-stop falling within the required isolation distance), provide flexible connectors. One end of each flexible connector shall be installed directly to a flange of the isolated equipment (between the equipment and isolation valves) unless otherwise indicated on the drawings.

.13 Electrical Connections:

.1 Coordinate with the Division 26 to ensure all electrical connections to vibration isolated equipment is made with flexible conduit or other flexible means and does not restrict the maximum anticipated movement.

1.6 Regulatory Requirements

.1 Tested values must show that the seismic restraint hardware used in conjunction with the vibration isolation product is capable of withstanding the increased forces, as calculated for the specific project, using the formulae provided in the applicable building code.

.2 Supply isolators and seismic restraints meeting the structural requirements of the building code, including Section 4.1.8.18 with respect to seismic snubbers, or provide equivalent requirements where integral seismic restraint is provided in isolators / bolting.

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

2. PRODUCTS

2.1 General

.1 Isolation, anchors, bolts, bases, restraints, etc., are to be designed to withstand without failure or yielding, the dynamic G load as specified in Code for the seismic zone in which building is located. Design loads are ultimate limit state loads (1.5 times working load) acting through the centre of gravity of the anchored or restrained equipment. "Fail Safe" designs are acceptable.

.2 For both isolated and non-isolated floor mounted equipment, i.e. tanks, heat exchangers, boilers, etc., design and provide anchors and bolts to withstand, without failure or yielding, a dynamic ultimate limit state load as defined in Code, of the greater of 0.3 g or as required by Code, applied horizontally through the centre of gravity.

.3 Where impact forces may be significant, use ductile materials.

.4 Seismic restraining devices factory supplied with equipment are to meet requirements of this Section.

2.2 Acceptable Manufacturers

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

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

.1 Restrained spring mountings shall incorporate spring (Type 3), within a rigid steel housing that includes a minimum of two vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during installation and steel spacers shall be removed after adjustment such that the installed and operating heights are the same.

.2 An air gap of 3 mm in all directions, before contact is made between the rigid and resilient surfaces, shall be incorporated into the design. Limit stops shall be out of contact during normal operation.

.3 Since housing may be bolted or welded into position, there must be an internal isolation pad under the springs. Housing shall be designed to resist seismic forces.

2.4 Type 7SN - Spring Hangers with Neoprene Elements

.1 Hangers shall consist of rigid steel frames containing minimum 32mm (1 $^{1}/_{4}$") thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box.

.2 Provide a combination rubber and steel rebound washer as the seismic up stop for suspended piping, ductwork, and equipment. Rubber thickness shall be a minimum of 6mm ($^{1}/_{4}$").

.3 To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring.

.4 Spring diameters and hanger box lower hole diameters shall be large enough to permit the hanger rod to swing through a 30º arc from side to side before contacting the protruding neoprene bushing.

.5 Colour coded springs, rust resistant, painted box type hangers.

2.5 Type 13 - Flexible Piping Connections

.1 Flexible piping connectors are to be supplied with seismic restraint materials.

.2 Where flexible connections are not specified with piping in other Sections they are to be as specified herein.

.3 Expansion joints shall be peroxide cured EPDM throughout with Kevlar® tire cord reinforcement. Substitutions must have certifiable equal or superior characteristics. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable.

.4 Sizes 3/4" through 2" (19mm through 50mm) may have one sphere, bolted threaded flange assemblies, and cable retention.

.5 Sizes 11/2" through 14" (40mm through 350mm) shall have a ductile iron external ring between the two spheres. Sizes 16" through 24" (400mm to 600mm) may be single sphere.

.6 Minimum ratings through 14" (350mm) shall be 250psi at 170°F and 215psi at 250°F. (1.72MPa at 77°C and 1.48MPa at 121°C), 16"(400mm) through 24"(600mm) 180psi at 170°F and 150psi at 250°F. (1.24MPa at 77°C and 1.03 MPa at 121°C). Higher published rated connectors may be used where required.

.7 Safety factors shall be a minimum of 3/1. All expansion joints must be factory tested to 150% of maximum pressure for 12 minutes before shipment.

.8 The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2"(13mm) thick Neoprene washer bushings large enough to take the thrust at 1000psi (0.7 kg/mm^2) of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.

.9 Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration acceleration and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer.

.10 All expansion joints shall be installed on the equipment side of the shut off valves.

2.6 Bases – Type B2 - Steel

.1 Provide integral structural steel bases.

.2 Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem.

.3 Pump bases for split case pump shall include supports for suction and discharge elbows.

.4 All perimeter members shall be steel beams with a minimum depth equal to $^1/_{10}$ of the longest dimension of the base. Base depth need not exceed 14" (350mm) provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.

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

2.7 Closed Cell Foam Gaskets

.1 20 mm ($^3/_4$") thick continuous perimeter closed cell foam gasket to isolate base of package type equipment, air handler units, exhaust fans, etc. from concrete floors and roof curbs.

.2 Do not use on NFPA96 installations.

2.8 Anchor Bolts

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

3. EXECUTION

3.1 General

.1 All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

.2 Brace in-line equipment independently of ducts and pipes.

.3 Do not mix solid and cable bracing.

.4 All runs to have a minimum of two transverse and one longitudinal brace. A run is defined as any change in direction except offsets.

3.2 Seismic Restraint Installation

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

3.3 Mechanical Component Restraint Guide

Item	Type Of Restraint	Minimum No. of Restraints	Notes
Cooling Towers Open Circuit Coolers			
- Isolated	SNBR	4	
- Non-Isolated	BTSLPR	4	
Piping	SCR TSR	As required	As per Specification

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

3.4 Seismic Piping Restraints

.1 Seismic restrain all piping as follows:

.1 Seismically restrain all piping as follows:

.1 All other piping 2 ½ NPS and larger.

.2 Provide transverse piping restraints at 12m (40') maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

.3 Provide longitudinal restraints shall be at 24m (80') maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

.4 Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

.5 Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

3.5 Vibration Isolator Installation - General

.1 Vibration isolation products as outlined in section 2 above are to be applied based on 4 basic project specific situations. The requirements for each of these is outlined below:

.1 Acoustical classification AAA - Hospitals, Recording Studios, Theatres, High end Hotels

.2 Acoustical classification AA - Office Towers, Multi Storey Condominiums

.3 Acoustical classification A - Commercial

.4 Acoustical classification W - Warehouse, Industrial

.2 See Vibration Isolation Application Schedule for vibration isolation application requirements.

.3 Unless otherwise specified, vibration isolation products are to be product of one manufacturer.

.4 Ensure vibration isolation manufacturer coordinates material selections with equipment provided in order to ensure adherence to performance criteria. Allow for expansion and contraction when material is selected and installed.

.5 Use the lowest RPM scheduled for two-speed equipment in determining isolator deflection.

.6 Before bolting isolators to the structure, start equipment and balance the systems so that the isolators can be adjusted to the correct operating position before installing (seismically rated) anchors.

.7 Where hold down bolts for isolators or seismic restraint equipment penetrate roofing membranes, the sealing of all roofing membrane penetrations shall be in complete compliance with the installation and warranty requirements of the applicable roofing contractors association. Ensure sealing compound is compatible with isolator components such as neoprene.

.8 Unless otherwise indicated, install isolation materials for base mounted equipment on concrete housekeeping pad bases which extend at least over the full base and isolated area of the isolated equipment. Additional requirements are as follows:

.1 Block and shim bases level so ductwork and piping connections can be made to a rigid system at proper operating level, before isolated adjustment is made, and ensure there is no physical contact between isolated equipment and building structure;

.2 Steel bases are to clear the sub-base by 25 mm (1");

.3 Concrete bases are to clear the sub-base by 50 mm (2").

.9 Where a pump intake pipe or similar pipe configuration requires a pedestal support, construct inertia or steel base large enough to accommodate pedestal.

.10 Isolate piping larger than 25 mm (1") dia. directly connected to motorized and/or vibration isolated equipment with 25 mm (1") static deflection spring hangers at spacing intervals in accordance with following:

.1 For pipe less than or equal to 100 mm (4") dia. – first 3 points of support;

.2 For pipe 125 mm (5") to 200 mm (8") dia. – first 4 points of support;

.3 For pipe equal to or greater than 250 mm (10") dia. – first 6 points of support;

.11 First point of isolated piping support is to have a static deflection of twice the deflection of the isolated equipment but maximum 50 mm (2").

.12 Flexible pipe connectors (Type 13 isolator) shall be provided and installed per the Vibration Isolation Application Schedule.

.13 Provide hot dipped galvanized housings and neoprene coated springs, or other acceptable weather protection, for all isolation equipment located outdoors or in areas of high moisture which may cause corrosion.

.14 Provide a minimum clearance of 50mm (2") to other structures, piping, equipment, etc., for all equipment mounted on vibration isolators.

.15 Before bolting isolators to the structure, start equipment and balance the systems so that the isolators can be adjusted to the correct operating position before installing drilled inserts.

.16 When spring isolators are used for equipment with operating weights substantially different from installed weights, block the equipment with temporary shims to the final heights prior to making piping connections. When full load is applied, adjust the isolators to take up the load just enough to allow shim removal.

.17 After installation and adjustment of isolators, verify deflection under load to ensure loading is within specified range.

.18 Where hold-down bolts for isolators or attachments penetrate roofing membranes, co-ordinate with Division 7 and with roofing contractor.

.19 Ensure that the installed seismic restraints do not adversely affect the proper functioning of any vibration isolation products required by this section.

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

3.6 Type 3 - Spring Floor Mounts

.1 Isolate all floor or pier mounted equipment on spring floor mount isolators, unless otherwise specified.

.2 Mount cooling towers on spring floor mount isolators and, if necessary, seismic snubbers to meet seismic requirements unless scheduled otherwise.

3.7 Type 5 - Seismic Snubbers

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

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

.1 Erect roof curb vibration isolation in accordance with instructions shipped with assembly. Match vibration isolation with associated roof top unit and orient isolation as identified by manufacturer to ensure proper loading and optimum performance.

.2 Caulk top of roof curb with 2 beads of caulking provided and centre isolation assembly onto roof curb and, unless otherwise noted, screw in place with 50 mm (2") lag screws at 900 mm (36") O.C. Position gasket on top rail or alternatively, caulk with 2 beads of caulking provided and orient and lower roof top unit onto isolation rails and, unless otherwise noted, screw unit into top rail with 25 mm (1") lag screws at 900 mm (36") O.C.

.3 After roof top unit is secured in place, but before damageable work is installed, spray each isolated equipment assembly with water and correct any water leaks.

3.9 Type 7S & 7SN - Spring Hangers

.1 Locate isolation hangers as near to the overhead support structure as possible.

.2 Installation shall permit hanger box or rod to move through a 30 degrees arc without metal to metal contact.

3.10 Type 13 - Flexible Piping Connectors

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

3.11 Closed Cell Foam Gaskets

.1 Select width for nominal 21kPa (3psi) loading under weight of equipment and allow for 25% compression 5mm ($^{3}/_{16}$").

.2 Increase width of curb using steel shim if necessary to accommodate gasket.

.3 For light equipment such as exhaust fans, deflection should be a minimum of 1mm (0.05").

3.12 Vibration Isolation Application Schedule

Equipment	AAA	AA	A	W
Cooling Towers	4, B2 & 13	B2 & 13	3A, B2 & 13	1, B2 & 13
Piping				
Attached to Isolated Equipment	7SN - See 3.4.5	7SN - See 3.4.5	7SN - See 3.4.5	See 3.4.5

Note:

.1 Table indicates type of isolation required, base type (B) if required and any other sections of note.

3.13 Field Quality Control

.1 Seismic Engineer:

.1 The Seismic Engineer shall perform all field services as required to fulfil the Building Code obligation for the provision of the Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.

.2 Submit concise field reports to the Consultant within 3 days of each site review.

.3 Make adjustments and corrections in accordance with written report.

.2 Manufacturer's Field Services:

.1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract Documents.

.2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:

.1 Twice during the installation, at [25] % and [60] % completion stages.

.2 Upon completion of installation.

.3 Submit a concise manufacturer's report to the Consultant within 3 days of manufacturer representative's review.

.4 Make adjustments and corrections in accordance with written report.

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.2 Canadian Standards Association (CSA International):

.1 CAN/CSA B128.1 – Design and Installation of Non-potable Water Systems.

.2 CAN/CSA B128.2 – Maintenance and Field Testing of Non-potable Water Systems

.3 Canadian General Standards Board (CGSB):

.1 CAN/CGSB-1.60 – Interior Alkyd Gloss Enamel.

.2 CAN/CGSB-24.3 – Identification of Piping Systems.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:

.1 Submit data on all materials.

1.5 General Requirements

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

.2 Identify each system and system component according to the nomenclature used on the drawings and specifications. Identification to be consistent throughout the project.

.3 When identifying systems and components in existing buildings, the new items shall be numbered sequentially with existing systems. Where possible include the zone or building area serviced by each system.

.4 Submit list of system and component labels to the Consultant for review prior to engraving.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Piping Systems Governed by Codes

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

2.3 Manufacturer's Equipment Nameplates

.1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.

.2 Lettering and numbers raised or recessed.

.3 Information to include, as appropriate:

.1 Equipment: manufacturer's name, model, size, serial number, capacity.

.2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.4 System Equipment Nameplates

.1 Each piece of equipment shall be identified with its equipment schedule identification, e.g. supply fan SF-1, cooling coil CC-1, pump P-1, cooling tower CT-1.

.1 Coordinate equipment with drawings and with owner's requirements.

.2 Colours:

.1 Hazardous: red letters, white background.

.2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).

.3 Construction:

.1 3 mm (⅛") thick laminated plastic or white anodized aluminum, matte finish, with square corners, letters accurately aligned and machine engraved into core.

.4 Sizes:

.1 Conform to following table:

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

.2 Use maximum of 25 letters/numbers per line.

.5 Locations:

.1 Terminal cabinets, control panels: use size # 5.

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

2.5 Piping Systems Identification

.1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows to CAN/CGSB 24.3 except where specified otherwise.

.2 Pictograms:

.1 Where required by Workplace Hazardous Materials Information System (WHMIS) regulations.

.3 Letter Height:

.1 13 mm [1/2"] high - 1-1/4 NPS pipe & smaller.

.2 25 mm [1"] high - 1-1/2 NPS up to 2-1/2 NPS pipe.

.3 50 mm [2"] high - 3 NPS and larger pipe.

.4 Arrows showing direction of flow:

.1 Outside diameter of pipe or insulation less than 75mm (3"): 100mm long x 50mm high (4" x 2").

.2 Outside diameter of pipe or insulation 75mm (3") and greater: 150mm long x 50mm high (6" x 2").

.3 Use double-headed arrows where flow is reversible.

.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 20mm ($^3/_4$") and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.

.2 Other pipes: pressure sensitive plastic-coated cloth or vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C (302°F) and intermittent temperature of 200°C (392°F).

.7 Colours and Legends:

.1 Where not listed, obtain direction from the Consultant.

.2 Colours for legends, arrows to following table:

Background Colour	Legend, Arrows
Yellow	BLACK
Green	WHITE
Red	WHITE
Blue	WHITE

.3 Background colour marking and legends for piping systems:

Contents	Background Colour Marking	Legend
Make-Up Water	Yellow	MAKE-UP WTR
Storm Water	Green	STORM
Sanitary	Green	SAN
Condensate Drain	Green	COND
Grey Water	Per CSA B128.1	

2.6 Valves, Controllers Identification

.1 Provide valve identification and secure with non-ferrous chain or "S" hooks suitable for the system temperature.

.2 Identification tags shall be of brass, aluminum, metalphoto, lamicoid or fiberglass, stamped or engraved with 12mm (½") high identifier markings.

.3 Tag the following valves as a minimum:

.1 Valves on main piping circuits.

.2 Valves on major branch lines.

.3 Valves on minor branch lines in horizontal or vertical service spaces and mechanical rooms.

.4 Drain valves and hose bibbs on systems containing glycol.

.5 Control valves.

.4 Do not tag the following valves:

.1 Valves on control valve stations.

.2 Valves on steam trap stations.

.3 Plumbing fixture stops or hose bibbs.

.4 System drain valves.

.5 Provide a valve tag schedule. Include in the identification of each tagged item, valve type, service, function, normal position and location of tagged item.

.6 Provide a flow diagram for each system, reference applicable charts and schedules.

2.7 Controls Components Identification

.1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section. Include: sensors, transmitters, BMS controlled valve and damper actuators, end-devices, distributed control panels (DCP)'s, application specific controllers (ASC)'s and field panels.

.2 Inscriptions to include function and (where appropriate) fail safe position.

.3 Warning notices shall be provided at all equipment controlled by the BMS and at all associated motor starters. The warning notices shall state that the equipment is under the control of the BMS and may start or stop at any time without warning. Provide warning notices at minimum at all MCC's, at local disconnect switches, at AHU plenum doors, and electrical motors.

.4 Provide warning notices on all Distributed Control Panel doors indicating that hand held radio transmitters are not to be keyed within 3 meters or the DCP.

.5 All BMS wire and cable shall be identification tagged. Wire/cable shall be identification tagged at every termination location. Wire/cable and tubing terminating at distributed control panels (DCP) and application specific controllers (ASC) shall be tagged with the DCP/ASC controller termination number. Wire/cable and tubing terminating at field devices shall be tagged with both the DCP/ASC number and the DCP/ASC termination number. At any splices or terminal strips between the field device and DCP/ASC, the wiring shall be tagged on both sides of the termination point the same as for a field device termination.

3. EXECUTION

3.1 General

.1 Provide identification only after painting has been completed.

.2 Perform work in accordance with CAN/CGSB-24.3 Identification of Piping Systems except as specified otherwise.

.3 Provide ULC and/or CSA registration plates as required by respective agency.

3.2 Nameplates

.1 Location shall be in conspicuous location to facilitate easy reading and identification from operating floor.

.2 Provide standoffs for nameplates on hot and/or insulated surfaces.

.3 Do not paint, insulate or cover nameplate data.

3.3 Location of Identification on Piping Systems

.1 Provide on long straight runs in open areas in equipment rooms, galleries, tunnels: at not more than 17m (55') intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

.2 Provide adjacent to each change in direction.

.3 Provide at least once in each small room through which piping passes.

.4 Provide on both sides of visual obstruction or where run is difficult to follow.

.5 Provide on both sides of separations such as walls, floors, partitions.

.6 Provide where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.

.7 Provide at beginning and end points of each run and at each piece of equipment in run.

.8 Provide at point immediately upstream of major manually operated or automatically controlled valves, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.

.9 Identification shall be easily and accurately readable from usual operating areas and from access points. Position the identification approximately at right angles to the most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.4 Valves, Controllers Identification

.1 Provide identification on valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve.

.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass located in the main mechanical room. Provide one copy in each operating and maintenance manual.

.3 Number valves in each system consecutively.

.1 Identification coding is to start with a utility description followed by a maximum of three numerals:

.2 Domestic Water DW-1, DW-2, DW-3…

.3 HVAC to be numbered H-1, H-2, H-3…

END OF SECTION

1. GENERAL

1.1 Section Scope

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

.2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.

.3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges and document results.

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

.3 Section 23 08 00 – Commissioning of Mechanical Systems.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.2 National Environmental Balancing Bureau (NEBB)

.1 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

1.4 General Requirements

.1 TAB is used throughout this Section to describe the process, methods, and requirements of testing, adjusting and balancing for HVAC.

.2 TAB means to test, adjust, and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this section.

1.5 Approved TAB Agencies

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

1.6 Qualifications of TAB Personnel

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

.2 Submit names of personnel to perform TAB to the Owner's Consultant within 90 days of award of contract. Provide documentation confirming qualifications, years of direct field testing and balancing experience and successful experience. Provide a list of a minimum of ten comparable projects successfully completed by all key members of the balancing team and the Standard under which the projects were completed.

.3 TAB shall be performed in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved:

.1 AABC – National Standards for Total System Balance, MN-1

.2 NEBB – Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

.3 SMACNA -HVAC Systems – Testing, Adjusting and Balancing

.4 Recommendations and suggested practices contained in the TAB Standard are mandatory.

.5 Use TAB Standard provisions, including checklists, and report forms to satisfy the Contract requirements.

.6 Where the instrument manufacturer's calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.

.7 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.

.1 For systems or system components not covered in TAB Standard, use TAB procedures developed by the TAB Specialist.

.2 Where new procedures, and requirements, are applicable to the Contract requirements, procedures shall have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), requirements, and recommendations contained in these procedures and requirements are mandatory.

1.7 Exceptions

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

1.8 Submittals

.1 Comply with Section 21 05 01 – Common Work Results for Mechanical, Submittals, and the following:

.2 Preliminary TAB Report

.1 Submit for checking and approval of the Owner's Consultant, prior to submission of formal TAB report, sample of rough TAB sheets. Include:

.1 Details of instruments used.

.2 Details of TAB procedures employed.

.3 Calculations procedures.

.4 List of liquid systems to be TAB

.5 Summaries.

.3 TAB Report

.1 Format in accordance with referenced standards.

.2 TAB report to show results in SI units and to include:

.1 Project record drawings.

.2 System schematics.

.3 Date of test, Name, and address of building and balancing technician's name.

.4 Cooling Towers: Tag, location, manufacturer, model, and size. Specified and actual capacity, fluid flow rates, entering & leaving temperatures, pressure drop, amps, and voltage of fan(s).

.5 Flow measuring devices: Flow rates.

.3 Submit copies of TAB Report to the Owner's Consultant for verification and approval.

1.9 Co-ordination

.1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule to ensure completion before acceptance of project.

.2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.10 Pre-TAB Review

.1 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

.2 Ensure devices are accessible and maintainable. Advise the installing Contractor of omissions or conflicts affecting the scope of this section.

.3 Review contract documents before project construction is started and confirm in writing to Consultant the adequacy of provisions for TAB and that other aspects of design and installation are pertinent to the success of TAB.

.4 Review specified standards and report to Consultant in writing describing any proposed procedures which vary from the standard.

1.11 Start-up

.1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.

.2 Follow special start-up procedures specified elsewhere in Divisions 21, 22, 23 and 25.

2. PRODUCTS

2.1 Instruments

.1 Prior to TAB, submit to the Owner's Consultant a list of instruments used together with serial numbers.

.2 Calibrate in accordance with requirements of most stringent of referenced standards for applicable system.

.3 Calibration shall be within 6 months of TAB. Provide certificate of calibration to the Owner's Consultant.

3. EXECUTION

3.1 Start of TAB

.1 Notify the Consultant 7 days prior to start of TAB.

.2 Start TAB when building is essentially completed, including:

.1 Installation of ceilings, doors, windows, other construction affecting TAB.

.2 Application of weather-stripping, sealing, and caulking.

.3 Pressure, leakage, other tests specified elsewhere Division 23.

.4 Provisions for TAB installed and operational.

.3 Start-up, verification for proper, normal, and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:

.1 Proper thermal overload protection in place for electrical equipment.

.2 Fluid systems:

.1 Flushed, filled, vented.

.2 Correct pump rotation.

.3 Strainers in place, baskets clean.

.4 Isolating and balancing valves installed, open.

.5 Calibrated balancing valves installed, at factory settings.

.6 Chemical treatment systems complete, operational.

3.2 Tolerances

.1 Application Tolerances:

.1 Do TAB to following tolerances of design values:

.1 Hydronic systems: plus or minus 10%.

.2 Accuracy Tolerances:

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

3.3 Testing

.1 Test ducts and piping before installation of insulation or other forms of concealment. Do not externally insulate or conceal work until tested and approved.

.2 Test after seals have cured.

.3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.

.4 Conduct tests in presence of the Owner's Consultant or Owner's representative.

.5 Bear costs including retesting and making good.

.6 Refer to Piping Sections for specific test requirements.

.7 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.

3.4 Balancing of Hydronic Systems

.1 Open all (except pressure bypass must be closed) valves to fully open position including balancing valves, isolation valves, and control valves.

.2 Set pumps to deliver 10% excess flow if possible.

.3 Adjust flows through chiller to ensure equal flow.

.4 Check and adjust flows and temperatures at inlet side of coils.

.5 Position and mark all automatic valves, hand valves and balancing cocks for design flow through all coils, connectors and all items in system requiring circulation of chilled water, hot water or glycol.

.6 Upon completion of flow readings and coil adjustments, mark setting and record data.

.7 Coordinate shaving of impellor to operating condition on pumps larger than 1.5 kW. (2 Hp).

.8 Ensure all bypass valves are tightly closed.

.9 After making all terminal unit adjustments, re-check settings at pumps. Re-adjust as required.

.10 Calibrate all pressure and temperature gauges.

.11 Install pressure gauges on each coil then read pressure drop through coil and set flow rate on call for full flow through coil. Set pressure drop across bypass valve to match coil full flow pressure drop.

.12 For each pump, plot maximum and minimum flows on curve.

3.5 Balancing and Adjusting of Domestic Water Systems

.1 Adjust PRV on main line to 550kPa (80psi) maximum.

.2 Ensure all cold supply shut off valves are fully open.

3.6 Verification

.1 Reported results subject to verification by the Owner's Consultant.

.2 Provide personnel and instrumentation to verify up to 30% of reported results.

.3 Number and location of verified results as directed by the Owner's Consultant.

.4 Pay costs to repeat TAB as required to satisfaction of the Owner's Consultant.

3.7 Settings

.1 After TAB is completed to satisfaction of the Owner's Consultant, replace drive guards, close access doors, lock devices in set positions, ensure sensors are at required settings.

.2 Permanently mark settings to allow restoration at any time during life of facility. Do not eradicate or cover markings.

3.8 Completion of TAB

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

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.2 Applicable Building Code – Refer to Section 21 05 01 – Common Work Results for Mechanical.

.3 Applicable energy code or standard – Refer to Section 21 05 01 – Common Work Results for Mechanical.

.4 British Columbia Insulation Contractors Association (BCICA) – Quality Standard for Mechanical Insulation Manual.

.5 CAN/ULC S102-M88 – Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

.6 ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

.7 ASTM C547 – Standard Specification for Mineral Fibre Pipe Insulation.

.8 ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

.9 ASTM C755 – Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:

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

.2 Manufacturer's installation instructions.

1.5 General Requirements

.1 The Installation firm shall be a current member of one of the following:

.1 Thermal Insulation Association of Canada (TIAC).

.2 British Columbia Insulation Contractors Association (BCICA)

.2 Only Journeyman insulation applicators, with 3 years minimum successful experience in this size and type of project, shall perform the work.

.3 Definitions:

.1 "CONCEALED" insulated mechanical services in trenches, chases, furred spaces, shafts and hung ceilings (services in tunnels are not considered to be concealed.)

.2 "EXPOSED" will mean not concealed.

.3 “K” value means Thermal Conductivity.

.4 UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO).

.5 ASJ: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper

.6 SSL: Self-Sealing Lap.

.7 FSK: Foil Scrim Kraft; jacketing.

.8 PSK: Poly Scrim Kraft; jacketing.

.9 PVC: PolyVinyl Chloride.

.4 Provide thermal insulation on all HVAC piping, valves and fittings and as follows:

.1 Condenser water piping, outside building.

.1 Cooling tower sump, spray water, drain, overflow, and chemical feed piping, outside building.

.2 Insulate the following valves and fittings if the pipe is insulated:

.1 Elbows, tees, reducers.

.2 Valve bodies on valves and check valves, over 2½ NPS

.3 Flanges.

.4 Strainers.

.5 DO NOT insulate the following, unless noted otherwise:

.1 Piping located within perimeter heating enclosures.

.2 Relief piping.

.3 Drain lines.

.4 Flexible interconnections between ceiling radiant heating panels.

.5 Condenser water piping inside building, except systems that employ water side economizing.

.6 Insulate and vapour seal the following fittings, if the pipe is insulated:

.1 Elbows, tees, reducers.

.2 Valves, (bodies and bonnets) except check valve covers.

.3 Strainers.

.4 Flanges.

.5 Unions.

.7 DO NOT insulate the following, unless otherwise noted:

.1 Drain lines for sumps 15°C (60°F) and over.

.8 If the Contractor, during renovations, should discover asbestos (or material suspected to be asbestos) on piping, etc., he shall immediately cease all work in that area and contact Owner's representative.

.9 Make good all existing insulation disturbed or removed to facilitate alterations and additions to existing piping

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

.1 Products shall not contain asbestos, lead, mercury, mercury compounds or Polybrominated diphenyl ethers (PBDE).

.2 Mineral fibre specified includes glass fibre and rock wool.

.3 Thermal conductivity ("k" factor) not to exceed specified values when tested in accordance with ASTM C547

.4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88 and NFPA 90A

.5 Foam insulation products shall not use CFC or HCFC blowing agents in the manufacturing process and be formaldehyde free.

.6 Glass mineral wool products shall have a recycled content of a minimum of 50 percent recycled glass content.

.7 Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation, insulation shall be UL GREENGUARD Certified.

2.3 Preformed Pipe Covering

.1 Low Temperature Thermal Insulation

.1 Piping service temperature -40°C to 5°C (-40°F to 41°F)

.2 Complying with ASTM C534

.3 Preformed and pre-slit flexible foamed elastomeric insulation with self-adhesive self seal or lap seal joints:

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

.4 Preformed flexible closed cell insulation:

.1 Maximum “K” value at 24°C (75°F) = 0.036 W/m.°C (0.24 Btu.in/hr.ft2.°F)

.5 Phenolic closed cell preformed rigid insulation with all service jacket vapour retarder (ASJ). ASJ shall be re-enforced with glass fibre, factory applied with pressure sensitive lap closure.

.1 Maximum “K” value at 24°C (75°F) = 0.019 W/m.°C (0.13 Btu.in/hr.ft2.°F)

.2 Low to Intermediate Temperature Thermal Insulation

.1 Piping service temperature 5°C to 315°C (41°F to 599°F)

.2 Preformed insulation, mineral glass wool pipe insulation with all service jacket vapour retarder (ASJ). ASJ shall be re-enforced with glass fibre, factory applied with pressure sensitive lap closure.

.3 Complying with ASTM C547.

.4 ASJ vapour transmission rate 0.02 perms maximum

.5 Maximum “K" value at 38°C (100°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft2.°F)

.1 This conductivity requires an insulation thickness adjustment of 125% from the "Minimum Insulation Thickness Schedule"

.6 Preformed insulation, expanded perlite pipe insulation with reinforcing fibres without jacket.

.1 Maximum "K" value at 121°C (250°F) = 0.074 W/m.°C (0.51 Btu.in/hr.ft2.°F)

.2 This conductivity requires an insulation thickness adjustment of 150% from the "Minimum Insulation Thickness Schedule"

2.4 Fastenings, Adhesives and Coatings

.1 Insulation Fastenings: min. 1.6 mm thick [16 ga.] galvanized wire, 0.6 mm thick aluminium wire, 0.6 mm thick type 304 stainless steel wire or 1.6 mm thick copper wire as commercially available.

.2 Jacket Fastenings:

.1 Thermocanvas and All Service Jacket:

.1 Staples (flare type), compatible jacket finishing tape, contact adhesives recommended by the jacket manufacturer.

.2 Metal Jackets:

.1 Sheet metal screws, pop rivets, stainless steel bands.

.3 PVC Jacket and Fitting Covers:

.1 PVC self-adhesive tape, plastic pop rivets, bonding cement.

.3 Adhesives:

.1 Fabric adhesive to insulation pipe covering, water based, ultra white, washable, anti-microbial, to ASTM C755-19.

.4 Coatings:

.1 Vapour barrier coating on reinforcing membrane or on insulating cement.

2.5 Finish Jackets

.1 Jackets:

.1 Thermocanvas Jacket: fire rated, 170g (6 oz) fire retardant canvas jacket for covering mechanical insulation indoors, 25/50 fire class, plain wave cotton, no dyes.

.2 All Service Jacket: high puncture and tear resistance with 0.03 mm [0.0019"] minimum thick foil. Water vapour permeance of 0.02 perms maximum. Self-adhesive material, flame spread/smoke development rating not to exceed 25/50.

.3 PVC Finishing Jacket: white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02") thick.

.4 Aluminum Jacket: 0.51 mm (22 ga.) thick stucco or smooth aluminum jacketing with longitudinal slip joints and 50mm (2") end laps with factory applied protective liner on interior surface.

.5 Stainless Steel: 0.25m thick [304][316] [smooth] [corrugated] [stucco embossed] longitudinal slip and circumferential slip joints with 0mm lasp, 19mm wide metal banding, 0.5mm thick, 300mm spacing.

.2 Preformed Fitting Covers:

.1 PVC Fitting Covers pre-moulded one piece covers, white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02") thick.

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

3. EXECUTION

3.1 General

.1 Install in accordance with British Columbia Insulation Contractors Association (BCICA) standards

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

.3 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified prior to insulation installation.

.4 Use two layers of preformed insulation with staggered joints when the required nominal wall thickness exceeds 75 mm.

.5 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.

.6 Install hangers, supports outside vapour retarder jacket.

.7 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

.8 Ensure insulation is continuous through inside walls. Pack around pipes with fire proof self-supporting insulation material, properly sealed.

.9 Insulate piping, fittings, and valves.

.10 Contractor to provide valve stem extensions as required to enable insulation of valve stems. Insulate void space around valve fittings. Valves to be fully operational without compromising the insulation integrity.

.11 Locate insulation or cover seams in least visible locations. Locate seams on piping in ceiling spaces on the underside of the pipe.

.12 Terminate insulation 75 mm (3") back from all uninsulated fittings to provide working clearance. Terminate insulation at 90°, finish with reinforced scrim cloth, and vapour barrier mastic system or use vapour barrier mastic and pre-formed fitting cover over.

.13 On vertical pipes over 3 NPS, provide insulation supports welded or bolted to pipe, directly above the lowest pipe fitting. Provide supports on 4.5 m (15') centres.

.14 Where insulation is not specified:

.1 Hot Piping: Coat exposed hot pumps, pipe and fittings with Therma-Lite liquid insulation product to prevent skin burns

.2 Cold Piping: Coat exposed cold pumps, pipes, and fittings, connecting surfaces of thermometers, pressure gauges, flow switches, controllers, etc. with a No Sweat paint product to prevent condensation.

3.2 Installation Cold and Chilled Water Application - (5°C to 15°C) TIAC 1501-C

.1 Piping: Apply pipe insulation with integral vapor retarder jacket to piping and hold in place by securing the jacket flap. Seal all flaps and butt strips with vapor retarder adhesive. Pipe insulation with integral self-sealing vapor retarder jacket will not require additional fastening.

.2 Screwed or welded fittings: Insulate fittings with section of the pipe insulation mitered to fit tightly. All seams shall be sealed using vapor retarder tape.

.3 Valves, Strainers: Insulate valve bodies, bonnets, and strainers with fitted pipe insulation or mitered blocks all to thickness of adjacent pipe insulation, and then seal all seams of vapor retarder with vapor retarder tape.

.4 Flanged and grooved fittings: Insulate with oversized pipe insulation or mitered blocks to the thickness of the adjacent pipe insulation, then seal all seams of vapor retarder jacket with vapor retarder tape.

3.3 Finishes

.1 Concealed piping shall be left as factory finished, TIAC standard CPF/2.

.2 Exposed Piping Indoor (Canvas) CPF/1

.1 The factory applied integral all service jacket shall be neatly applied to receive the fabric jacket. Apply a jacket with a fire resistive lagging coating. Apply a finishing coat of fire resistive lagging coating

.3 Exposed Piping Outdoor (Aluminum Jacket) CPF/3

.1 Apply aluminum jacketing with a 60mm overlap at 3 o'clock using necessary fastenings on approximately 150mm centers.

.2 Over insulated fittings, valve bodies, valve bonnets, strainers and flanges apply aluminum jacket or preformed metal fitting covers to provide a complete jacket system. Secure with necessary fastenings.

.4 Exposed Piping Outdoor (Mastic) CPF/5

.1 On glass mineral wool style insulation, apply a coat (minimum 1 litre per 1.5 m) of weather coating over the insulated surfaces. While still wet, embed a layer of reinforcing membrane, and finish with a final coat (minimum 1 liter per 1.5 m) of weather coating.

.2 On elastomeric style insulation, provide two (2) coats of Armaflex WB finish or equivalent weather resistant coating. Coverage shall be a per manufacturers recommendations.

3.4 Application Design Operating Temperatures

.1 Condenser Water (Exterior) Condenser Water (Exterior) 41°C (106°F)

.2 Cooling Tower Sump Spray Piping, Drain and Overflow 41°C (106°F)

3.5 Piping Insulation Minimum Thickness Schedule

Type Of System	Design Operating Temperature Range °C (°F)	Thermal Conductivity of Insulation		Nominal Pipe Diameter NPS				
		Conductivity Range W/m.°C	Mean Rating Temperature °C (°F)	< 1	1 to 1¼	1½ to 3	4 to 6	≥ 8
				Minimum Thickness of Piping Insulation (mm)				
Heating Systems (Steam, Condensate, and Hot Water)	41-60 (105-141)	0.032-0.040	38 (100)	25	25	40	40	40
Cooling Systems (Chilled Water, Refrigeration)	5-16 (41-61)	0.030-0.039	24 (75)	25	25	25	25	25

Note: For piping located exterior to the building envelope (incl. unheated areas of the building i.e. parkade) the insulation thickness shall increase to the next higher row for temperature range in the table above (i.e. 82°C HWS would move from 61-93°C range to the 94-121°C range).

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

U2 = proposed insulation "k" value at the table mean rating temperature.

U1 = upper range limit "k" value from the table above.

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

U2 = proposed insulation "k" value at the table mean rating temperature.

U1 = lower range limit "k" value from the table above.

3.6 Piping Finish Schedule

.1 Conform to the following:

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

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

.1 Commissioning Agency (CxA)

.2 The latest revisions of the following standards shall apply unless noted otherwise.

.1 Applicable Building Code - Refer to Section 21 05 01.

1.4 Submittals

.1 Comply with Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:

.1 Certificates of readiness.

.2 Certificates of completion of installation, prestart, and start-up activities.

1.5 Contractor's Responsibilities

.1 Perform commissioning tests.

.2 Attend construction phase controls coordination meeting.

.3 Attend testing, adjusting, and balancing review and coordination meeting.

.4 Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection.

.5 Provide information requested by the CxA for the final commissioning documentation.

.6 Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA's Responsibilities

.1 Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R, plumbing and fire suppression systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

.2 Verify and participate in commissioning testing.

.3 Verify testing, adjusting, and balancing of work are complete.

1.7 Commissioning Documentation

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

.1 Plan for delivery and review of submittals, systems manuals, and other documents and reports.

.2 Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

.3 Process and schedule for completing construction checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.

.4 Certificate of completion certifying that installation, start-up checks, and start-up procedures have been completed.

.5 Certificate of readiness, certifying that HVAC&R, plumbing and fire suppression systems, subsystems, equipment, and associated controls are ready for testing.

.6 Test and inspection reports, and certificates.

.7 Corrective action documents.

.8 Documented verification of testing, adjusting, and balancing reports.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 Testing Preparation

.1 Certify that HVAC&R, plumbing and fire suppression systems, subsystems, and equipment, have been installed, calibrated, and started and are operating according to the Contract Documents.

.2 Construction documents review:

.1 Provide full set of Div 21, 22, 23, 25 drawings and specifications for preliminary design review.

.3 Certify that HVAC&R, instrumentation, and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

.4 Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

.5 Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

.6 Inspect and verify the position of each device and interlock identified on checklists.

.7 Check safety cut-outs, alarms, and interlocks with life-safety systems during each mode of operation.

.8 Testing instrumentation: Install measuring instruments and logging devices to record test data.

3.2 Testing and Balancing Verification

.1 Prior to performance of testing and balancing (TAB) work, provide copies of TAB procedures, reports, sample forms, checklists, and certificates to the CxA.

.2 Notify the CxA at least 10 working days in advance of testing and balancing work, and provide access for the CxA to witness testing and balancing work.

.3 Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems.

.1 The CxA will notify testing and balancing Contractor 10 working days in advance of the date of field certification. Notice will not include data points to be verified.

.2 The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

.3 Failure of an item includes, other than for sound measurements, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3dB shall result in rejection of final testing.

.4 Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 General Testing Requirements

.1 Scope of HVAC&R testing includes entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditions space. Testing shall include measuring capacities and effectiveness of operational and control functions.

.2 Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

.3 The CxA along with the HVAC&R Contractors, testing and balancing Contractor, and the HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

.4 Tests will be performed using design conditions whenever possible.

.5 Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Calibrate testing instruments before simulating conditions. Provide equipment to simulate loads. Set simulated conditions and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

.6 Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.

.7 Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.

.8 If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

.9 If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

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

.1 Heating and cooling plant.

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

.3 Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

3.5 Procedures for Sound-Level Measurements

.1 Perform sound-pressure-level measurements with an octave-band analyser complying with ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

.2 Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and having NIST certification.

.3 Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100fpm (0.51 m/s), use a widescreen on the microphone.

.4 Perform sound-level testing after water balancing and equipment testing are complete.

.5 Close windows and doors to the space.

.6 Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

.7 Clear space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

.8 Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.

.9 Take sound measurements in a dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

.10 Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.

.1 Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

3.6 Commissioning of Plumbing Systems

.1 Provide commissioning of all plumbing piping, equipment, and systems including the following:

.1 Domestic cold water.

.2 Commissioning related to plumbing systems shall include the start-up, set up, adjustment, and recording of the operational data of at least all of the following systems and components as related to the project:

.1 Pressure reducing valve set points and downstream pressures.

.2 Megger tests of heat trace cables for freeze protection and temperature maintenance. Verification of ground fault interrupter protection for heat cable electrical circuits.

.3 Set points for all control devices.

.4 Testing and completed certification of all backflow preventers.

END OF SECTION

1. GENERAL

1.1 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical

.3 Section 23 05 15 – Common Installation Requirements for HVAC Pipework

.4 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC

1.2 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.1 Applicable Building Code - Refer to Section 21 05 01

1.3 Hydronic Systems - Performance Verification (PV)

.1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.

.2 When systems are operational, perform following tests:

.1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.

.2 Verify performance of hydronic system circulating pumps as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.

.1 Pump operation.

.2 Pressure bypass open/closed.

.3 Control pressure failure.

.4 Maximum cooling demand.

.5 Cooling tower (and/or industrial fluid cooler) fan failure.

.6 Outdoor reset. Re-check heat exchanger output supply temperature at 100% and 50% reset, maximum water temperature.

1.4 Hydronic System Capacity Test

.1 Perform hydronic system capacity tests after:

.1 TAB has been completed

.2 Verification of operating, limit, safety controls.

.3 Verification of primary and secondary pump flow rates.

.4 Verification of accuracy of temperature and pressure sensors and gauges.

.2 Calculate system capacity at test conditions.

.3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.

.4 When capacity test is completed, return controls and equipment status to normal operating conditions.

1.5 Condenser Water Systems

.1 In addition to procedures specified above, perform following:

.1 Add chemicals once per week as required.

.2 Perform TAB as specified Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

.3 Set up and adjust drip feeders, timer controls, pump strokes as required to maintain required chemical feed rates.

.4 Inject inhibitor into cooling tower sump.

1.6 Potable Water Systems

.1 When cleaning is completed and system filled:

.1 Verify performance of equipment and systems as specified elsewhere in Division 23.

.2 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor or recharge air chambers. Repeat for each outlet and flush valve.

.3 Confirm water quality consistent with supply standards, verifying that no residuals remain resulting from flushing and/or cleaning.

2. PRODUCTS

2.1 Not Used

3. EXECUTION

3.1 Not Used

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Electric/electronic line voltage and low voltage electric/electronic standalone non-BAS control for HVAC (this could range from as simple as programmable thermostat up to stand- alone local controller, project specific).

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

.3 Division 26 – Electrical.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.1 Applicable Building Code - Refer to Section 21 05 01 – Common Work Results for Mechanical.

.2 British Columbia Codes:

.1 British Columbia Electrical Code.

.2 British Columbia Safety Authority.

1.4 Coordination of Work

.1 Products furnished but not installed under this Section:

.1 Division 22 – Plumbing:

.1 Temperature Sensor Wells and Sockets.

.2 Division 23 – Heating, Ventilation, and Air Conditioning:

.1 Control Valves.

.2 Flow Switches.

.2 Products not furnished or installed under but integrated with the work of this Section:

.1 Division 23 – Heating, Ventilation, and Air Conditioning:

.1 Variable frequency drives.

.3 Work Scope by Control Contractor (Division 23):

.1 All control system components to make a complete and operable system, except those supplied as part of packaged equipment controls, but including all auto-sequencing devices and electrical interlocks required to accomplish the sequences specified. Refer to the electrical equipment schedule, the electrical drawings, and the electrical specification, which describes the limits of the extent to the work in Division 26 serving mechanical systems. Materials, equipment, connections, and power not provided by Division 26 but required for the Control System shall be provided under this section.

.2 All control circuit transformers (120/1/60 or 24/1/60 and as designated).

.3 All control wiring and metallic conduit for mechanical system controls.

.4 Supply, installation, and connection of all electric control items including: control valves, damper actuators, relays, control circuits, safety devices, electric thermostats, aquastats, flow switches, wiring to terminal strips, controllers, etc.

.5 All wiring and conduit from power distribution system to any control devices needing power (including B.M.S components)

.6 Be responsible for coordinating with Division 26.

.7 Electrical work installed under Division 23 shall be to the standards specified under Division 26.

1.5 Submittals

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

.2 Provide submittals on all hardware and installation. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent. Provide drawings as files on optical disk (file format: .dwg, .dxf, pdf, or comparable). When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall include a complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data and the following:

.1 Manufacturer's description and technical data, product specification sheets, and installation/maintenance instructions for:

.1 Thermostats.

.2 Actuators.

.3 Valves.

.4 Relays/Switches.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Flow Switches

.1 Flow-proving switches shall be either paddle or differential pressure type, as shown.

.2 Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.

.3 Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.

.4 Provide vapour tight enclosure for chilled water applications.

2.3 Voltage Transformers

.1 AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection.

.2 Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ±0.5% accuracy at 24 VAC and a 5 VA load.

.3 Windings (except for terminals) shall be completely enclosed with metal or plastic material.

2.4 Differential Pressure Switches

.1 Differential Pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

.2 Sensors shall have the following pressure and accuracy ratings:

.1 Low and medium steam sensors shall be rated at 1030 kPa. Low pressure shall operate from 0 to 207 kPa with an accuracy of plus or minus 3 kPa. Medium pressure shall operate from 0 to 700 kPa and with an accuracy of plus or minus 7.0 kPa.

.2 High pressure steam sensors shall be rated at 2100 kPa, have a full operating range of 0 to 2100 kPa with an accuracy of plus or minus 14 kPa.

.3 Pressure switches for pump operation shall have a range of 20 kPa to 350 kPa and adjustable differential from 1 kPa to 35 kPa.

.4 Pressure switches for fan operation shall have a range of 0 to 1500 Pa and adjustable differential from 10 to 50 Pa.

.5 Sensors on steam lines and high temperature water shall be protected by pigtail siphon installed between the sensor and the fluid line.

.6 All sensors shall have an isolation valve and snubber installed between the sensor and pressure source.

2.5 Control Relays

.1 Control pilot relays: equal to Johnson Controls Inc. or Lectro modular plug-in design with snap-mount mounting bases, retaining springs or clips, DPDT, 3 PDT or 4 PDT as required for the application, with contacts rated for 10 amperes at 120 VAC.

2.6 Control Valves and Operators

.1 All control valve operators are to be spring return type for fail safe operation, sized to tightly shut the control valves against differentials imposed by system, equipped with position indicators, and suitable in all respects for environment in which they are located.

.2 Unless otherwise indicated, control valves for proportional operation are to have equal percentage characteristics, and control valves for open/shut 2-position operation are to have straight line flow characteristics. All valves are to have position indicators. Valves for outdoor applications must be suitable in all respects for the application.

.3 Heating valves are to be normally open unless otherwise specified.

.4 Cooling valves are to be normally closed unless otherwise specified

.5 Electric valve operators are to be equal to Belimo "EF Series" enclosed reversible gear type operators that can accept modulating control signals as required. Each is to be 1-phase AC, 120 or 24 volt as required or indicated, overload protected, and complete with an enclosure to suit the mounting location.

2.7 Wiring and Raceways

.1 General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 26.

.2 All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

3. EXECUTION

3.1 Verification of Conditions

.1 Verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for electric and electronic control systems installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate.

.2 Inform the Consultant of unacceptable conditions immediately upon discovery.

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

3.2 General Installation

.1 On outside wall, mount thermostats on bracket or insulated pad 25 mm from exterior wall.

.2 Install remote sensing device and capillary tube in metallic conduit. Conduit enclosing capillary tube must not touch heater or heating cable.

3.3 Wiring

.1 All control and interlock wiring shall comply with national and local electrical.

.2 All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.

.3 All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.)

.4 Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.

.5 All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage— shall be installed in raceway at levels below 3 m (10 ft).

.6 Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

.7 Do not install wiring in raceway containing tubing.

.8 Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.

.9 Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

.10 All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

.11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

.12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

.13 All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

.14 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

.15 Size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

.16 Include one pull string in each raceway 2.5 cm (1 in.) or larger.

.17 Use coded conductors throughout with conductors of different colors.

.18 Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

.19 Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

.20 Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

.21 Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

.22 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

.23 The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

.24 Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than 12mm (½"). Electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

.25 Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.4 Flow Switch

.1 Install in upright position in horizontal run of pipe.

.2 Install a minimum of 5 pipe diameters downstream of any valves, elbows, orifices or any other obstructions.

.3 Adhere to manufacturer's installation recommendations.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Factory-assembled open circuit cooling tower(s) of induced draft design with vertical air discharge.

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 Common Work Results for Mechanical.

.3 Section 23 05 01 Acceptable Manufacturers.

.4 Section 23 05 14 Variable Frequency Drives.

.5 Section 23 05 33 Heat Tracing for Mechanical Piping and Tanks.

.6 Section 23 05 48 Vibration and Seismic Control for Mechanical.

.7 Division 25 - Integrated Automation.

1.3 References

.1 The latest revisions of the following standards shall apply unless noted otherwise.

.1 Applicable Building Code - Refer to Section 21 05 01 – Common Work Results for Mechanical.

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

.1 ASTM A123/A123M-17, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

.2 ASTM A153/A153M-16a, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

.3 ASTM A653/A653M-20, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

.4 ASTM A666-15, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

.5 ASTM B117-18, Standard Practice for Operating Salt Spray (Fog) Apparatus.

.6 ASTM E84-19b, Standard Test method for Surface Burning Characteristics of Building Materials.

.3 American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE):

.1 Guideline 12 [2020] – Managing the Risk of Legionellosis Associated with Building Water Systems

.2 Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings

.3 Standard 188-2018, Legionellosis: Risk Management for Building Water Systems

.4 Cooling Technology Institute (CTI)

.1 CTI ATC-105-2019, Acceptance Test Code.

.2 CTI ATC-105S-2011, Acceptance Test Code for Closed Circuit Cooling Towers.

.3 CTI STD-201RS-2019, Standard for the Certification of Water Cooling Tower Thermal Performance.

.4 CTI STD-201OM-2019, Operations Manual for Thermal Performance Certification of Evaporative Heat Rejection Equipment.

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

.1 Material Safety Data Sheets (MSDS).

.6 Underwriters Laboratories' of Canada (ULC)

.1 CAN/ULC-S102-[18], Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

.7 National Electrical Manufacturers Association (NEMA)

.1 NEMA MG 1-[2016], Motors and Generators.

1.4 Submittals

.1 For each cooling tower provide shop drawings that indicate:

.1 Rated capacities, pressure drop, fan performance and rating curves.

.2 Outline dimensions, connection points, and corner weights.

.3 Manufacturers recommended clearances.

.4 Customer connection and power wiring diagrams.

.5 Complete technical product description include a complete list of options provided.

.6 Sound curves and characteristics of sound attenuators if required to meet the noise criteria.

.7 Seismic Certification and Installation requirements.

.8 Any portions of this specification not met must be clearly indicated on a separate page and cross-referenced to the specification or the supplier and contractor shall be liable to provide all additional components required to meet this specification.

.2 Quality assurance submittals: submit following in accordance with Section [01 33 00 - Submittal Procedures].

.1 Test reports:

.1 Submit certified test reports for cooling towers from approved independent testing laboratories, indicating compliance with specifications for specified performance characteristics and physical properties.

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

.3 Instructions: submit manufacturer's installation instructions.

.4 Manufacturer's Field Reports: manufacturer's field reports specified.

.3 Closeout submittals:

.1 Submit all maintenance and test schedules and reviewed shop drawings for incorporation into manual specified in Section 21 05 01 – Common Work Results for Mechanical.

.2 Include:

.1 Description of equipment giving manufacturers name, type, model year, capacity.

.2 Start-up and commissioning procedures.

.3 Details of operation, servicing and maintenance.

.4 Recommended spare parts list.

1.5 Performance Requirements

.1 The open circuit cooling tower(s) shall comply with the energy efficiency requirements of ASHRAE Standard 90.1.

.2 The open circuit cooling tower(s) shall be warranted by the manufacturer to meet the capacity requirements as scheduled on the drawings.

1.6 Performance Warranty

.1 The performance shall be certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201 or, lacking such certification, a field acceptance test shall be conducted within the warranty period in accordance with CTI Acceptance Test Code ATC-105, by the Cooling Technology Institute, or other qualified independent third party testing agency.

.2 Manufacturers' performance guarantees or performance bonds without CTI Certification of water ratings shall not be accepted.

1.7 Warranty

.1 The complete cooling tower shall be warranted for one (1) year.

.2 Rotating mechanical equipment, including fans, fan motors, fan shafts, bearings, sheaves, and associated supports shall be warranted for not less than five (5) years.

1.8 Quality Assurance

.1 The manufacturer shall have a Management System certified by an accredited registrar as complying with the requirements of ISO-9001 to ensure consistent quality of products and services. Manufacturers that are not ISO-9001 certified shall not be acceptable.

1.9 Design Loading

.1 The tower structure, anchorage and all its components shall be designed by licensed professional engineers, employed by the manufacturer, per the applicable building code, identified in Section 21 05 01 – Common Work Results for Mechanical, to withstand a wind load of 1436 Pa (30 psf), a .3g seismic load, shipping and hoisting loads.

.2 The fan deck, hot-water basin covers and, where specified, maintenance platforms shall be designed for a minimum of 2872 Pa (60 psf) live load or a 90 kg (200 lb) concentrated load.

.3 Guardrails, where specified, shall be designed in accordance with OSHA guidelines.

1.10 Maintenance

.1 Furnish following spare parts: basic recommended spare parts and parts to consider if extended downtime is a concern.

.2 Furnish spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 8 months prior to date of occupancy.

.3 Include with data complete list of parts and supplies, with current unit prices, source of supply, recommended spare parts list for 1 year of operation, and list of parts recommended by manufacturer to be replaced on routine basis.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 General

.1 Conform in all aspects to the specifications and schedules as shown on the plans. Overall dimensions shall not exceed those indicated on the plans. If total connected fan horsepower exceeds the scheduled values, this Contractor shall be responsible for all costs associated with any electrical upgrades to support the change.

2.3 Size and Weight

.1 Dimensions: as scheduled on drawings.

.2 Operating weight: as scheduled on drawings.

2.4 Open Circuit Cooling Towers with Induced Draft Design

.1 General:

.1 Provide as indicated, factory-assembled open circuit cooling tower(s) of induced draft counterflow design with vertical air discharge. Tower(s) shall be shipped to site in a knock down configuration for assembly on site.

.2 Tower Construction:

.1 Unless otherwise specified, metal components, including support structure, casing, and nuts, bolts and fasteners constructed of G-235 hot-dipped galvanized steel complying with ASTM A653/A653M, with cut edges given a heavy factory coat of zinc-rich compound.

.2 Fasteners: 304 stainless steel bolts or tapping screws for assembly. Use stainless steel washers with neoprene backing where required for preventing leaks.

.3 Tower structure constructed using double-brake flanges with water-tight joints.

.4 Fan(s) and drive system, including motor, factory mounted and aligned and located in dry entering air stream.

.5 The heat transfer section(s) shall consist of a fill, spray water distribution system and drift eliminators arranged for optimal thermal performance with minimal drift.

.3 Water Distribution System:

.1 Water shall be distributed evenly over the fill by a water distribution system consisting of a header and branch spray piping with nozzles providing overlapping, umbrella spray patterns, and all secured in place by means of snap-in removable rubber grommets.

.2 Piping: Schedule 40 PVC pipe.

.3 Nozzles: large orifice non-clog stainless steel nozzles.

.4 Fill and Eliminators:

.1 Fill: vertical sheets of PVC or chevron configuration of film type PVC.

.2 The fill shall be formed from self-extinguishing (per UL94 HB and UL94 V-0 testing) polyvinyl chloride (PVC) having a flame spread rating of 5 per ASTM E84 and shall be impervious to rot, decay, and fungus or biological attack. The fill shall be manufactured and performance tested by the cooling tower manufacturer to assure single source responsibility and control of the final product.

.3 Eliminators: Eliminators shall be constructed of specially formulated PVC and be removable in easily handled sections. They shall have a minimum of three changes in air direction.

.5 Cold Water Basin:

.1 Constructed of heavy-gauge Type 304 stainless steel panels and structural members up to the heat transfer section/basin joint and complete with:

.1 Large area lift out strainers, constructed of same material as basin, with perforated openings sized smaller than the water distribution nozzles;

.2 Anti-vortexing device, constructed of same material as basin, to prevent air entrainment;

.3 Corrosion resistant slow-acting water make-up valve with polystyrene filled plastic float for adjustment of the operating water level;

.4 Circular access doors for access to strainer and water make-up valve assembly;

.5 Required pipe connections.

.6 Fan(s):

.1 Forward curved, statically and dynamically balanced centrifugal type fan(s) with housings equipped with curved inlet rings and -sided rectangular discharge cowls which extend into water basin to prevent water from splashing into fan(s).

.2 Fan and shaft of each tower shall be supported by heavy-duty, self-aligning, relubricatable bearings with cast iron housings, designed for a minimum L10 life of 40,000 hours. Lubrication fittings shall be readily accessible outside the wet air stream. Provide access doors for inspection and cleaning.

.3 The fan(s) shall be driven by matched V-belts with taper lock sheaves designed for not less than 150% of the motor nameplate horsepower. Motor shall be located on a heavy-duty motor base, adjustable by a single threaded bolt-and-nut arrangement. Removable galvanized steel screens or panels shall protect the fan drive and all moving parts.

.7 Variable Frequency Drive (VFD):

.1 In accordance with requirements specified in Section 23 05 14 Variable Frequency Drives, supplied with tower by tower manufacturer/supplier, and complete with:

.1 Solid state, PID temperature controller to adjust frequency output of drive in response to tower cold water temperature, and temperature of cold water displayed on VFD door;

.2 Communication protocol to interface with building automation system;

.3 Bypass contactor to be cycled on/off while operating in bypass to maintain set-point temperature of cold water;

.4 Operator controls mounted on front of enclosure and consisting of start and stop push button, bypass/VFD selector switch, auto/manual selector switch, manual speed potentiometer, and solid state temperature controller;

.5 Cycle motor on/off when the minimum allowable motor speed is reached to prevent motor overheating problems.

.8 Power and Control Panel:

.1 Factory pre-wired panel provided with a loose spray pump starter, consisting of a surface wall mounting enclosure (NEMA 2 for indoor and NEMA 4X for outdoor) and equipped with:

.1 Lockable main power disconnect switch;

.2 Main power "on" indicator light;

.3 Basin heater control:

.1 "Off/Auto" selector switch;

.2 "On" indicator light;

.3 Basin heater contactor;

.4 120V heater control power transformer;

.4 Spray pump "H-O-A" selector switch;

.5 Spray pump "on" indicator light;]

.6 Damper "H-O-A" selector switch;

.7 Damper "open" indicator light;

.8 Integral Honeywell T775 (or similar) multi-output controller to stage components;

.9 Ability to provide power to VFD;

.10 Separate enclosed thermostatic temperature controller, with a pipe mounting temperature sensor with well supplied loose for field installation;

.11 An across-the-line protected type magnetic contactor for each motor speed;

.9 Guarding:

.1 Handrail, kneerail and toeboard around perimeter of top of tower, designed and constructed in accordance with local governing occupational health and safety Standards, Regulations and Guidelines, and capable of withstanding a 890 N concentrated live load in any direction, and a vertical 450 mm (18") wide aluminum ladder with 75 mm (3") I-beam side rails and 32 mm (1-¼") diameter rungs permanently attached to tower casing and extended up from base of tower to top of handrail.

.2 Ladder extension constructed as for access ladder, and of a length to extend from roof or grade (as applicable) to base of tower for connection to access ladder.

.10 Accessories:

.1 Weatherproof vibration isolation rails, zinc coated after fabrication, designed for a 25 mm (1") static deflection and a maximum wind speed of 80 km/h (50 miles/hr), factory supplied loose with tower and conforming to requirements specified in Section 23 05 48 Vibration and Seismic Control for Mechanical.

.2 Suitable seismic restraint anchoring connection hardware factory installed on tower to suit requirements of Section 23 05 48 Vibration and Seismic Control for Mechanical.

.3 Basin Heater: One or more stainless steel electric immersion heaters complete with low water cutout and thermostat, installed in threaded couplings and secured in place in the side of the cold water basin, and capable of maintaining 4.4°C (40°F) water temperature in basin with a -26°C (-15°F) ambient temperature and a wind velocity of 25 km/h (15.5 miles/hr). The heater(s) shall be provided with low water cutout and thermostat. Refer to drawing schedule for capacities.

3. EXECUTION

3.1 Tower Installation

.1 Unit to be installed as indicated and to manufacturers recommendations, ensuring adequate clearances for servicing and maintenance.

.2 Comply with Section 23 05 48 Vibration and Seismic Control for Mechanical.

.3 Provide support steel frame under cooling tower(s) as required to facilitate installation and comply with vibration and seismic measures.

.4 Unless otherwise noted, all wiring between the respective disconnect switch and the electrical device shall be by cooling tower manufacturer.

.5 Ensure manufacturers field service representative approves installation and is present to supervise start up and to instruct operators.

3.2 Piping Installation

.1 Install piping, including flanges or union adjacent to cooling towers to allow for service and maintenance.

.2 Install flexible pipe connectors at connections to cooling towers mounted on vibration isolators.

.3 Install shutoff/balancing valves at cooling tower inlet connections.

.4 Install piping adjacent to cooling towers to allow service and maintenance.

.5 Provide drain piping with valve at cooling tower drain connections and at low points in piping.

.6 Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

.7 Domestic Water Piping: Comply with applicable requirements in Section 22 11 16 Domestic Water Piping. Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.

.8 Supply and Return Piping: Comply with applicable requirements in Section 23 21 13 Hydronic Piping. Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union.

.9 Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

3.3 Startup and Testing

.1 Provide the services of a factory-authorized and qualified representative to perform start up service.

.2 Clean entire unit including basin.

.3 Inspect field-assembled components and equipment installation, including piping and electrical connections.

.4 Verify that accessories are properly installed.

.5 Obtain and review performance curves and tables.

.6 Perform startup checks, according to manufacturer's written instructions, and as noted below:

.1 Check clearances for airflow and tower servicing.

.2 Check for vibration isolation and structural support.

.3 Verify fan rotation for correct direction and for vibration or binding and correct problems.

.4 Adjust belts to proper alignment and tension.

.5 Lubricate rotating parts and bearings.

.6 Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.

.7 Check vibration switch setting. Verify operation.

.8 Verify operation of basin heater and control.

.9 Operate equipment controls and safeties.

.10 Verify that tower discharge is high enough and it does not recirculate into HVAC air intakes. Recommend corrective action.

.7 Adjust water level for operating level and balance condenser water flow to each tower inlet.

.8 Check water treatment water system, including blow down for proper operation of the tower. Refer to Specification Section 23 25 00 HVAC Water Treatment. Check makeup water-level control and valve.

.9 Start cooling tower, including condenser water pumps and verify the tower operation.

.10 Prepare and submit a written report of startup and inspection service to the mechanical consultant.

.11 Replace defective and malfunctioning units.

3.4 Performance

.1 Control electric sump heaters from sump-mounted thermostat and interlock with float control so heaters will operate only when there is water in sump.

.2 Provide time delay relay to limit fan motor starts to maximum of 6 per hour.

.3 Capacity control for unit suitable for stable operation down to 10% of rated cooling.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 A description of the sequence of operation for each system, including ramping periods and reset schedules.

1.2 Related Requirements

.1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.

.2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 General

.1 The control sequences contain a general description of the operational intent for the systems to be controlled. The Contractor shall review individual systems to ensure equipment and life safety interlocks are not overridden.

.2 The controls contractor shall be Ainsworth.

.3 Existing control sequences to remain. Controls contractor to commission and verify the controls sequences.

.4 Where existing devices are re-used, verify operation and re-calibrate as required.

.5 Report any existing control device which need replacement. Replacement will be by building management or via change order, at the discretion of the owner.

.6 Refer to control diagrams and equipment schedules in the contract drawings for additional requirements. Refer to Mechanical Motor list and points list in the contract drawings, and detailed specification sections for additional requirements.

.7 The Controls Contractor shall provide all necessary programming and equipment required to meet this sequence of operation.

.8 Contractor shall not remove or override any manufacturer's safeties.

.9 Note that the sequences in this section outline overall operational intent. Coordinate all interface requirements with equipment for the sequences in this section to be successfully executed.

.10 Consult with the Mechanical Consultant during the shop drawing stage to finalize the control sequences for each system. The controls contractor shall submit the final sequence of operation during shop drawing phase.

1.4 Abbreviations

.1 The following abbreviations may be used in graphics, schematics, point names, and other control applications where space is at a premium.

AC	Air Conditioning	CHW	Chilled Water
ACU	Air Conditioning Unit	CHWP	Chilled Water Pump
AHU	Air Handling Unit	CHWR	Chilled Water Return
AI	Analog Input	CHWS	Chilled Water Supply
AO	Analog Output	COND	Condenser
AV	Analog Value	CW	Condenser Water
AVG	Average (mean)	CWP	Condenser Water Pump
AUTO	Automatic	CWR	Condenser Water Return
AUX	Auxiliary	CWS	Condenser Water Supply
C	Common	DA	Discharge Air

DI	Digital Input
DO	Digital Output
DV	Digital Value
EA	Exhaust Air
EF	Exhaust Fan
EVAP	Evaporator
FCU	Fan Coil Unit
HOA	Hand / Off / Auto
HP	Heat Pump
HRU	Heat Recovery Unit
HTEX	Heat Exchanger
HW	Hot Water
HWP	Hot Water Pump
HWR	Hot Water Return
HWS	Hot Water Supply
MAX	Maximum
MIN	Minimum
MISC	Miscellaneous
N/C	Normally Closed
N/O	Normally Open
OA	Outdoor Air
OAT	Outdoor Air Temperature
OAH	Outdoor Air Humidity
PIU	Powered Induction Unit
RA	Return Air
RF	Return Fan
RH	Relative Humidity
RTU	Roof-top Unit
SA	Supply Air
SF	Supply Fan
SP	Static Pressure
TEMP	Temperature
UH	Unit Heater
UV	Unit Ventilator
VAV	Variable Air Volume
VVTU	Variable Volume Terminal Unit
W/	With
W/O	Without
WSHP	Water Source Heat Pump

1.5 Programming Requirements

.1 Provide all programming required to implement the control sequences and to make system operational, as well to meet design intent.

.2 Programs shall be modular in nature and shall be as structured as the language will permit.

.1 Unconditional “GOTO” statements shall be used sparingly and shall always jump forwards. All jumps from the body of a module shall target the end of that module. Similarly, jumps from the body of a sub-module shall target the end of that sub-module.

.2 All conditional "GOTO" statements, which make a single choice from multiple choice sub-module options, shall form the opening lines of code of the module. Each succeeding conditional jump shall direct the execution of software to the relevant sub-module, which shall be in the reverse order of the conditional jump statement. The exit from each sub-module shall jump to the end of the module.

.3 All conditional "GOTO" statements, for "AND"/"OR" choices between sub-modules, shall form the opening line of code in each sub-module which the conditional statement controls.

.4 Do not use double negatives in programming language.

.3 All programs must include a sufficient number of comments to allow another person to make changes to the strategies at a later time.

.4 Additional programming may be provided by the Contractor as desired, so long as it does not affect the intended operation of the specified sequences. Ensure that all equipment will operate in a safe manner.

.5 Programming required for equipment safety may be installed by the Contractor as necessary. The Owner shall be notified of these changes as soon as practical.

.6 All deviations from the specified programming, except those related to equipment safety, must receive prior written approval from the Mechanical Consultant.

.7 All control loops shall be tuned such that they are stable through all seasons and operating conditions including start-up.

.8 All HVAC controls shall implement Building operating modes. Unit system description is modifications to the Building operation modes.

.9 Staggered starting:

.1 Motors must not be allowed to start at the same time. Under all conditions of start-up, return from power failure or panel reset, there must be at least a 15 second delay between the time one motor starts and another is allowed to start.

.10 Motor and equipment status:

.1 All mechanical equipment motors that are enabled by the BMS shall be provided with status and alarm indication by a current sensor. This includes all pumps, fans, and electric motor driven devices.

.2 Equipment status may also be indicated by flow switches as an alternate status indication, with prior acceptance by the Consultant, or where specifically indicated in the Contract Documents.

.3 Exclude small unitary bathroom exhaust fans, domestic range hoods and manually operated fans and devices, unless noted otherwise.

.4 Current sensors shall provide status and an out of range alarm.

2. PRODUCTS

.1 Refer to Section 25 09 01 – Control Systems.

3. EXECUTION

3.1 Building Operating Modes

.1 The existing building operation modes are to remain.

.2 Four operating modes are required: Purge, Occupied, Unoccupied, and Fire. Mode flags are required for the purge, occupied and fire modes. By definition, unoccupied mode occurs when both purge and occupied mode flags are not set (i.e. off).

.3 An optimum start routine shall be used to determine when the air systems are to begin operation such that adequate comfort conditions are reached just before occupancy begins.

.4 Occupied Mode:

.1 The beginning and ending time of this mode shall be determined by a weekly schedule. An annual holiday schedule shall be used to bypass statutory holidays.

.2 One weekly/annual schedule is required. Required flags: OCCUP (units yes/no).

.3 During this mode, all spaces within the building are to be at occupied comfort conditions. Air systems are to be running. Heating and cooling are to be used as required.

.4 The optimum start routine enables the occupied mode flag prior to scheduled occupancy. This allows the air systems to condition the spaces such that they are comfortable at the time of scheduled occupancy.

3.2 Variable Frequency Drive (VFD) Interface

.1 All variable frequency drives (VFDs) shall be native BACnet.

.2 The VFD interface shall be connected directly to the main BMS network trunk to monitor, display, trend ad report the following minimum points. VFD interface shall not be networked indirectly to the main BMS through equipment controllers:

.1 Speed Output

.2 Hand / Auto selection indication

.3 Drive Amps

.3 kW (compare instantaneous value, the connected motor nameplate HP/kW (constant) and the ratio).

.1 kWh

.2 Operating hours

.3 Warnings

.4 Faults

.4 The following points shall be hardwired to the BMS independently of Serial Communications interface so they can be monitored in the event network connection has failed.

.1 VFD Start/Stop

.2 VFD speed and feedback

.3 VFD Fault

3.3 Heat Trace

.1 Heat Trace is to be provided with integral control for thermostatic control based on OAT and pipe surface temperature.

.2 Points List:

.1 Provide all hardware and software points required to achieve the specified sequence, generally matching existing points including, but not limited to, the following points:

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	DI	DO	AV	DV	Sched	Trend	Alarm	
Heat Trace Status			X					X		X
Alarm			X						X	X

3.4 Cooling Tower

.1 Cooling Tower Fan

.1 When condenser water return temperature rises 2 deg F (adj.) above the condenser water temperature setpoint, the cooling tower fan shall be enabled at minimum speed. The fan speed shall be modulated to maintain the condenser water temperature to its setpoint.

.2 The fan shall be disabled when; The fan is on minimum speed, and the cooling tower leaving water temperature falls to 5F (adj.) below condenser water temperature setpoint.

.3 Cooling tower fan shall have a three (3) minute (adj.) minimum on and off and speed change delays.

.4 Alarms:

.1 Failure: Commanded on, status is off

.2 Fan in Hand: Commanded off, status is on

.2 Cooling Tower Sump

.1 Sump heater shall be enabled when the tower's condenser water system flow is disabled, and the outdoor temperature is 3.3dC (38dF) or below. Sump heater shall maintain the sump temperature of 7.2dC (45dF)

.2 System shall monitor sump level sensor.

.3 Alarms:

.1 Low Sump temperature

.2 Low Water level

.3 High Water level

.3 Control Points

.1 Provide all hardware and software points required to achieve the specified sequence.

END OF SECTION