Group2
Architecture
Interior Design

Addendum No. 01

Drumheller Aquaplex Mechanical Upgrades

June 9, 2023
File No. 000c-1309-22

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This addendum forms part of, and will be included with, bidding documents for this project. No consideration will be given to requests for extra costs as a result of contractor being unfamiliar with this addendum. Acknowledge receipt of addendum in space provided in submitted tender.

1. Architectural

1.1 Specifications

.1 Section 00 00 10 – Project information:

.1 **Mandatory Pre-Bid Meeting:**

.1 See attached sign-in sheet from the Mandatary Pre-Bid Meeting. (1 page)

2. Mechanical

.1 Refer to attached Mechanical Addendum M-01 for mechanical specifications.

Addendum Pages: 1
Total Attached Pages: 206
Total Pages This Addendum: 207

End of Addendum

Group2
Architecture
Interior Design

Sign in Sheet
Drumheller Aquaplex Mechanical Updgrades

Pre-Bid Meeting
June 8, 2023, 10:00am
Drumheller, Alberta
File No. 23012

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DRUMHELLER AQUAPLEX MECHANICAL UPGRADE

PROJECT NO.: 000c-1309-22

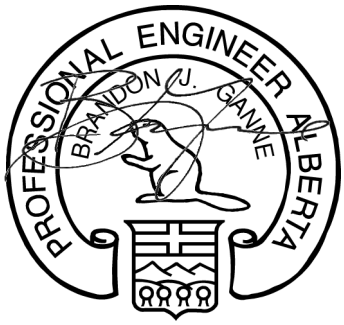
MECHANICAL SPECIFICATION

ISSUED FOR IFT/IFC

JUNE 6th, 2023

710 – 1122 4th St. SW
Calgary, AB T2R 1M1

T 403-252-2333



06/07/2023
APEGA ID: 227412

PROFESSIONAL'S SEAL & SIGNATURE

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

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

.2 Drawings and General Provisions of the Contract, including General and Supplementary Conditions, Division 00 and Division 01 Specification Sections apply to work specified in this section.

.3 Alberta Codes:

.1 National Building Code – 2019 Alberta Edition.

.2 National Fire Code – 2019 Alberta Edition.

.3 Alberta Boilers Safety Association (ABSA).

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

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

.1 Material Safety Data Sheets (MSDS).

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

1.3 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 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" – any person or entity retained by the Client or another Consultant to provide architectural or engineering services in connection with the Project, as those Persons may be substituted from time to time. The term Consultant includes a Consultant's authorized representative as defined in the Construction Manager's Agreement with the Client and as follow:

.1 The documents also make references to "the Architect", "the Engineer" or "the A/E"; these words have the same meaning as the defined term for Consultant as described above.

.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.

1.4 General Scope

.1 The scope of 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 and ductwork, furnished by Division 25.

1.5 Coordination of Work

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

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

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

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

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

1.6 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.

1.7 Examination of Site

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

1.8 Tender Price Breakdown

.1 Submit a tender price breakdown at tender closing and before first progress claim, in a format agreed to with the Consultant.

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

.1	Site Services:	Materials, labour
.2	Mechanical:	Equipment, materials, labour
.3	Plumbing:	Equipment, materials, labour
.4	Sheet Metal:	Equipment, materials, labour
.5	Fire protection:	Equipment, materials, labour
.6	Controls:	Equipment, materials, labour

1.9 Submittals

.1 Submittals shall be in accordance with Submittal Procedures, Closeout Procedures, and Closeout Submittals and the following:

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

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

.3 Shop drawings shall be reviewed by the General Contractor and Mechanical Sub-Contractor indicating that the shop drawings have been reviewed, coordinated with the work and that the shop drawings are submitted without qualifications. Shop drawings shall bear the 'reviewed' stamp dated and 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 fire stopping.

.3 Contractor shall provide and submit to the Consultant Schedule B-1: Letter of Commitment by the Registered Professional of Record; Schedule B-2: Summary of Design and Field Review Requirements; and Schedule C-2: Assurance of Professional Field Review and Compliance for fire protection engineering.

.4 Contractor shall provide and submit to the Consultant Schedule B-1: Letter of Commitment by the Registered Professional of Record; Schedule B-2: Summary of Design and Field Review Requirements; and Schedule C-2: Assurance of Professional Field Review and Compliance for fire stopping.

.5 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.

.6 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.

.7 Submit the following shop drawings stamped and signed by professional engineer registered or licensed in Province of Alberta.

.1 Fastening details for Seismic restraints.

.2 Mounting details for spring isolation of equipment.

.8 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.

.9 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.

.10 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.

.11 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 (letter format). If the original page is 11” x 17” (tabloid), the digital copy shall also be 11” x 17” (tabloid).

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

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

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

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

.8 Approvals:

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

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

.9 Warranties

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

.10 Additional data:

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

.2 Chemical treatment reports.

.3 Back-flow preventer test certificates.

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

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

.2 Site records:

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

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

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

.4 Make available for reference purposes and inspection.

.5 Before applying for a Certificate of Substantial Performance of the Work, update a clean copy of Contract Drawing set in accordance with marked up set of "as-built" white prints including deviations from original Contract Drawings, thus forming an "as-built" drawing set. Submit "as-built" site drawing prints to Consultant for review. Make necessary revisions to drawings as per Consultant’s comments, to satisfaction of Consultant.

.3 As-Built Drawings:

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

.2 Use final reviewed "as-built" drawing set to provide CAD/Revit files of drawings thus forming true "as-built" set of Contract Drawings. Identify set as "Project Record Copy". Load digital copies of final reviewed by Consultant as-built drawings onto USB type flash drive. Provide 2 complete sets of "as-built" drawings on separate USBs. Submit "as-built" sets of white prints and USBs to Consultant

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

.4 Submit to Consultant for approval and make corrections as directed.

.5 Perform testing, adjusting and balancing for HVAC using as-built drawings.

.6 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.

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

.8 Submit copies of as-built drawings for inclusion in final testing and balancing report.

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

1.10 Construction Detail Samples

.1 Samples of repetitive items encountered during the construction of this project are required to establish quality control.

.2 Samples shall be provided within 30 days of contract award or 14 days prior to installation on site of specific samples.

.3 Construction details are samples specifically required for this project and are required as follows:

.1 Ductwork Fittings - high pressure (including joints and sealer).

.2 Ductwork Fittings - low pressure (including joints and sealer).

.3 Fire damper installation (mounted in mock stud wall c/w breakaway duct section, 40" x 40" overall).

.4 Pipe sleeve installation - fire rated wall/floor.

.5 Pipe sleeve installation - non-fire rated wall.

.6 Pipe anchor and sleeve detail.

.7 Internal duct insulation c/w butt joints, open ended duct, high velocity and low velocity details.

.8 Pipe hangers.

.9 Typical seismic restraint details for equipment, ductwork and piping.

.4 Acceptance of the standard of the sample is strictly at the discretion of the Consultant.

.5 Once the quality of the sample has been accepted it shall establish the quality expected throughout the remainder of the project.

1.11 Spare Parts Submittals

.1 Furnish spare parts in accordance with Division 01 - Closeout Submittals and as follows:

.1 One set of packings for each pump.

.2 One casing joint gasket for each size pump.

.3 One head gasket set for each heat exchanger.

.4 One set of V-belts for each piece of machinery.

.5 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.

.2 Additional spare parts shall also be included as outlined in their appropriate sections.

.3 Provide one set of special tools if required to service equipment as recommended by manufacturers.

1.12 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.

1.13 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.

1.14 Drawings and Specifications

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

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

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

1.15 Cutting, Patching and Coring

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

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

.3 Perform x-rays and obtain written approval from the Structural Consultant before cutting or burning structural members. Use of Ground Penetration Radar (GPR) method to locate concealed electrical conduit, structural re-bar, post-tension cables, etc. is also acceptable.

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

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

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

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

1.16 Excavation and Backfill

.1 Refer to the requirements of Division 31.

.2 Provide all excavating to facilitate installation of the mechanical work to suit a structural slab, including shoring, pumping, hangers, insulation, void form, and backfill over piping and ducting.

.3 Refer to structural and mechanical drawing details as applicable.

1.17 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.

1.18 Connections to Existing Services

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

.2 Major services shall not be interrupted before all preparatory work is completed and all required materials are on site. Provide a minimum of 48 hours' notice for all service shutdowns. Allow for major service interruptions outside of normal operating hours of the facility.

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

.4 The local Fire Department shall be advised of any shut down or disruption of the fire suppression systems.

1.19 Equipment and Materials

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

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

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

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

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

1.20 Pressure Piping

.1 For regulations for the design registration, under specific requirements, of pressure piping systems and components that convey an expansible fluid or non-expansible fluid between two points refer to Alberta Safety Codes Act Pressure Equipment Safety Regulation.

1.21 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.

1.22 Delivery, Storage and Handling

.1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements, the manufacturer's written instructions and the following:

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

.3 Storage and Handling Requirements:

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

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

.3 Replace defective or damaged materials with new.

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

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

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

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

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

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

.10 Develop a Construction Waste Management Plan or Waste Reduction Work plan as related to Work of this Section in accordance with Division 01 - Waste Management and Disposal and Division 01 - LEED Requirements.

.11 Packaging Waste Management

.1 Remove for reuse and return pallets, crates, padding, packaging materials etc. as specified in the Construction Waste Management Plan or Waste Reduction Work plan in accordance with Division 01 - Waste Management and Disposal and Division 01 - LEED Requirements.

1.23 Fire Stopping and Smoke Seals

.1 Provide fire stopping and smoke seals in accordance with Division 07 – Fire Stopping and Section 22 07 11. If the requirements for fire stopping of mechanical services penetrations of Section 22 07 11 differ from the requirements of Division 07, the most stringent requirements shall apply.

1.24 Access Doors

.1 General

.1 Provide access doors for maintenance or adjustment of all parts of the mechanical system. This shall apply but not be limited to valves, dampers, cleanouts and controls. Finish and colour to match adjacent.

.2 Where equipment is concealed by a T-bar ceiling, the location of equipment shall be indicated by coloured markings. Refer to Section 23 05 53 Identification for Mechanical Piping and Equipment.

.3 Where equipment is concealed by a continuous structural or architectural surface, supply access doors of design to suit and match the surface in which they will be installed.

.4 Provide stainless steel doors in walls of washrooms, kitchen, janitor rooms and laundry rooms.

.5 Provide Drywall type access doors in all public drywall spaces requiring access to equipment.

.6 All fasteners on access panels shall be tamper proof, contractor shall provide three (3) sets of keys.

.7 Locate all access doors outside of secure areas where possible. Where not possible, review the locations of panels with the Owner’s Consultant prior to installation. All access panels within secure areas are to be of penal quality, lockable, vandal-proof and ligature resistant.

.8 Provide 300 mm x 300 mm minimum size for inspection and hand access.

.9 600 mm x 600 mm minimum size, larger if indicated on drawings, where entry is required and access is difficult.

.10 Size to suit masonry modules when located in a masonry wall.

.11 When located in a finished floor with tile, stonework, terrazzo, etc., a recessed bearing type access door is required. The door surface shall have a recess to take the particular surface material and pattern if this is available at the time the units are ordered.

.12 Security Access Doors:

.1 Access doors for security areas shall be 1.70 mm [14 gauge] thick double skinned internally reinforced at 150 mm [6"] on centre, 4.76 mm [3/16"] thick, insulated in pressed sink wiped cold rolled steel metal frame (similar to door frame) complete with necessary preparation to receive security lock escutcheon and hinges.

.2 Submittals:

.1 Submit shop drawings for all access doors anticipated on this project.

1.25 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.

1.26 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.

1.27 Pipe Sleeves

.1 Pipe sleeves shall be provided for piping passing through walls and floors. Minimum schedule 40 steel pipes or factory fabricated, flanged, high-density polyethylene sleeves with reinforced nail bosses. Sleeves shall extend 25 mm on either side of the wall.

.2 Schedule 40 steel pipes shall be used as floor pipe sleeves in wet areas with a 50 mm up-stand.

.3 Review and coordinate sleeve diameters with fire stop installation details as applicable.

.4 Pipe sleeves are not required where pipes pass through cored concrete walls or floors.

.5 Provide concrete curbs in mechanical spaces.

1.28 Water Proofing Materials

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

.2 Acceptable products are:

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

.2 The Metraflex Co. "MetraSeal" type ES

1.29 Escutcheons and Plates

.1 Provide escutcheons and plates on all piping and ductwork passing through finished walls, floors and ceilings.

.2 Escutcheons shall be one piece, stainless or chrome plated steel.

1.30 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.

1.31 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.

1.32 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.

1.33 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.

1.34 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.

1.35 Instruction to Owner

.1 Refer to equipment and system operational and maintenance training requirements specified in Division 01.

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

.3 Unless where specified otherwise in trade Sections, minimum requirements are for manufacturer/suppliers of each system and major equipment, to provide minimum two separate sessions each consisting of minimum 4 hours on site or in factory training (at Owner’s choice), of Owner’s designated personnel, on operation and maintenance procedures of system.

.4 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Use Operating and Maintenance Manuals during training sessions. Training modules include but are not limited to:

.1 Operational Requirements and Criteria – equipment function, stopping and starting, safeties, operating standards, operating characteristics, performance curves, and limitations;

.2 Troubleshooting – diagnostic instructions, test and inspection procedures;

.3 Documentation – equipment/system warranties, and manufacturer's/supplier's parts and service facilities, telephone numbers, email addresses, and the like;

.4 Maintenance – inspection instructions, types of cleaning agents to be used as well as cleaning methods, preventive maintenance procedures, and use of any special tools;

.5 Repairs – diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.

.5 Before instructing Owner's designated personnel, submit to Consultant for review preliminary copy of training manual and proposed schedule of demonstration and training dates and times. Incorporate Consultant's comments in final copy.

.6 Obtain in writing from Owner a list of Owner's representatives to receive instructions. Submit to Consultant prior to application for Certificate of Substantial Performance of the Work, complete list of systems for which instructions were given, stating for each system:

.1 Date instructions were given to Owner's staff;

.2 Duration of instruction;

.3 Names of persons instructed;

.4 Other parties present (manufacturer's representative, consultants, etc.).

.7 Obtain signatures of Owner's staff to verify they properly understood system installation, operation and maintenance requirements, and have received operating and maintenance instruction manuals and "as-built" record drawings.

1.36 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.

1.37 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 Final Gas Inspection Certificate from the Authority having Jurisdiction.

.3 Schedule C-2 for Fire Suppression.

.4 Fire alarm test certificate (via DIV.26).

.5 Schedule C-2 for fire stopping work.

.6 Final Backflow Prevention test reports for all backflow devices.

.7 Commissioning checklists are completed and submitted as per Division 01.

.8 Fire stopping and Fire Damper test letter.

.9 Vibration isolation supplier's inspection report.

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

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

.12 Major equipment – suppliers start-up test sheets and letters certifying start up (Boilers, chillers, packaged equipment).

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

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

.15 Air and water systems have been balanced with draft report submitted to the Consultant.

.16 Mechanical identification is complete.

.17 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.

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

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

.20 As-built drawings have been submitted.

.21 Fan plenums have been cleaned, and temporary filters have been replaced with permanent filters.

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

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

.1 Submit final air and water balance reports.

.2 Submit final operating and maintenance manuals.

.3 Complete final calibration.

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

.5 The Contractor shall provide qualified personnel in appropriate numbers to operate the facility's mechanical equipment until substantial performance is declared and automatic operation has been confirmed.

1.38 Alternate Materials and Equipment

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

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

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

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

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 73 11

2.2 Existing Services

.1 Disconnect and cap all mechanical services in accordance with requirements of the authority having jurisdiction. Natural gas supply lines shall be removed by the local gas company or by a qualified tradesman in accordance with gas company instructions.

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

.3 Maintain all trap seals and cap open-end pipe to ensure no sewer gas enters the building during renovations or demolition work. Maintain all existing sewer piping in a wet condition daily.

2.3 Fire Stopping and Smoke Seals

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

2.4 Access Doors

.1 Drywall Surface: Extruded aluminum frame with gypsum board inlay and structural corner elements. Hinge to be concealed 2-point hinge, non-corroding with screwdriver operated cam latch.

.2 Masonry Surface: Universal design, steel door (16ga) and steel frame (18ga), door flush to frame, rounded safety corners, continuous concealed hinge, screwdriver operated cam latch, prime coat grey painted finish.

.3 Tile Surface: Universal design, stainless steel door (16ga) and stainless steel frame (18ga), door flush to frame, rounded safety corners, continuous concealed hinge, screwdriver operated cam latch, #4 satin stainless steel finish.

.4 Plaster Walls and Ceiling: steel door (14ga) and steel frame (14ga), door flush to frame edge, expansion casing bead and 75 mm wide galvanized lath surround recessed 18 mm to receive plaster, continuous concealed hinge, screwdriver operated cam latch, prime coat grey painted finish.

.5 Acoustic Plaster: Steel door (16ga) and steel frame (14ga), door recessed 12 mm lined with self-furring lath, 75 mm wide galvanized lath surround recessed 18 mm to receive plaster flush to frame edge, concealed pivoting rod type hinge, screwdriver operated cam latch, prime coat grey painted finish.

.6 Acoustical Tile Ceilings: Steel door (16ga) and steel frame (14ga), door recessed 25 mm to receive acoustic tile, concealed pivoting rod type hinge, screwdriver operated cam latch, prime coat grey painted finish.

.7 Fire Rated Walls:

.1 Non-combustible construction: Uninsulated steel door (16ga) and steel frame (16ga), door flush to frame edge, 25mm mounting frame with masonry anchor straps, concealed self-closing hinge, flush key latch, prime coat grey painted finish, ULC rated 2 hour 'B' label.

.2 Combustible construction: Insulated steel door (20ga) for maximum 250°C rise after 30 minutes and steel frame (16ga), door flush to frame edge, 25mm mounting frame with masonry anchor straps, concealed self-closing hinge, flush key latch, prime coat grey painted finish, ULC rated 1-1/2 hour 'B' label.

.8 Fire Rated Ceilings: 50mm Insulated steel door (16ga) and steel frame (16ga), door flush to frame edge, 25mm mounting frame with masonry anchor straps, concealed upswing self-closing hinge, L handle latch, white baked enamel finish, size 600mm x 600mm (24” x 24”) ULC rated 2 hour 'B' label.

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

.10 All access door finish and colour to match adjacent.

3. EXECUTION

3.1 Painting Repairs and Restoration

.1 Do painting in accordance with Division 09 - Interior Painting.

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

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

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

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

3.2 System Cleaning

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

3.3 Field Quality Control

.1 Manufacturer's Field Services:

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

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

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

3.4 Demonstration

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

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

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

.4 Use operation and maintenance manual, as-built 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 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 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 tender 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
Access Doors - Drywall	Baucoplus

Type of Equipment **Plumbing & HVAC**	Approved Manufacturers
Access Doors - Wall	Maxam, Acudor, Milcor, Can.Aqua, Mifab, Bilco, Baucoplus, Elmdor
Actuators	Belimo, Honeywell, Siemens
Air Blenders	Blender Products
Air Handling Units - Packaged	Engineered Air pre purchased by owner
Air Terminals - Fixed Louvre	Airolite, CS Louvre (Exhaust Use Only), EH Price, Nailor, Ten Plus Architectural Products Ltd., Ruskin, Ventex, Westvent
Air Terminals - Grilles, Registers, Diffusers	Anemostat, E.H. Price, Krueger, Nailor Industries, Tuttle & Bailey, Swegon, Titus, Trox, Primex, Zehnder
Air Terminals - Motorized Louvre	Airolite, Pottorff, Ruskin
Balancing Agents (AB)	Big Sky Balancing Co., Enviro-Metrics Technical Services Ltd., Hydro-Air Technical Services, Perfection-Aire Ltd., Tabtek Air & Hydronics Ltd., Western Mechanical Systems
Boilers - Finned Tube	Raypak, Laars, Rudd, Superhot, RBI
Boilers – Condensing	Aerco, Heat Transfer Products, Laars, Lochinvar, Thermal Solutions, RBI, Viessman, Reillo
Bypass Filter (Closed Loop Systems)	Sumco, GESL, Pace Chemicals
Chemical Injection	LMI, Brae
Chemical Pot Feeder	Axiom Industries
Chimneys, Breeching and Venting	DuraVent, ICC, Metal Fab, Selkirk
Cleaning Agencies - Ductwork	Power Suction Services, Enviro-Vac Systems Inc., Clean Air Services Canada, AirCare
Commissioning Agents	AME Group, KD Engineering, Blue Collar Group, MDT Systems, Western Mechanical Services, Kane Consulting, Wyndham Commissioning (Vancouver Island), WSP, Zenith, Raincity Technical Services
Controls Contractors – Alberta	Convergint, Concept, Ainsworth, Johnson Controls, Siemens

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Controls – Room Pressure	Critical Room Control, Paragon Controls, Triatek/JCI, TSI
Dampers - Backdraft	Alumavent, E.H. Price, Penn, Pottorff, Ruskin, Tamco
Dampers – Backdraft – Heavy Duty	Pottorff, Ruskin CBS7, Tamco
Dampers - Balancing	Maxam, Ruskin
Dampers - Control	EH Price, Nailor Industries, Pottorff, Ruskin, Tamco
Dampers - Fire	Alumavent, EH Price, Maxam, Nailor Industries, Pottorff, Ruskin
Dampers - Motorized	Alumavent, EH Price, Maxam, Nailor Industries, Pottorff, Ruskin, Swegon, Tamco
Ductwork - Access Doors	Nailor Industries, Ortech, Ventlok
Ductwork - Concealed Regulator	Maxam, Pottorff, Ruskin, Young
Ductwork - Duct Connectors - Thermal Break	Ventifabrics "Ventlon”
Ductwork - Duct Connectors - Vibration	Duro Dyne "Durolon", Dynair "Hypalon", Ventfabrics "Ventlon”
Ductwork - Duct Sealer	Foster 32-14, Hardcast Versa Grip, Hardcast Foil Grip 1402, United Duct Sealer, Trans Continental Multi-Purpose
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
Fans - Cabinet - General Purpose	Greenheck, PennBarry, Loren Cook, Delhi, Twin City
Fans - Centrifugal	Acme, Chicago Blower, Greenheck, Loren Cook, New York Blower, PennBarry, S&P, Sheldons, Twin City

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Fans - In-Line Centrifugal	Chicago Blower, Delhi, Greenheck, PennBarry, Loren Cook, S&P, Twin City
Fans - In-Line Centrifugal (Tubular)	Chicago Blower, Greenheck, Loren Cook, New York Blower, PennBarry, S&P, Twin City
Filters - Air - Mechanical	AAF, Cambridge, Camfil, Flanders, Pacific, Viledon
Firestopping	Hilti (Canada) Limited, 3M Fire Protection Products, Tremco Sealants & Coatings, AD Firebarrier, Specified Technologies Inc (STI)
Flexible Connectors - Ducting	Thermaflex, G.I. Industries Type IHP
Flexible Connectors - Piping	Flexonics, Tube Turn, Atlantic, Hyspan, Hydroflex, Metraflex, United Flexible, Mason, Techniquip, United Flexible, Triflex, Victaulic, Anvilstar, Unisource
Flexible Ductwork	Flexaust, Flexmaster, Thermaflex, Wiremold, GI Industries
Gas Monitoring Systems (CO, CO2, NO2, etc.)	ACME, Critical Environment Technologies, Honeywell, MSA, QEL, Opera/Belimo, Canadian Gas Service
Grooved Mechanical Pipe Couplings / Valves / Fittings	Victaulic, Shurjoint, Gruvlok
Heat Exchangers - Brazed Plate	Armstrong, Alpha Laval, Bell & Gossett, Sondex, SPX (APV), Swep
Heat Exchangers - Immersion	Armstrong, B&G, Taco
Heat Exchangers – Instantaneous	Leslie
Heat Exchangers - Plate & Frame	Alpha Laval, Armstrong, Bell & Gossett, Polaris, Sondex, Tranter, Kelvion, SPX (APV)
Heat Exchangers - Shell and Tube	Armstrong, Bell & Gossett, Taco, AIC
Heaters - Gas - Unit Heaters	Lennox, Modine, Reznor
Insulation - Acoustic - Duct - Fibre-Free	K-flex, Armacell, Evonik (Solcoustic)
Insulation - Acoustic - Duct	Manson, Knauf, CertainTeed, Johns Manville, Owens Corning, Evonik
Insulation - Canvas jacket	Robson, Fattal, Tai-Can

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Insulation - Fabric Adhesive, Coatings	Robson, Bakor, Childers, Epolux, Foster
Insulation - Low Temp Preformed Pipe Insulation	Aeroflex, Armacell, Therma-Cel, Kingspan
Insulation - Low to Intermediate Temp Pipe Insulation	Knauf, Owens Corning, Roxul, Johns Manville, Manson
Insulation - PVC jacket	Knauf, Speedline, Proto, Zeston, Shur-Fit, Belform
Insulation - Thermal - Duct	CertainTeed, Manson, Knauf, Johns Manville, Owens Corning
Insulation - Thermal - Pipe	Manson, Knauf, Johns Manville, Owens Corning
Insulation - Undersink Piping Covers	McGuire, Truebro, Brocar
Insulation - Vapour Barrier Jacket Adhesive	Bakor, Epolux, Nacan, Foster, Childers
Insulation – Vapour Barrier-Jacket	Knauf ASJ, Kingspan ASJ, Manson ASJ, Johns Manville AP-T Plus, Owens Corning ASJ, Roxul ASJ, VentureWrap 1555U.
Meters - HVAC / Plumbing	Marsh, Weiss, Marshalltown, Taylor, Trerice
Meters - Water - Positive Displacement	Neptune, Rockwell, Badger
Natural Gas - Over Pressurization Protection Device	Sensus, Fisher, American
Pipe and Valve Identification	Seton, Brady, Incom
Pipe Restraints	Trelleborg
Piping - CPVC Pipe and Fittings	Ipex, Spears, FlowGuard
Piping - Ductile Iron Grooved Pipe	Canada Pipe
Piping - Hydronic - Pipe Pre Insul Direct Bury, PEX	Rehau
Piping - Hydronic - Polypropylene Pipe	

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Piping - Insulation Shields	Klo-Shure
Piping – No-Hub Cast Iron-Fitting Restraints	HoldRite
Piping – Potable Water PEX-a	Uponor, REHAU, Sioux Chief, Heatlink, Apollo, Sharkbite, Viega Uponor – up to 3” REHAU, Sioux Chief, Heatlink – up to 2” Apollo, Sharkbite, Viega – up to 1”
Piping - Potable Water - Stainless Steel Mechanical Joints	Victaulic, Shurjoint
Piping - Potable Water Copper Roll Grooved Pipe	Victaulic copper connection, Grinnell Gruvlok, Shurjoint
Piping - Potable Water Stainless Steel Press Type Joining Method for LMFM Facilities	For 12mm up to 50mm dia. only: Viega ProPress, Victaulic Vic-Press, Grinnell G-Press
Piping - Potable Water Type K Copper Press Type Joining Method for LMFM Facilities	For 12mm up to 50mm dia. only: Viega ProPress, Grinnell G-Press, Streamline (Mueller Industries)
Piping - PP-R Pipe and Fittings	
Piping - Pressfit Stainless Steel Pipe	Victaulic Vic-Press (12mm to 50mm), Viega ProPress (12mm to 100mm), Grinnell G-Press (12mm to 100mm) For B.C. Lower Mainland Health Care Facilities, press fit type fittings shall only be allowed for 12mm - 50mm pipe sizes.
Piping - PVC Perforated for Footing Drains	Ipex, Westlake Pipe
Piping – Reverse Osmosis - 316 Stainless Steel Tubing	Swagelok, Associated Tube Canada, Valex
Piping – Reverse Osmosis – Low Extractable PVC (LXT)	GF Piping Systems, Spears
Piping – Reverse Osmosis - Polypropylene	GF Piping Systems
Piping - Sanitary / Storm - PVC 15 (XFR) pipe	Ipex

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Piping - Sewage - Glass DWV	Kimax
Piping - Sewage - Poly Propylene	Ipex, Orion
Piping - Sewage - Polyvinylidene Flouride DWV	Ipex, Orion
Piping – PVC DWV – Double Wall Containment	Ipex
Piping Hangers and Saddles	Anvil, Myatt, Taylor Walraven
Plumbing - Air Admittance Valves	Studor, Oatey, FraJon, Sioux Chief
Plumbing - Air Vents	Watts, Bell & Gossett, Caleffi, Braukmann, Armstrong, Maid-O-Mist, Hoffman, Taco
Plumbing - Backflow Preventers	Watts, Hersey, Singer, Ames,Zurn/ Wilkins, Conbraco, Febco
Plumbing - Cleanouts	Watts, Jay R. Smith, Zurn, Mifab
Plumbing – Trap Seals	MiFab, Zurn, Green Drain
Plumbing - Trench Drains	Jay R. Smith, Watts, Zurn, NDS, MEA, ACO
Plumbing - Vacuum Breakers	Watts, Febco, Conbraco
Plumbing - Water Hammer Arrestors	Sioux Chief, Zurn, Watts
Pre-Cast Manholes, Sumps and Catch Basins	Langley Concrete, Ocean Pipe, Precon, Lafarge Canada
Pump Accessories - Suction Diffusers	B&G, Armstrong, Grundfos, Taco, Victaulic, Wilo
Pump Accessories - Triple Duty Valves	Armstrong, B&G, Victaulic, Taco, Wilo
Pumps - Air Operated Diaphragm	Raasm, Graco, Aro (Ingersoll Rand), Lincoln, Samson
Pumps - Base Mounted	Armstrong, Aurora, Bell & Gossett, Grundfos, Taco, Wilo
Pumps - Centrifugal	Armstrong, Bell & Gossett, Grundfos, Taco, Wilo
Pumps - In-Line Circulators	Armstrong, Bell & Gossett, Grundfos, Taco, Wilo

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Pumps - Vertical In-Line	Armstrong, Bell & Gossett, Grundfos, Taco, Wilo
Silencers - Fan and Duct	E. H. Price, Kinetics Noise Control, Vibro Acoustics, VAW Systems
Strainers - HVAC / Plumbing	Kitz, Red & White/Toyo, Mueller Locxend, Sarco, Armstrong, Victaulic, Anderson, Yarway
Tanks - Expansion	Amtrol, Armstrong, Bell & Gossett, Sparco Taco, Watts, Wessels, Wheatley, State
Test Plugs – Pressure / Temperature	Flow Design Superseal, Miljoco P/T Plugs, Sisco P/T Plugs
Thermometers	Trerice, Marsh, Ashcroft, Winters, Moeller, Weiss, Weksler, Winters
Valves - Alarm	Fire Flex, Reliable Simplex Grinnell, Tyco, Victaulic, Viking
Valves - Auto Balance	Griswold, Hays, Nexus Valve, Tour and Anderson
Valves – Backwater	Zurn, J R Smith, Watts, Wade
Valves – Ball	Apollo, Crane/Jenkins, KVC, Gruvlok, Kitz, NCI Canada, Nexus Valve, Red&White, Victaulic, Watts, MAS
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, MAS
Valves – Check – Lever and Weight	Cla-Val, Valmatic, Mueller, Kennedy
Valves – Check – PVC (Pools)	Chemline, Hayward, Braukmann
Valves – Check – Silent	APCO, Gruvlok, NCI Canada, StreamFlo, Val-matic, Victaulic
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

Type of Equipment **Plumbing & HVAC**	Approved Manufacturers
Valves - Control - Pressure Independent	Belimo, Flow Control Industries, Griswold, Tour & Andersson, Victaulic
Valves – Domestic Water Thermostatic Balancing.	Circuit Solver, Tour & Andersson, Victaulic
Valves – Domestic Water Balancing	Armstrong, Bell & Gossett, Griswold, Nexus Valve, Red & White/Toyo, Tour & Andersson, Victaulic
Valves – Drain - Radiator	Crane, Dahl, Jenkins, Kitz, Nexus Valve, Toyo
Valves – Eccentric Plug	DeZurik, Homestead
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
Valves - Pressure Balance Mixing Valves	Symmons, Leonard, Acorn, Powers
Valves – Pressure Reducing	Watts, Armstrong, Bell & Gossett, Taco, Crosby, Sarco, Clayton, Singer, Zurn, Wilkins, BCA, Cash Acme, Braukman, Bermad/Victaulic
Valves - Pressure Sustaining	Cla-Val, Singer
Valves – Relief	Armstrong, Bell & Gossett, Taco, Wheatley, Watts, Farris, Singer, Lonergan
Valves – Relief – Water Bypass	Braukmann, Fulflo, Lonergan
Valves – Stainless Steel for Reverse Osmosis and High Purity Water Systems	Valex, Swagelok,
Valves – Seismic	Koso, Pacific Seismic Products
Valves – Thermostatic Mixing	Cash Acme, Symmons, Leonard, Powers
Valves – Thermostatic Mixing for Emergency Safety Equipment.	Guardian, Haws, Bradley, Speakman
Variable Frequency / Speed Drives	ABB, Allen-Bradley, Baldor, Danfoss, Eaton, Hitachi, Siemens, Teco-Westinghouse, Toshiba, WEG, Yaskawa
Venting – Polypropylene	Duravent, Centrotherm

Type of Equipment	Approved Manufacturers
Plumbing & HVAC	
Venting - Stainless Steel	Industrial Chimney Co., Metal-Fab PIC, Security Chimneys, Selkirk PS & IPS, Van-Packer DW
Vibration – Neoprene Pad	Mason, Korfund, Vibro-Acoustics
Vibration – Neoprene Washer Bushing	Mason, Korfund, Vibro-Acoustics
Vibration – Post Disaster Seismic Snubbers	Mason, Korfund, Vibro-Acoustics
Vibration – Restrained Air Springs	Mason, Korfund, Vibro-Acoustics
Vibration – Rubber Floor Mounts	Mason, Korfund, Vibro-Acoustics
Vibration – Seismic Snubbers	Mason, Korfund, Vibro-Acoustics
Vibration – Spring Floor Mounts	Mason, Korfund, Vibro-Acoustics
Vibration – Spring Hangers	Mason, Korfund, Vibro-Acoustics
Vibration Isolation	Mason, Korfund, Vibro-Acoustics
Water Softeners	Duro, Petwa, Gladwell, Water Conditioning Canada
Water Treatment Agents	Pace Chemicals, Dubois Chemicals, Enercon, Magnus Chemicals Ltd

3. EXECUTION

3.1 Post Tender 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 tender. If no Manufacturer's names are submitted, it will be assumed that the price carried in the tender 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 Division 26 – Electrical

1.3 References

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

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

1.4 General

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

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

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

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

1.5 Submittals

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

.1 For each VFD provide:

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

.2 Customer connection and power wiring diagrams.

.3 Complete technical product description 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 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 73 11

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 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.

.5 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

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

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

.8 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.

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

.10 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.

.11 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

.5 Lon Works (available as an option)

.6 BACnet IP (available as an option)

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

.3 Serial communication minimum capabilities shall include:

.1 Run-stop controls

.2 Speed set adjustment

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

.4 % torque

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

.6 Operating hours (resettable)

.7 Drive temperature.

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

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

.10 Remote VFD fault reset.

.7 Serial communication in bypass

.1 Minimum capabilities shall include:

.1 Bypass run-stop control.

.2 The BAS shall be capable of monitoring the bypass relay output status, and all digital input status.

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

.4 Remote bypass fault reset.

.5 The VFD / bypass shall allow the BAS to control the drive and bypass digital and analog outputs via the serial interface.

.8 BYPASS – Bypasses shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All VFD with bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

.1 A complete factory wired and tested bypass system consisting of a door interlocked; pad lockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes.

.2 Standalone keypad with LCD display.

.3 The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.

.4 Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication.

.5 The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.

.6 Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications that match the VSD.

.7 The bypass serial communications shall allow control of the drive/bypass (system) digital outputs via the serial interface. This control shall be independent of any bypass function or operating state. All system analog and digital I/O shall be capable of being monitored by the BAS system.

.8 Provide manual or automatic transfer to bypass. Drive faults for automatic transfer to bypass mode shall be user selectable for the following drive fault conditions:

.1 Over current

.2 Over voltage

.3 Under voltage

.4 Loss of analog input

.9 The bypass shall include the ability to select the operating mode of the system (VFD/Bypass) from either the bypass keypad or digital input.

.10 Provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.

.11 Fireman's Override Mode: Programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above to suit the local Authority Having Jurisdiction (AHJ). The Override action may be initiated via the serial communications link.

3. EXECUTION

3.1 Installation

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

.2 Power wiring shall be completed by Division 26.

3.2 Testing

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

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

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

.4 Field Testing

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

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

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

.5 Harmonics Testing

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

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

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

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

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

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

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

END OF SECTION

1. GENERAL

1.1 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 American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME)

.1 ANSI/ASME B31.1 – Power Piping.

.3 ASTM International

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

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

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

.4 [Factory Mutual (FM)]

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

.1 MSS SP58 – Pipe Hangers and Supports - Materials, Design and Manufacture.

.6 Underwriter's Laboratories of Canada (ULC)

.7 Canadian Standards Association

.1 CSA B149.1 – Natural Gas and Propane Code

1.4 Submittals

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

.1 Submit shop drawings for:

.1 Bases, hangers and supports.

.2 Connections to equipment and structure.

.3 Structural assemblies.

.2 Certificates:

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

.3 Manufacturers' Instructions:

.1 Provide manufacturer's installation instructions.

1.5 General Requirements

.1 Plumbing piping: to National Plumbing Code of Canada.

.2 Fire protection: to applicable NFPA Standards.

.3 Natural gas/propane piping: to CSA B149.1 Natural Gas and Propane Code

.4 Construct pipe hangers and supports to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.

.5 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP58.

.6 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.

.7 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.

.8 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP58.

.9 Provide hangers and supports to secure equipment in place, prevent vibration, protect against damage from earthquake, maintain grade, provide for expansion and contraction and accommodate insulation.

.10 Support from (top of) structural members. Where structural bearings do not exist or inserts are not in suitable locations, suspend hangers from steel channels or angles. Provide supplementary structural members, as necessary.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

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

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

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

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

2.3 Pipe Hangers

.1 Finishes:

.1 Pipe hangers and supports: galvanized.

.2 Ensure steel hangers in contact with copper piping are copper plated, epoxy coated or have a non-metallic sleeve coupling between the dissimilar metals.

.2 Upper attachment structural: suspension from lower flange of I-Beam:

.1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.

.2 Cold piping NPS 2½ or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed, FM approved to MSS-SP58.

.3 Upper attachment structural: suspension from upper flange of I-Beam:

.1 Cold piping NPS 2 maximum: ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed, FM approved.

.2 Cold piping NPS 2 ½ or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed, FM approved.

.4 Upper attachment to concrete:

.1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm ($^1/_4$") minimum greater than rod diameter.

.2 Concrete inserts: wedge shaped body with knockout protector plate UL listed, FM approved. Size inserts to suit threaded hanger rod diameter. Refer to "minimum rod diameter" table below.

.5 Shop and field-fabricated assemblies:

.1 Trapeze hanger assemblies and steel brackets: to ASME B31.1 and MSS SP58.

.2 Sway braces for seismic restraint systems: to Section 23 05 48 - Vibration and Seismic Control for Mechanical.

.6 Hanger rods: threaded rod material to MSS SP58:

.1 Minimum rod for fire suppression is 9 mm ($^3/_8$") UL listed or 13 mm (½ inch) for FM approved.

.2 Ensure that hanger rods are subject to tensile loading only.

.3 Provide linkages where lateral or axial movement of pipework is anticipated.

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

.4 Provide reinforcing hanger angle for rod lengths in excess of maximum length as scheduled by the Seismic Engineer. Refer to Section 23 05 48 – Vibration and Seismic Control for Mechanical.

.7 Pipe attachments: material to MSS SP58:

.1 Attachments for steel piping: carbon steel galvanized.

.2 Attachments for copper piping: copper plated black steel.

.3 Use insulation shields for cold pipework.

.4 Oversize pipe hangers and supports to accommodate insulation thickness and maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.

.8 Adjustable clevis: material UL listed and FM approved, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.

.9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll.

.10 U-bolts: carbon steel with 2 nuts at each end to ASTM A563.

.1 Finishes for steel pipework: galvanized.

.2 Finishes for copper, glass, brass or aluminum pipework: galvanized with formed portion plastic coated or epoxy coated.

.11 Pipe rollers: cast iron roll and roll stand with carbon steel rod.

2.4 Riser Clamps

.1 Steel or cast iron pipe: galvanized carbon steel to MSS SP58, type 42, UL listed, FM approved.

.2 Copper pipe: carbon steel copper plated to MSS SP58, type 42.

.3 Bolts: to ASTM A307.

.4 Nuts: to ASTM A563.

2.5 PEX Pipe Support

.1 NPS 3 and under

.1 Non-combustible, self-gripping, galvanized-steel channel for crosslinked polyethylene (PEX-a) pipe. To provide continuous, uninterrupted support of PEX-a pipe.

.2 PEX-a pipe support shall be minimum 2700 (108”) long complete with stainless-steel strapping.

.2 Use PEX-a Pipe Support in conjunction with un-insulated Uponor AquaPEX® or Wirsbo hePEX™ PEX-a pipe in ASTM E84 plenum applications.

.3 The PEX-a pipe with pipe support can be insulated with typical CTS (copper tube size) pipe insulation.

2.6 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.

2.7 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.

2.8 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

2.9 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.

2.10 Equipment Anchor Bolts and Templates

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

2.11 Other Equipment Supports

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

.2 Submit structural calculations with shop drawings.

3. EXECUTION

3.1 Manufacturer's Instructions

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

3.2 Installation

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

.2 Vibration Control Devices:

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

.3 Clamps on riser piping:

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

.2 Bolt-tightening torques to industry standards.

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

.4 Cast iron pipes: install below joint.

.4 Clevis plates:

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

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

.6 Use approved constant support type hangers where:

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

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

.7 Use variable support spring hangers where:

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

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

3.3 Hanger Spacing

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

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

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

.3 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

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

3.4 Hanger Installation

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

.2 Adjust hangers to equalize load.

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

.4 Do not support from metal deck.

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

.6 Support vertical piping at every other floor.

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

.8 Support riser piping independently of connected horizontal piping.

.9 Install plastic inserts between steel studs and piping.

.10 Provide insulation protection saddles on all insulated piping.

3.5 Horizontal Movement

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

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

3.6 Final Adjustment

.1 Adjust hangers and supports:

.1 Ensure that rod is vertical under operating conditions.

.2 Equalize loads.

.2 Adjustable clevis:

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

.2 Tighten upper nut after adjustment.

.3 C-clamps:

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

.4 Beam clamps:

.1 Hammer jaw firmly against underside of beam.

3.7 Inserts

.1 Install in accordance with manufacturer’s recommendations.

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

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

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

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

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 The work in this section includes, but is not limited to the following:

.1 Vibration isolation for piping, ductwork, and equipment.

.2 Equipment isolation bases.

.3 Flexible piping connections.

.4 Seismic restraints for isolated equipment.

.5 Seismic restraints for non-isolated equipment.

.6 Certification of seismic restraint designs and installation supervision.

.7 Certification of seismic attachment of housekeeping pads.

1.2 Related Requirements

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

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

.3 Section 23 21 16 – Hydronic Piping Specialties.

.4 Section 23 33 00 - Duct Accessories.

1.3 References

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

.2 Applicable Building Code: Refer to Section 21 05 01 – Common Work Results for Mechanical.

.3 National Fire Protection Association (NFPA):

.1 NFPA 13-[2013] – Standard for the Installation of Sprinkler Systems.

.4 Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

.1 SMACNA – Seismic Restraint Manual Guidelines for Mechanical Systems.

.5 American Society of Heating, Refrigeration, and Air Conditioning Engineers ASHRAE):

.1 ASHRAE HVAC Applications Handbook (Seismic Design Chapter 54).

.6 Federal Emergency Management Agency (FEMA):

.1 FEMA – Installing Seismic Restraints for Mechanical Equipment.

.7 Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

.1 VISCMA – Installing Seismic Restraints for Mechanical Equipment.

1.4 Submittals

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

.1 Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.

.2 Shop drawings: submit drawings for vibration control stamped and signed by a Professional Engineer.

.3 Shop drawings: submit drawings for seismic control stamped and signed by a Professional Engineer registered or licensed in Province of Alberta.

.4 Provide separate shop drawings for each isolated system complete with performance and product data.

1.5 General Requirements

.1 All mechanical equipment, piping, and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

.2 Provide seismic restraints for all required equipment, piping, and ductwork.

.3 All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.

.4 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.

.5 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.

.6 Seismic restraints shall be designed in accordance with seismic force levels as indicated in the Building Code for the specific region of the project.

.7 All elastomeric components in isolation pads, mounts, and seismic snubbers shall be bridge bearing neoprene, meeting CSA Standard CAN3-S6 Section 11.10.

.8 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.

.9 Bolt all equipment to the structure. Do not bridge isolation elements.

.10 Use ductile materials in all vibration isolation equipment.

.11 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.

.12 Bases:

.1 Provide all concrete inertia bases where specified or required by equipment manufacturers. Bases to be located between the vibrating equipment and the vibration isolation elements. Provide concrete inertia bases for centrifugal fans with static pressure in excess of 0.875 kPa (3.5” SWG) and/or motors in excess of 30 kW (40 HP) and on base mounted pumps over 15 kW (20 HP), except slab on grade installations or unless otherwise specified. Provide concrete inertia bases on all plug fans that also require thrust restraints.

.2 Other than equipment requiring concrete inertia bases, provide structural steel bases for all vibration isolated equipment, unless the equipment manufacturer certifies direct attachment capabilities.

.3 Co-ordinate with Division 03 for the provision of housekeeping pads at least 100 mm (4”) high under all isolated equipment. Provide at least 175 mm (7”) clearance between drilled inserts and edge of housekeeping pads and follow structural consultant’s instructions for drilled inserts.

.13 Ducting:

.1 Install flexible duct connectors on all ductwork connected to isolated equipment.

.14 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.

.15 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.

2. PRODUCTS

2.1 General

.1 Isolation, anchors, bolts, bases, restraints, etc., are to be designed to withstand without failure or yielding, the dynamic G load as specified in Code for the seismic zone in which building is located. Design loads are ultimate limit state loads (1.5 times working load) acting through the centre of gravity of the anchored or restrained equipment. "Fail Safe" designs are acceptable.

.2 For both isolated and non-isolated floor mounted equipment, i.e. tanks, heat exchangers, boilers, etc., design and provide anchors and bolts to withstand, without failure or yielding, a dynamic ultimate limit state load as defined in Code, of the greater of 0.3 g or as required by Code, applied horizontally through the centre of gravity.

.3 Where impact forces may be significant, use ductile materials.

.4 Seismic restraining devices factory supplied with equipment are to meet requirements of this Section.

2.2 Acceptable Manufacturers

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

2.3 Open Spring Mounts

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

2.4 Closed Spring Mounts

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

2.5 Totally Retained Spring Mounts

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

2.6 Type 1 - Neoprene Pad Isolators

.1 Neoprene or neoprene / steel / neoprene pad isolators.

.2 Minimum static deflection 2.5 mm (0.1") or greater.

.3 Use hold down bolts selected for seismic loads. Isolate bolts from base of unit using neoprene washer/bushing.

.4 Size bolt and washer/bushing for minimum lateral clearance.

2.7 Type 2 - Rubber Floor Mounts

.1 Bridge bearing neoprene mountings.

.2 Minimum static deflection of 5mm (0.2") or greater and all directional seismic capability.

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

2.8 Type 3 - Spring Floor Mounts

.1 Spring isolators shall be free standing, laterally stable and supplied complete with a lower molded neoprene acoustical cup or $^{1}/_{4}$" (6mm) neoprene acoustical friction pad between the baseplate and the support.

.2 All mountings shall have a leveling bolt that allows for rigid attachment to the equipment.

.3 Spring diameters shall be no less than 0.8 of compressed height at rated load and have an additional travel to solid equal to 50% of rated deflection.

.4 Nominal static deflection shall be 25 mm. No spring shall be loaded to less than 70% of its rated capacity nor exceed manufactures capacity.

.5 Open springs may be used in conjunction with Type 5 or 5PD seismic snubbers or housed in a seismically rated housing. Where spring is housed to meet seismic requirements, the housing shall be of ductile iron or steel construction and allow for all directional seismic snubbing. The snubber shall be vertically adjustable and designed for a maximum of 6.4 mm travel in all directions. Potential impact areas to be protected by a minimum of a 3.2 mm neoprene bushing. Submittals to include spring diameter, rated deflection, spring constant, and free and operating height.

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

.1 Restrained spring mountings shall incorporate spring (Type 3), within a rigid steel housing that includes a minimum of two vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during installation and steel spacers shall be removed after adjustment such that the installed and operating heights are the same.

.2 An air gap of 3 mm in all directions, before contact is made between the rigid and resilient surfaces, shall be incorporated into the design. Limit stops shall be out of contact during normal operation.

.3 Since housing may be bolted or welded into position, there must be an internal isolation pad under the springs. Housing shall be designed to resist seismic forces.

2.10 Type 4 - Restrained Air Springs

.1 Restrained air springs shall have upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed.

.2 Air spring configuration shall be multiple bellows.

.3 Natural frequency at 690 kPa shall be 1.5 Hz.

.4 Air inlet to the air spring assembly shall be from the side. Designed to operate at maximum air pressure of 690kPa [100psig]. All air spring systems shall be interconnected and supplied with either the building control air or a supplementary air supply. The air spring system shall be supplied complete with three leveling valves to maintain leveling within plus or minus 3mm (⅛"). Provide air compressor where necessary (if no suitable building supply is available).

.5 Air springs shall be used in conjunction with either Type 5 or 5PD seismic snubbers or be fitted within an OSHPD approved integral housing (see type 3A).

.6 Suitable for outdoor installation.

2.11 Air Compressor Set and Accessories for Type 4 Air Spring Isolators

.1 Air Compressor

.1 DeVilbiss, Quincy, or Air King simplex, receiver mounted, packaged air compressor set supplied with air spring isolators by isolator manufacturer, suitable for a 1035 kPa (150 psi) working pressure and complete with:

.1 Air cooled compressor with unloader assembly and air intake filter-silencer;

.2 ½ HP, 120 volt, 1-phase, 60 Hz electric motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, receiver mounted on an adjustable motor base and complete with V-belt drive with guard;

.3 45 L (12 USG) ASME rated enamelled steel air receiver with a CRN, pressure gauge, Code relief valve, air outlet with ball valve, manual bottom drain outlet with ball valve, and automatic drain trap, and a braided stainless steel flexible connection, combination adjustable pressure regulator, air filter, water trap, and downstream pressure gauge for air outlet connection;

.4 Seismic restrained vibration isolation;

.5 Factory prewired NEMA 2 barriered power and control panel with door interlock disconnect switch, protected motor starter, H-O-A switch, pressure switch, power on LED, power and control wiring terminal strips, and auxiliary dry contacts.

.2 Compressed Air Piping and Valves

.1 Type K hard temper copper tubing with forged copper solder type fittings and 95/5 solder joints, properly sized but minimum 6.5 mm (¼") dia., leak tested to 1035 kPa (150 psi) after installation but before connection to springs, properly and rigidly secured and complete with:

.1 Ball type shut-off valves at connections to springs and piping mounted equipment;

.2 Combination filter and automatic drain trap, and a 50 mm (2") dia. pressure gauge downstream of filter in piping adjacent to equipment with air spring isolators.

2.12 Type 5 - Seismic Snubbers

.1 Omni-directional seismic snubbers consisting of interlocking steel members restrained by a one piece molded neoprene bushing of bridge bearing neoprene.

.2 Bushing shall be replaceable and a minimum of 6mm (1/4") thick.

.3 Rated loadings shall not exceed 6895 kPa (1000 psi).

.4 A minimum air gap of 3mm (⅛") shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Ensure neoprene bushing can easily be rotated by hand after installation ensure no short circuits exist before systems are activated.

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

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

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

.1 Continuous rooftop isolation shipped completely assembled, consisting of:

.1 galvanized steel sections formed to fit roof curb and associated equipment with a flexible air and weather seal joining upper and lower rail sections;

.2 stable springs, cadmium plated and selected to provide minimum deflection with 50% additional travel to solid;

.3 neoprene cushioned and wind restraints allowing 6 mm (¼") movement before engaging and resisting wind loads in any lateral direction.

2.15 Type 7N – Neoprene Hangers

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

2.16 Type 7S – Spring Isolation Hangers

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

2.17 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.

2.18 Type 8 - Neoprene Washer/Bushing

.1 A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact.

.2 Use washer/bushing only on light-weight equipment.

2.19 Type 9 – Horizontal Thrust Restraints

.1 Spring isolated air handling equipment shall be fitted with horizontal thrust restraints design to keep movement due to thrust to ±1/4” at equipment start and stop.

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

2.20 Type 10 – Acoustical Split Wall Seals

.1 Split wall seals shall consist of two bolted pipe halves with a minimum 18 mm thick neoprene sponge bonded to the liner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping.

.2 Concrete may be packed around the seal to make it integral with the floor, wall, or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum 25 mm past both sides of the wall.

.3 Where temperatures exceed 113°C 10# density fiberglass may be used in lieu of the sponge.

2.21 Type 11 - Pipe Riser Anchor

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

.2 Provide hot application isolators as required.

2.22 Type 12 – Pipe Riser Guides

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

2.23 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.

2.24 Type 14 - Flexible Duct Connectors

.1 Flexible duct connectors of Durodyne with Durolon fabric or approved equal.

.2 Provide 75 mm (3") flexible duct connectors and a 40 mm (1½") metal to metal gap. Centrifugal fans with 900 mm (36") diameter and larger fan wheels, use 150 mm (6") long flexible connection.

.3 Do not install connectors on perchloric acid fume exhaust systems.

.4 Provide stabilizing springs limiting movement at flexible connections to 25% of fabric width under steady state conditions and 40% at start up.

2.25 Bases – Type B1 - Concrete Inertia

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

.2 Minimum thickness of the inertia base shall be according to the following tabulation:

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

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

2.26 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").

2.27 Bases - Type B3 - Combination Steel /Concrete Inertia Equipment Base

.1 Welded steel bases with a structural black steel channel frame, concrete reinforcing rods, bottom sheet steel pan, brackets for spring mounts welded to frame and adjustable motor slide rails.

2.28 Bases - Type B4 - Slung Steel Base

.1 Slung steel bases of structural members with gusset plates welded to ends and complete with adjustable motor slide rails and vertical section size to suit equipment's motor power output.

2.29 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.

2.30 Anchor Bolts

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

2.31 Seismic Cable Restraints

.1 Galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint.

.2 Cables must be pre-stretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement.

.3 Cables must not be allowed to bend across sharp edges.

.4 Cable assemblies shall suit installation type:

.1 Ceiling and at the clevis bolt.

.2 Between the hanger rod nut and the clevis.

.3 Clamped to a beam.

3. EXECUTION

3.1 General

.1 All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

.2 Brace in-line equipment independently of ducts and pipes.

.3 Do not mix solid and cable bracing.

.4 All runs to have a minimum of two transverse and one longitudinal brace. A run is defined as any change in direction except offsets.

3.2 Seismic Restraint Installation

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

3.3 Mechanical Component Restraint Guide

Item	Type Of Restraint	Minimum No. of Restraints	Notes
In-line Pumps	SCR	2	Pipe mounted type pump
Pumps Non-Isolated	BTHP	4	Base mount type pump
Pumps Isolated	SNBR	4	Base mount type pump
Expansion Tanks	SCR	4	
D.H.W. Tanks	SCR	4	Attach to removable steel strap yoke
Glycol Tanks	SCR	4	Attach to removable steel strap yoke
Boilers			
- With Base	BTHP	4	
- Without Base	CSSB	4	
Chillers			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
Cooling Towers Closed Circuit Coolers			
- Isolated	SNBR	4	
- Non-Isolated	BTSLPR	4	
Heat Exchangers	BTHP	4	Bolt to custom support frame
Radiant Panels	SCR	4	Per panel section
Unit Heaters	TSR-SCR	4	
Force Flow Heaters	TSR-SCR	4	
AHU's and A/C Units Free Standing			

Item	Type Of Restraint	Minimum No. of Restraints	Notes
- With Base	BTHP	4	
- Without base	CSSB	4	
AHU's and A/C Units Suspended			
- Isolated	SCR	4	
- Non-Isolated	SCR	4	
Packaged Rooftop Air Units (all types)			
On roof curb	BTRC	4	Roof curb bolted to roof.
Humidifiers	BTHP	4	Bolt unit to custom stand.
Electronic		4	Bolt stand to housekeeping pad or structure.
Fans – Suspended			
- Isolated	SCR	4	
- Non-Isolated	SCR	4	
Fans – Freestanding			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
Grilles, Registers, Diffusers	SCR	4	Where not bolted to duct (i.e. in tee-bar ceilings)
Airflow Control Valves	SCR	4	Where suspended
Air Compressor Receiver Sets			
- Isolated	BTHP	4	
- Non-Isolated			
Piping	SCR TSR	As required	As per Specification
Ductwork	SCR TSR	As required	As per Specification

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

3.4 Seismic Piping Restraints

.1 Seismic restrain all piping as follows:

.1 Seismically restrain all piping as follows:

.1 Fuel oil piping, gas piping, medical gas piping, and compressed air piping that is 1 NPS or larger.

.2 Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1 ¼ NPS and larger.

.3 All other piping 2 ½ NPS and larger.

.2 Provide transverse piping restraints at 12m (40') maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

.3 Provide longitudinal restraints shall be at 24m (80') maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

.4 For fuel oil and all gas piping transverse restraints must be at 6m (20') maximum and longitudinal restraints at 12m (40') maximum spacing.

.5 Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

.6 Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

3.5 Seismic Ductwork Restraints

.1 Seismically restrain all ductwork as follows:

.1 Restrain all ductwork and duct mounted equipment.

.2 Transverse restraints shall occur at 9m (30') intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.

.3 Longitudinal restraints shall occur at 18m (60') intervals with at least one restraint per duct run.

.4 The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.

.5 A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.

.6 Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

3.6 Seismic Cable Restraints

.1 Cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

.2 Cable assemblies are installed taut on non-isolated systems.

.3 Where cable restraints are installed on support rods with spring isolators, the spring isolation hangers must be specification type.

3.7 Vibration Isolator Installation - General

.1 Vibration isolation products as outlined in section 2 above are to be applied based on 4 basic project specific situations. The requirements for each of these is outlined below:

.1 Acoustical classification AAA - Hospitals, Recording Studios, Theatres, High end Hotels

.2 Acoustical classification AA - Office Towers, Multi Storey Condominiums

.3 Acoustical classification A - Commercial

.4 Acoustical classification W - Warehouse, Industrial

.2 This project has an acoustical classification of ( ). 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 Isolate steam Pressure Reducing Stations (PRV's) and upstream and downstream piping for a distance of 15 m. Install PRV station pipe pedestals on 12 mm thick heat insulating pads, with heat insulating grommets on the hold down bolts and Type 1 pads below. The insulating pad shall be sufficient to maintain Type 1 pad within manufacturer's temperature limits. Submit shop drawing of detail.

.13 Connect emergency generator mufflers directly to structure. Provide seismic restraint for mufflers. (Flex connection between generator and exhaust piping provided by Div. 26).

.14 Flexible pipe connectors (Type 13 isolator) shall be provided and installed per the Vibration Isolation Application Schedule.

.15 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.

.16 Provide a minimum clearance of 50mm (2”) to other structures, piping, equipment, etc., for all equipment mounted on vibration isolators.

.17 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.

.18 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.

.19 After installation and adjustment of isolators, verify deflection under load to ensure loading is within specified range.

.20 Where hold-down bolts for isolators or attachments penetrate roofing membranes, co-ordinate with Division 7 and with roofing contractor.

.21 For all pump installations, ensure that pumps are installed and aligned such that no piping loads are imposed on the pump. Pumps and piping should be independently supported and aligned prior to final connection.

.22 Where isolated piping connected to noise generating equipment is routed from the mechanical room through plumbing chases or other openings, position isolated piping to avoid contact with the structure, framing, gypsum wallboard and other elements which may radiate noise. Submit proposed details to meet this requirement. On all AAA and AA projects, Type 10 acoustical seals shall be provided on piping entering or leaving mechanical rooms.

.23 Ensure that the installed seismic restraints do not adversely affect the proper functioning of any vibration isolation products required by this section.

.24 All fire protection piping shall be braced in accordance with NFPA 13 and 14.

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

3.8 Type 2 - Rubber Floor Mounts

.1 Mount in-line pumps on two (2) rubber floor mount isolators under each support foot, where scheduled.

.2 For equipment mounted on a slab on grade, mount on rubber floor mount isolators unless otherwise specified.

.3 Provide protection of the rubber element from contact with oil in the mechanical room.

3.9 Type 3 - Spring Floor Mounts

.1 Isolate all floor or pier mounted equipment on spring floor mount isolators, unless otherwise specified.

.2 Isolate air-cooled chillers on spring floor mount isolators and Neoprene pads under isolator base plates. Submit details of pipe supports on roof and wall/roof penetration.

.3 Isolate air compressors on spring floor mount isolators and concrete inertia base unless scheduled otherwise.

.4 Mount cooling towers on spring floor mount isolators and, if necessary, seismic snubbers to meet seismic requirements unless scheduled otherwise.

3.10 Type 4 - Restrained Air Springs

.1 Isolate 19kW (25HP) pumps and larger on restrained air mounts except use rubber floor mounts for slab on grade installations.

.2 Isolate Chillers on restrained air mounts as scheduled.

3.11 Type 5 - Seismic Snubbers

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

3.12 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.

3.13 Type 7S & 7SN - Spring Hangers

.1 Locate isolation hangers as near to the overhead support structure as possible.

.2 Installation shall permit hanger box or rod to move through a 30 degrees arc without metal to metal contact.

.3 All discharge ductwork runs for a distance of 15m (50') from the connected equipment shall be isolated from the building structure by means of spring hangers. Spring deflection shall be a minimum of 19mm (0.75").

3.14 Type 8 - Neoprene Washer/Bushing

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

3.15 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.

3.16 Type 14 - Flexible Duct Connectors

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

3.17 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").

3.18 Minimum Static Deflection Schedule

Equipment	**Equipment Supported By:**	
	Slab on Grade	**Elevated Slab**
Hot Water Boilers	Nil	3mm (⅛")
Heat Pumps (see Note 5)	9mm ($^{3}/_{8}$")	38mm (1½")
Pumps:		
In-line under 1.5kW (2HP)	1mm ($^{1}/_{16}$")	3mm (⅛")
In-line 1.5kW (2 HP) to 11.5kW (15 HP)	3mm (⅛")	5mm (¼")
In-line over 11.5kW (15 HP)	3mm (⅛")	9mm (⅜")
Base mounted under 5.5kW (7.5 HP)	5mm (¼")	19mm (¾")
Base mounted 5.5kW (7.5 HP) and greater	19mm (¾")	38mm (1½")
Fans, Blowers & Packaged H & V Units:		
Under 0.5 HP	1mm ($^{1}/_{16}$")	1mm ($^{1}/_{16}$")
0.5 HP to 7.5 HP	25mm (1")	25mm (1")
7.5 HP to 40 HP - up to 400 rpm	38mm (1½")	38mm (1½")
7.5 HP to 40 HP - over 400 rpm	25mm (1")	25mm (1")
Over 40 HP – up to 400 rpm	38mm (1½')	38mm (1½")
Over 30 KW (40 Hp) – over 400 rpm	25mm (1")	38mm (1½")

NOTES:

.1 Table indicates required static deflection of isolators for all fans regardless of power rating and for all other motor driven equipment over 0.37kW (0.5 HP).

.2 Advise consultant of equipment not contained in this table and obtain clarification as to the isolation performance requirements.

.3 Steel spring isolators shall be used for all deflections 12mm (½") and over.

.4 Neoprene isolators shall be used for deflections 6mm (¼") and under.

.5 Use housed spring isolators for heat pump.

.6 Concrete inertia bases required for pumps over 15kW (20HP), fans over 30kW (40HP).

3.19 Vibration Isolation Application Schedule

Equipment	**AAA**	**AA**	**A**	**W**
Cooling Towers	4, B2 & 13	4, B2 & 13	3A, B2 & 13	1, B2 & 13
Multi-Stage Centrifugal Chillers				

Equipment	AAA	AA	A	W
Upper Floor	4, B2 & 13	4, B2 & 13	3A, B2 & 13	1
On Grade	3A, B2 & 13	3A, 13	2 & 13	-
Chillers - Other				
Upper Floor	3A, B2 & 13	3A, B2 & 13	2	1
On Grade	2 & 13	2 & 13	1	-
Pumps>7.5 hp Floor Mounted				
Upper Floor	3, B1 & 13	3, B1 & 13	3, B1 & 13	3
On Grade	3, B1 & 13	3, B1 & 13	3 & 13	3
Pumps >1/2hp< 7.5hp Floor Mounted				
Upper Floor	3, B2 & 13	2, stanchions or B2 & 13	1, stanchions or B2 & 13	1
On Grade	2, stanchions or B2 & 13	2, stanchions or B2 & 13	1	1
Pumps <<1.2hp floor mounted	8	8	-	-
Heat Pumps & Hung Pumps				
>>1/2hp	7SN & 13	7S & 13	7N	-
<<1/2hp	7S & 13	7N	8	-
Piping				
Attached to Isolated Equipment	7SN - See 3.4.5	7SN - See 3.4.5	7SN - See 3.4.5	See 3.4.5
Through Mechanical Room Walls 1½"	10	10	-	-
Hot Water Risers - No Expansion Loops	11,12,13	11,12,13	-	-
Compressors				
>>10hp recip. (remote tank)	3, B1 & 13	3, B1 & 13	2 & 13	2
>>10hp centrif. (remote tank)	2 & 13	2 & 13	1	-
>>5hp - tank mounted	3, B1 & 13	3, B1 & 13	2 & 13	1
>>5hp - tank mounted	2 & 13	2 & 13	1	-
Roof Mounted Packaged Air Handling Equipment				
Internally Isolated	6S & 14	6S & 14	6N & 14	-
Not Internally Isolated	6S & 14	6S & 14	6N & 14	6N & 14
Fans Floor Mounted				
>>40hp				
Above Grade	4, B1, 9(if req'd) & 14	3, B1, 9(if req'd) & 14	3, B1, 9(if req'd) & 14	3, B2, 9(if req'd) & 14
On Grade	3, B1, 9(if req'd) & 14	3, B1, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14
>>5hp<<40hp<<1200rpm				
Above Grade	4, B1, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14
On Grade	3, B1, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	-
>>5hp<<40hp<<1200rpm				
Above Grade	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14
On Grade	3, B2, 9(if req'd) & 14	3, B2, 9(if req'd) & 14	2, B2, 9(if req'd) & 14	1,9 (if req'd) & 14
>>1/2hp<<5hp				
Above Grade	3 & 14	2 & 14	2 & 14	1 & 14
On Grade	2 & 14	1 & 14	1 & 14	-

Equipment	AAA	AA	A	W
Fans Hung				
>>5hp<<1200 rpm	7SN & 14	7S & 14	7S & 14	7S & 14
>>5hp>> 1200 rpm	7SN & 14	7S & 14	7N & 14	8 & 14
>>1/2hp>>1200 rpm	7S & 14	7N & 14	8 & 14	8 & 14
Fractional	8 & 14	8 & 14		

Note:

.1 Table indicates type of isolation required, base type (B) if required and any other sections of note.

.2 Type 3 and 4 isolators may be used with Type 5 and 5PD and snubbers. Those pieces of equipment requiring seismic ‘post disaster’ protection must use 5PD snubbers with Type 3 and 4 isolators.

3.20 Field Quality Control

.1 Seismic Engineer:

.1 The Seismic Engineer shall perform all field services as required to fulfil the Building Code obligation for the provision of the Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.

.2 Submit concise field reports to the Consultant within 3 days of each site review.

.3 Make adjustments and corrections in accordance with written report.

.2 Manufacturer's Field Services:

.1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract Documents.

.2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:

.1 Twice during the installation, at [25] % and [60] % completion stages.

.2 Upon completion of installation.

.3 Submit a concise manufacturer's report to the Consultant within 3 days of manufacturer representative's review.

.4 Make adjustments and corrections in accordance with written report.

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

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

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

1.3 References

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

.2 Canadian Standards Association (CSA International):

.1 CAN/CSA B128.1 – Design and Installation of Non-potable Water Systems.

.2 CAN/CSA B128.2 – Maintenance and Field Testing of Non-potable Water Systems

.3 Canadian Gas Association (CGA):

.1 CSA/CGA B149.1 – Natural Gas and Propane Installation Code.

.4 Canadian General Standards Board (CGSB):

.1 CAN/CGSB-1.60 – Interior Alkyd Gloss Enamel.

.2 CAN/CGSB-24.3 – Identification of Piping Systems.

.5 National Fire Protection Association (NFPA):

.1 NFPA 13 – Standard for the Installation of Sprinkler Systems.

.2 NFPA 14 – Standard for the Installation of Standpipe and Hose Systems.

1.4 Submittals

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

.1 Submit data on all materials.

1.5 General Requirements

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

.2 Identify each system and system component according to the nomenclature used on the drawings and specifications. Identification to be consistent throughout the project.

.3 When identifying systems and components in existing buildings, the new items shall be numbered sequentially with existing systems. Where possible include the zone or building area serviced by each system.

.4 Submit list of system and component labels to 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.

.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

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

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 Ductwork Systems Identification

.1 50mm (½") high stencilled letters and directional arrows 150mm long x 50mm high (6" x 2").

.2 Colours: black, or co-ordinated with base colour to ensure strong contrast.

2.8 Ductwork Access Identification

.1 Secure 50 mm (2") high, self-adhesive stick-on letters, on duct access panels to identify their usage, according to the following:

.1 Cleaning and service access, colour black, tag "C.A"

.2 Controls including sensors, colour black, tag "C"

.3 Backdraft dampers, balance dampers and control dampers, colour black, tag "D"

.4 Fire dampers, colour red, tag "F.D."

.5 Smoke dampers and duct smoke detectors, colour red, tag "S.D."

2.9 Controls Components Identification

.1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section. Include: sensors, transmitters, BMS controlled valve and damper actuators, end-devices, distributed control panels (DCP)'s, application specific controllers (ASC)'s and field panels.

.2 Inscriptions to include function and (where appropriate) fail safe position.

.3 Warning notices shall be provided at all equipment controlled by the BMS and at all associated motor starters. The warning notices shall state that the equipment is under the control of the BMS and may start or stop at any time without warning. Provide warning notices at minimum at all MCC's, at local disconnect switches, at AHU plenum doors, and electrical motors.

.4 Provide warning notices on all Distributed Control Panel doors indicating that hand held radio transmitters are not to be keyed within 3 meters 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.

2.10 Ceiling Access Identification

.1 Provide 6 mm ($^1/_4$") self adhesive coloured dots to the T-bar framing, adjacent to panel to be removed or to access doors in solid ceilings. Identify the location of equipment concealed above as follows:

.1 ***Yellow*** - Concealed equipment and cleaning access.

.2 ***Black*** - Control equipment, including control valves, dampers and sensors.

.3 ***Red*** - Fire and smoke dampers, fire protection equipment and fire system drains.

.4 ***Green*** – Heating water, chilled water, domestic cold water, domestic hot water isolation valves.

3. EXECUTION

3.1 General

.1 Provide identification only after painting has been completed.

.2 Perform work in accordance with CAN/CGSB-24.3 Identification of Piping Systems except as specified otherwise.

.3 Provide ULC and/or CSA registration plates as required by respective agency.

3.2 Nameplates

.1 Location shall be in conspicuous location to facilitate easy reading and identification from operating floor.

.2 Provide standoffs for nameplates on hot and/or insulated surfaces.

.3 Do not paint, insulate or cover nameplate data.

3.3 Location of Identification on Piping and Ductwork Systems

.1 Provide on long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: at not more than 17m (55') intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

.2 Provide adjacent to each change in direction.

.3 Provide at least once in each small room through which piping or ductwork passes.

.4 Provide on both sides of visual obstruction or where run is difficult to follow.

.5 Provide on both sides of separations such as walls, floors, partitions.

.6 Provide where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.

.7 Provide at beginning and end points of each run and at each piece of equipment in run.

.8 Provide at point immediately upstream of major manually operated or automatically controlled valves, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.

.9 Identification shall be easily and accurately readable from usual operating areas and from access points. Position the identification approximately at right angles to the most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.4 Valves, Controllers Identification

.1 Provide identification on valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve.

.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass located in the main mechanical room. Provide one copy in each operating and maintenance manual.

.3 Number valves in each system consecutively.

.1 Identification coding is to start with a utility description followed by a maximum of three numerals:

.2 Domestic Water DW-1, DW-2, DW-3…

.3 Natural Gas G-1, G-2, G-3…

.4 Steam S-1, S-2, S-3...

.5 Heating Water HW-1, HW-2, HW-3…

.6 HVAC to be numbered H-1, H-2, H-3…

.7 Fire Protection to be numbered FP-1, FP-2, FP-3…

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

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

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

1.3 References

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

.2 Applicable Building Code – Refer to Section 21 05 01 – Common Work Results for Mechanical

.3 Applicable energy code or standard – Refer to Section 21 05 01 – Common Work Results for Mechanical.

.4 Thermal Insulation Association of Canada (TIAC) – National Insulation Standards.

.5 CAN/ULC S102-M88 – Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

.6 CGSB 51-GP-52MA – Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation

.7 ASTM C612 – Standard Specification for Mineral Fiber Block and Board Thermal Insulation

.8 ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

.9 ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

.10 ASTM C755 – Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.

.11 ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining.

.12 ASTM C1290 – Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

1.4 Submittals

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

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

.2 Manufacturer's installation instructions.

1.5 General Requirements

.1 The Installation firm shall be a current member of one of the following:

.1 Thermal Insulation Association of Canada (TIAC).

.2 Thermal Insulation Association of Alberta (TIAA).

.2 Only Journeyman insulation applicators, with 3 years minimum successful experience in this size and type of project, shall perform the work.

.3 Definitions:

.1 "CONCEALED" insulated mechanical services in trenches, chases, furred spaces, shafts and hung ceilings (services in tunnels are not considered to be concealed.)

.2 "EXPOSED" will mean not concealed.

.3 “K” value means Thermal Conductivity

.4 “UNCONDITIONED SPACE” referred to in the duct thickness tables are crawlspaces (vented or not vented), parkades, warehouse space, shipping and receiving areas and other areas noted on the drawings.

.5 “EXTERIOR SPACE” referred to in the duct thickness tables are all spaces outside the building insulation envelope, including attic spaces, unless noted otherwise.

.6 UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO).

.7 ASJ: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper

.8 SSL: Self-Sealing Lap.

.9 FSK: Foil Scrim Kraft; jacketing.

.10 PSK: Poly Scrim Kraft; jacketing.

.11 PVC: PolyVinyl Chloride.

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

.5 Provide thermal insulation on all HVAC ductwork and as follows:

.1 Heating only duct and plenum – service temperature 20°C to 65°C (68°F to149°F)

.2 Cooling only or combined cooling and heating duct and plenum - service temperature 5°C to 65°C (41°F to149°F)

.3 Outside air duct and plenum - -40°C (-40°F) to ambient

.4 All exhaust air ductwork from outside wall or roof to damper but a minimum of 3 m (10 ft.) inside building.

.5 Combustion intake / relief air

.6 Supply and return ductwork exposed in the space being served does not require insulation unless noted otherwise.

.7 Where an internal duct liner is used in lieu of external insulation, the internal thickness shall match that of the “Rigid Exterior Duct Insulation” table.

.8 Insulation may be omitted on heating only ductwork in return air plenums provided the ductwork serves that area.

.6 Provide acoustic internal insulation on ductwork as follows:

.1 All ductwork indicated on drawings with cross hatching.

.2 All exposed supply and return ductwork in mechanical rooms from fan discharge to duct shaft or mechanical room perimeter wall.

.3 Where internal insulation is required, external insulation may be reduced or omitted by an equivalent thickness.

.7 If the Contractor, during renovations, should discover asbestos (or material suspected to be asbestos) on piping, ductwork, etc., he shall immediately cease all work in that area and contact Owner's representative.

.8 Make good all existing insulation disturbed or removed to facilitate alterations and additions to existing piping.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

.1 Products shall not contain asbestos, lead, mercury, mercury compounds or Polybrominated diphenyl ethers (PBDE).

.2 Mineral fibre specified includes glass wool and rock wool.

.3 The RSI value shall not be reduced from the specified values when tested in accordance with ASTM C1290.

.4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88.

.5 Elastomeric insulation shall comply with NFPA 90A, 90B and ASTM C1534

.6 Foam insulation products shall not use CFC or HCFC blowing agents in the manufacturing process and be formaldehyde free.

.7 Glass mineral wool products shall have a recycled content of a minimum of 50 percent recycled glass content.

.8 Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation, insulation shall be UL GREENGUARD Certified.

2.3 Intermediate Temperature Range Insulation

.1 External rigid Insulation (TIAC C-1):

.1 Service temperature 5°C to 232°C (41°F to 450°F)

.2 Glass mineral wool board for low and medium temperature applications.

.3 Complying with ASTM C1071 and CGSB 51-GP-52MA

.4 All service aluminum foil-scrim kraft (FSK) jacket with glass fibre reinforcement, factory applied.

.5 Density 36kg/m3 (2.25 PCF)

.6 Minimum RSI 0.76/25mm (R 4.3/in)

.2 External flexible duct wrap insulation (TIAC C-2):

.1 Service temperature 5°C to 121°C (41°F to 250°F)

.2 For service temperatures above 121°C refer to 2.4 High Temperature Insulation

.3 Glass mineral wool flexible blanket for low and medium temperature applications.

.4 Complying with CGSB 51-GP-52MA, ASTM C1071 and ASTM C553.

.5 All service aluminum foil-scrim kraft (FSK) jacket with glass fibre reinforcement, factory applied.

.6 Density 12kg/m3 (0.75PCF),

.7 Minimum RSI 0.49/25mm (R 2.8/in) (installed)

.3 Internal rigid duct liner:

.1 Rigid glass mineral wool board, for low and medium temperature acoustical applications.

.2 Complying with ASTM C1071 and CGSB 51-GP-52MA

.3 Airstream surface faced with a black mat bonded to the glass mineral wool substrate.

.4 Air velocity rating 25.4 m/s (5,000 ft/min)

.5 Density 48kg/m3 (3 PCF),

.6 Minimum RSI 0.76/25mm (R 4.3/in)

.7 Sound absorption coefficients (type 'A' mounting):

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

.4 Internal flexible duct liner:

.1 Flexible glass mineral wool blanket, for low and medium temperature acoustical applications.

.2 Complying with CGSB 51-GP-52MA, ASTM C1071 and ASTM C553.

.3 Airstream surface faced with non-woven fiberglass mat bonded to the glass mineral wool substrate.

.4 Air velocity rating 25.4 m/s (5,000 ft/min)

.5 Density 24kg/m3 (1.5 PCF)

.6 Minimum RSI 0.74/25mm (R 4.2/in)

.7 Sound absorption coefficients (type 'A' mounting):

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

.5 Internal fibre free elastomeric duct liner:

.1 Service temperature -40°C to 93°C (-40°F to 200°F)

.2 Flexible, closed-cell elastomeric insulation in sheet form, for low and medium temperature acoustical applications.

.3 Complying with ASTM C534, NFPA 90A and 90B.

.4 Insulation materials shall be manufactured without the use of CFC's, HFC's, HCFC's PBDE, or formaldehyde.

.5 Insulation materials shall be low VOCs, fibre free, dust free and resist mold and mildew, be ultra violet and weather resistant.

.6 Factory applied pressure sensitive adhesive or field applied adhesive.

.7 Air velocity rating 20.3 m/s (4,000 ft/min)

.8 Density 48kg/m3 (3 PCF)

.9 Minimum RSI 0.74/25mm (R 4.2/in)

.10 Sound absorption coefficients (type 'A' mounting):

Thickness		**Frequency (Hz.)**						
mm	inches	125	250	500	1000	2000	4000	NRC
25	1	0.01	0.13	0.39	0.69	0.29	0.26	0.40
40	1.5	0.07	0.26	0.92	0.31	0.49	0.53	0.50
50	2	0.14	0.62	0.44	0.43	0.51	0.45	0.50

2.4 High Temperature Range

.1 External flexible insulation (TIAC C-2):

.1 Service temperature 121°C to 538°C (250°F to 1000°F)

.2 Rock mineral wool or glass mineral wool flexible blanket for medium and high temperature applications.

.3 Complying with ASTM C553 and ASTM C1290.

.4 Density 25.6kg/m3 (1.6PCF),

.5 Minimum RSI 0.76/25mm (R 4.3/in)

.2 External flexible fire barrier insulation:

.1 Service temperature to 538°C (1000°F)

.2 Glass fiber or mineral fiber flexible batt and blanket, encapsulated in an aluminum foil fibreglass reinforced scrim covering.

.3 Nominal 40mm (1.5") thick

.4 Fire Resistance: For use in 1 hour fire resistant systems (single layer).

.5 Fire Resistance: For use in 2 hour fire resistant systems (double layer)

.6 Density 93.6 kg/m3 (6PCF),

.7 Minimum RSI 0.89 (R 6.4)

.8 Complying with ASTM E 2336 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems

2.5 Fire Rated Duct Wrap

.1 Flexible, non-combustible, blanket type mineral fibre duct wrap completely encapsulated in reinforced foil, suitable for installation with zero clearance to combustibles (for grease ducts), and ULC tested and listed (ULC Designs FRD-17 & 23 for ventilation ducts, ULC Design FRD-19 for kitchen exhaust/grease duct) to facilitate a 2 hour fire resistance rating (76 mm [3"] thick) to kitchen grease exhaust duct in accordance with requirements of NFPA-96, and/or a 1 or 2 hour fire resistance rating (38 mm [1-½"] thick) to ventilation or pressurization ductwork in accordance with requirements of ISO 6944.

2.6 Fastenings, Adhesives and Coatings

.1 Insulation Fastenings:

.1 Min. 1.6 mm thick (16 ga) galvanized wire , 0.6 mm thick aluminium wire, 0.6 mm thick type 304 stainless steel wire or 1.6 mm thick copper wire.

.2 Mechanical fasteners, welded fasteners or adhesive fasteners to meet SMACNA HVAC Duct Construction Standard for mechanical fasteners.

.2 Corner Beads: Galvanized steel or aluminum 38 mm x 38 mm x 0.37 mm thick.

.3 Jacket Fastenings:

.1 Thermocanvas and All Service Jacket: Staples (flare type), compatible jacket finishing tape, contact adhesives recommended by the jacket manufacturer.

.2 Metal Jackets: Sheet metal screws, pop rivets.

.4 Adhesives:

.1 Fabric adhesive to insulation covering, water based, ultra white, washable, anti-microbial, to ASTM C755-19.

.2 Internal elastomeric insulation adhesive shall be as per manufacturer’s recommendations.

.5 Coatings: Vapour barrier coating on reinforcing membrane.

2.7 Finish Jackets

.1 Thermocanvas Jacket: fire rated, 170g (6 oz) fire retardant canvas jacket for covering mechanical insulation indoors, 25/50 fire class, plain wave cotton, no dyes.

.2 Aluminum Jacket: 51 mil (22 ga.) thick stucco or smooth aluminum jacketing with longitudinal slip joints and 50mm (2") end laps with factory applied protective liner on interior surface.

.3 Bitumen Membrane: 55 mil composite membrane consisting of a multiply embossed UV-resistant aluminum foil/polymer laminate over a layer of rubberized asphalt specially formulated for use on insulated duct and piping applications.

3. EXECUTION

3.1 General

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

3.2 Rigid Insulation External Application

.1 Heating only Duct and Plenum – Service Temperature 20° to 65°C (CER/1)

.1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers, each direction.

.2 Provide insulation without integral vapor retarder with horizontal surfaces overlapping vertical surfaces and edges tightly butted together. Secure insulation by impaling on mechanical fasteners.

.3 In areas of limited space wire fastenings, insulation adhesive, or other suitable methods of attachment may be substituted.

.2 Cooling only or Combined Cooling and Heating Duct and Plenum - Service Temperature 5°C to 65°C (CER/2)

.1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers, each direction.

.2 Install vapor retarder toward the ambient atmosphere with horizontal surfaces overlapping vertical surfaces tightly butted together. Secure insulation by impaling on mechanical fasteners.

.3 Where mechanical fasteners penetrate vapor retarder, and at all corners and joints, apply self adhesive vapor retarder tape or vapor retarder strips adhered with vapor retarder adhesive. Where raised seams are encountered, add a strip of insulation above seam termination on each side of the seam, secure to the seams an overlapping strip of insulating material of equal thickness to the one required to provide a continuous vapor retarder. Seal all joints and edges with self adhesive vapor retarder tape.

.4 In areas of limited space wire fastenings, insulation adhesive, or other suitable methods of attachment may be substituted.

.3 Outside Air Duct and Plenum - -40°C to Ambient (CER/3)

.1 As per CER/2 application but firstly apply a layer of rigid insulation without vapor retarder before applying layer of rigid insulation with vapor retarder. All joints shall be staggered.

3.3 Flexible Insulation External Application

.1 Heating only Duct and Plenum – Service Temperature 20°C to 65°C (CEF/1)

.1 On rectangular ducts ≥ 600mm in width, apply mechanical fasteners to the bottom surface at approximately 300 mm centres.

.2 Apply insulation without integral vapour retarder with 50 mm overlap at each joint. Secure insulation with wire fastening on approximately 300 mm centres, or by stapling laps.

.2 Cooling only or Combined Cooling and Heating Duct and Plenum – Service Temperature 5°C to 65°C (CEF/2)

.1 On rectangular ducts ≥ 600 mm in width, apply to bottom surface mechanical fasteners at approximately 300 mm centers.

.2 Apply insulation with vapor retarder to the outside.

.3 Where mechanical fasteners or staples penetrate the vapor retarder and at all joints apply vapor retarder tape or vapor retarder strips adhered with vapor retarder adhesive.

.4 All joints shall be overlapped a minimum of 50 mm and stapled on approximately 100 mm centers.

.5 Secure insulation with wire fastening on approximately 300 mm centers.

.3 Heating only Duct and Plenum Fire Barrier – ambient to 538°C (1000°F)

.1 As per manufacturers installation instructions

3.4 Duct Insulation Minimum Thickness Table (Climatic Zone 7)

Rigid Exterior Duct Insulation				
Duty	**Plenum-Concealed (4)**	**Duct Location**		
		Interior		**Exterior**
		Conditioned Space	Unconditioned Space	
	Minimum Insulation Thickness in mm (in.)			
Cooling Only Air Supply	25 (1")	25 (1")	25 (1")	175 (7")
Heating or H/C Air Supply	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	175 (7")
Outdoor Air Supply	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	0
Combustion Air	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	0
Return Air	25 (1")	0	25 (1")	175 (7")
Exhaust Air (1)(2)	25 (1")	0	25 (1")	25 (1")
Grease Hood Exhaust (5)	N/A	38 (1-1/2")	38 (1-1/2")	0
Tempered Air Supply or Makeup Air	0	0	25 (1")	175 (7")
Mixed Air (3)	25 (1")	25 (1")	25 (1")	175 (7")
See note (6) for factory installed duct and plenums				

Flexible Exterior Duct Insulation				
Duty	**Plenum-Concealed (4)**	**Duct Location**		
		Interior		**Exterior**
		Conditioned Space	Unconditioned Space	
	Minimum Insulation Thickness mm (in.)			
Cooling Only Air Supply	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	250 (10")
Heating or H/C Air Supply	50 (2")	50 (2")	50 (2")	250 (10")
Outdoor Air Supply	50 (2")	50 (2")	50 (2")	0
Combustion Air	50 (2")	50 (2")	50 (2")	0
Return Air	38 (1-1/2")	0	38 (1-1/2")	250 (10")
Exhaust Air (1)(2)	38 (1-1/2")	0	38 (1-1/2")	38 (1-1/2")
Grease Hood Exhaust (5)	N/A	38 (1-1/2")	38 (1-1/2")	0
Tempered Air Supply or Makeup Air	0	0	38 (1-1/2")	250 (10")
Mixed Air (3)	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	250 (10")
See note (6) for factory installed duct and plenums				

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

Note (2): Provide 38mm (1-1/2”) flexible duct insulation on all exhaust air ductwork from outside wall or roof to damper but a minimum of 3 m (10 ft.) inside building.

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

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

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

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

3.5 Liner Internal Application

.1 General

.1 Where an interior duct liner is used, external insulation shall not be applied unless noted otherwise.

.2 Where an interior duct liner is used, the thickness shall be selected to match the thickness specified for external rigid insulation. Where no external insulation is required internal acoustic duct liner shall be a minimum 25mm (1”).

.2 Rigid Duct Liner (CIR/1)

.1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers each direction.

.2 Apply insulation with surfaces overlapping vertical surfaces and with edges tightly butted together.

.3 Insulation shall be applied to the ductwork with a minimum 90% coverage of adhesive and mechanical fasteners.

.4 Where mechanical fasteners penetrate factory finish and at all joints, apply a heavy layer of seal coating.

.5 On high velocity duct systems 20 m/s to 30 m/s (4000 fpm -6000 fpm) apply reinforcing membrane over the entire insulation joint surface.

.6 Seal off leading edge of insulation to duct surface on low velocity ductwork with reinforced seal coating or metal nosing. On high velocity duct systems, (over 20 m/s (4000 fpm) use metal nosing.

.3 Flexible Duct Liner (CIF/1)

.1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers each direction.

.2 Apply insulation with edges tightly butted together.

.3 Insulation shall be applied to the ductwork with a minimum 90% coverage of adhesive and mechanical fasteners.

.4 Where mechanical fasteners penetrate factory finish and at all joints, apply a heavy layer of seal coating.

.5 On high velocity duct systems 20 m/s to 30 m/s (4000 fpm -6000 fpm) apply reinforcing membrane over the entire insulation joint surface.

.6 Seal off leading edge of insulation to duct surface on low velocity ductwork with reinforced seal coating or metal nosing. On high velocity duct systems, (over 20 m/s (4000 fpm) use metal nosing.

3.6 External Flexible Fire Barrier Insulation

.1 Install as per manufacturers installation instructions.

.2 Install in the following locations

.1 Where noted on drawings

.2 Grease Hood Exhaust Ducts withing 450mm of combustibles or 150mm of limited combustibles

.3 Life safety air systems, unless within a fire rated enclosure, see architectural drawings

.4 Generator exhaust flue interior to the building and exterior of generator room, unless within a fire rated enclosure. See architectural drawings.

3.7 Finishes

.1 General

.1 Insulation on concealed ductwork shall be left with factory finish. No further finish is required.

.2 The following finishes apply to exposed ductwork and plenums only.

.2 Canvas Jacket – Indoor (CRF/1) (CRD/1)

.1 Use over rigid insulation for rectangular ductwork and flexible insulation for round ductwork, all with an integral vapor retarder. Apply continuous metal corner bead to all corners. Adhere vapor retarder tape over all joints and breaks in vapor retarder, and at all corners.

.2 Secure canvas jacket over insulation using fire resistive lagging coating and adhesive, and finish with one (1) coat of dire resistive lagging coating adhesive.

.3 Aluminum Jacket – Outdoor (CRF/3) (CRD/3)

.1 Adhere vapour retarder tape over all joints and breaks in vapor retarder and at all corners on cold or dual temp ductwork.

.2 Apply over the insulation surface a stucco embossed aluminum jacket secured with pop rivets or stainless s steel self tapping screws. All joints sealed or flashed to prevent water infiltration.

.4 Bitumen Membrane – Outdoor (CRF/5) (CRD/4)

.1 Install a modified bitumen membrane on rectangular ductwork and an aluminized modified bitumen membrane on round ductwork.

.2 Install in accordance to manufacturer's instructions.

3.8 Duct Finishes Table

.1 Conform to the following:

Duty	Rectangular Duct		Round Duct	
	Type	TIAC Code	Type	TIAC Code
Indoor Concealed	None	None	None	None
Indoor Exposed in Mechanical Room & Elsewhere except Utility Areas	Canvas Jacket	CRF/1	Canvas Jacket	CRD/1
Indoor Exposed in Utility Areas, Parkade, Etc.	Utility Finish	CRF/2	Utility Finish	CRD/2
Outdoor Exposed to Precipitation	Aluminum Jacket	CRF/3	Aluminum Jacket	CRD/3
Outdoor Elsewhere	Bitumen Membrane	CRF/5	Bitumen Membrane	CRD/4

3.9 Scope of Work

.1 Insulate all ductwork as shown in the drawings and referenced in this specification section.

END OF SECTION

1. GENERAL

1.1 Section Scope

1.2 Related Requirements

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

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

1.3 References

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

.2 Applicable Building Code - Refer to Section 21 05 01 – Common Work Results for Mechanical

.3 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.

.4 CAN/ULC S102-M88 – Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

.5 CGSB 51-GP-52MA – Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation

.6 ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

.7 ASTM C612 – Specifications for Mineral Fiber Block and Board Insulation

1.4 Submittals

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

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

.2 Manufacturer's installation instructions.

1.5 General Requirements

.1 The Installation firm shall be a current member of one of the following:

.1 Thermal Insulation Association of Canada (TIAC).

.2 Thermal Insulation Association of Alberta (TIAA)

.2 Only Journeyman insulation applicators, with 3 years minimum successful experience in this size and type of project, shall perform the work.

.3 Definitions:

.1 "CONCEALED" insulated mechanical services in trenches, chases, furred spaces, shafts and hung ceilings (services in tunnels are not considered to be concealed.)

.2 "EXPOSED" will mean not concealed.

.3 “K” value means Thermal Conductivity

.4 UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO).

.4 Provide thermal insulation on mechanical equipment and the following:

.1 Chillers

.2 Converters/Heat Exchangers

.3 Pumps (chilled/hot)

.4 Expansion Tanks

.5 Air Eliminators

.6 Engine silencer and exhaust

.7 Breechings/Flues

.8 Flash Tanks

.9 Condensate Receivers, Deaerator and Feed Water Tanks

.10 Domestic Hot Water Storage Tanks

.11 Buffer Tanks (chilled/hot)

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

.1 Products shall not contain asbestos, lead, mercury, mercury compounds or Polybrominated diphenyl ethers (PBDE).

.2 Mineral fibre specified includes glass wool and rock wool.

.3 The RSI value shall not be reduced from the specified values when tested in accordance with ASTM C553.

.4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88.

.5 Elastomeric insulation shall comply with NFPA 90A, 90B and ASTM C1534

.6 Foam insulation products shall not use CFC or HCFC blowing agents in the manufacturing process and be formaldehyde free.

.7 Glass mineral wool products shall have a recycled content of a minimum of 50 percent recycled glass content.

.8 Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation, insulation shall be UL GREENGUARD Certified.

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

.1 Flexible Elastomeric (TIACA-6)

.1 Sheet and roll flexible foamed elastomeric insulation. Plain and self-adhering as required:

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

.2 Complying with ASTM C534.

2.4 Low to Intermediate Temperature Range (5°C TO 315°C)

.1 Rigid (TIAC C-1):

.1 Service temperature 5°C to 315°C (41°F to 599°F)

.2 Glass mineral wool board for low and medium temperature applications.

.3 Plain or Aluminum foil-scrim kraft (FSK) jacket reinforced with glass fibre reinforcement or all service jacket (ASJ) consisting of a white kraft bonded to aluminum foil, reinforced with glass fibre reinforcement. Type as required. All jackets factory applied.

.4 Minimum density 36kg/m3 (2.25 PCF)

.5 Maximum “K” value at 24°C (75°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft2.°F)

.6 Complying with ASTM C612 – Specifications for Mineral Fiber Block and Board Insulation

.2 Flexible (TIAC C-2):

.1 Service temperature 5°C to 315°C (41°F to 599°F)

.2 Glass mineral wool flexible blanket for low and medium temperature applications.

.3 Plain or Aluminum foil-scrim kraft (FSK) jacket reinforced with glass fibre reinforcement or all purpose (AP) jacket consisting of a white kraft bonded to aluminum foil, reinforced with glass fibre reinforcement. Type as required. All jackets factory applied.

.4 Minimum density 40kg/m3 (2.5PCF),

.5 Maximum “K” value at 24°C (75°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft2.°F)

.6 Complying with ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

2.5 High Temperature Range (315°C TO 815°C)

.1 Flexible (TIAC C-2):

.1 Service temperature to 538°C (1000°F)

.2 Glass mineral wool or rock mineral wool flexible batt and blanket, unfaced

.3 Density 25.6 kg/m3 (1.6PCF)

.4 Maximum “K” value at 38°C (100°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft2.°F)

.5 Complying with ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

.2 Rigid (TIAC A-2):

.1 Service temperature 315°C to 815°C (600°F to 1500°F)

.2 Preformed insulation, type 1 calcium silicate pipe insulation without jacket.

.1 Maximum “K” value at 121°C (250°F) = 0.061 W/m.°C (0.42 Btu.in/hr.ft2.°F)

.3 Preformed type 2 calcium silicate in sections and blocks, and with special shapes to suit project requirements

.1 Maximum “K” value at 121°C (250°F) = 0.055 W/m.°C (0.39 Btu.in/hr.ft2.°F)

.4 Complying with ASTM C533 Standard Specification Calcium Silicate Block and Pipe Thermal Insulation.

2.6 Fastenings, Adhesives and Coatings

.1 Insulation Fastenings: min. 1.6 mm thick [16 ga.] galvanized wire, 0.6 mm thick aluminum wire, 0.6 mm thick type 304 stainless steel wire or 1.6 mm thick copper wire as commercially available. Jacket Fastenings:

.1 Thermocanvas and All Service Jacket:

.1 Staples (flare type), compatible jacket finishing tape, contact adhesives recommended by the jacket manufacturer.

.2 Metal Jackets:

.1 Sheet metal screws, pop rivets, stainless steel bands.

.3 PVC Jacket and Fitting Covers:

.1 PVC self-adhesive tape, plastic pop rivets, bonding cement.

.2 Adhesives:

.1 Fabric adhesive to insulation pipe covering, water based, ultra white, washable, anti-microbial

.3 Coatings:

.1 Vapour barrier coating on reinforcing membrane or on insulating cement:

2.7 Finish Jackets

.1 Jackets:

.1 Thermocanvas Jacket: fire rated, 170g (6 oz) fire retardant canvas jacket for covering mechanical insulation indoors, 25/50 fire class, plain wave cotton, no dyes.

.2 PVC Finishing Jacket: white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02”) thick.

.3 Aluminum Jacket: 0.51 mm (22 ga.) thick stucco or smooth aluminum jacketing with longitudinal slip joints and 50mm (2") end laps with factory applied protective liner on interior surface.

3. EXECUTION

3.1 General

.1 Install in accordance with Thermal Insulation Association of Canada (TIAC) National Standards.

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

.3 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified prior to insulation installation.

.4 Use two layers of preformed insulation with staggered joints when the required nominal wall thickness exceeds 75 mm.

.5 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.

.6 Locate insulation or cover seams in least visible locations.

3.2 Removable, Pre-Fabricated, Insulation and Enclosures

.1 Application: At expansion joints, valves, flanges and unions at equipment.

.2 Installation to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.

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

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

3.4 Cold Tanks and Equipment (TIAC 1503-C)

.1 For this application use, either insulation with an integral vapor retarder or field apply a vapor retarder treatment. All openings, joints, and seams shall be sealed with self adhesive vapor retardant tape. Insulation shall be fitted neatly to all contours without voids.

.2 Apply insulation block board segments or pipe and tank insulation and secure firmly with mechanical fasteners, wire, or banding.

3.5 Finish Jackets

.1 Aluminum Jacket - Indoor/Outdoor (CEF/1)

.1 On cold service equipment, adhere vapour retarder tape over all joints and breaks in vapor retarder and at all corners.

.2 Apply over the insulation surface an aluminum jacket secured with pop rivets or stainless s steel self tapping screws. All joints sealed or flashed to prevent water infiltration.

.2 Canvas/PVC Jacket – Indoor (CEF/2)

.1 Secure canvas jacket using fire resistive lagging coating and adhesive. Finish with one (1) coat of fire resistive lagging coating. Alternatively, finish with a layer of PVC jacket with all joints and seams sealed.

3.6 Insulation Minimum Thickness Schedule

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

.2 Thermally insulate equipment to the following:

Duty	Thickness		TIAC Insulation Type	Application
	mm	inches		
Boiler Breaching	100	4	A-2	TIAC 1503-H
Boiler Stack - Interior	50	2	A-2	TIAC 1503-H
Boiler Stack - Exterior	100	4	A-2 or C-2	TIAC 1503-H
Buffer Tanks - Hot Water	50	2	C-2	TIAC 1503-H
Expansion Joints ①	50	2	C-2	TIAC 1503-H
Heat Exchanger(s)	50	2	C-1 or C-2	TIAC 1503-H
Humidifier Separate Bodies ①	50	2	C-1	TIAC 1503-H
① Removable insulated cover type application				

3.7 Equipment Finishes Schedule

.1 On all externally insulated equipment, provide the following finish material:

.1 Low temperature equipment in mechanical rooms: PVC jacket to TIAC standard CEF/2

.2 Intermediate temperature equipment in mechanical room's canvas jacket to TIAC standard CEF/2.

.3 High temperature equipment in mechanical room's aluminum jacket to TIAC standard CEF/1.

.4 Indoor equipment elsewhere canvas/PVC jacket to TIAC standard CEF/2.

.5 Outdoor equipment aluminum jacket to TIAC standard CEF/1.

.6 Engine exhaust piping and muffler aluminum jacket to TIAC standard CEF/1

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

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

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

1.3 References

.1 Commissioning Agency (CxA)

.2 Commissioning Authority (CxAu) if applicable shall be engaged by the Client directly and act independent to this specification section.

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

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

1.4 Submittals

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

.1 Certificates of readiness.

.2 Certificates of completion of installation, prestart, and start-up activities.

1.5 Contractor’s Responsibilities

.1 Perform commissioning tests.

.2 Attend construction phase controls coordination meeting.

.3 Attend testing, adjusting, and balancing review and coordination meeting.

.4 Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection.

.5 Provide information requested by the CxA for the final commissioning documentation.

.6 Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA’s Responsibilities

.1 Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R, plumbing and fire suppression systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

.2 Verify and participate in commissioning testing.

.3 Verify testing, adjusting, and balancing of work are complete.

1.7 Commissioning Documentation

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

.1 Plan for delivery and review of submittals, systems manuals, and other documents and reports.

.2 Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

.3 Process and schedule for completing construction checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.

.4 Certificate of completion certifying that installation, start-up checks, and start-up procedures have been completed.

.5 Certificate of readiness, certifying that HVAC&R, plumbing and fire suppression systems, subsystems, equipment, and associated controls are ready for testing.

.6 Test and inspection reports, and certificates.

.7 Corrective action documents.

.8 Documented verification of testing, adjusting, and balancing reports.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 Testing Preparation

.1 Certify that HVAC&R, plumbing and fire suppression systems, subsystems, and equipment, have been installed, calibrated, and started and are operating according to the Contract Documents.

.2 Construction documents review:

.1 Provide full set of Div 21, 22, 23, 25, 26 drawings and specifications for preliminary design review.

.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 And acceptance procedures: testing requirements are specified in Division 23 boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

.3 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.

.4 Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Section 23 21 13 Hydronic Piping and 23 25 00 HVAC Water Treatment. HVAC Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

.1 Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

.2 Description of equipment for flushing operations.

.3 Minimum flushing water velocity.

.4 Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

.5 Energy supply system testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas and hot water systems and equipment. Determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

.6 Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors, and condensers, heat pumps, and other refrigeration systems. Determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

.7 HVAC&R Distribution System and Testing: Provide technicians, instrumentation, tools, and equipment, to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

.8 Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

3.5 Procedures for Space Pressurization Measurements and Adjustments

.1 Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

.2 Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

.3 Measure space pressure differential where pressure is used as the design criteria and measure airflow differential where differential airflow is used as the design criteria for space pressurization.

.1 For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.

.2 For applications with cascading levels of space pressurization, being in the most critical space and work to the least critical space.

.3 Test room pressurization first, then zones, and finish with building pressurization.

.4 To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure of airflow difference.

.5 For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the indicated pressure or airflow difference.

.1 Compare the values of the measurements taken to the measured values of the control system instruments and report findings.

.2 Check the repeatability of the controls by the successive tests designed to temporarily alter the ability to achieve space pressurization. Test over pressurization and under pressurization, and observe and report on the system's ability to revert to the set point.

.3 For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

.6 In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

.7 Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.6 Procedures for Vibration Measurements

.1 Use a vibration meter that meets the following criteria:

.1 Solid-state circuitry with a piezoelectric accelerometer.

.2 Velocity range of 2.5 to 254 mm/s (0.1 to 10 ins/s)

.3 Displacement range of 0.0254 to2.54 mm (1 to 100 mils).

.4 Frequency range of at least 0 to 1000 Hz.

.5 Capable of filtering unwanted frequencies.

.2 Calibrate the vibration meter before each day of testing.

.1 Use a calibrator provided with the vibration meter.

.2 Follow vibration meter and calibrator manufacturer's calibration procedures.

.3 Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.

.1 Turn off equipment in the building that might interfere with testing.

.2 Clear the space of people

.4 Perform vibration measurements after air and water balancing and equipment testing is complete.

.5 Clean equipment surfaces in contact with the vibration transducer.

.6 Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

.7 Measure and record vibration on rotating equipment over 3hp.

.8 Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.

.1 Pumps:

.1 Pump Bearing: Drive end and opposite end.

.2 Motor Bearing: Drive end and opposite end.

.3 Pump Base: Top and side.

.4 Building: Floor.

.5 Piping: To and from the pump after flexible connections.

.2 Fans and HVAC Equipment with Fans:

.1 Fan Bearing: Drive end and opposite end.

.2 Motor Bearing: Drive end and opposite end.

.3 Equipment Casing: Top and side.

.4 Equipment Base: Top and side.

.5 Building: Floor.

.6 Ductwork: To and from equipment after flexible connections.

.7 Piping: To and from equipment after flexible connections.

.3 Chillers and HVAC Equipment with Compressors:

.1 Compressor Bearing: Drive end and opposite end.

.2 Motor Bearing: Drive end and opposite end.

.3 Equipment Casing: Top and side.

.4 Building: Floor.

.5 Piping: To and from equipment after flexible connections.

.9 For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

.10 Inspect, measure, and record vibration isolation.

.1 Verify that vibration isolation is installed in the required locations.

.2 Verify that installation is level and plumb.

.3 Verify that isolators are properly anchored.

.4 For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.

.5 Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.7 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 air and 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.

.11 Perform sound testing at locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.

.1 Private office.

.2 Open office area.

.3 Conference room.

.4 Auditorium/large meeting room/lecture hall

.5 Classroom/training room.

.6 Each space with a noise criterion of RC or NC 25 or lower.

.7 Each space with an indicated noise criterion of RC or NC 35 and lower hat is adjacent to a mechanical equipment room or roof mounted equipment.

.8 Inside each mechanical equipment room.

.9 Locations where roof top mechanical equipment exist.

END OF SECTION

1 GENERAL

1.1 Summary

.1 Section Includes:

.1 Materials and installation for piping, valves and fittings for gas fired equipment.
.2 Sustainable requirements for construction and verification.

1.2 References

.1 American Society of Mechanical Engineers (ASME)

.1 ASME B16.5-03, Pipe Flanges and Flanged Fittings.
.2 ASME B16.18-01, Cast Copper Alloy Solder Joint Pressure Fittings.
.3 ASME B16.22-01, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
.4 ASME B18.2.1-96, Square and Hex Bolts and Screws Inch Series.

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

.1 ASTM A47/A47M-99(2004), Standard Specification for Ferritic Malleable Iron Castings.
.2 ASTM A53/A53M-04, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
.3 ASTM B75M-99, Standard Specification for Seamless Copper Tube Metric.
.4 ASTM B837-01, Standard Specification for Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.

.3 Canadian Standards Association (CSA International)

.1 CSA W47.1-03, Certification of Companies for Fusion Welding of Steel.

.4 Canadian Standards Association (CSA)/Canadian Gas Association (CGA)

.1 CAN/CSA B149.1HB-00, Natural Gas and Propane Installation Code Handbook.

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

.1 Material Safety Data Sheets (MSDS).

1.3 Action and Informational Submittals

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.

.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 Closeout Submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 23 – Operation and Maintenance Data and Manuals and 01 78 43 Spare Parts and Maintenance Materials.

1.4 Delivery, Storage and Handling

.1 Waste Management and Disposal:

.1 Packaging Waste Management: remove for reuse or recycling of pallets, crates, and packaging materials in accordance with Section 01 74 19 - Waste Management.

1.5 Cash Allowance

.1 Contractor to carry a $10,000.00 cash allowance to cover the cost of the gas service and 35 kPa gas meter. Refer to Architectural specification.

2 PRODUCTS

2.1 Materials

.1 Materials and products in accordance with Section 01 35 40 LEED Sustainable Design Requirements.

2.2 Pipe

.1 Steel pipe: to ASTM A53/A53M, Schedule 40, seamless as follows:

.1 NPS 1/2 to 2, screwed.
.2 NPS2 1/2 and over, plain end.

.2 Copper tube: to ASTM B837.

2.3 Jointing Material

.1 Screwed fittings: pulverized lead paste.

.2 Welded fittings: to CSA W47.1.

.3 Flange gaskets: nonmetallic flat.

.4 Brazing: to ASTM B837.

2.4 Fittings

.1 Steel pipe fittings, screwed, flanged or welded:

.1 Malleable iron: screwed, banded, Class 150.
.2 Steel pipe flanges and flanged fittings: to ASME B16.5.
.3 Welding: butt-welding fittings.
.4 Unions: malleable iron, brass to iron, ground seat, to ASTM A47/A47M.
.5 Bolts and nuts: to ASME B18.2.1.
.6 Nipples: schedule 40, to ASTM A53/A53M.

.2 Copper pipe fittings, screwed, flanged or soldered:

.1 Cast copper fittings: to ASME B16.18.
.2 Wrought copper fittings: to ASME B16.22.

2.5 Valves

.1 Provincial Code approved, lubricated ball type.

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 Piping

.1 Install in accordance with Section 23 05 05 - Installation of Pipework, applicable Provincial/Territorial Codes and CAN/CSA B149.1, supplemented as specified.

.2 Install drip points:

.1 At low points in piping system.
.2 At connections to equipment.

3.3 Valves

.1 Install valves at branch take-offs to isolate pieces of equipment, and as indicated.

3.4 Field Quality Control

.1 Site Tests/Inspection:

.1 Test system in accordance with CAN/CSA B149.1 and requirements of authorities having jurisdiction.

3.5 Adjusting

.1 Purging: purge after pressure test in accordance with CAN/CSA B149.1.

.2 Pre-Start-Up Inspections:

.1 Check vents from regulators, control valves, terminate outside building in approved location, protected against blockage, damage.
.2 Check gas trains, entire installation is approved by authority having jurisdiction.

3.6 Cleaning

.1 Cleaning: in accordance with Section 23 08 02 - Cleaning and Start-Up of Mechanical Piping Systems CAN/CSA B149.1, supplemented as specified.

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

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

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

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

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

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

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

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

.7 Section 23 25 00 – HVAC Water Treatment.

1.3 References

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

.2 American National Standards Institute (ANSI)/American Welding Society (AWS).

.1 ANSI/AWS A5.8/A5.8M, Specification Filler Metals for Brazing and Bronze Welding.

.3 American Society of Mechanical Engineers (ASME).

.1 ASME Boiler and Pressure Vessel Code (BPVC), Section V, Non-Destructive Examination.

.2 ASME B1.20.1, Pipe Threads, General Purpose.

.3 ASME B16.1, Cast Iron Pipe Flanges, and Flanged Fittings.

.4 ASME B16.3, Malleable Iron Threaded Fittings.

.5 ANSI/ASME B16.4, Gray-Iron Threaded Fittings.

.6 ASME B16.5, Pipe Flanges, and Flanged Fittings.

.7 ASME B16.9, Factory-Made Wrought Butt welding Fittings.

.8 ANSI/ASME B16.15, Cast Bronze Threaded Fittings.

.9 ANSI/ASME B16.18, Cast Copper Alloy, Solder Joint Pressure Fittings.

.10 ANSI/ASME B16.22, Wrought Copper and Copper-Alloy Solder Joint Pressure Fittings.

.11 ASME B18.2.1, Square and Hex Bolts and Screws

.12 ASME B18.2.2, Square and Hex Nuts.

.13 ASME B31.1, Power Piping.

.14 ASME B31.9, Building Services Piping.

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

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

.2 ASTM A234, Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

.3 ASTM A536, Standard Specification for Ductile Iron Castings.

.4 ASTM B32, Standard Specification for Solder Metal.

.5 ASTM B62, Standard Specification for Composition Bronze, or Ounce Metal Castings.

.6 ASTM B88M, Seamless Copper Water Tube.

.7 ASTM B283, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).

.8 ASTM D 1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

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

.10 ASTM F1960 - Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-Linked Polyethylene (PEX) Tubing

.11 ASTM F2389, Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

.5 American Water Works Association (AWWA).

.1 AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

.6 Canadian Standards Association (CSA International).

.1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.

.2 CSA B214, Installation Code for Hydronic Heating Systems.

.3 CSA B137.5, Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.

.4 CSA B137.11, Polypropylene (PP-R) Pipe and Fittings for Pressure Applications

.5 CSA B242, Groove and Shoulder Type Mechanical Pipe Couplings.

.6 CSA W47.1, Certification of Companies for Fusion Welding of Steel.

.7 CSA W117.2, Safety in Welding, Cutting, and Allied Processes.

.8 CSA W178.2 Certification of Welding Inspectors

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

.1 MSS-SP-67, Butterfly Valves.

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

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

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

.5 MSS SP-82, Valve Pressure Testing Methods.

.6 MSS-SP-85, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

.7 MSP-SP-110, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved, and Flared Ends.

.8 MSS SP 125:2010, Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves

.8 Standards Council of Canada (CAN/ULC)

.1 CAN/ULC S102.2 Standard Method of Test for Surface Burning Characteristics of building Materials and Assemblies

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

1.4 Submittals

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

.1 Submit detailed shop drawings of valves. Shop drawings shall clearly indicate valve make, model, location, type, size and pressure rating, Cv rating and Provincial CRN number for each valve type.

.2 Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified with the applicable style or series designation.

.3 Polypropylene pipe and fittings

.4 Crosslinked polyethylene pipe and fittings

.5 Pre-Insulated, direct buried piping system

1.5 Quality Assurance

.1 All components, products, and fabrication techniques shall be provided in compliance with the Regulations and Requirements of the Alberta Boiler Safety Authority (ABSA) and the “Pressure Equipment Safety Regulation”.

.2 Pipe welding:

.1 Installation and repair or alterations to, pressure piping systems shall be performed only by licensed Contractors and licensed Welders, certified for the work being done in accordance with Alberta Boiler Safety Authority (ABSA) and the “Pressure Equipment Safety Regulation”.

.2 All field welding to be in accordance with the procedures of CSA-W117.2 and the current edition of ASME/ANSI B31.3 Code and the Alberta Boiler Safety Authority (ABSA) and the “Pressure Equipment Safety Regulation”

.3 The Contractor shall submit names and qualifications of all personal (including sub-trades) intended for this project within twenty-one (21) days of contract award. The Owner reserves the right to accept or reject any individual proposed for the project, based on qualifications.

.4 Welders must be qualified for the process for which they are welding in. Typical field welding processes are listed below:

.1 SMAW (Shielded Metal Arc Welding) also known as stick welding

.2 FCAW (Flux-cored arc welding) also known as wire welding

.5 Welders Qualifications

.1 Welding qualifications in accordance with CSA B51

.2 Use qualified and licensed welders possessing certificate for each procedure performed from authority having jurisdiction.

.3 Furnish welder's qualifications to Owner’s Representative.

.4 Each welder to possess identification symbol issued by authority having jurisdiction.

.6 Inspectors Qualifications

.1 Inspectors qualified to CSA W178.2.

.3 Grooved Piping

.1 All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. (Combining products of multiple manufacturers is not permitted.) Grooving tools shall be of the same manufacturer as the grooved components.

.2 The manufacturer shall be ISO 9001 certified.

.3 All gaskets, coupling housings, fittings, and valve (body and component) castings will be date stamped for quality assurance and traceability.

.4 Gaskets shall be molded and produced by the coupling manufacturer.

.1 EPDM elastomer materials shall be developed, manufactured, and tested in the coupling manufacturer's facility. The EPDM shall be a proprietary blend that exceeds industry standards for performance over the long term.

.2 The coupling manufacturer's gasket development and production shall be periodically audited by quality and polymer industry professionals.

.3 The Victaulic proprietary blend is the only EHP that is considered acceptable for hot water heating systems to 120°C (250°F).

.5 Where grooved end joint methodology is the primary construction method, the system will include grooved balancing, isolation, pressure reducing valves, control valves, check valves, strainers and engineered vibration isolation pump drops. Unless a required valves, specialty or accessories is not manufactured as part of their offering

.6 All grooved joint products shall comply with CSA B242.

1.6 Regulatory Requirements

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

1.7 System Pressure Ratings

.1 Pipe Fittings:

.1 Piping systems 860 kPa (125 psig) or less operating pressure - 860 kPa (125 psig) rating.

.2 Piping systems 870 kPa (126 psig) to 1730 kPa (250 psig) operating pressure – 1730 kPa (250 psig) rating.

.2 Valves: Suitable for maximum system operating temperature and pressure.

1.8 Maintenance

.1 Extra Materials. Provide the following spare parts:

.1 Valve seats: one for every ten valves, each size. Minimum one.

.2 Discs: one for every ten valves, each size. Minimum one.

.3 Stem packing: one for every ten valves, each size. Minimum one.

.4 Valve handles: two of each size.

.5 Gaskets for flanges: one for every ten flanges.

1.9 Valves

.1 Wherever possible all valves shall be of one manufacturer.

.2 Grooved valves shall be of the same manufacturer as the adjoining couplings.

.3 Provide valves with manufacturer's name and pressure rating clearly marked on outside of body. All valves must be suitable in all respects for service used.

.4 All valves shall have a Provincial CRN number, which is current.

.5 Include lock shield handles where shown or noted.

.6 Where lockshield valves are specified, provide three (3) keys of each size: malleable iron cadmium plated.

.7 Use non-rising stem valves where there is insufficient clearance for stem to rise.

.8 Where butterfly valves are installed to permit removal of equipment, they shall be of the threaded full lug type or grooved if grooved system is used. They may however, be of the wafer type if an additional pair of flanges (not those installed to contain the valve) are installed.

.9 All valves shall be inspected and pressured tested in accordance with MSS SP-82.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 Pipe Hangers and Supports

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

2.3 Steel Pipe and Fittings

.1 Steel Pipe:

.2 6 NPS and smaller: Schedule 40, complying with ASTM A53, Grade B.

.1 Applications: Heating water, chilled water, condenser water in closed circuits., chemical feed, relief valve vents.

.3 8 NPS and over: Schedule 40, complying with ASTM A53, Grade B.

.1 Applications: Heating water, chilled water, condenser water in closed circuits..

.4 Fittings:

.1 NPS 2 and under: Screwed fittings, except where otherwise noted, with PTFE tape or lead-free pipe dope.

.1 Screwed fittings: malleable iron, to ASME B16.3, Class 150.

.2 Unions: malleable iron, to ASME B16.3.

.2 NPS 2-1/2 and over: welded fittings and flanges to CSA W47.1.

.1 Butt-welding fittings: steel, to ASME B16.9.

.3 NPS 2 to 12: Fittings for roll grooved piping to CSA B242 Couplings will have bolts of equal length and diameter, and multi-segmented couplings will not be accepted at any size.

.1 Housings shall be cast with shift limiting slant pad design, with torque absorber, one-touch bolt tightening and bolt pad to bolt pad assembly in accordance with ANSI B31.1 and B31.9.

.2 Rigid Type Coupling: Installation-Ready complete with pre-lubricated centre leg gaskets, for direct stab installation without field disassembly, with grade EHP gasket rated to 120°C (250°F).

.1 Victaulic Style 107 or equivalent.

.3 Flexible Type Coupling: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 120°C (250°F). For use in locations where vibration attenuation and stress relief are required. Three flexible couplings may be used in lieu of flexible connector provided it meets vibration isolation requirements. The couplings shall be placed in close proximity to the source of the vibration.

.1 Victaulic Installation-Ready Style 177 to 120°C (250°F) for NPS 2 to 8 or Victaulic Style 77 to 110°C (230°F) for NPS 10 to 12, or equivalent products

.4 NPS 14 to 24 Couplings will have two (2) symmetrical halves with no other loose parts. Couplings will have bolts of equal length and diameter, and multi-segmented couplings will not be accepted at any size. Fittings for roll grooved piping to CSA B242.

.1 Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal gasket.

.2 Rigid Type Coupling: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.

.1 Victaulic Style W07.

.3 Flexible Type Coupling: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.

.1 Victaulic Style W77.

.5 Roll Groove Fittings

.1 Roll grooved fitting gaskets: Grade “EHP” gasket for temperature range -34°C (-30°F) to 120°C (250°F) or “EPDM” gasket for temperature range -34°C (-30°F) to 110°C (230°F).

.2 Roll groove couplings shall consist of two ductile iron housing segments, pressure responsive gasket, and zinc electroplated steel bolts and nuts conforming to ASTM A536 Grade 65-45-12. (Multiple segment type couplings are not permitted.)

.3 Fittings for roll grooved piping: -Ductile iron to ASTM A536 Grade 65-45-12

.4 536; wrought steel to ASTM A234; or where cast or wrought pattern is not available factory fabricated and tested to ASTM A53.

.5 Fittings shall be of the same manufacturer as the adjoining couplings.

.6 Grooving tools shall be of the same Manufacturer as the grooved components.

.7 All castings used for coupling housings, fittings, valve bodies, etc., shall be dated stamped for quality assurance and traceability.

.5 Flanges:

.1 Cast iron: to ASME B16.1, class 125 or 150 to match system pressure class.

.2 Steel: to ASME B16.5. Class 125 or 150 to match system pressure class.

.3 Roll Groove: Flange Adapter, flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125, or 150 flanged components.

.1 Victaulic Style 741 / W741.

.4 Flange Bolts and Nuts, carbon steel: to ANSI B18.2.1 and ANSI B18.2.2.

.5 Gaskets to AWWA C111

.1 Up to 860 kPa (125 psig) system pressure - non-asbestos gaskets for mating surfaces.

2.4 Crosslinked Polyethylene Pipe (PEX)

.1 2 NPS and smaller.

.2 High-density crosslinked polyethylene conforming to ASTM F876, ASTM F1960, and CSA B137.5.

.3 All PEX tubing, fittings, and fitting assemblies shall be by one manufacturer.

.4 Pipe shall be rated for continuous operation of 690 kPa @ 82°C (100 psi @ 180°F).

.5 PEX tubing shall be ASTM F876 tested and approved for excessive temperature and pressure for 725 hours at 99°C (210°F) @ 1035 kPa (150 psi).

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

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

.8 PEX pipe to have an oxygen barrier. PEX pipe to allow oxygen permeation no more than 0.1g/m3/day at 40°C in accordance to DIN 4726

.9 Manufacturer's warranty shall be twenty-five (25) years on pipe and fittings.

.10 Fittings in compliance with CSA B137.5 and approved by the manufacturer's PEX piping system, with applicable plumbing and mechanical code certifications.

.11 Distribution manifolds shall be stainless steel or brass and supplied by the piping manufacturer.

2.5 Pipe – Pre-Insulated, Direct Buried

.1 General:

.1 The project drawings are diagrammatic and although efforts have been made to provide information regarding the number of offsets, not all are necessarily shown. Changes may be required in pipe routings and elevation to eliminate interference with ground conditions, other services, and system expansion.

.2 The piping system layout shall be analyzed by the piping system manufacturer to determine the stresses, expansion and any displacements of the service pipe. The system manufacturer shall provide all necessary engineering and components; including but not limited to offsets, anchors, expansion compensation as required for a complete installation.

.3 All straight sections, fittings, anchors and other accessories shall be factory fabricated, insulated and jacketed.

.4 High-density crosslinked polyethylene (PEX) carrier pipe conforming to the requirements of one or more of the following: ASTM F876, DIN 16892, and/or DIN 16893. PEX carrier pipe shall have a minimum degree of crosslinking of 70% when tested in accordance with ASTM D2765, Method B.

.5 Maximum operating pressure: 689 kPa (100 psi) @ 82°C (180°F) or 550 kPa (80 psi) @ 93°C (200°F). PEX tubing shall be ASTM F876 tested and approved for excessive temperature and pressure for 725 hours at 99°C (210°F) @ 1035 kPa (150 psi).

.6 Oxygen diffusion barrier to be a coextruded barrier layer that limits oxygen diffusion through the PEX carrier pipe to less than 0.32 mg/m2/dat 104°F temperature, as defined by DIN 4726, shall be applied to the PEX carrier pipe.

.7 Insulation:

.1 Closed-cell polyurethane foam or layered expanded cross-linked water-resistant polyethylene closed cell foam with sealed seams.

.2 Minimum density to be 3.5 lb/ft3, measured in accordance with ASTM D1622.

.3 Closed cell structure to be minimum 90%, in accordance with ASTM D2856.

.4 Closed cell foam insulation shall have a maximum thermal conductivity of 0.02 BTU/hr-ft-°F, measured in accordance with ASTM C177.

.5 Minimum water diffusion resistance of 90 μ, and a maximum water absorption of 1.5% after 24 hours, in accordance to DIN 53428.

.8 Insulation Jacket:

.1 Jacket shall be made from seamless, extruded low or high density polyethylene (LDPE) (HDPE).

.9 Fittings

.1 Mechanical fittings to be of ASTM F2080 compression-sleeve style, manufactured of metal suitable for the fluid application, in a size suitable for the PEX carrier pipe dimensions or to ASTM F1960 Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-Linked Polyethylene (PEX) Tubing.

.2 Fittings with Solder-joint Ends: Solder-joint end dimensions shall be in accordance with ASME B16.18, ASME B16.22, or MSS SP-104.

.3 Tapered Threaded Ends: Fitting threads shall be right-hand, conforming to ASME B1.20.1, and shall be tapered threads (NPT).

.4 Compression-Sleeve Fittings: Mechanical compression-sleeve ASTM F2080 cold-expansion fittings to consist of a metal ribbed insert and a metal compression-sleeve. Fittings must meet the temperature and pressure performance requirements of the PEX carrier pipe.

.10 Warranty

.1 The pipe manufacturer shall warrant the crosslinked polyethylene carrier pipe to be free from defects in material and workmanship for a period of twenty-five (25) years.

2.6 Isolation Valves

.1 Gate Valve (for shut-off and isolation)

.1 NPS 1 and smaller, soldered:

.1 W.O.G. non-shock 1380 kPa (200 psi)

.2 Bronze body, solid wedge disc, bronze, or stainless steel trim, rising stem, union or screwed bonnet, complying with MSS SP 80.

.2 NPS 2 and smaller, threaded:

.1 ANSI Class 125 (860 kPa)

.2 Bronze body, solid wedge disc, bronze, or stainless steel trim, rising stem, union or screwed bonnet, complying with MSS SP 80.

.3 NPS 2½ and over, flanged:

.1 ANSI Class 125 (860 kPa)

.2 Cast iron body, solid wedge disc, bronze or stainless steel trim, bolted bonnet, rising stem, outside screw and yoke complying with MSS SP 70

.2 Ball Valve (in lieu of gate valves or as specified)

.1 Ball valves for isolation service shall have a large/full port.

.2 Ball valves for balancing service shall have a reduced port and valve handle shall have a memory stop.

.3 In compliance with MSS-SP-110

.4 NPS 1 and smaller, soldered:

.1 W.O.G. non-shock 4140 kPa (600 psi)

.2 Brass two piece body, blow-out proof stem, PTFE seats, brass chrome plate ball, lever handle operator rating complying with ASTM B283.

.5 NPS 2 and smaller, threaded:

.1 W.O.G. non-shock 4140 kPa (600 psi)

.2 Brass two piece body, blow-out proof stem, PTFE seats, brass chrome plate ball, lever handle operator, complying with ASTM B283.

.3 Ball Valve (Installation ready)

.1 Dezincification resistant brass body, chrome-plated brass ball and stem, full port, blow-out-proof stem with double EPDM O-ring, PTFE seats, zinc-plated carbon steel handle with orange vinyl grip, and plain ends for use with the small diameter installation-ready system in sizes ½" through 2" (DN15 through DN50). Rated for services to 2065 kPa (300 psi).

.4 Globe Valves

.1 NPS 1 and under, soldered:

.1 W.O.G. non-shock 2070 kPa (300 psi)

.2 Bronze body, rising stem, bronze disc, screwed bonnet, PTFE disc, complying with MSS-SP-80

.2 NPS 2 and under, threaded:

.1 ANSI Class 150 (1035 kPa)

.2 W.O.G. non-shock 2070 kPa (300 psi)

.3 Bronze body, rising stem, bronze disc, screwed bonnet, PTFE disc, complying with MSS-SP-80

.3 NPS 2 1/2 to NPS 10

.1 Working pressure 860 kPa (125 PSI) steam, W.O.G. non shock 1400 kPa (200 PSI)

.2 Outside stem and yoke with bolted bonnet, bronze disc to ASTM B62, fully guided from bottom, renewable and regrindable seat, bronze stem. Hand wheel operated.

.3 Complies with MSS-SP-70

.5 Butterfly Valves

.1 NPS 2-1/2 and over:

.1 ANSI Class 150 (1035 kPa)

.2 Ductile iron body with bronze disc, stainless steel stems and extended neck to clear minimum of 50 mm (2") thick insulation, EPT or EPDM, complying with MSS-SP-67.

.3 Threaded full lug type or wafer type (with or without integral flanges).

.4 Resilient EPT or EPDM seat.

.5 Operators (unless otherwise specified in the Controls Section):

.1 NPS 8 and under - lever handle with minimum 10 position ratchet and disc position indicator.

.2 NPS 10 and over - worm gear operator.

.2 NPS 2-1/2 to 14 – steel roll grooved piping:

.1 W.O.G. non-shock 2070 kPa (300 psi) suitable for bi-directional and dead-end service to full rated pressure.

.2 Ductile iron body, blow-out proof stainless steel stem, electroless nickel coated ductile iron, aluminum bronze or stainless steel disc, grooved ends.

.3 EPDM seat

.4 Stainless steel stem. (Stem shall be offset from the disc centreline to provide full 360-degree circumferential seating.)

.5 Operators, unless noted otherwise in the Controls Section:

.1 NPS 2-1/2 through NPS 8: lever handle with minimum 10 position ratchet and disc position indicator.

.2 NPS 10 and over: worm gear operator.

2.7 Automatic Flow Control Valves

.1 General: Devices shall automatically control the required flow quantity between differential pressure ranges of 7 to 600 kPa (1 to 87 psig).

.2 NPS 2 and smaller:

.1 W.O.G. non-shock 4140 kPa (600 psi)

.2 Body shall be forged brass complying with ASTM B283.

.3 Flow Cartridge shall be accessible non-clogging piston type with + 5% accuracy. Return from coil: (downstream side of Temperature Control Valve); Combination assembly including:

.1 Body fitted with ball shut off valve, hard chrome plated, Teflon Ball Seals and Viton O-Rings.

.2 Two P/T Plugs, union for accepting temperature control valve (by controls contractor).

.4 Return from coil: (upstream side of Temperature Control Valve); Combination assembly including:

.1 Full port union with manual air vent and P/T test plug.

.5 Supply to coil; Combination assembly including:

.1 Ball valve, strainer P/T test plug, and blow down drain valve.

.3 NPS 2½ and larger:

.1 W.O.G. non-shock 2760 kPa (400 psi)

.2 Body shall be epoxy coated ductile iron complying with ASTM A536.

.3 Flow cartridges 304 SS moving parts in brass housing, 14 to 310 kPa (2 to 45 psig) 1.9 to 144 l/s (25 to 2280 gpm)

.4 P/T Plugs, thermometer well and drain.

.4 Provide a dual hose temperature/pressure meter kit with flow conversion chart and carrying case.

2.8 Circuit Balancing Valves

.1 NPS 2 and under:

.1 Maximum operating pressure 2065 kPa (300 psi).

.2 Operating temperature -20°C to 150°C (-4 to 300°F)

.3 Lead free brass or copper alloy body, double regulating valve, 'Y' pattern globe, threaded ends with test points, memory stop and hand wheel providing flow measurement, flow balancing and drip-tight shut-off. 90° ‘circuit-setter’ style ball valves are not acceptable.

.2 NPS 2-1/2 and over:

.1 Maximum operating pressure 863 kPa (125 psi).

.2 Operating temperature to 110°C (230°F)

.3 Cast iron body with flanged connections or ductile iron with grooved ends, double regulating valve, 'Y' pattern globe, with test points, memory stop and hand wheel providing flow measurement, flow balancing and drip-tight shut-off. 90° ‘circuit-setter’ style ball valves are not acceptable.

.3 Calibration charts and adjustment tools to be included.

.4 Provide one (1) differential pressure meter kit suitable for direct readout c/w connection hoses suitable for the system pressure.

2.9 Swing Check Valves

.1 In compliance with MSS-SP-71

.2 NPS 1 and under, soldered:

.1 W.O.G. non-shock 1380 kPa (200 psi)

.2 Bronze body, bronze swing disc, screw in cap, re-grindable seat.

.3 NPS 2 and under, threaded:

.1 W.O.G. non-shock 1380 kPa (200 psi)

.2 Bronze body, bronze swing disc, screw in cap, re-grindable seat.

.4 NPS 2-1/2 and over, grooved:

.1 W.O.G. non-shock 2065 kPa (300 psi)

.2 Ductile iron body, EPDM seat, stainless steel swing disc, coupled cap.

.5 NPS 2-1/2 and over, flanged:

.1 ANSI Class 125 (860 kPa)

.2 Cast iron body, renewable or re-grindable seat, bronze swing disc, bolted cap.

2.10 Silent Check Valves (Spring Type)

.1 NPS 2 and under, threaded:

.1 ANSI Class 125 (860 kPa)

.2 Bronze body, bronze trim, stainless steel spring, (heavy duty spring in vertical down flow application)

.2 NPS 2-1/2 and over, flanged:

.1 ANSI Class 125 (860 kPa)

.2 Cast steel, wafer style, renewable bronze trim, stainless steel spring (heavy duty spring in vertical down flow application). Complying with MSS-SP-125

.3 NPS 2-1/2 through 12, grooved ends

.1 W.O.G. non-shock 2065 kPa (300 psi)

.2 Ductile iron body, electroless nickel plated seat, EPDM coated disc and seals, stainless steel spring and shaft.

.4 NPS 14 through 24, grooved ends

.1 W.O.G. non-shock 1575 kPa (230 psig)

.2 Ductile iron body, stainless steel dual disc(s), EPDM seat. Stainless steel spring and shaft.

2.11 Combination Balance/Check Valves

.1 Combination Balance/Check Valves are not acceptable.

2.12 Needle Valves

.1 Bronze body, screwed, globe type with cadmium plated steel stem.

.2 ANSI Class 400 (2760 kPa).

2.13 Drain Valves

.1 Minimum 2070 kPa (300 psi) WOG rated, 20 mm (¾") diameter straight pattern bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm (¾") diameter hose, and a cap and chain.

2.14 Pressure Relief Valves

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

2.15 Air Vents

.1 Manual Air Vents

.1 Equal to Conbraco 27 Series, 3.2 mm (⅛") diameter with a key handle.

.2 Automatic Air Vents

.1 Float actuated air vents, each complete with a semi-steel body and cap, a stainless steel float assembly and seat, and a neoprene head.

2.16 Strainers

.1 Cast iron wye shaped strainers, minimum 890 kPa (125 psi) rated and complete with a removable type 304 stainless steel screen with perforations sized to suit the application, and, for strainers 50 mm (2") diameter and larger, a blowdown pipe connection tapping

2.17 Hose Bibbs

.1 1724 kPa (250 psi) to 121°C (250°F).

.2 Brass ball valve with forged brass cap and chain, NPS 3/4 male threaded hose end, lockshield in public areas.

2.18 Coil Piping Packages:

.1 Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V may be used at coil connections. The kit shall include a Victaulic Series 786/787/78K circuit balancing valve or Victaulic automatic balancing valve or Series 7CP or 7MP PIBCV, Series 78Y Strainer-Ball, Series 78U Union-Port fitting, or Series 78T union / ball valve and required coil hoses. Or equivalent coil kits or equivalent

.2 A Style 793 and/or 794 differential pressure controller shall be provided as required. A meter shall be provided by the valve manufacturer that shall remain with the building owner after commissioning.

.3 6-Way Coil-Hook-up Connections: Victaulic/TA Six-way valve shall be on/off and connected to a pre-set combination PICV and control valve. NPS 1/2 NPS 3/4 7CP Compact-P or 7MP Modulator with Slider 160 Plus control valve to control both the hot and chilled lines with one valve. The control valve will be programmed to handle both hot and chilled water GPM requirements with the use of TA Dongle. Or equivalent coil kits.

3. EXECUTION

3.1 General

.1 Installation shall meet or exceed all applicable Federal, Provincial and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

.2 Install in accordance with manufacturer’s instructions.

.3 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 21 05 01 Common Work Results for Mechanical.

.4 Avoid installation of service components (such as valves, air vents, strainers, etc.) in secure areas.

3.2 Clearances

.1 Provide clearance around systems, equipment, valves, fittings and components for observation or operation, inspection, servicing, maintenance and as recommended by the manufacturer. Maintain a minimum of 25 mm (1") space between adjacent flanges or pipe insulation, whichever has the larger diameter.

.2 Provide space for disassembly, removal of equipment and components as recommended by the manufacturer or as indicated, whichever is greater, without interrupting operation of other systems, equipment and components.

.3 Provide adequate clearance for installation of insulation.

3.3 Routing and Grading

.1 Route piping in an orderly manner and maintain proper grades. Install to conserve headroom and interfere as little as possible with use of space. Run exposed piping parallel to walls. Group piping wherever practical at common elevations. Install concealed pipes close to the building structure to keep furring to a minimum.

.2 Install piping free of sags and bends.

.3 Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and services areas.

.4 Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

.5 Avoid piping in exterior walls unless otherwise directed. If required, install this piping protected from the outside by the building insulation and vapour barrier.

.6 Avoid locating water and drain piping over electrical equipment. Where this is unavoidable, provide galvanized drip pans under such pipe, and weld piping and fittings. Provide drain and piping from drip pans to satisfactory floor drain.

.7 Slope water piping at 0.2% and arrange to drain at low points.

.8 Make reductions in water pipe sizes with eccentric reducers to provide drainage and venting.

3.4 Piping

.1 Ream pipe ends. Clean scale and dirt, inside and outside before and after assembly. Remove welding slag or other foreign material from piping.

.2 During construction, protect all openings in piping and equipment, by capping or plugging to prevent entry of dirt.

.3 Where more than one piping system material is specified, ensure system components are compatible, and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.

.4 Select system components with pressure rating equal to or greater than rated pressure of system piping.

.5 Screw, or weld, QVSD or groove fittings (unless otherwise specified) for all piping systems up to NPS 2.

.6 Weld or Victaulic groove (unless otherwise specified) all piping systems NPS 2-1/2 and over.

.7 Make screwed joints with full cut standard taper pipe threads with approved non-toxic compound applied to male threads only.

.8 Saddle type branch fittings are not acceptable.

.9 Saddle type branch fittings may be used on mains, if branch line is half size or smaller than main. Hole saw or drill and ream main to maintain full inside diameter of branch line prior to welding saddle. Victaulic Style 920/920N mechanical tees.

.10 Use long radius elbows. Victaulic #10 or W10 standard radius elbows may be used in lieu of long radius elbows in grooved piping systems in equipment rooms and where space considerations must be made.

.11 Install all thermometer wells and immersion sensor wells specified under the Controls Section. Where wells will restrict flow in small diameter pipes (NPS 1-1/2 and smaller) install a section of oversized pipe at least NPS 2.

.12 Remake leaking joints using new materials, do not caulk, or cement leaking threaded joints.

.13 Use eccentric reducers at pipe size changes, flush on top side, to permit positive venting and drainage.

.14 Do not use thread protection couplings, close nipples, running nipples or street elbows.

.15 Bull head tees shall not be used for converging flows.

.16 Make connections to equipment and branch mains with unions.

.17 All run-outs shall be installed with swing joints to allow for movement due to expansion and contraction of the main.

.18 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

.19 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. Refer to Section 09 Painting.

.20 Install temperature probe ports and pressure probe ports upstream and downstream of all heating systems components including but not limited to the following items: heat exchangers, all hydronic coils, finned tube elements, radiant heaters, in-floor heating zones, pumps, boilers, chillers, and cogeneration units. The contractor shall coordinate these items with the balancing contractor to ensure that all ports are installed as required by the balancer.

3.5 Pipe – Pre-Insulated, Direct Buried

.1 Installation of the piping system shall be in accordance with manufacturer's instructions. Factory trained field technical assistance shall be provided for critical periods of installation, unloading, field joint instruction and testing.

.2 Field Joints:

.1 Hydrostatically test steel piping system to 1034 kPa (150 psig) or 1-1/2 times the design pressures, whichever is greater. Insulation shall then be poured in place into the field joint area. All field-applied insulation shall be placed only in straight sections of pipe. Field insulation of fittings is not acceptable.

.2 Installer shall seal the field joint area with a heat shrinkable adhesive backed sleeve. Backfilling shall not begin until the heat shrink sleeve has cooled. All insulation and jacketing materials for the field joint shall be furnished by the piping manufacturer.

.3 Backfill:

.1 A 100 mm layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding in 150 mm compacted layers to a minimum height of 150 mm above the top of the insulated pipe. The remaining trench shall be evenly and continuously backfilled and compacted in uniform layers with suitable excavated soil.

3.6 Soldering and Brazing

.1 Pressure fluid systems - with chemical treatment (heating, chilled and condenser water) braze with silver base brazing alloy, 538°C (1000°F) melting point.

.2 Pressure fluid systems - without chemical treatment, (heat recovery, domestic water) solder with 95/5 tin-antimony to ASTM B32.

.3 Non-pressure systems, (drains) solder with 50/50 tin lead.

.4 Piping connections to radiant ceiling panels, solder with 95/5 tin-antimony.

3.7 Roll Groove Piping

.1 Use lubricant supplied by Manufacturer, where applicable and recommended by manufacturer, and coat gasket. Lubricate gaskets in accordance with manufacturer's recommendation with lubricant supplied by the coupling manufacturer that is suitable for the gasket elastomer and system media..

3.8 Grooved Joint Piping

.1 Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.

.2 Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

.3 Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer.

.4 The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products.

.5 The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation and report their findings to the Consultant.

3.9 Connections to Equipment

.1 Connect to equipment in accordance with manufacturer's instruction unless otherwise noted.

.2 Provide line sized isolation valves at each piece of equipment.

.3 Install unions, flanges, or grooved couplings downstream of isolation valves and at equipment or apparatus connection. Do not use direct welded or threaded connections to valves, equipment, or other apparatus.

.4 Install removable sections of pipe or 300 mm (12") spool pieces on the suction side of end suction pumps and where required for ease of maintenance.

.5 Arrange piping connections to allow ease of access and for removal of equipment.

.6 Align and independently support piping connections adjacent to equipment to prevent piping stresses being transferred.

.7 Do not reduce equipment connection sizes by bushing.

.8 Use double swing joints when equipment mounted on vibration isolation and when piping is subject to movement.

3.10 Drain Connections

.1 Make connections to all equipment drains, drain pans, ductwork drains, discharge from all liquid relief valves, liquid safety valves, high capacity air vents, steam drip pan elbows, equipment blowdowns, water columns, and overflows. Pipe to nearest floor drain or approved connection. Install a brass, bronze or copper receiving funnel on the drain where shown. Where item being drained is under pressure, provide a deep seal trap.

.2 If a gravity drained connection cannot be made because of invert elevations, provide a packaged condensate pump with integral float control to be wired by this contractor to the unit power connection. The condensate drain line shall be insulated with continuous 25 mm (1") thick insulation from the point of connection to the indirect waste connection.

.3 Drains from drain pans shall be DWV copper NPS 1-1/4 minimum size.

.4 Drain and vent piping shall be of the same material as the piping system to which it is connected, except where otherwise specified.

3.11 Valves

.1 General

.1 Install all valves in accordance with manufacturer's recommendations.

.2 Valves to be provided with stem extension to allow for proper insulation thickness. Stem extension to stay stationary to ensure vapor barrier seal is not broken when valve is exercised.

.3 Install valves in accessible locations with stems upright or angled 45° above horizontal unless approved otherwise. Valves must be accessible without removing adjacent piping.

.4 Provide valves suitable to connect to adjoining piping as specified for pipe joints. Use line sized valves unless specifically noted otherwise.

.5 Remove interior parts before soldering.

.6 Provide stem extensions on all insulated valves.

.7 Provide ball valves in piping NPS 2 and smaller and butterfly valves in piping NPS 2-1/2 and larger for shut-off, equipment isolation, throttling, bypass or manual flow control services.

.8 Throttling valves are not to be used for shut-off; additional valves shall be installed for isolation purposes.

.2 Isolation valves:

.1 Provide isolation valves at branch take-offs, to isolate each piece of equipment, upstream of all meters, gauges, automatic air vents, and as indicated.

.2 Provide isolation valves in all systems such that floor by floor for horizontal systems, all risers in vertical systems and zone areas on a large horizontal system can be isolated.

.3 All pressure service cap-offs for future shall be provided with isolation valves.

.4 Ball valves used for shut-off / isolation shall be full port.

.3 Check valves:

.1 Use swing or soft seated spring loaded check valves in horizontal and vertical upflow pipes and on the discharge of pumps. Spring loaded water check valves shall be located eight (8) pipe diameters downstream of pumps or elbows.

.2 Use silent check valves on discharge of pumps and in vertical pipes with downward flow, and as indicated.

.4 Check valves:

.1 Use swing or soft seated spring loaded check valves in horizontal and vertical upflow pipes and on the discharge of pumps. Spring loaded water check valves shall be located eight (8) pipe diameters downstream of pumps or elbows.

.2 Use silent check valves on discharge of pumps and in vertical pipes with downward flow, and as indicated.

.5 Balancing valves:

.1 Use circuit setting globe valves complete with lockshield to control flow in circuits, except where balancing cocks are specifically specified.

.2 Install balancing valves in return piping connections to each terminal heating and cooling unit – e.g. radiators, unit heaters, fan coil units, heating and cooling coils, and radiant panels.

.3 [Triple duty valves are not acceptable for this project].

.4 Coordinate with the balancing subcontractor regarding the appropriate sizing of all balancing valves and calibrated balancing valves. The balancing subcontractor shall provide direction to the mechanical contractor for the appropriate size for each balancing valve within each system that is to be balanced. The valves shall be selected to provide appropriate throttling range without imposing a pressure drop of more than 2.5 psi. The balancer is to determine each valves respective flow rate (even if heat transfer and temperature differential calculations are required to determine flow rates). If full line sized valve meets these requirements, then a full line installation of appropriate fittings to transition from the pipe size indicated on the drawings to the recommended valve size.

.5 Install circuit balance valves at least five pipe diameters downstream from any fitting, and at least ten pipe diameters downstream from any pump. Two pipe diameters downstream from the circuit balance valve should be free of any fittings. When installed, easy and unobstructed access to the valve handwheel and metering ports for adjustment and measurement are to be provided. Valve orientation shall prevent sediment build-up in metering ports.

.6 Install globe valves in by-pass around control valves as indicated.

.7 Do not install balancing or throttling valve on discharge of pumps equipped with VFD unless noted otherwise on the drawings. Install pressure ports for flow measurement.

.8 Install radiator valves in the supply connections to each convection heating element.

.6 Control Valves:

.1 Install control valves provided by controls contractor.

.2 Install control valves with their stems upright unless approved otherwise and with adequate clearance for removal of actuators.

.7 Needle Valves:

.1 Install needle valves where petcocks or manual vents are indicated.

.8 Drain Valves and Hose Bibbs

.1 Install drains, consisting of a tee fittings, NPS 3/4 ball valve, and short NPS 3/4 threaded connection with cap and chain at low points in piping system mains, bases of vertical risers, at equipment, as noted on drawings, and elsewhere as required for system drainage.

.2 Provide main piping system drain valves at a low point and pipe to drain. Drain valves shall be two (2) pipe sizes smaller than largest mains but not less than NPS 1.

.3 Provide drain valve and hose connections off the bottom of all strainers.

.4 Install NPS 3/4 hose bibbs at all downfed terminal heating and cooling units.

3.12 Air Vents

.1 Provide manual air vents at high points on lines and equipment connections in exposed piping system and pipe air vent discharge to the nearest drain complete with air gap.

.2 Provide automatic air vents at all high points, as indicated on the drawings, and as required for proper operation of the system. Install an isolating valve upstream of each air vent. Pipe air vent discharge to approved location using NPS ¼ diameter hard drawn copper pipe and terminate where discharge is visible.

.3 Provide access to all air vents.

3.13 Sleeves

.1 Provide Schedule 40 black steel pipe sleeves or factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses where pipes pass through masonry, concrete structures, fire rated assemblies, and elsewhere as indicated.

.2 Construction:

.1 Foundation walls and where sleeves extend above finished floors to have annular fins continuously welded on at mid-point.

.3 Size:

.1 Minimum 6 mm (1/4”) clearance between sleeve and un-insulated pipe or between sleeve and insulation for insulated pipe.

.4 Installation:

.1 Terminate flush with finished surface at concrete, masonry walls, and concrete floors on grade.

.2 Terminate 25 mm (1”) above finished floor for all other floors.

.3 Paint exposed exterior surfaces with heavy application of zinc-rich paint before installation.

.5 Sealing:

.1 Foundation walls and below grade floors: Fire retardant, waterproof non-hardening mastic.

.2 Elsewhere: Provide space for fire stopping. Maintain fire rating integrity.

.3 Sleeves installed for future use: Fill with lime plaster or other easily removable filler.

.4 Ensure not contact between copper pipe or tube and sleeve.

3.14 Escutcheons

.1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.

.2 Construction: One piece type with set screws. Chrome or nickel plated brass or type 302 stainless steel.

3.15 Piping Tests

.1 Notify the Consultant and the Inspection Authority having jurisdiction, 48 hours in advance of intended test dates.

.2 Before testing piping, isolate all equipment, which cannot withstand the test pressure.

.3 Leave joints, including welds, un-insulated and exposed for examination during test.

.4 Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

.5 Do not insulate, backfill or conceal until tests have been completed and approved by the inspection authorities.

.6 Examine all systems under test for leaks.

.7 Joints shall remain dry during the test. A general sweating around a weld shall be reason for rejection.

.8 Remake all leaking connections and joints.

.9 Tests shall be limited to new piping only.

.10 New connections to existing piping shall be warranted.

.11 Initial Hydrostatic test: 150% of working pressure, but not less than 860 kPa (125 psig) for 1 working day. For PP-R piping, do not exceed 1034 kPa (150 psi). For PEX piping, do not exceed 690 kPa (100 psi).

.12 Final Hydrostatic test: 150% of working pressure (For PP-R piping do not exceed 1034 kPa (150 psi)) (For PEX piping do not exceed 690 kPa (100 psi)), after piping connections to all equipment are complete, maintain until all parts of piping systems have been inspected.

.13 Notify Consultant when pipe tests are being performed. Consultant may review as timing permits. Otherwise, have all pipe pressure tests signed off by the Contractors' Site Foreman Manager.

.14 Prepare written report of testing and certificate and submit copies to Consultant.

3.16 Welding Tests

.1 Retain a third party Welding Inspector qualified to:

.1 CSA W178.1 Certification of Welding Inspection Organizations

.2 CSA W178.2 Certification of Welding Inspectors

.3 Approved by the Consultant.

.2 Conduct testing in compliance with:

.1 ASME Boiler and Pressure Vessel Code – Section V

.2 ASME B31.1 Power Piping

.3 ASME B31.3 process piping (if high pressure piping used)

.4 ASME B31.9 Building Service Piping

.5 Authority having jurisdiction

.3 The Welding Inspector shall provide an "Inspection and Test Plan" in co-operation with the Consultant prior to start of testing.

.4 The Welding Inspector shall co-ordinate testing and inspection activities with the Authority having Jurisdiction.

.5 The Welding Inspector shall visually inspect welds during early stages of welding procedures.

.6 Leave welds uncovered until inspected and approved by the Welding Inspector or Boiler Inspection Branch.

.7 Visual examination:

.1 In addition to the hydrostatic tests specified under "Pipe Testing" all welds shall be given a non-destructive visual examination.

.2 Visual examinations shall include the entire circumference of weld externally and wherever possible internally.

.3 The following indications are unacceptable:

.1 Cracks - external surface.

.2 Undercut on surface that is greater than 1 mm (1/32") deep.

.3 Weld reinforcement greater than specified in ASME B31.1 Table 127.4.2.

.4 Lack of fusion on surface.

.5 Incomplete penetration (applies only when inside surface is readily accessible).

.6 Any other linear indications greater than 5mm (3/16”) long.

.7 Surface porosity with rounded indications having dimensions greater than 5mm (3/16”) or four or more rounded indications separated by 2mm (1/16”) or less edge to edge in any direction. Rounded indications are indications that are circular or elliptical with their length less than three times their width.

.4 Replace welds of poor or doubtful quality at Contractor's expense to the satisfaction of the Welding Inspector and the Authority having Jurisdiction.

.8 Radiographic examination:

.1 Radiographic examination shall be undertaken by a third party agency, which is specialized in this type of inspection.

.2 Provide radiographic examination in accordance with the ASME Boiler and Pressure Vessel Code, Section V.

.3 Provide radiographic examination on [20%] of welds for the following NPS 2 and greater piping systems:

.1 827 kPa (120PSI) steam pressure or above

.2 Operating temperature 176°C (350°F) or above

.3 As directed by the Authority having Jurisdiction

.4 Radiograph over full circumference.

.5 Radiographs shall be interpreted by the Consultant and representative of the firm carrying out radiographing.

.6 Replace welds of poor or doubtful quality at Contractor's expense.

.9 In the event of weld rejection, the Owner has the right to insist on further testing at the Contractor's cost. Repairs will also be at the Contractor's cost.

3.17 Flushing and Cleaning

.1 Flushing and cleaning shall commence only after all piping tests have been completed. Refer to section 23 25 00 HVAC Water Treatment.

.2 Install temporary bypass connections around all heat pump units before commencing chemical cleaning.

.3 Chemically clean the following piping systems as recommended by an approved professional chemical cleaning and treatment agency who shall supervise the work:

.1 Heating hot water system(s).

.2 Chilled water and glycol system(s).

.3 Radiant slab water system(s).

.4 Flush out all traces of chemicals with clean water after chemical cleaning is complete.

.5 Install final connections to heat pump units after flushing is complete.

.6 Remove, clean and reinstall all strainer baskets.

.7 Submit a report signed by a principal of the Agency, which certifies that the cleaning has been satisfactorily completed.

3.18 Filling of System

.1 Refill system with clean water adding water treatment as specified.

3.19 Chemical Treatment

.1 Chemically treat water systems in accordance with Section 23 25 00 HVAC Water Treatment.

3.20 Start-Up of Hydronic Systems

.1 After cleaning is completed and system is filled:

.1 Establish circulation and expansion tank level, set pressure controls.

.2 Ensure air is removed.

.3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.

.4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.

.5 Clean out strainers repeatedly until system is clean.

.6 Commission water treatment systems as specified in Section 23 25 00 - HVAC Water Treatment.

.7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.

.8 Repeat with water at design temperature.

.9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.

.10 Bring system up to design temperature and pressure slowly

.11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

.12 Adjust pipe supports, hangers, springs as necessary.

.13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.

.14 If sliding type expansion joints bind shut down system, re-align, repeat start-up procedures.

.15 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.

.16 Check operation of drain valves.

.17 Adjust valve stem packings as systems settle down.

.18 Fully open balancing valves (except those that are factory-set).

.19 Check operation of over-temperature protection devices on circulating pumps.

.20 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

3.21 Testing and Balancing

.1 Balance all piping systems in accordance with Section 23 05 93 Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Materials and installation of low-pressure and high pressure metallic ductwork, flexible ductwork, underground ductwork, joints and accessories.

1.2 Related Requirements

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

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

.3 Section 23 32 00 – Air Plenums and Casings

.4 Section 23 33 00 – Duct Accessories

1.3 References

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

.1 National Fire Protection Association (NFPA)

.1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

.2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

.1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

.2 SMACNA - HVAC Air Duct Leakage Test Manual.

1.4 Submittals

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

.1 Shop Drawings:

.1 Sealants, tapes, proprietary joints.

1.5 General Requirements

.1 Duct sizes on drawings indicate clear inside dimensions. For acoustically lined or internally insulated ducts, maintain inside duct dimensions.

.2 Where duct sizes are shown in nominal metric sizes, round and oval duct sizes may be supplied in nearest available sizes in equivalent imperial units.

.3 Provide openings of correct size and locations through slabs and walls. Openings shall be planned to include installation of fire dampers at all rated fire separations.

.4 Where ducts penetrate roofs, provide roof curbs with flashing, and counter flashing. Ensure that penetration details are coordinated with the Building Envelope Consultant and Architect.

.5 The project drawings are diagrammatic and although efforts have been made to provide information regarding the number of offsets and transitions, not all are necessarily shown. Changes may be required in duct routings, elevation and duct shape to eliminate interference with structure and other services. All required adjustments shall be established when coordinating and field measuring the work prior to fabrication and must be provided as part of the contract and all associated costs must be considered and included.

.6 Ductwork shall be clean and free from scale, corrosion, and deposits. Ductwork shall be degreased and wiped clean of all oil and other surface films with appropriate solvents prior to installation.

.7 Ductwork shall be delivered clean to the site and maintained in clean condition. Dirty ductwork shall be removed from site.

.8 Where welded ductwork is indicated, the welding shall be continuous. Tack welding is unacceptable, except as specifically noted. Paint damaged areas with zinc coating after welding.

.9 In exposed ductwork installations, the contractor shall have a consistent ductwork fabrication methodology. Longitudinal seam ducts shall not be intermixed with spiral seamed ductwork. Slip joint seams shall not be intermixed with flanged type seams where practical. Shop drawing submittals shall also indicate the duct fabrication type - spiral seam versus longitudinal seam, and duct joining method etc.

.10 The contractor shall allow for the design, supply, and installation of all transition fittings required to connect ductwork to all mechanical equipment (both inlet and outlet connections). Where feasible, the fittings shall be fabricated per SMACNA standards in terms of maximum angles of convergence and divergence. Flexible connections shall be provided for all equipment / duct connections.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Ductwork and Plenum Pressures

.1 Provide ductwork constructed, reinforced, sealed and installed to withstand 1½ times the working static pressure

.2 Low Pressure Galvanized Steel Ductwork 500 Pa (2” W.G.) and under

.1 Supply ductwork and plenums on systems without terminal mixing boxes or air valves.

.2 Supply ductwork downstream from terminal mixing boxes or air valves.

.3 Outdoor air ductwork and plenums, unless noted otherwise.

.4 Return air ductwork and plenums, unless noted otherwise.

.5 Exhaust and relief air ductwork and plenums, unless noted otherwise.

.3 Low Pressure Flexible Ductwork 500 Pa (2” W.G.) and under

.1 Connect outlet terminals to low pressure ducts with 900mm (36”) maximum length of stretched flexible duct. Hold in place with strap or clamp, caulk sealed. Do not use flexible duct to change directions.

.2 Provide a flexible connection where low pressure ducts are connected to fan equipment, terminal boxes, or any other apparatus. Joint shall be screwed or bolted flexible gasketed joint, minimum 50mm (2”) wide.

.4 Medium Pressure Galvanized Steel Ductwork to 1000 Pa (4”W.G.)

.1 Supply air ductwork downstream from supply air handling units discharge, to terminal mixing boxes or air valves.

.2 Exhaust and return air ductwork downstream of return/exhaust air valves to the return/exhaust fans and discharge ductwork from the return/exhaust fans to the air handling units and/or relief opening.

.3 Outdoor intake plenums in mechanical room(s).

.4 Where flexible air ducts are used to connect terminal mixing boxes or air valves to metal ducts, the flexible air ducts shall be rated for 30.5 m/s (6000 fpm) velocity and 2500 Pa (10” W.G.). Maximum stretched length of flexible air duct shall be 300 mm (12”). Do not use flexible duct to change direction. Where flexible air ducts are attached to metal insulated duct, furnish flexible air ducts with fiberglass wool insulation and metalized jacket.

.5 Medium Pressure Galvanized Steel Ductwork to 1500 Pa (6”W.G.)

.1 Stair, vestibule and elevator pressurization ducts.

.2 Smoke evacuation ducts.

2.3 Flexible Plain Ductwork

.1 Minimum Requirements:

.1 Non-corrosive spiral wire reinforcing with flexible vinyl coated fiberglass cloth membrane.

.2 Rated for use up to 30.7 m/s (6000 fpm) air velocity

.3 Suitable for up to 2500 Pa (10" w.g.) positive static pressure and 500 Pa (2" w.g.) negative static pressure.

.4 U.L. or U.L.C. labelled, Class 1, duct connector.

.5 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

2.4 Flexible Insulated Ductwork

.1 Minimum Requirements:

.1 Flexible vinyl coated steel helix bonded to inner duct liner. Fibrous glass thermal insulation.

.2 Outer jacket of metalized fire-resistant vapour barrier.

.3 Rated for use up to 30.7 m/s (6000 fpm) air velocity

.4 Suitable for up to 2500 Pa (10" w.g.) positive static pressure and 500 Pa (2" w.g.) negative static pressure.

.5 UL or ULC labelled, Class 1, duct connector.

.6 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

.7 Acoustically rated.

2.5 Ductwork – Aluminum

.1 The following ductwork shall be fabricated from aluminum:

.1 Exhaust ductwork from showers/baths, to the extent noted on the drawings.

.2 Discharge ductwork through the roof, where noted on the drawings.

.2 Low Pressure Aluminum ductwork shall be constructed in accordance with “Rigid Ductwork - 500 Pa (2" W.G.) Static Pressure”

.3 For round and rectangular aluminum ductwork, use four gauges heavier than that scheduled in Table 1-5 or Tables 1-14, 1-15, 1-16 of the SMACNA Duct Standards for galvanized ductwork.

.4 Aluminum shall be utility grade.

.5 Support aluminum ductwork using aluminum straps, cadmium plated threaded rods, aluminum flat bar or aluminum angle hangers. Support shall be similar to that specified for galvanized iron ductwork.

.6 Do not cross break duct panels. Grade to drain as indicated.

.7 Weld all longitudinal seams and lateral joints and finish all exposed seams and lateral joints by grinding smooth and buffing to finish of the sheet. Do not penetrate stainless steel with screws, bolts, or rivets.

.8 Provide gasketed companion flange connections where necessary to connect to equipment. Flanged connections shall be made up by slipping a formed 1.8 mm (14 ga.) thick matching stainless steel welded angle frame over the end of the duct, leaving space for continuously welding the frame to the duct on the inside.

.9 Provide gasketed cleanouts not smaller than 450 mm x 300 mm (18" x 12"), with formed 1.8 mm (14 ga.) thick matching stainless steel welded angle reinforcing frames, in the side of the ductwork at not more than 6 m (20 ft.) intervals, changes in direction and base of risers. Cleanouts shall be fastened with wing nuts at 150 mm (6") centres. Cleanouts openings shall terminate not less than 40 mm (1½") from the bottom of the duct.

2.6 Metallic Fittings

.1 Fabrication: to SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition.

.2 Radius elbows.

.1 Rectangular: standard radius with single thickness turning vanes Centreline radius: 1.5 times width of duct.

.2 Round: smooth radius piece.

.1 Centreline radius: 1.5 times diameter for ductwork 750 Pa (3” W.G.) and greater

.2 Centreline radius: 1 times diameter for ductwork 500 Pa (2” W.G.) and less.

.3 Mitred elbows, rectangular:

.1 Install mitred elbows where space will not permit the use of full radius elbows.

.2 Provide single thickness turning vanes. Vanes in galvanized sheet metal ducts shall be constructed from galvanized steel, minimum thickness 0.76 mm (22 ga). Vanes shall be spaced at 40 mm (1½”) centres and shall turn through 90 deg., with a radius of 50 mm (2”). Vanes shall not include a straight trailing edge. The maximum supported vane length shall be 750 mm (30”). Use multiple single thickness turning vane sections for wider ducts. Install vanes tangent to airflow. Refer to Figs. 2-3 and 2-4 of the SMACNA Duct Construction Standards. Vanes and runners in aluminum ducts shall be constructed from aluminum. Aluminum vanes shall be 0.86 mm (18 ga) thick.

.4 Branches:

.1 Rectangular main and branch: with radius on branch 1.5 times width of duct and 45 degrees entry on branch.

.2 Round main and branch: enter main duct at 45 degrees with conical connection.

.3 Provide volume control damper in branch duct near connection to main duct.

.5 Transitions:

.1 In accordance with Fig. 2-9 of the SMACNA Duct Construction Standards.

.2 Diverging: 20 degrees maximum included angle.

.3 Converging: 30 degrees maximum included angle.

.4 Maximum divergence upstream of equipment to be 30 deg. and 45 deg. Convergence downstream.

.6 Offsets:

.1 Short radius elbows.

.2 Obstruction deflectors: maintain full cross-sectional area.

2.7 Ductwork – Acoustically Lined

.1 Where round ductwork is indicated to be acoustically insulated, it shall consist of two concentric round ducts with 25 mm (1") thick flexible fibrous glass duct liner between the two ducts. The inner duct shall be perforated and correspond to the duct diameter noted on the drawings. The outer duct shall be suitable for the static pressure and shall be sealed airtight where it joins the adjacent ductwork.

2.8 Ductwork – Outdoors

.1 The internally or externally insulated supply, return and exhaust ducts (down stream of heat recovery coils) including silencers, located outdoors on the roof, shall be constructed watertight.

.2 All joints shall be caulked with a water impervious sealant. TDC clips should be continuous on the top and sides of the ducts.

.3 The top of the finished product (waterproof membrane) should be pitched to avoid pooling of water.

2.9 Hangers and Supports

.1 Hangers and Supports: in accordance with Section 23 05 29 - Hangers and Supports for Mechanical Piping and Equipment.

.2 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.

.1 Maximum size duct supported by strap hanger: 500 mm.

.3 Hanger configuration: to SMACNA.

.4 Hangers: galvanized steel angle with galvanized steel rods to SMACNA per the following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

.5 Upper hanger attachments:

.1 For concrete: manufactured concrete inserts.

.2 For steel joist: manufactured joist clamp.

.3 For steel beams: manufactured beam clamps.

3. EXECUTION

3.1 Ductwork Leakage Test

.1 Leakage test all 750 Pa (3") and greater static pressure supply ductwork installed under this contract, as recommended in the SMACNA H.V.A.C. Air Duct Leakage Test Manual to a static pressure 500 Pa (2" W.G.) in excess of the specified ductwork design static pressure.

.2 Use equipment capable of demonstrating leakage.

.3 Test the first 30 m (100 ft) of installed ductwork in the presence of the Consultant.

.4 Test a representative 30m (100ft) section of 500 Pa (2") static pressure ductwork, where complete systems over 30m (100 ft) long are installed.

.5 The total allowable leakage for the entire system shall be not greater than 5 percent of the total system capacity.

.6 Submit test reports for all ducts tested.

END OF SECTION

1. GENERAL

1.1 Summary

.1 Section Includes:

.1 Fans, motors, accessories, and hardware for commercial use.

.2 Sustainable requirements for construction and verification.

.2 Related Sections:

.1 Section 01 33 00 Submittal Procedures.

.2 Section 01 35 29 Health and Safety Requirements.

.3 Section 01 45 00 Quality Control.

.4 Section 01 61 00 Common Product Requirements.

.5 Section 01 74 19 Waste Management and Disposal.

.6 Section 01 78 00 Closeout Submittals.

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

.8 Section 23 05 01 Acceptable Manufacturers.

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

.10 Section 25 09 01 Control Systems.

.11 Section 25 90 00 Integrated Automation Control Sequences.

1.2 References

.1 Air Movement and Control Association International, Inc. (AMCA)

.1 AMCA Publication 99, Standards Handbook.

.2 AMCA 300, Reverberant Room Method for Sound Testing of Fans.

.3 AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

.2 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.3 Canadian General Standards Board (CGSB)

.1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.

1.3 System Description

.1 Performance Requirements:

.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.

.2 Capacity: flow rate, static pressure, bhp, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.

.3 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.

.4 Sound ratings: comply with AMCA 301, tested to AMCA 300. Supply unit with AMCA certified sound rating seal.

.5 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210. Supply unit with AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.

1.4 Submittals

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

.2 Shop Drawings:

.1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.

.3 Provide:

.1 Fan performance curves showing point of operation, BHP, and efficiency.

.2 Sound rating data at point of operation.

.4 Indicate:

.1 Motors, sheaves, bearings, shaft details.

.2 Minimum performance achievable with variable speed controllers and variable inlet vanes as appropriate.

.5 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

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

.6 Closeout Submittals:

.1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.5 Quality Assurance

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Section 01 35 29 - Health and Safety Requirements.

1.6 Maintenance

.1 Extra Materials:

.1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.

.1 Spare parts to include:

.1 Matched sets of belts.

.2 Furnish list of individual manufacturer's recommended spare parts for equipment, include:

.1 Bearings and seals.

.2 Addresses of suppliers.

.3 List of specialized tools necessary for adjusting, repairing, or replacing.

1.7 Delivery, Storage, and Handling

.1 Packing, shipping, handling, and unloading:

.1 Deliver, store and handle in accordance with Section 01 61 00 – Common Product Requirements.

.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

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

2. PRODUCTS

2.1 Fans General

.1 Motors:

.1 In accordance with Section 21 05 01 - Common Work Results for Mechanical supplemented as specified herein.

.2 Sizes as indicated.

.2 Accessories and hardware: matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards fan inlet safety screens as indicated and as specified in Section 21 05 01 - Common Work Results for Mechanical.

.3 Factory primed before assembly in colour standard to manufacturer.

.4 Scroll casing drains: as indicated.

.5 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.

.6 Vibration isolation: to Section 23 05 48 - Vibration and Seismic Control for Mechanical.

.7 Flexible connections: to Section 23 33 00 - Duct Accessories.

2.2 Axial Flow Fans (Tube-Axial or Vane-Axial)

.1 Casings: welded steel with welded motor support, hinged access plates, streamlined inlet cone and discharge bell sections and integral silencer casing.

.2 Blade material: aluminum. Hub material: steel.

.3 Supports:

.1 Ceiling suspended units: support brackets welded to side of casing. Extend grease lubrication facilities to outside of casing.

.2 Provide slack & spring isolation per Seismic & vibration isolation requirements.

.4 Bearings: ball or roller with extension tubes to outside of casing.

.5 Belt drive:

.1 Drive fixed blades by externally mounted motors through V-belt drive. Provide internal belt fairing, external belt guards, and adjustable motor mounts.

.2 Adjust blades for varying range of volume and pressure. Hubs to facilitate indexing of blade angle. Provide manual adjustment stops to avoid overloading motor.

2.3 Cabinet Fans - General Purpose

.1 Fan characteristics and construction: as centrifugal fans.

.2 Cabinet hung single with DWDI centrifugal fans in factory fabricated casing complete with vibration isolators and seismic control measures, motor, V-belt drive and guard outside casing.

.3 Fabricate casing of aluminum reinforced and braced for rigidity. Provide removable panels for access to interior. Integral duct connection flanges, adjustable motor pulley, corrosion resistant fasteners, stainless steel shaft, aluminum rub ring, housing, and motor cover for corrosive environments.

2.4 Cabinet Fans - General Purpose

.1 Fan characteristics and construction: as centrifugal fans.

.2 Cabinet hung single or multiple wheel with DWDI centrifugal fans in factory fabricated casing complete with vibration isolators, motor, V-belt drive and guard outside casing.

.3 Fabricate casing of zinc coated or phosphate treated steel reinforced and braced for rigidity. Provide removable panels for access to interior. Paint uncoated, steel parts with corrosion resistant paint to CAN/CGSB 1.181. Finish inside and out, over prime coat, with rust resistant enamel. Internally line cabinet with 50 mm thick rigid acoustic insulation.

2.5 Centrifugal Fans

.1 Minimum Requirements:

.1 Welded steel fan wheel with airfoil backward inclined blades, unless otherwise specified.

.2 Bearings: Heavy-duty pillow-block grease lubricated ball or roller self-aligning type.

.3 Gasketted scroll access panel, secured with quick release fasteners.

.4 20 mm [3/4"] scroll drain and brass plug.

.5 Enamel painted steel fan wheels and inside scrolls.

.6 Prime coat painted outside scroll including supports and steel accessories.

.7 Rust preventative coating on fan shafts.

.8 Drip proof motor.

.9 On single inlet fans, provide extended lubricators on inlet side bearings.

.2 Accessories:

.1 Belt drives.

.2 Belt guards c/w tachometer holes.

.3 Weatherhood.

.4 Coupling guards.

.5 Fan inlet safety screens.

.6 Outlet and inlet flanges.

.7 Backdraft damper

.8 Extended lubrication lines.

.9 Steel frame base and motor slide rails (refer to section 23 05 48).

2.6 Centrifugal (Plenum)

.1 Minimum Requirements:

.1 Welded steel fan wheel with airfoil backward inclined blades, unless otherwise specified.

.2 Bearings: Heavy-duty pillow-block grease lubricated ball or roller self-aligning type.

.3 Gasketted scroll access panel secured with quick release fasteners.

.4 20 mm [3/4"] scroll drain and brass plug.

.5 Enamel painted steel fan wheels.

.6 Rust preventative coating on fan shafts.

.7 Drip proof motor.

.8 Direct drive fans shall be designed specifically for the duty and allow for easy motor replacement. Provide heavy-duty mechanical coupling and bearings for arrangement 8 where called for.

.9 Belt drives with belt guards c/w tachometer holes.

.10 Coupling guards.

.11 Fan inlet safety screens.

.2 Accessories:

.1 Steel frame base and motor slide rails (refer to section 23 05 48).

2.7 In-Line Centrifugal

.1 Minimum Requirements:

.1 In-line centrifugal fan with axial flow construction.

.2 Square housing, steel with galvanized finish.

.3 Access panel to provide cleaning and service access.

.4 Backward inclined, non-overloading wheel.

.5 Drip-proof motor.

.6 Permanently lubricated pillow block ball bearings.

.7 Rust preventative coating on shafts.

.8 Belt or direct driven as scheduled.

.2 Accessories:

.1 Belt guard, motor cover, where externally belt driven.

.2 Plug-in electrical disconnect switch, mounted on the outside of the fan housing.

.3 Insulated housing lining.

.4 Solid state speed controller where scheduled.

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 Fan Installation

.1 Install fans as indicated, complete with vibration isolators and seismic restrains as specified in Section 23 05 48 - Vibration and Seismic Control for Mechanical, flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Duct Accessories.

.2 Install fans with flexible connections on inlet ductwork and on discharge ductwork. Ensure metal bands of connectors are parallel with minimum 25 mm [1"] flex between ductwork and fan during running.

.3 Install connectors such that connectors are clear of the air stream. Provide flange extensions as necessary. Ensure accurate alignment of duct to fan.

.4 Provide safety screens where fan inlet or outlet is exposed.

.5 Provide belt guards on belt driven fans.

.6 Provide sheaves and belts required for final air balance.

.7 Bearings and extension tubes to be easily accessible.

.8 Access doors and access panels to be easily accessible.

.9 Mount roof mounted fans on curbs 200 mm [8"] minimum above roof.

3.3 Anchor Bolts and Templates

.1 Size anchor bolts to withstand seismic acceleration and velocity forces as specified.

END OF SECTION

1. GENERAL

1.1 Summary

.1 Section Includes:

.1 Materials, accessories, and installation for breechings, chimneys, and stacks.

.2 Sustainable requirements for construction and verification.

.2 Related Sections:

.3 Section 01 33 00 - Submittal Procedures.

.4 Section 01 61 00 – Common Product Requirements.

.5 Section 01 74 19 - Waste Management and Disposal.

.6 Section 01 78 00 - Closeout Submittals.

1.2 References

.1 Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

.2 Underwriters' Laboratories of Canada (ULC)

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

.1 Material Safety Data Sheets (MSDS).

1.3 Submittals

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

.1 Provide manufacturers sizing complete with venting layout and sizing procedure. Sizing to be completed with B-1 and B-2.

.2 Shop Drawings:

.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.

.1 Submit drawings stamped and signed by professional engineer registered or licensed in Province of Alberta, Canada.

.2 Indicate following:

.1 Methods of sealing sections.

.2 Methods of expansion.

.3 Details of thimbles.

.4 Bases/Foundations.

.5 Supports.

.6 Guy details.

.7 Rain caps.

.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

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

.4 Closeout Submittals

.1 Submit operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 Quality Assurance

.1 Regulatory Requirements: work to be performed in compliance with CEPA, CEAA, TDGA, and applicable Provincial /Territorial regulations.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance with Section 01 35 29 - Health and Safety Requirements.

1.5 Delivery, Storage, and Handling

.1 Packing, shipping, handling, and unloading:

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

.2 Waste Management and Disposal:

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

2. PRODUCTS

2.1 Breechings

.1 Fabricated of corrosion resistant material designed to meet a Category IV vented appliance for condensing boilers.

.2 Refer to manufacturers recommendations for product types.

2.2 Accessories

.1 Hangers and supports: in accordance with recommendations of Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA).

.2 Rain cap

.3 Flue collector, gasket, and exhaust connector kit.

.4 Acid neutralizer.

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 - General

.1 Follow manufacturer's and SMACNA installation recommendations for shop fabricated components.

.2 Suspend breeching at 1.2 m centres and at each joint.

.3 Support chimneys at bottom, roof, and intermediate levels as indicated.

.4 Provide sufficient clearances to openings as outlined in manufacturers recommendations

.5 Install rain caps and cleanouts, as indicated.

.6 Provide a drain tee at the bottom of each vent stack to safely remove any condensate that may form. Pipe condensate to the acid neutralizer prior to piping to floor drain.

END OF SECTION

1. GENERAL

1.1 Scope

.1 Boilers, Control and Trim

.2 Hot Water Connections

.3 Fuel Connections

.4 Electrical connections, Controls and Power

.5 Flue, Draft Damper and Flue Stack Connection

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 01 77 00 Closeout Procedures.

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

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

.5 Section 23 51 00 Breeching, Chimneys, and Stacks.

1.3 References

.1 American Boiler Manufacturers Association (ABMA)

.2 ANSI

.1 ANSI Z21.13: Gas-Fired Low Pressure Steam and Hot Water Boilers.

.3 ASME

.1 ASME Boiler and Pressure Vessel Code (BPVC): Section I, Rules for Construction of Power Boilers, High Pressure, High Temperature Water in excess of 160 PSIG/250°F.

.2 ASME BPVC: Section IV, Heating Boilers

.3 ASME BPVC: Section VII-[2017].

.4 ASME CSD-1 [2018], Controls and Safety Devices for Automatically Fired Boilers

.4 CSA Group

.1 CAN1-3.1-[77(R2011)], Industrial and Commercial Gas-Fired Package Boilers.

.2 CSA B51-[14], Boiler, Pressure Vessel, and Pressure Piping Code.

.3 CSA B139-[09], Installation Code for Oil Burning Equipment.

.4 CSA B140.7-05[(R2014)], Oil Burning Equipment: Steam and Hot-Water Boilers.

.5 CSA B149.1-[15], Natural Gas and Propane Installation Code.

.6 ANSI Z21.13-[17]/CSA 4.9-[17], Gas-Fired Low-Pressure Steam and Hot Water Boilers.

.5 Electrical and Electronic Manufacturers Association of Canada (EEMAC)

.6 Underwriters' Laboratories, Inc. (UL) Listed Products

1.4 Action and Informational Submittals

.1 Submit in accordance with Section [01 33 00 - Submittal Procedures].

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for heating boilers and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Submit drawings stamped and signed by professional engineer registered or licensed in Alberat.

.2 Indicate on drawings:

.1 General arrangement showing terminal points, instrumentation test connections.

.2 Clearances for operation, maintenance, servicing, tube cleaning, tube replacement.

.3 Foundations with loadings, anchor bolt arrangements.

.4 Piping hook-ups.

.5 Equipment electrical drawings for power, signal, and control wiring.

.6 Burners and controls.

.7 All miscellaneous equipment, furnished specialties and accessories.

.8 Flame safety control system.

.9 Breeching and stack configuration.

.10 Stack emission continuous monitoring system to measure CO, O, NOx, SO, stack temperature and smoke density of flue gases.

.3 Engineering data to include:

.1 Boiler efficiency at 25%, 50%, 75%, 100%, of design capacity.

.2 Radiant heat loss at 100% design capacity.

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

1.5 Closeout Submittals

.1 Submit in accordance with Section [01 78 00 - Closeout Submittals].

.2 Operation and Maintenance Data: submit operation and maintenance data for heating boilers for incorporation into manual.

.3 Submit certificate of inspection from ABSA

1.6 Quality Assurance

.1 Boilers to comply with Provincial Regulations and bear the CSA Approval Stamp/Seal.

.2 Boilers shall have Canadian CRN numbers and shall be approved and labelled by the Underwriters Laboratories.

1.7 Maintenance Material Submittals

.1 Extra materials:

.1 Submit maintenance materials in accordance with Section [01 78 00 - Closeout Submittals].

.1 Special tools for burners, access opening, hand holes and Operation and Maintenance.

.2 Spare parts for 1 year of operation.

.3 Spare gaskets.

.4 Spare gauge glass inserts.

.5 Probes and sealants for electronic indication.

.6 Spare burner tips.

.7 Spare burner gun.

.8 Safety valve test gauge.

1.8 Start-Up

.1 Provide the services of a factory trained representative to start up the boiler(s), test the efficiency, and train the operators.

1.9 Warranty

.1 Warranty all electrical components against defects in workmanship and material for a period of one (1) year from date of start-up, and the pressure vessel for a full five (5) years Non Pro-Rated from date of start-up, provided that the unit is installed and operated within the scope of the vessel design and operating capability. Each heater shall be shipped with a complete set of installation and operating instructions including spare parts list and approved drawings.

.2 Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

.1 Failures include, but are not limited to, the following:

.1 Structural failures including storage tank and supports.

.2 Faulty operation of controls.

.3 Deterioration of metals, metal finishes, and other materials beyond normal use.

.2 Warranty Periods: From date of Substantial Completion.

.1 Commercial, Electric, Domestic-Water Instantaneous Heaters:

.1 Controls and Other Components: Three years.

1.10 Warranty

.1 All equipment is to be guaranteed against defects in materials and/or workmanship for a period of 12 months from date of start-up or 18 months from date of shipment, whichever comes first.

.1 SPEC Warranty Period: Manufacturer’s standard, but not less than 25 years from date of Substantial Completion on the heat exchanger. Warranty shall be non-prorated and not limited to thermal shock.

2. PRODUCTS

2.1 General

.1 Packaged boiler: complete with burner and necessary accessories and controls, and ready for attachment of water supply, return and drain piping, fuel piping, electrical connections, and chimney connection.

.2 Designed and constructed in accordance with ASME Boiler and Pressure vessel Code requirements.

.3 The pressure vessels shall bear Canadian Registration Number (CRN) to CSA B51 for The Province of Alberta before being shipped from the factory.

.4 Boiler/burner package to bear ULC label.

.5 Electrical components CSA approved.

.6 The packaged boiler must receive factory tests to check the construction, controls, and operation of the unit. Boilers to be test fired at rated capacity to, and bearing seal or nameplate certifying compliance with, [CSA B140.7] [CAN1-3.1].

.7 Performance in accordance with American Boiler Manufacturers Association (ABMA), [or ANSI Z21.13/CSA 4.9 (gas burning)] testing procedures.

.8 Include erection and wiring diagrams and an operating and maintenance manual with boiler package.

.9 Check all available drawings and ensure that the boiler proposed will fit in the space allotted and can be maintained and operated in a normal manner without difficulty.

2.2 High Efficiency Boiler

.1 Construction

.1 Combustion Chamber: The combustion chamber shall be constructed of minimum 16-gauge stainless steel. Aluminum or galvanized steel is not acceptable. An access door shall be provided for ease of service and inspection of the heat exchanger.

.2 Heat Exchanger: The heat exchanger shall be inspected and bear the A.S.M.E. Section IV seal of approval. The heat exchanger shall be a four pass heat exchanger with a maximum working pressure of 160 psi. The heat exchanger's vertical design shall provide equal amounts of heat transfer throughout the entire heating surface. Each heat exchanger shall have copper tubes, with an integral copper finned tube of 7/8" I.D., .064" minimum wall thickness, 7 fins per inch, with a fin height of 3/8". Each end of the water tubes shall be strength rolled into the header. The heat exchanger shall be gasketless. Each individual tube can be re-tubed without the disturbance of the surrounding tubes. A pressure relief valve of 50 lb/sq. in. shall be equipped with the boiler and factory mounted. The headers shall be of cast iron construction.The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the U.S. and Canada. The boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard and the minimum efficiency requirements of the latest edition of the ASHRAE 103 Standard. The boiler shall operate at a minimum of 92% thermal efficiency at full fire as registered with AHRI. All models shall operate up to 98% thermal efficiency with return water temperatures at 90°F or below. The boiler shall be certified for indoor installation.

.3 Jackets: 18-gauge brushed stainless steel.

.4 Gas Burner: Metal fiber mat premix burner shall fire to provide equal distribution of heat throughout the entire heat exchanger. Burner composition shall be FecralloyTM. The burner shall be easily removed for maintenance without the disruption of any other major component of the boiler. Ignition electrodes shall be removed for inspection and proper alignment without removing the burner. A window view port shall be provided for visual inspection of the flame during firing.

.5 Ignition Components: Turbo Pilot™ proven spark to pilot ignition system hardware shall consist of an Alumina ceramic insulated ignition electrodes and UV sensing tube permanently arranged to ensure proper ignition electrode and UV alignment. Electrodes must be capable of removal while leaving the burner intact. Hot surface ignition systems of any type will not be accepted. Turbo Pilot™ will produce a stable robust fire of 6,000 BTU's and will operate at minimum gas pressures of 1.5" W.C. and ,aximum pressures of 5.5" W.C. The Gas Regulating valve supplied with the pilot has a full adjustment within these parameters.

.6 Rated Capacity: The boiler shall be capable of operating at rated capacity with pressures as low as 2" W.C. at the inlet to the burner pressure regulator. Boilers that cannot provide full BTUH inputs at 2" W.C. will not be accepted.

.7 The burner shall be capable of 88.1% efficiency without exceeding a NOx reading above 10 ppm.

.8 The burner and gas train shall be provided with the following trim and features:

.1 Burner Firing: TrueFlowTM Full modulation with 4:1 turndown @ Continuous CO2.

.2 Burner Ignition: Intermittent spark

.3 Safety Controls: Energize ignition, limit time for establishing flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, and allow gas valve to open.

.4 Flue Gas Collector: Enclosed combustion chamber with integral combustion air blower and single venting connection.

.5 Gas Train: Manual gas valves (2), main gas valve (motorized), 'B' valve, pilot gas pressure regulator, and automatic pilot gas valve. All components to be factory mounted.

.6 Safety Devices: Optional high/low gas pressure switches, air flow switch, and blocked flue detection switch. All safeties to be factory mounted.

.2 Boiler Trim

.1 Controls: The boiler control package shall be a MTI HeatNet or equivalent, integrated boiler management system. The control system must be integral to each boiler, creating a control network that eliminates the need for a "wall mount" stand-alone boiler system control. Additional stand-alone control panels, independent of a Building Management System (BMS), shall not be allowed to operate the boiler network. The HeatNet control shall be capable of operating in the following ways:

.1 As a stand-alone boiler control system using the HeatNet protocol, with one "Master" and multiple "Member" units.

.2 As a boiler network, enabled by a Building Management System (BMS), using the HeatNet protocol, with one "Master" and multiple "Member" units.

.3 As "Member" boilers to a Building Management System (BMS) with multiple input control methods.

.4 MASTER: A boiler becomes a Master when a resistance type 10K sensor is connected to the J10 "SYS/DHW HEADER" terminals. The sensor shall be auto detected. The Master senses and controls the header/loop temperature utilizing a system setpoint. It uses any boilers it finds "HeatNet Members" or those defined in the control setup menus to accomplish this. The "Master" shall also have the option of monitoring Outside Air Temperature "OA" to provide full outdoor air reset functionality. Only one master shall be allowed in the boiler network.

.5 When operating as a “Master”, the HeatNet control provides a stand-alone method using a PID algorithm to regulate water temperature. The algorithm allows a single boiler “Master” or multiple “Master + Member” boilers in a network of up to 16 total boilers.

.6 The control algorithm is based upon a control band, at the center of which is the setpoint. While below the control band, boilers are staged on and modulated up until the control band is entered. Once in the control band, modulation is used to maintain setpoint. Optimized system efficiency is always accomplished by setting the Modulation Maximum “Mod-Max” setting to exploit each boiler in the network’s inverse efficiency curve. The control shall operate so that the maximum number of boilers required, operate at their lowest inputs until all boilers are firing. Once all boilers are firing, the modulation clamp is removed and all boilers are allowed to fire above this clamped percentage up to 100%. This “boiler efficiency” clamp is defaulted to 80% and thus limits all the boilers individual outputs to 80% until the last boiler fires. The 80% default must be field adjustable for varying operating conditions. All boilers modulate up and down together always at the same modulation rate. Boilers are shut down only when the top of the band is breached, or before the top of the band, if the control anticipates that there is a light load. Timers shall also be included in each control in the network to prevent any boiler from short cycling.

.7 MEMBER: Additional boilers in the network always default to the role of member. The lack of sensors connected to the J10 terminals “SYS/DHW Header” on each additional boiler shall ensure this.

.8 Each “Member” shall sense its supply outlet water temperature and modulate based on signals from a Building Management System (BMS) or “Master” boiler. When operating as a member, starting, stopping, and firing rate shall also be controlled by the “BMS” or “Master” boiler.

.9 When using the HeatNet protocol, the system setpoint shall be sent from the “Master”, along with the modulation value to control firing rate. It also receives its command to start or stop over the HeatNet cable. Each “Member” will continuously monitor its supply outlet temperature against its operating limit. If the supply temperature approaches the operating limit temperature (adjustable), the boilers input control rate is limited and its modulation value decreases to minimize short cycling. If the operating limit is exceeded, the boiler shall shut off.

.10 Each HeatNet control in the boiler network shall have the following standard features:

.1 Digital Communications Control.

.1 Boiler to Boiler: HeatNet

.2 Building Management System (BMS): MODBUS standard protocol.

.3 Building Management System (BMS): BACnet, LonWorks and N2 optional protocols.

.2 Analog 4:20 and 0-10vdc also supported.

.3 Distributed control using HeatNet protocol for up to 16 total boilers.

.4 System/Boiler operating status in English text display.

.5 Interlock, Event, and System logging with a time stamp.

.6 Advanced PID algorithm optimized for specific boilers.

.7 Four dedicated temperature sensor inputs for: Outside Air Temperature, Supply (Outlet)Temperature, Return Temperature (Inlet), and Header Temperature.

.8 Automatically detects the optional temperature sensors on start up.

.9 Menu driven calibration and setup menus with a bright 4-line Vacuum Fluorescent Display.

.10 (8) Dedicated 24vac interlock monitors and 8 dedicated 120vac system monitors used for diagnostics and providing feedback of faults and system status.

.11 Multiple boiler pump or motorized boiler valve control modes.

.12 Combustion Air Damper control with proof time.

.13 Optional USB/RS485 network plug-in to allow firmware updates or custom configurations.

.14 Optional BACnet, LonWorks and N2 interface.

.15 Alarm contacts.

.16 Runtime hours.

.17 Outdoor Air Reset with programmable ratio.

.18 Time of Day clock to provide up to four (4) night setback temperatures.

.19 Failsafe mode when a Building Management System (BMS) is controlling setpoint. If communications is lost, the boiler/system shall run off the Local Setpoint.

.20 Boiler(s) shall be equipped with an integrated web based monitoring system.

.1 Monitoring system shall provide an email or SMS text message notification upon detecting an out of tolerance condition.

.2 The integrated monitoring system shall provide a web portal with performance dashboard displaying key data points for the system and each boiler in the system.

.3 The web portal shall provide the following capabilities;

.1 Detailed status of data points and system set-points

.2 Boiler and System runtime and cycle count

.3 Intelligent diagnostics and troubleshooting guide

.4 Provide original factory test data including as built bill of materials

.5 The ability to enter field service records with file upload capabilities

.6 The ability to view time stamped history of data points and settings

.7 The ability to view detailed event log entries

.8 Video tutorials explaining each section of the web portal

.4 The monitoring system shall have the capability of connecting directly to a 10/100mbps TCP/IP network Optionally when a facility network connection is not available the system shall be capable of utilizing wireless cellular network

.5 The monitoring system shall utilize a non-public proprietary data encryption algorithm

.6 Secure data transmission shall be directly to the cloud from HeatNet enabled system(s) without third party integration

.2 Safety Relief Valve: ASME rated, factory set to protect boiler and piping as per schedule/drawings.

.3 Gauge: Combination water pressure and temperature shipped factory installed. LCD inlet/outlet temperature gauges to be an integral part of the front boiler control panel to allow for consistent easy monitoring of temperatures factory mounted and wired.

.4 Flow Switch: Prevent burner operation when water falls below a safe level or when water flow is low. Flow switch shall be factory mounted and wired. Provision for installation of a low water cut off shall be provided.

.5 Operating Controls: Boiler shall be provided with a Honeywell RM7800 series digital flame safe guard. The flame safeguard shall be capable of prepurge cycles.

.6 Operating Temperature Control: Shall be a manual probe type controller adjustable from 120°F to 240°F, 49°C to 116°C. Control shall be factory mounted and sense the inlet and outlet temperature of the boiler through a resistance sensor.

.7 High Limit: Temperature control with manual reset limits boiler water temperature in series with the operating control. High limit shall be factory mounted and sense the outlet temperature of the boiler through a dry well.

.8 PROVIDE THE FOLLOWING STANDARD TRIM:

.1 Cast iron headers

.2 Low air pressure switch

.3 Blocked flue detection switch

.4 Flow switch (factory mounted and wired)

.5 Modulation control

.6 Temperature/pressure gauge

.7 Manual reset high limit

.8 Air inlet filter

.9 Inlet/outlet temperature display

.10 Full digital text display for all boiler series of operation and failures

.11 Variable frequency drive and combustion air fan

.12 FM and CSD-1 gas train

.9 PROVIDE THE FOLLOWING JOB SPECIFIC TRIM AND FEATURES

.1 Vent termination hood for exterior termination of vent pipe (shipped loose)

.2 FM or IRI controls and gas train

.3 CSD-1 controls

.4 Diagnostic keyboard display for RM7800 series control

.5 Probe type low water cut off, manual reset (shipped loose)

.6 208V - 24V 1PH (models 1250 - 2000)

.7 208V - 240V, 460/600V 3PH (models 1250 - 2000)

.8 Category I (available on sizes 750 - 2000)

.3 MOTORS

.1 Refer to Division 23 Section “Motors” for factory installed motors.

.2 Boiler Blower Motor: Open drip-proof motors where satisfactorily housed or remotely located during operation. There shall be no requirement to remove gas train components to remove the blower motor. Blower motor shall not exceed 1 HP and not require more than 13 amps.

.4 SOURCE QUALITY CONTROL

.5 Test and inspect boilers according to the ASME Boiler and Pressure Vessel Code, Section IV. Boilers shall be test fired in the factory with a report attached permanently to the exterior cabinet of the boiler for field reference.

.6 Venting Kits

.1 Kit: ASTM A 959, type AL29-4C, stainless steel, vertical vent terminal, roof passage thimble, indoor wall plate, vent, vent adapter, condensate trap and sealant.

.2 Direct Vent system with vertical roof top termination of both the exhaust vent and combustion air. The flue shall be Category IV approved Stainless Steel sealed vent material terminating at the rooftop with the manufacturer’s specified vent termination. A separate pipe shall supply combustion air directly to the boiler from the outside. The air inlet pipe must be sealed and may be other materials listed in the Installation manual. The boiler’s total combined air intake length shall not exceed 100 equivalent feet. The boiler’s total combined exhaust venting length shall not exceed 100 equivalent feet. The air inlet must terminate on the rooftop with the exhaust.

.7 Acid Neutralizer

.1 This contractor is to provide an acid neutralizer recommend by the boiler manufacturer for the specific installation for this project. Provide acid neutralization chips suitable for 2 years operation.

3. EXECUTION

3.1 Examination

.1 Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

.1 Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

.2 Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Boiler Installation

.1 Install boilers level on concrete base. Concrete base is specified in Section 23 05 48 Vibration and Seismic Control for Mechanical, and concrete materials and installation requirement are specified in Division 3.

.2 Concrete Bases: Anchor boilers to concrete base.

.1 Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

.2 For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

.3 Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

.4 Install anchor bolts to elevations required for proper attachment to supported equipment.

.5 Cast-in-place concrete materials and placement requirements are specified in Division 3.

.3 Vibration Isolation: Rubber pads with a minimum static deflection of 0.25 inch. Vibration isolation devices and installation requirements are specified in Section 23 05 48 Vibration and Seismic Control for Mechanical.

.4 Install gas-fired boilers according to CSA B149.1.

.5 Install oil fired boilers in accordance with CSA B139.

.6 Burner pilot light shall be connected to "uninterruptible" gas supply on dual fuel (oil and gas) boilers.

.7 Assemble and install boiler trim.

.8 Arrange boilers so controls and devices that require servicing are accessible. Install electrical devices furnished with boiler but not specified to be factory mounted.

.9 The contractor shall allow for the supply, installation, and full wiring of remote wall mounted boiler kill switches (provide switches at all boiler room exits). The switch shall be wired such that it interrupts all boiler burner controls, allowing the boiler safeties to shut down boiler operation. The switches are to be wall mounted adjacent to all exit doors of the boiler rooms. The switches are to be a mushroom type with manual key activated reset. The switches shall be labeled “Boiler Emergency Shutdown”. All wiring is to be by this contractor, following requirements for wiring application, sizing, and conduits.

3.3 Connections

.1 Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

.2 Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 23 05 48 Vibration and Seismic Control for Mechanical.

.3 Connect gas piping full size to boiler gas-train inlet with union.

.4 Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

.5 Install piping from safety relief valves to nearest floor drain. Run separate discharge from each valve.

.6 Install piping from safety valves to drip-pan elbow and to nearest floor drain.

.7 Install piping from blowdown/drain to blowdown tank/floor drain.

.8 Connect breeching full size to boiler outlet. Refer to Section 23 51 00 Breeching, Chimneys, and Stacks for venting materials.

.9 Install piping adjacent to boiler to allow service and maintenance.

.10 Ground equipment according to Division 26 Section "Grounding and Bonding”.

.11 Connect wiring according to Division 26 Section "Conductors and Cables."

.12 Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 Startup Service

.1 Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service.

.2 Perform installation and startup checks according to manufacturer's written instructions.

.3 Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

.4 Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

.5 Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

.6 Adjust initial temperature set points.

.7 Set field-adjustable switches and circuit-breaker trip ranges as indicated.

.8 Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

.9 Prepare written report that documents testing procedures and results.

.10 Install acid neutralizer per manufacturer’s recommendations.

3.5 Cleaning

.1 Flush and clean boilers on completion of installation, according to manufacturer’s written instructions.

.2 After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris.

3.6 Demonstration

.1 Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 01 77 00 Closeout Procedures.

END OF SECTION

1. GENERAL

1.1 Related Documents

.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

.1 This Section includes variable air-volume, modular air-handling units with coils for indoor installations.

.2 Related Sections include the following:

.1 01 61 00 Common Product Requirements.

.2 23 05 14 – Variable Frequency Drives

1.3 References

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

.1 ANSI/ASHRAE 90.1-2007, (I-P) Energy Standard for Buildings Except Low-Rise Residential Buildings.

.2 ANSI/ASHRAE 52.2-2007, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

1.4 ACTION AND INFORMATIONAL SUBMITTALS

.1 Product Data:

Provide manufacturer's printed product literature and datasheets for insulation, filters, adhesives, and paints, and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Shop Drawings:

Indicate following: fan, fan curves showing point of operation, motor drive bearings, filters, mixing box, dampers heat wheel VAV coil; include performance data.

1.5 CLOSEOUT SUBMITTALS

Provide maintenance data for incorporation into O&M manual.

1.6 Delivery, Storage and Handling

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

1.7 Quality Assurance

.1 Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.

.2 Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated.

.3 Comply with NFPA 70.

1.8 WARRANTY

.1 The contractor warrants the air handling units to be free of defects and material for the shorter of:

.1 Twelve (12) months from date of unit start-up, or

.2 Eighteen (18) months from date of shipment.

.2 In case of defects in material, the air handling unit manufacturer's warranty shall be limited to the exchange of new parts. In the case of defect in workmanship, design, or non-compliance with submittals, the contractor will either repair, replace, modify or refund the purchase price as necessary to correct the defect or non-compliance.

1.9 ACCEPTABLE MANUFACTURER

.1 Engineered Air, Price, Bousquet, Temprite.

.2 The following manufacturer's reps can be contacted as references for quality assurance:

.1	Engineered Air:	Kevin Whitehead	403-444-2810	kevin.whitehead@engineeredair.com
.2	Price:	Teejay Preete	403-777-2792	TPreete@ehpricesales.com
.3	Bousquet:	Rick Westower	403-279-7958	rick@aquaair.ab.ca
.4	Temprite:	David Lamarre	403-263-8339	david.lamarre@exelsystems.ca

1.10 Extra Materials

.1 Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

.1 Filters: One set for each indoor air-handling unit.

.2 Fan Belts: One set for each modular indoor air-handling unit fan.

2. PRODUCTS

2.1 General

.1 Each unit shall be specifically designed for indoor pool application. Units shall be of a modular design with factory installed access sections available to provide maximum design flexibility.

.2 Furnish unit configuration, layout, performance and electrical characteristics as shown on project plans and schedule.

.3 The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final test of all fan assemblies, a unit control system operations checkout, and a final unit inspection.

.4 The complete unit shall be ETL listed.

.5 Unit shall be completely factory assembled and shipped in multiple pieces to allow full installation at site.

.6 All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

.7 Performance: All scheduled EER, IEER, capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

3. UNIT CONSTRUCTION

.1 Unit casing shall be of minimum 18 ga (1.3 mm) satin coat galvanized sheet metal. Surfaces on indoor and outdoor units shall be cleaned with a degreasing solvent to remove oil and metal oxides. All unprotected metal and welds shall be factory coated.

.2 All exposed surfaces shall have a finish coat of alkyd enamel to all exposed surfaces with an ASTM B117-11 salt spray rating of 500 hrs.

.3 Units shall be provided with access doors to the following components: fans, motors, filters, dampers and operators, access plenums, humidifiers/wet cells, electrical control panels and burner/compressor compartments. Access doors shall be as large as practical for easy access. Screwed wall panel access will not be acceptable for the above listed components.

.4 Units shall be provided with hinged access doors with e-profile gasket, fully lined, and a minimum of two lever handles.

.5 All units shall be internally insulated with 1" (25 mm) thick, 1 1/2 lb./ft.3 (24 kg/m3) density coated insulation.

.6 The coated insulation shall be secured to metal panels with a fire retardant adhesive and welded steel pins at 18" (450 mm) o/c. All longitudinal insulation joints and butt ends shall be covered by a sheet metal break to prevent deterioration of exposed edges. Drain pans and all floor areas shall be insulated on the underside.

.7 Provide a drain in the mixing section.

4. FANS

.1 Centrifugal fans shall be rated in accordance with AMCA Standard Test Code - Bulletin 210. Fan manufacturer shall be a member of AMCA. All fans and fan assemblies shall be dynamically balanced during factory test run. Fan shafts shall be selected for stable operation at least 20% below the first critical RPM. Fan shafts shall be provided with a rust inhibiting coating.

.2 Single low pressure forward curved fans of 20" (508 mm) diameter or larger shall be equipped with greaseable pillow block bearings supported on a rigid structural steel frame.

.3 Fan motor sheaves shall be adjustable with motors 7 1/2 HP (5.6 kW) and smaller. On fans with larger motors, fixed drives shall be provided. All drives shall be provided with a rust inhibiting coating. The air balancer shall provide for drive changes (if required) during the air balance procedure.

.4 Fan and motor sheaves shall be factory installed, fan balanced, and tested prior to shipment.

.5 Blower(s) to be 2-part epoxy painted (Provide separate cost)

.6 Install flexible connections at fan inlet and fan outlet.

.7 Install vibration isolator.

.8 Supply Fan Variable Air Volume: Refer to Section 23 05 14 – Variable Frequency Drives

.9 Fan-motor assemblies shall be provided with vibration isolators. Isolators shall be bolted to steel channel welded to unit floor that is welded to the structural frame of the unit. Use of separate bumpers or snubbers are not acceptable. Fans shall be attached to the discharge panel by a polyvinyl chloride coated polyester woven fabric with a sealed double locking fabric to metal connection.

.10 All forward curve fans 18” (457mm) in diameter and larger and all backward inclined fans shall incorporate vertical spring isolators with leveling bolts and bridge bearing waffled pads with minimum 1" (25 mm) static deflection designed to achieve high isolation efficiency.

.11 Provide single extended grease line from far side to access side bearing.

.12 Fan motors shall be TEFC (totally enclosed fan cooled) high efficiency.

5. GAS HEAT SECTION (DJS) - INDIRECT FIRED

5.1 General

.1 Heating units shall be indirect natural gas fired approved for both sea level and high altitude elevations. The entire package including damper controls, fan controls, and all other miscellaneous controls and accessories shall be pre-wired and factory certified by an approved testing agency such as ETL, UL, or CSA for the destination.

.2 Operating natural gas pressure at unit(s) shall be 7”WC (1750 Pa)

.3 Installation and venting provisions must be in accordance with installation code CAN/CSA B149.1, ANSI Z223.1-NFPA54 and the requirements of the local authorities having jurisdiction.

5.2 Heat Exchanger/Burner Assembly

.1 Heat exchanger shall be a primary drum and multi-tube secondary assembly constructed of titanium stainless steel with multi-plane metal turbulators and shall be of a floating stress relief design. Heat exchanger shall be provided with condensate drain connection. The heat exchanger casing shall have 1" (25 mm) of insulation between the outer cabinet and inner heat reflective satin coat galvanized steel liner. Blower location shall be engineered to optimize the required air flow pattern around the heat exchanger. Duct type furnaces with closed coupled blowers are not acceptable.

.2 Units with high efficiency heat exchangers shall be tested and certified to the National Energy Code of Canada and local authorities having jurisdiction. A minimum of 81% efficiency shall be provided throughout the entire operating range of the heat exchanger. The manufacturer shall be routinely engaged in the manufacture of this type of high efficiency equipment.

.3 The heat exchanger/burner assembly shall be a blow through positive pressure type. Units incorporating the DJM module shall have an interrupted pilot ignition system to provide increased safety. Units using continuous or intermittent pilots are not acceptable.

.4 Flame surveillance shall be from the main flame after ignition not the pilot flame. The burner and gas train shall be in a cabinet enclosure. Atmospheric burners or burners requiring power assisted venting are not acceptable.

5.3 Factory testing of indirect fired gas heating section.

.1 The minimum test requirements on all cabinet / fan size / fan type / fan orientation / heat exchanger / outlet configuration combinations previously built are listed below:

.2 Tests shall be performed after completing final unit assembly just prior to shipping to job site. The tests shall be performed in accordance with the equipment standard that the gas heating section is certified.

.3 Heat exchanger shall be clocked with a dedicated calibrated gas meter to ensure proper set up of the gas manifold.

.4 High and low input flue gas combustion analysis using a calibrated combustion analyzer including O2 and CO to provide proper air fuel ratio throughout the entire operating range.

.5 Heat Exchanger airflow pattern shall be tested to ensure uniform airflow across all parts of the heat exchanger.

.6 Once the equilibrium operating temperatures have been reached, the heat exchanger temperatures shall be checked to ensure that all surfaces are below 1075°F (579.4°C). Temperatures above this can lead to premature heat exchanger failure.

.7 Flue gas temperature and combustion analysis shall be performed. The heat exchanger efficiency shall be analyzed and must meet current requirements.

.8 High limit operational check shall be performed to ensure proper function at all normal airflows including loaded filters.

.9 If the unit is capable of or intended to operate at varying air flows, all of the above tests must be performed at high flow and low flow.

5.4 Venting

.1 Manufacturer supplied draft hoods on indoor units for field installed DJS series to accommodate "B" type venting. "B" vent sizing must be in accordance with installation code CAN/CSA B149.1, ANSI Z223.1-NFPA54 and the requirements of the local authorities having jurisdiction.

.2 The heat exchanger/burner assembly shall include 15:1 turndown for all input ranges. The high turn down heat exchanger/burner assembly minimum input shall be capable of controlling down to 6.7% of its rated input, excluding the pilot assembly, without on/off cycling and include built in electronic linearization of fuel and combustion air. Efficiency shall increase from high to low fire.

6. FILTERS

.1 Filter sections shall be provided with adequately sized access doors to allow easy removal of filters. Filter removal shall be from one side of the unit as noted on the drawings.

.2 The filters shall be designed to slide out of the unit. Side removal filters shall slide into a formed metal track sealing against metal spacers at each end of the track.

.3 2" (50 mm) Extended Media (Pleated) Disposable Filters: Filters shall be extended surface pleated complete with 100% synthetic media that does not support microbial growth. Frame shall be a high wet strength beverage board with a cross member design that increases filter rigidity and prevent breaching. Frame shall be recyclable. Filters shall have an expanded metal support grid bonded to the air-exiting side of the filter to maintain pleat uniformity and prevent fluttering. Metal support grid shall be recyclable. The filters shall be MERV 13 per ASHRAE 52.2. and rated U.L. 900 Class II.

7. DAMPERS

.1 Dampers shall be extruded aluminum, low leak, insulated blade Tamco Series 9000 SW for outdoor air, and Tamco Series 1000 for R/A.

.2 Mixing dampers shall be parallel blade type.

.3 Mixing box controls shall be controlled by others. Actuators shall be provided by unit manufacturer.

8. FACTORY SUPPLIED CONTROLS/WIRING

.1 Provide a system of motor control, including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, control transformers, auxiliary contactors, and terminals for the connection of external control devices or relays.

.2 Gas fired units shall also include high limit and combustion airflow safeties.

.3 Fire alarm circuits (where required) shall be powered from a relay in unit circuitry.

.4 Factory installed and wired non-fused disconnect switch in NEMA type 1.

.5 Controls shall be housed in a control panel mounted in or on the unit that will meet the standard of the specific installation.

.6 Provide a discharge air low limit equipped with an automatic by-pass time delay to allow for cold weather start-up. On a heating system failure, this device will shut down the fan and close the outdoor air damper.

8.2 NextGen Base

.1 The controller shall be ETL certified.

.2 A numerical display and LED lights shall provide status information.

.3 The controller shall have a computer connection diagnostic via Ethernet complete with web based interface.

.4 Minimum operating ambient temperature shall be -40°F (-40°C).

.5 The controller shall provide continuous ambient temperature sensing.

.6 Self-check on start-up shall be provided to ensure air proving and all sensors are operating within design tolerances.

.7 Blower delay functionality shall be provided to ensure damper(s) are open before blower starts.

.8 The controller shall have a non-recycling auto by-pass low limit complete with alarm contacts.

8.3 Sequences of Operation:

.1 AHU-1 to operate at variable volume supply air system (0 - 10v signal)

.2 Outdoor Damper and return damper to be controlled by ECMS (0 – 10v signal)

.3 Discharge air temperature sensor to modulate burner to maintain set point completed with reset from ECMS (0 – 10V signal)

9. EXECUTION

9.1 Application

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

9.2 Installation

.1 the AHU unit needs to be split into sections prior to be installed in the Mech room. the manufacturer will be required to visit the site to verify the opening size and ensure the unit will fit into the Mech room.

.2 Provide appropriate protection apparatus.

.3 Install units in accordance with manufacturer's instructions and as indicated.

.4 Ensure adequate clearance for servicing and maintenance.

9.3 Fans

.1 Install fan sheaves required for final air balance.

.2 Install flexible connections at fan inlet and fan outlets.

.3 Install vibration isolators.

9.4 Drip Pans

.1 Install deep seal P-traps on drip lines.

.2 Depth of water seal to be 1.5 times static pressure at this point.

9.5 Examination

.1 Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

.2 Examine roughing-in of hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

.3 Proceed with installation only after unsatisfactory conditions have been corrected.

9.6 Cleaning

.1 Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

.2 After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

9.7 Demonstration

.1 Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain indoor air-handling units. Refer to Section 01 77 00 Closeout Procedures.

END OF SECTION

1. GENERAL

1.1 Related Sections

.1 Section 01 33 00 Submittal Procedures.

.2 Section 01 74 19 Waste Management and Disposal.

.3 Section 01 61 00 Common Product Requirements.

.4 Section 01 78 00 Closeout Submittals.

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.

.2 Indicate:

.1 Equipment, capacity, and piping connections.

.2 Dimensions, internal and external construction details, recommended method of installation with proposed support, sizes, and location of mounting bolt holes.

1.3 Closeout Submittals

.1 Provide operation and maintenance data for unit heaters for incorporation into manual specified in Section 01 78 00 Closeout Submittals.

1.4 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 01 74 19 Waste Management and Disposal.

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

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.

.4 Divert unused metal and wiring materials from landfill to metal recycling facility.

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

2. PRODUCTS

2.1 Vertical Unit Heaters

.1 Acceptable manufacturers:

.1 Refer to Section 23 05 01 Acceptable Manufacturers.

.2 Casing: 1.6mm thick cold rolled steel, glossed enamel finish, with threaded connections for hanger rods.

.3 Coils: seamless copper tubing, silver brazed to steel headers and with evenly spaced aluminum fins mechanically bonded to tubing. Hydrostatically test to 1 MPa.

.4 Fan: direct drive propeller type, factory balanced, with anti-corrosive finish.

.5 Motor: speed as indicated, continuous duty, ball bearing motor with built-in overload protection, and resilient motor supports.

.6 Air outlet: adjustable multi-vane diffuser with finish to match casing.

.7 Control room thermostat: low voltage.

3. EXECUTION

3.1 Installation

.1 Install in accordance with manufacturer's instructions.

.2 Provide double swing pipe joints as indicated.

.3 Check final location with Engineer if different from that indicated prior to installation.

.1 Should deviations beyond allowable clearances arise, request, and follow Engineer's directive.

.4 Hot water units: for each unit, install gate valve on inlet and calibrated balancing valve on outlet of each unit. Install drain valve at low point.

.1 Install manual air vent at high point.

.5 Clean finned tubes and comb straight.

.6 Provide supplementary suspension steel as required.

.7 Install thermostats in locations indicated.

.8 Before acceptance, set discharge patterns and fan speeds to suit requirements.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 This is a performance specification for the provision of all labour and materials necessary to install complete and ready for operation, integrated building automation systems for this project. The scope of work includes the field installation and wiring, (both low and line voltage wiring), of sensors, devices, and control panels that are supplied with other mechanical equipment specified in other sections of Divisions 21, 22 and 23. It is the responsibility of the Controls Contractor to read the other sections and to include any controls related scope. This work shall include, but is not limited to:

- .1 Controllers and Control Panels
- .2 Transformers and power supply units, including UPS
- .3 Routers
- .4 Gateways (for integration of other equipment than mechanical)
- .5 Third party controller(s) integration
- .6 Network switches
- .7 Servers
- .8 PC or Laptop (Operating working station)
- .9 Temperature and pressure sensors
- .10 Other various sensors (as called on drawings)
- .11 Relay panels,
- .12 Damper operators,
- .13 Control valves and valve operators
- .14 Meters (various meters as called on drawings)
- .15 Web browser interface (including remote access capabilities)
- .16 BACnet communication interfaces (BACnet MS/TP and BACnet IP only) for all mechanically controlled equipment
- .17 Remote control panels
- .18 Lighting control panel interfaces
- .19 Security system interfaces
- .20 Fire alarm system interfaces
- .21 Other control work not listed here but called for in construction documents

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 53 - Identification for Mechanical Piping and Equipment

.4 Division 25 - Integrated Automation

.5 Division 26 - Electrical

1.3 References

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

.2 ANSI/ASHRAE Standard 135 BACnet A Data Communication Protocol for Building Automation and Control Networks

1.4 System Description

.1 General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and an operator workstation. The operator workstation shall provide for overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

.2 Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

.3 Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

.4 General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and an operator workstation.

.5 System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed using a web browser over the control system network, the Owner's local area network, and remotely over the Internet (through the Owner's LAN).

.6 The intent of the thin-client architecture is to provide operators complete access to the control system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.

.7 Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

.8 Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

.9 General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and/or an operator workstation.

.10 The control system server and/or operator workstation shall provide for overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

.11 The system shall support web browser access to the building data. A remote user using a standard web browser shall be able to access the control system graphics and change adjustable set points with the proper password.

.12 Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

.13 Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

1.5 BAS Performance Standards

.1 The BAS system shall conform to the following minimum standards over network connections:

.1 Graphic Display: A graphic with 20 dynamic points shall display with current data within 10 seconds.

.2 Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 seconds.

.3 Object Command: Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.

.4 Object Scan: Data used or displayed at a controller or workstation shall have been current within the previous 6 seconds.

.5 Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 45 seconds.

.6 Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with the mechanical process under control.

.7 Performance: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.

.8 Multiple Alarm Annunciation: Each workstation on the network shall receive alarms within 5 seconds of other workstations.

.9 Reporting Accuracy: System shall report values with minimum end-to-end accuracy listed in Table 1.

.10 Control Stability and Accuracy: Control loops shall maintain measured variable at set point within tolerances listed in Table 1 under “Accuracy Required for Control.”

1.6 Sensors, Meters, Calculated Values, and Required Accuracies

Table 1

#	Object Description and Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval min	Trend Interval min	Accuracy Required for Control
S1	Ambient Dry-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	-29°C to 40°C (-20°F to 120°F)	±0.5°C (±0.1°F)	±0.25°C (±0.5°F)	1	10	±1.0°C (±2°F)
S2	Ambient Wet-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	–29°C to 40°C (-20°F to 120°F)	±1.5°C (±3.0°F)	±0.25°C (±0.5°F)	1	10	±1.5°C (±3°F)
S6	Building Main Meter Power	AI/BI (pulse)	True RMS		±1.0% of reading	1.0 kW	1	1	1.0 kW

Table 1

#	Object Description and Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval min	Trend Interval min	Accuracy Required for Control
S8	Zone (Space) Temperatures	AI	10000 ohm Thermistor or 1000 ohm RTD	–1°C to 38°C (30°F to 100°F)	±0.5°C (±0.1°F)	±0.25°C (±0.1°F)	1	1	±0.5°C (±1°F)
S9	Carbon Dioxide	AI	Nondispersive Infrared Sensor Technology	0 to 2000 ppm	±50 ppm	50 ppm	1	1	50 ppm
S10	Carbon Monoxide	AI	Electrochemical Sensor	0 to 100 ppm	±5 ppm	50 ppm	1	1	50 ppm
S11	Air Pressure (Ducts)	AI	Variable Capacitance	0 to 2 kPa (0 to 8 in. w.g.)	±25 Pa (±0.1 in. w.g.)	125 Pa (±0.5 in. w.g.)	1	1	25 Pa (0.1 in. w.g.)
S12	Air Pressure (Space)	AI	Variable Capacitance	-25 to 25 Pa (-0.1 to 0.1 in wg)'	3 Pa (±0.01 in. w.g.)	3 Pa (±0.01 in. w.g.)	1	1	1.3 Pa (0.005in. w.g.)
S13	Water Pressure	AI		0 to 1034 kPa (0 to 150 psi)	±2% of Full Scale	7 kPa (1 psi)	1	1	3.5 kPa (0.5 psi)
S14	Water Temperature	AI		(0°C to 107°C) (32°F to 225°F)	±0.5°C (±1°F)	±0.5°C (±1°F)	1	1	±0.5°C (±1°F)
S15	Delta-T	AI	10000 ohm Thermistor or 1000 ohm RTD Matched Pair		±0.15°C (±0.25°F)	±0.25°C (±0.5°F)	1	1	±0.15°C (±0.25°F)
S16	Relative Humidity	AI		0% to 100%	±5% RH	5%	1	1	±5% RH
S17	Water Flow	AI			±2% of Reading	1000 L/s	1	1	
S18	Ducted Air Temperature	AI	10000 ohm Thermistor or 1000 ohm RTD	7°C to 60°C (45°F to 140°F)	±0.5°C (±1°F)	±0.5°C (±1°F)	1	1	±0.5°C (±1°F)
S19	Electrical (Amps, Volts, Watts, PF not specified elsewhere)	AI/BI (Pulse)	Pulse Output		±1% of Full Scale	0.1	1	1	1/100 s or less
S28	Airflow Rate (Measuring Stations)	AI	Electronic or Differential Pressure		±5% of Reading Down to 0.75 m/s (150 fpm)	0.05 L/s (0.1 cfm)	1	1	±5% of Reading Down to 0.75 m/s (150 fpm)

Table 1									
#	**Object Description and Location if Applicable**	**Sensor or Value Type**	**Sensor Type or Calculation Method**	**Expected Range**	**Required End-to-End Accuracy**	**Display Resolution**	**Refresh Interval min**	**Trend Interval min**	**Accuracy Required for Control**
S30	Airflow (Terminal)	AI	Electronic or Differential Pressure		±10% of Reading	47 L/s (100 cfm)	1	1	±10% of Reading
S31	Airflow (Pressurized Spaces)	AI	Electronic or Differential Pressure		±3% of Reading	24 L/s (50 cfm)	1	1	±3% of Reading

AI = analog input; BI = binary input; calculated = value calculated by the BAS hardware or BAS software

2. PRODUCTS

2.1 Materials

.1 Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 Communications

.1 Control products, communication media, connectors, repeaters, hubs, and routers shall comprise an open protocol BAS. Controller and operator interface communication shall conform to open-protocol body certification requirements.

.2 Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BAS. Controller and operator interface communication shall conform to open protocol body certification requirements.

.3 Each controller shall have a communication port for connection to an operator interface.

.4 Internetwork operator interface and value passing shall be transparent to internetwork architecture.

.1 An operator interface connected to the BAS shall allow the operator to interface with each internetwork controller as if directly connected. BAS information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.

.2 Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified BAS operation. An authorized operator shall be able to manage, maintain, and access the BAS network of controllers.

.5 System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.

.6 Workstations, Building Control Panels and Controllers with real-time clocks shall use the open-protocol time synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.3 Operator Interface

.1 PC-based workstations shall reside on a high-speed network with building controllers as shown on the drawings. Each workstation or each standard browser connected to server shall be able to access all BAS information.

.2 Workstation and controllers shall communicate using open protocol. Workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and open protocol addressing as specified in open protocol body.

.3 Hardware. Each operator workstation or web server shall consist of the following:

.1 Computer: Hardware shall meet or exceed BAS manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The following hardware requirements also apply:

.2 The hard disk shall have sufficient memory to store:

.1 All required operator workstation software

.2 A B database at least twice the size of the delivered system database

.3 One year of trend data based on the points specified to be trended at their specified trend intervals.

.2 Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.

.4 Provide a notebook style PC as a Portable Operator’s Terminal. This device may be connected to any point on the system network or may be connected directly to any controller for programming, setup, and troubleshooting and full access to the BAS. Include all software and hardware required.

.5 System Software

.1 Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications. Examples include Microsoft Excel, Microsoft Access, or other SQL database software. Acceptable operating systems are Windows or the latest Windows Server release.

.2 System Graphics. The operator workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic such as analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.

.6 System Applications. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications:

.1 Automatic system database save and restore (include a enable/disable feature)

.2 Manual Database Save and Restore.

.3 System Configuration.

.4 On-Line Help.

.5 Security: Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application, editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable. All system security data shall be stored in an encrypted format.

.6 System Diagnostics.

.7 Alarm Processing.

.8 Alarm Messages: Alarm messages shall use the English language descriptor for the object in alarm without relying upon acronyms or other mnemonics.

.9 Alarm Reactions.

.10 Trend Logs.

.11 Alarm and Event Log.

.12 Trend Plots:

.1 User-selectable X and Y trend inputs.

.2 User-editable titles, point names, and X and Y axis titles.

.3 User-selectable time period options: 24-hour period, 7-day period, 1-month.

.13 Object and Property Status and Control.

.14 Reports and Logs: Provide a reporting package that allows the operator to select, modify, or create reports. Reports and logs shall be readily printed to the system printer and shall be set to be printed either on operator command or at a specific time each day.

.15 Standard Reports. The following standard BAS system reports shall be provided for this project. Provide ability for the owner to readily customize these reports for this project.

.1 All Objects/Points/Variables: All system (or subsystem) objects and their current values.

.2 Alarm Summary: All current alarms (except those in alarm lockout).

.3 Disabled Objects/points: All objects that are disabled.

.4 Alarm Lockout Objects/points: All objects in alarm lockout (whether manual or automatic).

.5 Alarm Lockout Objects/points in Alarm: All objects in alarm lockout that are currently in alarm.

.6 Logs:

.1 Alarm History

.2 System Messages

.3 System Events

.4 Trends

2.4 Controller Software

.1 Provide applications software for building and energy management. All software applications shall reside and operate in the system controllers.

.2 Editing of applications shall occur at the operator workstation.

.3 Software shall provide:

.1 System Security

.2 Scheduling; daily, weekly and exception (holiday) schedules. The contractor shall create schedules for each piece of equipment (not just provide the capability to do so).

.3 Binary and analog alarms.

.4 Alarm Reporting.

.5 Remote Communication

.6 Demand Limiting.

.1 The demand-limiting program shall monitor building power consumption from signals generated by a pulse generator (provided by others) mounted at the building power meter or from a watt transducer or current transformer attached to the building feeder lines.

.2 The demand-limiting program shall predict the probable power demand such that action can be taken to prevent exceeding the demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates the demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.

.3 Demand reduction shall be accomplished by the following means:

.1 Reset air-handling unit supply temperature set point up by 1ºC (2ºF).

.2 Reset space temperature set points up by 1ºC (2ºF).

.3 De-energize equipment based upon priority.

.4 Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which the local power company computes demand charges.

.5 Provide the means for an operator to make changes on-line.

.6 Provide the following information and reports, to be available on an hourly, daily, and monthly basis:

.1 Total electric consumption.

.2 Peak demand.

.3 Date and time of peak demand.

.4 Daily peak demand.

.7 Maintenance Management.

.8 Sequencing.

.9 PID Control.

.10 Staggered Start.

.11 Energy Calculations.

.12 Anti-Short Cycling.

.13 Run-Time Totalization.

2.5 Building and Custom Application Controllers

.1 Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

.2 This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:

.1 Data Sharing

.1 Data Sharing-Read Property-Initiate, Execute (DS-RP-A, B)

.2 Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A, B)

.3 Data Sharing-Write Property- Initiate, Execute (DS-WP-A, B)

.4 Data Sharing-Write Property Multiple- Execute (DS-WPM-B)

.5 Data Sharing-COV- Initiate, Execute (DS-COV-A, B)

.6 Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A, B)

.2 Scheduling

.1 Scheduling-Internal- Execute (SCHED-I-B)

.2 Scheduling-External- Execute (SCHED-E-B)

.3 Trending

.1 Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)

.2 Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)

.3 Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)

.4 Trending-Automated Trend Retrieval- Execute (T-ATR-B)

.4 Network Management

.1 Network Management-Connection Establishment- Initiate (NM-CE-A)

.5 Alarming

.1 Alarm and Event-Notification- Initiate (AE-N-A)

.2 Alarm and Event-Notification Internal- Execute (AE-N-E-B)

.3 Alarm and Event-Notification External- Execute (AE-N-E-B)

.4 Alarm and Event-ACK- Initiate, Execute (AE-ACK-A, B)

.5 Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)

.6 Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A, B)

.7 Alarm and Event –Information- Initiate, Execute (AE-ESUM-A, B)

.6 Device Management

.1 Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A, B)

.2 Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A, B)

.3 Device Management-Device Communication Control- Execute (DM-DCC-B)

.4 Device Management-Private Transfer- Initiate, Execute (DM-PT-A, B)

.5 Device Management-Text Message- Initiate, Execute (DM-TM-A, B)

.6 Device Management-Time Synchronization- Execute (DM-TS-B)

.7 Device Management-Reinitialize Device- Execute (DM-RD-B)

.8 Device Management-Backup and Restore- Execute (DM-RD-B)

.9 Device Management-List Manipulation- Execute (DM-RD-B)

.10 Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

.7 The Building Level Controller shall support the following Data Link Layers:

.1 BACnet IP Annex J

.2 BACnet IP Annex J Foreign Device

.3 MS/TP Master (Claus 9)

.8 The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:

.1 Calendar – Creatable, Deletable

.2 Command – Creatable, Deletable

.3 Event Enrollment – Creatable, Deletable

.4 Notification Class – Creatable, Deletable

.5 Schedule - Creatable, Deletable

.9 The Building Level Controller shall support transmitting and receiving segmented messages.

.10 The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

.11 The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

.3 This level of controller shall be used for the following types of systems:

.1 Chiller plant systems

.2 Heating plant systems

.3 Cooling Towers

.4 Pumping systems

.5 VAV air handlers

.6 Air handlers

.7 Systems with over 24 input/output points

.4 Computing power and memory minimum:

.1 A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.

.2 Inputs shall be 16-bit minimum analog-to-digital resolution

.3 Outputs shall be 10-bit minimum digital-to-analog resolution

.4 Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.

.5 Real time clock and battery

.6 Data collection/ Data Trend module sized for 10,000 data samples.

.7 Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

.5 Onboard or Modular hardware and connections:

.1 Primary Network communication module, if needed for primary network communications.

.2 Secondary Network communication module, if needed for secondary network communications.

.3 RJ45 port 10/100Mbaud

.4 RS485 ports for subnetworks and point expansion

.5 Man to Machine Interface port (MMI)

.6 USB Port

.6 Input and Output Points Hardware

.1 Input/output point modules as required including spare capacity.

.2 Monitoring of the status of all hand-off-auto switches.

.3 Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.

.4 Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.

.5 Graduated intensity LEDs or analog indication of value for each analog output.

.7 Code compliance

.1 Approvals and standards: UL916; CE; FCC

.2 Provide UL864-UUKL where called for in the sequences of operations.

.8 Accessories:

.1 Appropriate NEMA rated metal enclosure.

.2 Power supplies as required for all associated modules, sensors, actuators, etc.

.9 Keypad.

.1 A local keypad and display shall be provided for each floor controller. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display.

.10 The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

.11 Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

.12 Panel setup, point definitions, and sequencing diagrams shall be backed up on EEPROM memory.

.13 Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

.14 Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers, or terminals.

.15 Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives, and programming.

.16 Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

.17 Spare Capacity: Provide enough inputs and outputs to handle future floor VAV boxes connection to DDC system. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

.18 Environment.

.1 Controller hardware shall be suitable for the anticipated ambient conditions.

.2 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

.3 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

.19 Immunity to power and noise.

.1 Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

.2 Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

.3 Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

.1 RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.

.2 Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.

.3 Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.

.4 Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

.4 Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:

.1 IEEE Standard 587 1980

.2 UL 864 Supply Line Transients

.3 Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.6 Advanced Application Controllers

.1 Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

.2 This controller shall have the BTL listing and meet the BACnet device profile of an Advanced Application Controller (B-AAC) and shall support the following BACnet BIBBs:

.1 Data Sharing

.1 Data Sharing-Read Property-Initiate, Execute (DS-RP-A, B)

.2 Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A, B)

.3 Data Sharing-Write Property- Initiate, Execute (DS-WP-A, B)

.4 Data Sharing-Write Property Multiple- Execute (DS-WPM-B)

.5 Data Sharing-COV- Initiate, Execute (DS-COV-A, B)

.6 Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A, B)

.2 Scheduling

.1 Scheduling-Internal- Execute (SCHED-I-B)

.2 Scheduling-External- Execute (SCHED-E-B)

.3 Trending

.1 Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)

.2 Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)

.3 Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)

.4 Trending-Automated Trend Retrieval- Execute (T-ATR-B)

.4 Network Management

.1 Network Management-Connection Establishment- Initiate (NM-CE-A)

.5 Alarming

.1 Alarm and Event-Notification- Initiate (AE-N-A)

.2 Alarm and Event-Notification Internal- Execute (AE-N-E-B)

.3 Alarm and Event-Notification External- Execute (AE-N-E-B)

.4 Alarm and Event-ACK- Initiate, Execute (AE-ACK-A, B)

.5 Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)

.6 Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A, B)

.7 Alarm and Event –Information- Initiate, Execute (AE-ESUM-A, B)

.6 Device Management

.1 Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A, B)

.2 Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A, B)

.3 Device Management-Device Communication Control- Execute (DM-DCC-B)

.4 Device Management-Private Transfer- Initiate, Execute (DM-PT-A, B)

.5 Device Management-Text Message- Initiate, Execute (DM-TM-A, B)

.6 Device Management-Time Synchronization- Execute (DM-TS-B)

.7 Device Management-Reinitialize Device- Execute (DM-RD-B)

.8 Device Management-Backup and Restore- Execute (DM-RD-B)

.9 Device Management-List Manipulation- Execute (DM-RD-B)

.10 Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

.7 The Advanced Application Controller shall support the following Data Link Layers:

.1 BACnet IP Annex J

.2 BACnet IP Annex J Foreign Device

.3 MS/TP Master (Claus 9)

.8 The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:

.1 Calendar – Creatable, Deletable

.2 Command – Creatable, Deletable

.3 Event Enrollment – Creatable, Deletable

.4 Notification Class – Creatable, Deletable

.5 Schedule - Creatable, Deletable

.9 The Advanced Application Controller shall support transmitting and receiving segmented messages.

.10 The Advanced Application Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

.3 The Advanced Application Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP. This level of controller shall be used for the following types of systems:

.1 Secondary Pumping systems

.2 Systems with over 12 controlled points

.3 Systems with custom sequences

.4 Each System Level Control Panel shall, at a minimum, be provided with:

.1 Appropriate NEMA rated metal enclosure.

.2 A 32-bit, stand-alone, multi-tasking, multi-user, real-time digital control microprocessor module.

.3 Inputs shall be 16-bit minimum digital resolution

.4 Outputs shall be 10-bit minimum digital resolution

.5 Primary Network communication module, if needed for primary network communications.

.6 Secondary Network communication module, if needed for secondary network communications.

.7 Memory module (4 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.

.8 Real time clock and battery

.9 Data collection/ Data Trend module sized for 10,000 data samples.

.10 Power supplies as required for all associated modules, sensors, actuators, etc.

.11 Input/output point modules as required including spare capacity.

.12 Software modules as required for all sequences of operation, logic sequences, and energy management routines. Relay logic is not acceptable.

.13 Monitoring of the status of all hand-off-auto switches. The status of the hand-off-auto switch shall be available as a BAS data point.

.14 Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.

.15 Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.

.16 Graduated intensity LEDs or analog indication of value for each analog output.

.17 Approvals and standards: UL916; CE; FCC

.18 Provide UL864-UUKL where called for in the sequences of operations.

.5 Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

.6 Panel setup, point definitions, and sequencing diagrams shall be backed up on EEPROM memory.

.7 Each Advanced Application Control Panel shall provide battery backup to support the real-time clock and RAM memory, such as trend logs, for a minimum of 100 hours.

.8 Each System Level Control Panel shall support firmware upgrades without the need to replace hardware.

.9 System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications.

.10 Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

.11 Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be "future" on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2.7 Application Specific Controllers

.1 Each Application Level Control Panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each application specific controller shall be a microprocessor-based, multi-tasking, real-time digital control processor.

.2 This controller shall have the BTL listing and meet the BACnet device profile of an Application Specific Controller and shall support the following BACnet BIBBs:

.1 Data Sharing

.1 Data Sharing-Read Property-B (DS-RP-B)

.2 Data Sharing-Read Property Multiple-B (DS-RPM-B)

.3 Data Sharing-Write Property-B (DS-WP-B)

.2 Device Management

.1 Device Management-Dynamic Device Binding-B (DM-DDB-B)

.2 Device Management-Dynamic Object Binding-B (DM-DOB-B)

.3 Device Management-Device Communication Control-B (DM-DCC-B)

.3 The Advanced Application Controller shall support the following Data Link Layers:

.1 MS/TP Master or Slave (Claus 9)

.3 Provide an Application Specific Control Panel for all other equipment that is part of this project and presently connected to the existing DDC system.

.4 Each Application Specific Controller shall, at a minimum, be provided with:

.1 Appropriate NEMA rated enclosure

.2 Floor Level network communications ability

.3 Power supplies as required for all associated modules, sensors, actuators, etc.

.4 Software as required for all sequences of operation, logic sequences, and energy management routines.

.5 A portable operator terminal connection port

.6 Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure

.7 Each controller measuring air volume shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time

.8 Each controller measuring air volume shall include a differential pressure transducer

.9 Approvals and standards: UL916; CE; FCC

.5 Each Application Specific Controller shall continuously perform self-diagnostics on all hardware and secondary network communications. The Application Specific Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.

.6 Provide each Application Specific Controller with sufficient memory to accommodate point databases, operating programs, local alarming, and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

.7 The Application Specific Controller shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The controllers shall also function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

2.8 Routers

.1 Provide a router for each subnetwork to connect the floor level network to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet.

.2 The router shall be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

2.9 Base Building Backbone Ports

.1 On each floor, and mechanical room provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

2.10 Control Panels

.1 Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

.2 Mount on walls at an approved location or provide a free standing rack.

.3 Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

.4 Provide power supplies for control voltage power.

.5 Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

.6 Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

.7 All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

.8 Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator’s workstations.

.9 All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

.10 Provide a pocket to hold documentation.

2.11 Input/Output Interface

.1 Hardwired inputs and outputs may tie into the BAS through building, custom application, or application specific controllers.

.2 All input and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, without damage to the controller.

.3 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

.4 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

.5 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.

.6 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

.7 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

.8 Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

.9 Input/Output points shall be the universal type, i.e., controller input or output may be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

.10 System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.12 Power Supplies and Line Filtering

.1 Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

.1 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.

.1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.

.2 Line voltage units shall be UL recognized and CSA approved.

.2 Power line filtering.

.1 Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:

.1 Dielectric strength of 1000 volts minimum

.2 Response time of 10 nanoseconds or less

.3 Transverse mode noise attenuation of 65 dB or greater

.4 Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz

2.13 Electric Damper/Valve Actuators

.1 The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.

.2 Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing. Alternatively, an uninterruptible power supply (UPS) may be provided.

.3 Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.

.4 All 24 VAC/VDC actuators shall operate on Class 2 wiring

.5 All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank for this purpose.

2.14 Control Valves

.1 General

.1 Control valves shall be two-way or three-way type for two-position or modulating service as shown.

.2 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

.1 Water Valves:

.1 Two-way: 150% of total system (pump) head.

.2 Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

.2 Steam Valves: 150% of operating (inlet) pressure.

.2 Water Valves:

.1 Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

.2 Sizing Criteria:

.1 Two-position service: Line size.

.2 Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.

.3 Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.

.4 Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.

.5 Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

.3 Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

.1 Water zone valves—normally open preferred.

.2 Heating coils in air handlers—normally open.

.3 Chilled water control valves—normally closed.

.4 Other applications—as scheduled or as required by sequences of operation.

2.15 Temperature Sensors

.1 Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

.2 Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m2 (10 ft2) of duct cross section.

.3 Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.

.4 Space sensors shall be equipped with set point adjustment, override switch, display, and/or communication port as shown.

.5 Provide matched temperature sensors for differential temperature measurement.

2.16 Humidity Sensors

.1 Duct and room sensors shall have a sensing range of 20% to 80%.

.2 Duct sensors shall be provided with a sampling chamber.

.3 Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall be suitable for ambient conditions of -40°C to 75°C (-40°F to 170°F).

.4 Humidity sensor's drift shall not exceed 1% of full scale per year.

2.17 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.

2.18 Relays

.1 Control relays shall be UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

.2 Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

2.19 Current Transmitters

.1 AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.

.2 Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.

.3 Unit shall be split-core type for clamp-on installation on existing wiring.

2.20 Current Transformers

.1 AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.

.2 Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

.3 Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.

2.21 Voltage Transmitters

.1 AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.

.2 Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1% full-scale accuracy with 500 ohm maximum burden.

.3 Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

2.22 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.

2.23 Current Switches

.1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

2.24 Local Control Panels

.1 All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.

.2 Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

.3 Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

3. EXECUTION

3.1 Installation

.1 Provide all relays, switches, sources of emergency and UPS battery back-up electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the project scope of work to maintain existing system operational, as is now. All field wiring shall be by this contractor.

.2 Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

3.2 Electrical Wiring Scope

.1 This contractor shall be responsible for all power and control wiring on this project. Control contractor is to hire directly an electrical contractor.

.2 This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

.3 Interlock wiring shall be run in separate conduits from BAS associated wiring.

.4 Provide network wiring for equipment that is called to be integrated to the BAS.

3.3 Electrical Wiring and Connection Installation

.1 All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

.2 Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

.3 Install raceways, boxes, and cabinets as required in accordance with NEC.

.4 Install building wire and cable according to NEC.

.5 Installation shall meet the following requirements:

.1 Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.

.2 Install exposed cable in raceway or conduit.

.3 Install concealed cable using plenum rated cable.

.4 Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

.5 Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

.6 Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

.7 All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.

.6 Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

.7 Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90º angles.

.8 Install conduit adjacent to machine to allow service and maintenance.

.9 Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

.10 Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

.11 Ground equipment.

3.4 Communication Wiring

.1 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

.2 Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

.3 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

.4 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

.5 Cable bundling:

.1 RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.

.2 RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.

.3 RS485 cabling run between floors shall be in a communication only conduit.

.4 RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.

.5 Ethernet cabling shall be in a communication only conduit.

.6 Ethernet and RS485 can be run together.

.7 Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

.6 RS485 Cabling

.1 RS485 cabling shall be used for BACnet MS/TP networks.

.2 RS485 shall use low capacitance, 20-24 gauge, twisted shielded pair.

.3 The shields shall be tied together at each device.

.4 The shield shall be grounded at one end only and capped at the other end.

.5 Provide end of line (EOL) termination devices at each end of the RS485 network or subnetwork run, to match the impedance of the cable, 100 to 120ohm.

.7 Ethernet Cabling

.1 Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.

.2 CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.

.3 Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.

.4 When the BAS Ethernet connects to an Owner's network switch, document the port number on the BAS As-builts.

.8 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

.9 All runs of communication wiring shall be unspliced length when that length is commercially available.

.10 All communication wiring shall be labeled to indicate origination and destination data.

.11 Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.5 Installation of Sensors

.1 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

.2 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

.3 Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

.4 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m2 (1 ft of sensing element for each 1 ft2) of coil area.

.5 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

.6 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

.7 Differential air static pressure.

.1 The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

.2 All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

.3 All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

3.6 Installation of Actuators

.1 Mount and link control damper actuators according to manufacturer's instructions.

.1 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

.2 Provide all mounting hardware and linkages for actuator installation.

.2 Electric/Electronic

.1 Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.

.2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

.3 Pneumatic Actuators

.1 Size pneumatic damper actuator to operate the related control damper(s) with sufficient reserve power to provide smooth modulating action or two-position action. Actuator also shall be sized for proper speed of response at the velocity and pressure conditions to which the control damper is subject.

.2 Pneumatic damper actuators shall produce sufficient torque to close off against the maximum system pressures encountered. Size the pneumatic damper actuator to close off against the fan shutoff pressure, as a minimum.

.3 Where two or more pneumatic damper actuators are installed for interrelated operation in unison, such as dampers used for mixing, provide the dampers with a positive pilot positioner. The positive pilot positioner shall be directly mounted to the pneumatic damper actuator and have pressure gauges for supply input and output pressures.

.4 The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating. Provide at least one actuator for each damper section. Each damper actuator shall not power more than 2 m2 (20 ft2) of damper.

.5 Use line shafting or shaft couplings (jackshafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.

3.7 Fiber Optic Cable System

.1 Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.

.2 All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

.3 All terminations shall to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

3.8 Identification

.1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows: CAUTION This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

.2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows: CAUTION This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

.3 Control Equipment and Device labeling:

.1 Tag all new equipment as well as existing (that has not yet been tagged) that is part of this control upgrade scope of work.

.2 Labels and tags shall match the unique identifiers shown on the as-built drawings.

.3 All Enclosures shall be labeled to match the as-built drawing by either control panel name or the names of the DDC controllers inside.

.4 All sensors and actuators not in occupied areas shall be tagged.

.5 Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.

.6 Duct static pressure taps shall be tagged at the location of the pressure tap.

.7 Each device inside enclosures shall be tagged.

.8 Terminal equipment need only have a tag for the unique terminal number, not for each device. Match the unique number on:

.1 First, the design drawings, or

.2 Second, the control as-builts, or

.3 Third, the DDC addressing scheme

.9 Tags on the terminal units shall be displayed on the Operator Workstation Graphics.

.4 Tags shall be mechanically printed on permanent adhesive backed labeling strips, 12 point height minimum.

.5 Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

.6 Identification of Wires

.1 Tag each wire with a common identifier on each end of the wire, such as in the control panel and at the device termination.

.2 Tag each network wire with a common identifier on each end.

.3 Tag each 120V power source with the panel and breaker number it is fed by.

.7 Identification of Conduits:

.1 Identify the low voltage conduit runs as BAS conduit, including power feeds.

.2 Identify each electric box, junction box, utility box, and wiring tray with a blue paint mark or blue permanent adhesive sticker.

.3 For conduit runs that run more than 8 ft between junction boxes in 1 room, place a blue identifier at least every 8 feet.

.4 Place a blue identifier on each side of where a conduit passed through a wall or other inaccessible path.

.5 Identify all BAS communication conduits the same as above.

3.9 Field Quality Control

.1 Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

.1 Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.

.2 Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.

.3 Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

.1 Delete first paragraph below if factory-authorized service representative is not required.

.2 Engage a factory-authorized service representative to perform startup service.

.3 Replace damaged or malfunctioning controls and equipment.

.1 Start, test, and adjust control systems.

.2 Demonstrate compliance with requirements, including calibration and testing, and control sequences.

.3 Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.10 System Checkout and Startup

.1 Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

.2 After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:

.1 Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.

.2 Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.

.3 Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.

.4 Inspect the reading of each status switch to verify the DDC reads the open and close correctly.

.5 Command each relay to open and close to verify its operation.

.6 Command each 2-position damper actuator to open and close to verify operation.

.7 Command each 2-position valve to open and close to verify operation.

.8 Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.

.9 Ramp each modulating output signal, such as a VFD speed, to verify its operation.

.10 Test each safety device with a real life simulation, for instance check freezestats with ice water, water detectors with water, etc.

.3 Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

.4 Verify that each DDC controller communicates on its respective network correctly.

.5 After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:

.1 Start systems from DDC.

.2 Verify that each setpoint can be met by the system.

.3 Change setpoints and verify system response.

.4 Change sensor readings to verify system response.

.5 Test safety shutdowns.

.6 Verify time delays.

.7 Verify mode changes.

.8 Adjust filter switches and current switches for proper reactions.

.9 Adjust proportional bands and integration times to stabilize control loops.

.6 Perform all program changes and debugging of the system for a fully operational system.

.7 Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

.8 After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.11 System Commissioning, Demonstration and Turnover

.1 The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

.2 After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

.3 The BAS contractor shall fix punch list items within 30 days of acceptance.

.4 When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.12 Project Record Documents

.1 Project Record Documents: Submit three (3) copies of record (as-built) documents upon completion of installation. Submittal shall consist of:

.1 Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD compatible files in electronic format and as 11 x 17 inch prints.

.2 Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements in the Control System Demonstration and Acceptance section of this specification.

.3 Operation and Maintenance (O & M) Manual.

.1 As-built versions of the submittal product data.

.2 OM manuals to be linked on DDC graphics

.3 Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.

.4 Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.

.5 Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

.6 Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

.7 Documentation of all programs created using custom programming language, including setpoints, tuning parameters, and object database.

.8 Graphic files, programs, and database on electronic media.

.9 List of recommended spare parts with part numbers and suppliers.

.10 Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.

.11 Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

.12 Licenses, guarantees, and warranty documents for equipment and systems.

.2 Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum, include the following:

.1 Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.

.2 Description of manual override operation of all control points in system.

.3 BMS system manufacturers complete operating manuals.

.3 Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum, include the following:

.1 Complete as-built installation drawings for each building system.

.2 Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.

.3 Photographs and/or drawings showing installation details and locations of equipment.

.4 Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.

.5 Parts list with manufacturer's catalog numbers and ordering information.

.6 Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.

.7 Manufacturer's operation, set-up, maintenance, and catalog literature for each piece of equipment.

.8 Maintenance and repair instructions.

.9 Recommended spare parts.

.4 Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum, include the following:

.1 Complete programming manuals, and reference guides.

.2 Details of any custom software packages and compilers supplied with system.

.3 Information and access required for independent programming of system.

3.13 Training

.1 During System commissioning and at such time as acceptable performance of the Building Automation System hardware and software has been established, the BAS contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction during normal working hours shall be performed by a competent building automation contractor representative familiar with the Building Automation System's software, hardware, and accessories.

.2 At a time mutually agreed upon, during System commissioning as stated above, the BAS contractor shall give 16-hours of onsite training on the operation of all BAS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:

.1 Explanation of drawings and operator’s maintenance manuals.

.2 Walk-through of the job to locate all control components.

.3 Operator workstation and peripherals.

.4 DDC Controller and ASC operation/sequence.

.5 Operator control functions including scheduling, alarming, and trending.

.6 Explanation of adjustment, calibration, and replacement procedures.

.3 Additional 8-hours of training shall be given after the 30 day shakedown period.

.4 Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer’s standard pricing such as transportation, meals, etc.

3.14 Identification

.1 Comply with Section 23 05 53 Identification for Mechanical Piping and Equipment

.2 Permanent warning labels shall be affixed to all equipment that can be automatically started by the BAS.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows:

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning. Switch “disconnect” to “Off” position before servicing.

.3 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows:

C A U T I O N
This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing. Switch “disconnect” to “Off” position before servicing.

.4 All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 5 cm (2 in.) of termination with the BAS address or termination number.

.5 All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

.6 Permanently label or code each point of field terminal strips to show the instrument or item served.

.7 Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

.8 Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

.9 Identify room sensors relating to terminal box or valves with nameplates.

.10 Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

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.

.3 Section 23 08 10 – Measurement and Verification Requirements.

.4 Section 25 05 00 – Common Work Results for Integrated Automation.

.5 Section 25 09 -02 – Measurement and Verification Software.

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 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.

.3 The Controls Contractor shall provide all necessary programming and equipment required to meet this sequence of operation.

.4 Contractor shall not remove or override any manufacturer's safeties.

.5 This Section includes control sequences for HVAC, lighting, external shading systems, subsystems, and equipment. The section also includes control sequences for integration of other building systems unrelated to the HVAC systems.

.6 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.

.7 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.

.8 Coordinate the sequence of operation in all Life Safety modes. Mechanical systems shall have hard-wired interface to the Fire Alarm Control Panel (FACP). During activation of Smoke Venting mode (as signaled by the FACP), all required fans and dampers are to operate via the Smoke Venting sequence as defined in this section and noted on the drawings. Only where absolutely necessary shall this Smoke Venting sequence involve the BMS Direct Digital Controls system. Fail-safe sequences (such as interrupting power to spring-return dampers) shall be utilized as much as possible. Special interfaces to fire mode terminals on Variable Frequency Drives for fan operation shall also be used to ensure the highest level of reliability.

.9 Hard-wired pressure safeties: The controls contractor shall provide static pressure safety via pressure sensors mounted upstream and downstream of all fans that have the capability of over-pressurizing AHU casings or ductwork (systems that have motorized dampers or fire smoke dampers that would "seal" the system on either the inlet or outlet side of the fan system). These safeties shall all have adjustable setpoints, be hardwired to

shut down the fan system, and have manual reset type control. This applies to all systems with fans that are capable of generating a static pressure of 500 Pa (2" W.G).

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	HTEX	Heat Exchanger
ACU	Air Conditioning Unit	HW	Hot Water
AHU	Air Handling Unit	HWP	Hot Water Pump
AI	Analog Input	HWR	Hot Water Return
AO	Analog Output	HWS	Hot Water Supply
AV	Analog Value	MAX	Maximum
AVG	Average (mean)	MIN	Minimum
AUTO	Automatic	MISC	Miscellaneous
AUX	Auxiliary	N/C	Normally Closed
C	Common	N/O	Normally Open
CHW	Chilled Water	OA	Outdoor Air
CHWP	Chilled Water Pump	OAT	Outdoor Air Temperature
CHWR	Chilled Water Return	OAH	Outdoor Air Humidity
CHWS	Chilled Water Supply	PIU	Powered Induction Unit
COND	Condenser	RA	Return Air
CW	Condenser Water	RF	Return Fan
CWP	Condenser Water Pump	RH	Relative Humidity
CWR	Condenser Water Return	RTU	Roof-top Unit
CWS	Condenser Water Supply	SA	Supply Air
DA	Discharge Air	SF	Supply Fan
DI	Digital Input	SP	Static Pressure
DO	Digital Output	TEMP	Temperature
DV	Digital Value	UH	Unit Heater
EA	Exhaust Air	UV	Unit Ventilator
EF	Exhaust Fan	VAV	Variable Air Volume
EVAP	Evaporator	VVTU	Variable Volume Terminal Unit
FCU	Fan Coil Unit	W/	With
HOA	Hand / Off / Auto	W/O	Without
HP	Heat Pump	WSHP	Water Source Heat Pump
HRU	Heat Recovery Unit		

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 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).

.2 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.

.3 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.

.4 Purge Mode:

.1 This mode, indicated by flag PURGE (units yes/no), is used to purge the spaces with cool morning air on warm days or general purge due to high chloramines levels.

.2 Purge is allowed to start as soon as 3 hours before normal occupancy and is stopped as soon as the occupied mode starts or the time is later than 9:00 am. Once started it shall not stop until at least 30 minutes have elapsed or occupied mode has begun.

.3 This mode is allowed only if the outside air temperature is above 8°C and is at least 5°C lower than the average space temperature for free cooling purge. Chloramine purge may happen any time however do not allow space temperature to drop below 23°C.

.4 During this mode, no mechanical cooling or heating shall be allowed.

.5 Purging shall be optimized such that it is only active long enough to bring space temperatures well into the comfort range. A reasonable initial estimate of this time in hours is:

.1 (RTA - 22.5) / (RTa - (OAT + 2)) * 8

.1 Where RTA = average room temperature

.2 OAT = outside air temperature.

.5 Fire Mode:

.1 Refer to specific equipment control sequences and drawings in addition to the requirements of this sub-section.

.2 Fire Alarm Systems in buildings will override BMS control of designated equipment in an alarm condition. The BMS shall monitor a set of contacts output from the fire alarm system for status indication of a building fire alarm. Control sequences of all components that participate during all Fire Alarm modes (such as Smoke Exhaust) shall be hard-wired where possible. Where not possible (such as position of dampers in various positions depending on fire alarm mode), once the signal has been received from the fire alarm control panel the BMS system shall modulate the Fan speed and damper positions as noted below to put the systems in fire mode before fire alarm control panel is to operate unit. The BMS Controls Contractor shall coordinate building equipment that is shut down by the Fire Alarm System.

.3 Prior to control of systems by the fire alarm control panel the following operations are be performed by the BAS system:

.1 Supply and return fans are to operate at design air flow speed as noted on the mechanical equipment schedules.

.2 Outside air and relief air dampers are to open up 100%.

.3 Mixed air damper is to close.

.4 The supply and return fan high duct pressure cut off shall remain active to protect the fan and ductwork.

.4 Upon detection of air handling unit shut down the BMS shall close associated valves and stop associated pumps unless otherwise noted.

.5 Alarms shall be annunciated by the BMS to indicate the equipment failure/shut down and the building fire alarm condition. The BMS shall not annunciate nuisance alarms for monitored input points on systems shut down by the BMS or fire alarm system (e.g. high supply air temperature, low duct static pressure, etc.).

.6 Equipment shut down by the fire alarm system shall not be automatically restarted until the following has occurred:

.1 Building fire alarm condition has been cleared and a registered signal has been received from the fire alarm panel to the BMS.

.2 BMS Operator acknowledges the fire alarm.

.3 BMS Operator with appropriate access level resets the BMS system shut down software point.

.7 Once the above conditions have been satisfied and the BMS receives a Post Fire Alarm Equipment restart command, the BMS shall initiate the restart of any equipment shut down by the fire alarm system. The restart sequence shall provide an orderly start-up of the motors for each individual system with time delay between restarts of individual systems. Start of systems shall be according to normal system start up sequences. Only those motors, which should be operational in accordance with the Occupancy Schedule or application software programming requirements, shall be restarted.

3.2 General Building Conditions

.1 Monitor the following parameters:

.1 Building pressure differential sensors.

.2 Points: Provide all hardware and software points required to achieve the specified sequence 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	
Building Differential Pressure	X							X		X
Sensor Failure									X	

3.3 Outside Air Conditions

.1 Monitor the following parameters:

.1 Outdoor air temperature.

.2 Outdoor air humidity.

.3 CO_2.

.2 All values shall be made available to the system at all times.

.3 Measurement History: The controller shall monitor and record the high, low, and average readings for each variable. These readings shall be recorded on an hourly, daily, month-to-date and year-to-date basis.

.4 Cooling Degree Day: The controller shall provide a Degree Day index that reflects the energy consumption for the facilities cooling demand. Computations shall use a mean daily temperature of 18°C (adj.). The Degree Day peak value readings shall be recorded on a daily, month-to-date, and year-to-date basis.

.5 Heating Degree Day: The controller shall provide a Degree Day history index that reflects the energy consumption for the facilities heating demand. Computations shall use a mean daily temperature of 18°C (adj.). The Degree Day peak value readings shall be recorded on a daily, month-to-date, and year-to-date basis.

.6 24 Hour Average Outdoor Air Temperature (Rolling Average)

.1 The controller shall calculate and monitor the 24 Hour Average Outdoor Air Temperature.

.2 Recalculate the 24 Hour Average Outdoor Air Temperature in 15 minute intervals using the previous 24 hours of outdoor air temperature readings.

.7 Points: Provide all hardware and software points required to achieve the specified sequence 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	
Outdoor Air Temp					X			X		X
Outdoor Air Temp, Minimum					X			X		X
Outdoor Air Temp, Maximum					X			X		X
Outdoor Air Temp, Average					X			X		X
Dew Point Temp					X			X		X
Dew Point Temp, Minimum					X			X		X
Dew Point Temp, Maximum					X			X		X
Dew Point Temp, Average					X			X		X
Outdoor Air CO_2					X			X		X
Relative Humidity					X			X		X
Relative Humidity, Minimum					X			X		X
Relative Humidity, Maximum					X			X		X
Relative Humidity, Average					X			X		X
Air Pressure					X			X		X
Air Pressure, Minimum					X			X		X
Air Pressure, Maximum					X			X		X
Air Pressure, Average					X			X		X
Global Radiation					X			X		X
Radiation, Minimum					X			X		X
Radiation, Maximum					X			X		X
Radiation, Average					X			X		X
Precipitation, Absolute					X			X		X
Precipitation, Differential					X			X		X
Precipitation, Intensity					X			X		X
Cooling Degree Day					X			X		X
Heating Degree Day					X			X		X
Sensor Failure									X	
24 Hour Average OAT (Rolling Average)					X			X		X

3.4 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

3.5 Zone Sensors, Setpoints and Control Loops

.1 General:

.1 Refer to electrical drawings for locations and quantity of motion sensors and daylighting sensors.

.2 Zone Temperature

.1 Each zone shall have separate unoccupied and occupied setpoints, and separate heating and cooling setpoints. All setpoints shall be adjustable.

.2 Unless noted otherwise the occupied heating setpoint shall be 21°C and the occupied cooling setpoint shall be 25°C. The unoccupied heating setpoint shall be 16°C and the unoccupied cooling setpoint shall be 30°C.

.3 Room Temperature Occupied Set-points

Room Type	Set point (°C)	
	Summer	Winter
Pool Hall	27 (50-60%RH)	24 (50-60%RH)
Change Room	24	24
Multipurpose Room / Meeting Room	24	21
Seniors Lounge, Youth, Games, Arts Room	24	21
Pre-School, Indoor Play Area	22	22
Active Studio	19	19
Gymnasium	22	20
Fitness Room	19	18
Administration	24	21

Room Type	Set point (°C)	
	Summer	Winter
Lobby	26	21
Mechanical Room	Uncontrolled	8
Offices /Classrooms	24	21

.1 Setpoint Overlap Restriction:

.1 The software shall maintain a minimum 2°C (adj.) deadband between the heating and cooling setpoints at all times.

.2 Each zone shall have a local occupant setpoint adjustment knob / button limited in software and active only in occupied mode:

.1 As a default, the occupied cooling setpoint shall be limited between 24°C and 26°C (adj.).

.2 As a default, the occupied heating mode setpoint shall be limited between 18°C and 22°C (adj.).

.3 The adjustment shall move both the existing heating and cooling set points upward or downwards by the same amount unless the limit has been reached.

.3 In zones that have 2 or more temperature sensors, the BMS operator shall be able to easily select (globally and individually) between min-average-max comparative control functions. The default shall be set for average unless noted otherwise.

.4 Zone Carbon Dioxide (CO_2) Concentration

.1 Provide a CO_2 sensor(s) for each zone as noted on the drawings or in the sequence of operation.

.2 A proportional-only control loop shall be used to maintain the CO_2 concentration below setpoint by controlling outdoor air damper and/or transfer air fans as noted in the Sequence of Operation.

.5 Occupancy/Vacancy (Motion) Sensor

.1 Provide an occupancy sensor(s) for each zone as noted on the mechanical and electrical drawings and as noted in the Sequence of Operation.

.2 Occupancy sensors will be used to control HVAC and lighting systems as noted in the Sequence of Operations.

.6 Daylight Sensor

.1 Provide daylight sensor(s) for each zone as noted on the electrical drawings and in the Sequence of Operations.

.7 Control Loops:

.1 Two separate control loops shall operate to maintain space temperature at setpoint, the Cooling Loop and the Heating Loop. Both loops shall be continuously active. The Cooling Loop shall maintain the space temperature at the active cooling set point. The output of the loop shall be a virtual point ranging from 0% (no cooling) to +100% (full cooling). The Heating Loop shall maintain the space temperature at the active heating set point. The output of the loop shall be a virtual point ranging from 0% (no heating) to -100% (full heating).

.2 Loops shall use proportional + integral logic or fuzzy logic. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable from the Operator Workstation.

.3 Control Modes:

.1 Heating Mode: when the output of the space heating control loop is less than zero.

.2 Cooling Mode: when the output of the space cooling control loop is greater than zero and the output of the heating loop is equal to zero.

.3 Dead band Mode: when not in either the Heating or Cooling Mode.

.8 Zone Modes:

.1 Occupied Mode: A zone is in occupied mode when the time of day is between the system's scheduled occupied start and stop times AND occupancy is detected by the zone motion sensor.

.2 Stand-By Mode: A zone is in stand-by mode when the time of day is between the system's scheduled occupied start and stop times AND occupancy has not been detected in the zone for more than 15 minutes (adj.).

.3 Occupant Override Mode: A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule. The time of temporary occupied mode shall be initially set to 60 minutes. Timer shall reset each time the zone override button is pressed.

.4 Optimal Start: The unit shall use an adaptive optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period. The learning adaptive algorithm shall compare the zone temperature to its setpoint at beginning of scheduled occupied period and shall automatically adapt the warm-up or cool-down response time for the next unoccupied period. Refer to the Air handling unit sequence of operation for more information.

.5 Unoccupied Mode: A zone is in unoccupied mode when not in any other mode.

.9 Alarms

.1 High zone temperature: if zone temperature is greater than cooling setpoint by 3°C (adj.) for a minimum of 60 minutes (adj.) continuously, modulate damper to maximum position and annunciate alarm.

.2 Low zone temperature: if zone temperature is less than heating setpoint by 3°C (adj.) for a minimum of 60 minutes (adj.) continuously, modulate damper to minimum position and annunciate alarm.

.3 High Zone CO2 concentration: If the zone CO2 concentration is, greater than 10% (adj.) above setpoint for more than 30 minutes (adj.) annunciate alarm.

.4 Unstable PID loop: If any PID loop continues to cycle its output more than 40% or its range (adj.) 3 times (adj.) in any 60 minute interval, annunciate alarm.

.5 Inhibit alarms after zone set point is changed for a period of 20 minutes per degree of change (e.g. if set point changes from 21°C to 23°C, inhibit alarm for 40 minutes after the change) and while the System is in Warm-up or Cool-down Modes.

.10 Points List

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	DI	DO	AV	DV	Sched	Trend	Alarm	
Zone Temp	X							X		X
Zone CO2 Concentration	X							X		X
Zone Relative Humidity	X							X		X
Zone Daylight Sensor	X							X		X

Zone Motion Detection			X					X		X
Zone Override			X					X		X
Zone Heating Setpoint					X			X		X
Zone Cooling Setpoint					X			X		X
Heating Loop Output					X			X		X
Cooling Loop Output					X			X		X
Zone Dewpoint Temp					X			X		X
Zone Environmental Index					X			X		X
Schedule							X			
High Zone Temp									X	
Low Zone Temp									X	
High Zone CO2 Concentration									X	

3.6 Duct Smoke Detector

.1 Air handling systems serving more than one fire compartment shall be provided with a duct smoke detector in the supply air ductwork, provided by Division 26.

.2 Wire auxiliary contact on smoke detector to air handling unit supply fan starter or contact on variable frequency drive. Each air handling units' smoke detector upon detection of smoke shall stop its respective air handling unit

.3 Status of Air Handling systems shall be displayed on the Fire alarm control panel.

3.7 Static Pressure Control Reset for Multiple Zoned Air Systems

.1 This sequence shall be used for all air systems whose airflow volumes are variable and static pressure control is used. Static pressure set point shall be reset using Trim & Respond logic within the range 35 Pa to 325 Pa (adjustable). When the fan is off, the set point shall be 125 Pa (adjustable). While the fan is proven on, every two minutes, trim the set point by 10 Pa (adjustable) if there are two or fewer zone pressure requests. If there are more than two zone pressure requests, respond by increasing the set point by 15 Pa (adjustable). One zone pressure request is generated when the VAV damper is greater than 85% open until it drops to 70% open. Two pressure requests are generated when the damper is greater than 99% open until it closes to 85%. Contractor to use a standard proportional-integral-derivative (PID) control loop to adjust static pressure set point to maintain the most-open VAV damper position at 90% open.

3.8 Supply Air Temperature Reset for Multiple Zoned Air Systems

.1 This sequence shall be used for all air systems whose air temperature is reset for energy conservation. When the unit initially enters the occupied mode the discharge air temperature shall have a discharge temperature set-point of 14.0 Deg C in the cooling season and 20.0 Deg C in the heating season until room temperature is reached for 15 minutes (adjustable). The discharge temperature shall be reset from 12.8 Deg C to 18.0 Deg C when all of the VAV boxes cooling PID loops are less than 65%. Discharge temperature reset shall increment/decrement at a value of 0.5°F every 15 minutes. All values listed above shall be adjustable. This sequence is general in nature and shall apply unless noted specifically otherwise.

3.9 Heating During Unoccupied Periods

.1 During unoccupied periods in certain areas of the building where air-handling units are not required to run continuously, the AHU's shall be shut down unless space temperature falls below the unoccupied set point at which time the AHU will start in full recirculation mode and the heating coil modulated to maintain set point. Provide a suitable deadband to prevent fan cycling.

3.10 Air System Shutdown

.1 This sequence shall be used for all air systems with central supply and return fans. This sequence is general in nature and shall apply unless noted specifically otherwise. System shut down shall be initiated automatically by the BMS according to Occupancy Schedule requirements, by manual Operator command, or via hardwired interlocks.

.1 On system shut down the BMS shall ramp down the supply and return fan (where applicable) speeds and return the system to the state described for System Off.

.2 The BMS shall shut down the supply fan and the return fan (where applicable) and generate an appropriate alarm message on detection of a supply air temperature of less than 5 Deg. C. This BMS software shutdown sequence shall be disabled during the first ten (10) minutes following system start-up.

.3 System Off - When the system is off:

.1 The return fan (as applicable) shall be off.

.2 The supply fan shall be off.

.3 The outside air dampers and the relief air dampers shall be fully closed.

.4 VSD's shall be set to the minimum speed.

.5 System control loops shall be disabled.

3.11 Natatorium Ventilation Units (AHU-1, HRV-1, RF-1, EF-1)

.1 General:

.1 The air handler (AHU-1) will require modifications to its internal controls dampers to achieve the below sequence of operations. Refer to literature for details.

.2 System is designed as a heating/ cooling/ mixed air and supply air reset, single duct, constant volume air handing unit. Unit will have supply fan on variable speed drive for soft start and balancing purposes. The unit has a modulating gas heating and is interlocked with HRV-4, RF-1 and EF-1.

.3 To minimize evaporation, the pool space temperature must be maintained 1-2°C above the main lap pool temperature. (this is critical because a lower air temperature will result in excessive evaporation).

.4 Normal operation:

.1 The packaged controls shall modulate the supply air fan speed to maintain design airflow rate together with RF-1 and exhaust fan EF-1 to maintain a slight negative pressure within the space. Supply air static pressure high limit software facilities shall be provided to limit the supply fan speed to prevent excessively high static pressures. The supply air static pressure switch trip point shall be Operator adjustable and initially set by the controls contractor with direction from the balancing contractor onsite during the balancing phase of the project.

.5 Free cooling mode:

.1 When ambient air temperatures are above 15°C (adjustable) or space humidity levels exceed 60%, HRV-4 to be off, AHU-1 mixed air damper to close, supply fan to run at full speed, return air fan RF-1 to run at 100%, exhaust fan EF-1 to run at 100%.

.2 It will also operate in free cooling mode when the outdoor temperature is higher than the required supply temperature but the outdoor air enthalpy (or total heat content) is less than the enthalpy of the return air.

.3 The outdoor air damper modulates from minimum position, when the full cooling load can be met by the minimum outside air volume, to the 100% outdoor air position as the outdoor air temperature approaches the required supply air temperature. When outdoor air temperature (or enthalpy) is greater than the return air temperature (or enthalpy), the outdoor air damper should revert back to the minimum setting for ventilation.

.6 Winter Mode: Occupied:

.1 Fans to run continuously.

.2 AHU Outside air damper to be modulated to maintain RH.

.3 Relative humidity within the Natatorium shall be set to 50%. If RH rises, modulate O/A damper & RF-1 to increase air quantities to achieve set point.

.4 Alarm EMCS if R/H drops below 40% or rises above 75%.

.5 Modulate gas heating section to maintain supply air temperature setpoint. Reset supply air temperature according to space demand, measured as an average of temperature sensors. Should a single temperature sensor exceed a 5c differential range then alarm EMCS as faulty sensor.

.6 Disable normally closed outdoor and exhaust air dampers if supply or return fans shut down.

.7 HRV-4 to operate when ambient air is between -10°C and 15°C. confirm defrost set point with manufacturer.

.7 Winter Mode: Unoccupied:

.1 Fans to run continuously.

.2 O/A damper shall close and mixed air damper opens. E/A damper shall open to maintain space static pressure set point.

.3 Maximum relative humidity shall be set to 60%. If RH rises above set point, modulate outdoor air damper to maintain RH setpoint. Close once setpoint is achieved.

.4 Modulate gas heating section to maintain setpoint and prevent freezing when O/A temperature is below 0°C.

.5 Modulate gas heating section to maintain supply air setback temperature setpoint.

.6 Disable normally closed outdoor and exhaust air dampers if supply or return fans shut down.

.7 HRV-4 to operate when ambient air is between -10°C and 15°C. confirm defrost set point with manufacturer.

.8 Summer Mode: Occupied:

.1 Fans to run continuously.

.2 AHU Outside air damper to be set to minimum O/A damper position.

.3 If O/A temperature is above 65 F and no demand for heating, lock out relative humidity control. Allow system to provide 100% O/A to maintain space set point.

.4 If O/A temperature is above 65 F and demand for heating:

.1 Complete a mixed air calculation and modulate gas heating section to achieve building setpoint. Mixed air calculation shall include wb / db calculations to maintain space RH.

.5 HRV-4 to be off when ambient air temperature is above 15°C (adjustable)

.9 Summer Mode: Unoccupied:

.1 Fans to run continuously.

.2 Set AHU O/A damper to minimum position and E/A damper to modulate to maintain static pressure.

.3 If there is a demand for heat:

.1 Complete a mixed air calculation and modulate heating coil valve to achieve building setpoint. Mixed air calculation shall include wb / db calculations to maintain space RH.

.4 HRV-4 to be off when ambient air temperature is above 15°C (adjustable)

.10 Pool hall moisture control

.1 Monitor surface contact temperature sensors in pool hall

.2 Calculate natatorium dew point temperature at each air RH and temperature sensor adjacent to contact sensor.

.3 Increase relative humidity setpoint until dew point temperature is 5degC above coldest contact temperature or user adjusted maximum RH setpoint

.4 Should maximum RH setpoint be reached, reduce supply air fan speed to reach dew point differential. Ensure pressure control is still maintained.

.11 Alarms:

.1 Alarms shall be part of the air handler factory packaged controls and may include most of the alarms listed below.

.2 The low temperature detection device shall be hardwire interlocked to shut down the supply fan and close the outside air and relief air dampers whenever a duct air temperature of 5 Deg. C. or lower is sensed. Device shall be manual reset.

.3 Provide static pressure high limit devices in the supply air duct and return duct hardwire interlocked to shut down the associated fans and the air handling unit system in a high static pressure condition. Devices shall be manually reset.

.4 Freeze protection

.5 Supply fan failure

.6 Supply fan in Hand

.7 Supply fan VFD fault

.8 Pre and final filter change required (differential pressure above definable limit)

.9 High/Low mixed air temperature

.10 High/Low return air temperature

.11 High/Low supply air temperature

.12 Phase monitor for motors and compressors

.2 Control Points

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Final Filter Differential Pressure	×								×		
Mixed Air Temp	×								×		×
Outside Air Temp	×								×		×
Prefilter Differential Pressure	×								×		
Return Air Carbon Dioxide PPM	×								×		×
Return Air Humidity	×								×		×
Return Air Temp	×								×		×
Supply Air Static Pressure	×								×	×	×
Supply Air Temp	×								×		×
Gas Heat Section		×							×		×
Mixed Air Dampers		×							×		×
Return Fan VFD Speed		×							×		×
Supply Fan VFD Speed		×							×		×
Freezestat			×						×	×	×
High Static Shutdown			×						×	×	×
Return Fan Status			×						×		×
Return Fan VFD Fault			×							×	
Supply Air Smoke Detector			×						×	×	×
Supply Fan Status			×						×		×
Supply Fan VFD Fault			×							×	×
Return Fan Start/Stop				×					×		×
Supply Fan Start/Stop				×					×		×
Economizer Mixed Air Temp Setpoint					×				×		×
Supply Air Static Pressure Setpoint					×				×		×
Supply Air Temp Setpoint					×				×		×
Zone Carbon Dioxide PPM					×				×		×
Zone Carbon Dioxide PPM Setpoint					×				×		×
High Mixed Air Temp										×	
High Return Air Carbon Dioxide Concentration										×	
High Return Air Humidity										×	
High Return Air Temp										×	
High Supply Air Static Pressure										×	
High Supply Air Temp										×	
High Supply Air Temp										×	
High Zone Carbon Dioxide Concentration										×	
Low Mixed Air Temp										×	
Low Return Air Humidity										×	
Low Return Air Temp										×	

	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Low Supply Air Static Pressure										×	
Low Supply Air Temp										×	
Low Supply Air Temp										×	
Prefilter Change Required										×	×
Return Fan Failure										×	
Return Fan in Hand										×	
Return Fan Runtime Exceeded										×	
Supply Fan Failure										×	
Supply Fan in Hand										×	

3.12 Boiler Room Combustion Air Unit Heater (UH-1)

.1 General:

.1 The boiler room combustion air intake consists of:

.1 A duct, open to the outside through a roof or wall.

.2 One temperature sensor adjacent to the cold air trap. Mount temperature sensor approximately 300 AFF.

.3 One temperature sensor in the boiler room to control UH-1

.2 Heater to operate when the temperature outside is below 18 °C (Adjustable).

.2 Control description:

.1 When the outdoor air temperature is below 18 °C (Adjustable), the unit heater fan shall be enabled to recycle heat from the high level of the room. When the room temperature sensor adjacent to the cold air trap indicates the room temperature is below 16°C (Adjustable) the unit heater's gas heating section shall modulate to maintain temperature set point.

.2 If the combustion air falls below 12.8°C (55°F), an alarm shall be registered at the BMS.

.3 When the room temperature sensor adjacent to the cold air trap indicates that the air has reached set point the unit heaters shall stop and the fan shall operate until outdoor air temperature exceeds 18°C.

.3 Miscellaneous:

.1 Filters are not monitored by the BMS.

.4 Alarms:

.1 Low Zone Temp: If the zone temperature is less than 5°C (adj.) for more than 15 minutes (adj.).

.5 Points:

.1 Provide all hardware and software points required to achieve the specified sequence 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	
Zone Temperature	X							X		X
Fan Status			X					X		X
Fan Start/Stop				X				X		X
Heating Setpoint					X			X		X
Pump HWP-10 VFD Fault			X						X	X
Low Zone Temp									X	

3.13 Pool Boiler (B-1,2)

.1 The EMCS shall control this system.

.2 There is a master boiler tied into the EMCS through BACnet communication protocol, the other boilers communicate to the master boiler. The EMCS will enable the boiler plant but the boiler plant control will be through the integral master controller. The EMCS contractor to provide all wiring as follows:

.1 BACnet connection to master controller.

.2 Wiring from other boilers to master controller.

.3 Wiring from each boiler to associated boiler circulation pump.

.4 Wiring from each boiler to associated combustion air damper.

.3 Upon startup of the heating system, EMCS will enable the hot water boiler. Should the boiler fail to prove its operation an alarm shall be generated at the EMCS.

.4 The primary loop supply temperature setpoint shall be reset by the outdoor air temperature according to the following schedule (schedule to be adjustable):

.5 OAT HWST

.6 -35°C (-31°F) 82°C (180°F)

.7 16°C (60°F) 71°C (160°F)

.8 Sequence of Operation:

.1 A control loop monitoring the pool return water temperature will modulate the heat exchanger control valve in sequence in order to maintain the pool return water temperature at set point. Measure pool supply water temperature.

.2 Boiler and associated boiler circulation pump to activate and run until pool return water temperature is maintained at set point.

.9 Alarms:

.1 All analog temperature and pressure sensors will trigger an alarm at the HIGH or LOW alarm condition, as defined in the system database.

.10 The EMCS will monitor the operation status of the pumps and boilers via current switches. An alarm will be sent to the operator's workstation upon detection of any failed condition. The EMCS will also monitor the general alarm condition of the boilers.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	DI	DO	AV	DV	Sched	Trend	Alarm	
Primary Loop Supply Temperature	X							X		X

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	DI	DO	AV	DV	Sched	Trend	Alarm	
Primary Loop Return Temperature	X							X		X
Outside Air Temperature	X							X		X
Boiler B-1 Communication Interface	X	X								X
Boiler B-2 Communication Interface	X	X								X
Boiler B-1 Flow Switch			X							X
Boiler B-2 Flow Switch			X							X
P-1 Start/Stop				X				X		X
P-1 Status			X					X		X
P-2 Start/Stop				X				X		X
P-2 Status			X					X		X

3.14 Division 26 Alarms

.1 The BMS shall monitor Division 26 dry contact alarm outputs provided by Division 26 for recording and annunciation at the OWS(s). Systems to be monitored include Fridge/Freezers, Emergency generators, UPS, Security, Fire Alarm, Transformers etc. Final points list to be clarified with Div. 26.

.2 Wiring between the dry contacts and the BMS panels shall be by Division 26 contractor.

END OF SECTION