PURCHASING SECTION
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ADDENDUM #2

REQUEST FOR QUOTATIONS (RFQ) NO.:	**1220-040-2018-030**
TITLE:	**CHILLER REPLACEMENT – GUILDFORD RECREATIO CENTRE**
ADDENDUM ISSUE DATE:	**March 26, 2018**
REVISED CLOSING DATE:	**prefer to receive Quotations on or before:**
	April 3, 2018

INFORMATION FOR CONTRACTORS

This Addendum is issued to provide additional information to the RFQ for the above named project, to the extent referenced and shall become a part thereof. No consideration will be allowed for extras due to the Contractor not being familiar with this Addendum. This Addendum No. 2 contains 194 pages in total.

REVISED CLOSING DATE

The City would prefer to receive Quotations on or before **Tuesday, April 3, 2018**. The City's office hours are 8:30 a.m. to 4:00 p.m., Monday to Friday, except statutory holidays.

SUPPLEMENTARY SPECIFICATIONS – (PROJECT):

The following attached mechanical specifications are hereby added to Schedule B – Appendix 2 Supplementary Specifications – (Project) and are included as part of this RFQ:

Guildford Recreation Centre Chiller Replacement Mechanical Specifications dated March 26, 2018 by AME Group Consulting Mechanical Engineers:

Section No.	Section Title
Division 21	
21 05 01	Common Works Results for Mechanical
Division 23	
23 05 01	Acceptable Manufacturers
23 05 16	Expansion Fittings and Loops for Mechanical Piping
23 05 19	Meters and Gauges for Mechanical Piping
23 05 29	Hangers and Supports for Mechanical Piping and Equipment
23 05 48	Vibration and Seismic Control for Mechanical
23 05 53	Identification for Mechanical Piping and Equipment
23 05 93	Testing, Adjusting, and Balancing for HVAC
23 07 16	HVAC Equipment Insulation
23 07 19	HVAC Piping Insulation
23 08 00	Commissioning of HVAC
23 21 13	Hydronic Piping
23 21 16	Hydronic Piping Specialties
23 21 23	Hydronic Pumps
23 25 00	HVAC Water Treatment
23 82 16	Air Coils
Division 25	
25 05 00	Common Work Results for Integrated Automation
25 90 00	Integrated Automation Control Sequences

END OF ADDENDUM #2

All Addenda will become part of the RFQ Documents.

GUILDFORD RECREATION CENTRE CHILLER REPLACEMENT

PROJECT NO.: 085B-058-18

MECHANICAL SPECIFICATION
ISSUED FOR QUOTATION
26 MARCH, 2018

(PROFESSIONAL'S SEAL AND SIGNATURE)
DATE:_____

1100 – 808 West Hastings Street
Vancouver, BC V6C 2X4
T 604-684-5995

AME Group
consulting mechanical engineers

1. GENERAL

Mechanical Contractor shall be acting as General Contractor for the Guildford Recreation Centre Chiller Replacement Project. Therefore following specification sections shall be read with that understanding. The mechanical contractor means, general contractor and mechanical contract means, contract.

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

1.2 Related Requirements

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

.2 Section 25 05 00 – Common Works Results for Integrated Automation.

1.3 References

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

.2 British Columbia Codes:

.1 British Columbia Building Code 2012 (BCBC).

.2 British Columbia Fire Code 2012.

.3 British Columbia Plumbing Code 2012.

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

.1 ASHRAE 90.1-10, Energy Standard for Buildings Except Low-Rise Residential Buildings.

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

.1 Material Safety Data Sheets (MSDS).

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

1.4 Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.5 General Scope

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

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

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

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

.5 Install equipment generally in locations and routes indicated. Run piping and ductwork close to building structure, parallel to building lines, maximize head room 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 Install equipment to provide: service access, maintain service clearances and for ease of maintenance.

.7 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.

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

1.6 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. Specifications shall take precedence over drawings.

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

1.7 Permits and Fees

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

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

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

1.8 Examination of Site

.1 Before submitting 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.

1.9 Tender Price Breakdown

.1 Submit a tender price breakdown within thirty (30) days of 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	Mechanical:	Equipment, materials, labour
.2	Plumbing:	Equipment, materials, labour
.3	Sheet Metal:	Equipment, materials, labour
.4	Controls:	Equipment, materials, labour

1.10 Submittals

.1 Submittals shall be in accordance with Division 01 - Submittal Procedures, Division 01 – Closeout Procedures, Division 01 – Closeout Submittals and the following:

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

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

.4 Contractor shall provide and submit to the Consultant Assurance of Professional Design and Commitment for Field Review Schedule B and Assurance of Professional Field Review and Compliance Schedule C-B 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 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.

.8 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

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

.1 Fastening details for Seismic restraints.

.2 Mounting details for spring isolation of equipment.

.3 Sprinkler drawings including hydraulic calculations as per NFPA.

.10 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 Points of operation on performance curves.

.4 Manufacturer to certify current model production.

.5 Certification for compliance to applicable codes.

.11 Shop drawings to indicate:

.1 Material Specification including CSA or ULC reference numbers.

.2 Installation details to suit the applications on this project.

.3 Operating and maintenance requirements.

.12 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.

.13 Sustainable Design Submittals:

.1 LEED Canada submittals shall comply with Division 01- LEED Requirements and the following:

.1 Construction Waste Management Plan.

.2 Measurement and Verification Plan.

.3 Recycled Content list.

.4 Regional Materials list.

.5 Indoor Environmental Quality:

.1 Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

.2 Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Public Health Standard Method v1.1-2010.

.14 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 and Internal Documents Links.

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

.5 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 Record drawings:

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

.2 Use final reviewed "as-built" drawing set to provide CAD 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 record drawings.

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

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

.8 Should the Contractor choose to utilise this consultant for transferring as built information, allow [$200][$400] / sheet for all drawings in the construction set. This will cover costs for drafting time & printing costs.

.9 Submit copies of record drawings for inclusion in final testing and balancing report

.10 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.

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 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.

.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 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, including shoring, pumping, 150 mm compacted sand bedding under and first 300 mm of compacted sand over piping and ducting.

.3 Refer to 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.

1.19 Selective Demolition

.1 Reference Standards

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

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

.3 Existing Conditions

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

.4 Protection

.1 Prevent movement or settlement of adjacent work. Provide and place bracing or shoring and be responsible for safety of such work. Be liable for any such movement or settlement and any damage or injury caused.

.2 Cease operations and notify the Prime Consultant immediately for special protective and disposal instructions when any asbestos materials are uncovered during the work in this Section.

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

.5 Salvageable Materials

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

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

1.20 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)

1.21 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 - Construction/Demolition 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 - Construction/Demolition Waste Management and Disposal and Division 01 - LEED Requirements.

1.23 Firestopping and Smoke Seals

.1 Provide firestopping and smoke seals in accordance with Division 01 - Firestopping and as follows:

.2 Submittals:

.1 Submit shop drawings for all firestop systems anticipated on this project. Shop drawings shall be complete with a systems directory for system details.

.3 Scope:

.1 Provide firestopping for all mechanical work in Divisions 21, 22, 23 and 25

.2 For renovation projects, in addition to the necessary new penetrations, provide the firestopping for all existing mechanical assemblies where firestopping is damaged, discontinued or absent.

.4 Definition:

.1 Firestopping: Material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and hot gases through penetrations in fire rated wall and floor assemblies.

.5 Co-ordination Requirements

.1 Coordinate location and proper selection of cast-in-place Firestop Devices with trade responsible for the work. Ensure device is installed before placement of concrete.

.2 Responsible trade to provide adequate spacing of field run pipes to allow for installation of cast-in-place firestop devices without interferences.

.3 Obtain fire resistance ratings and classifications for all wall and floor assemblies from the Architectural contract documents.

.6 Performance Standards:

.1 Test Requirements:

.1 ULC-S115-M or CAN4-S115-M, "Standard Method of Fire Tests of Through Penetration Fire Stops".

.2 CAN4-S115-M under their designation of ULC-S115-M publishes test results in their "FIRE RESISTANCE RATINGS DIRECTORY" that is updated annually. All firestop system installations must meet the requirements of CAN4-S115-M or ULC S-115-M tested assemblies that provide a fire rating

.3 Underwriters Laboratories (UL) of Northbrook, IL runs ASTM E-814 under their designation of UL 1479 and publishes the results in their "FIRE RESISTANCE DIRECTORY" that is updated annually. UL tests that meet the requirements of ULC-S115-M are given a cUL listing and are published by UL in their "Products Certified for Canada (cUL) Directory

.4 International Firestop Council Guidelines for Evaluating Firestop Systems Engineering Judgments

.2 Inspection Requirements:

.1 ASTM E 2174 – 01, "Standard Practice for On-site Inspection of Installed Fire Stops.

.2 CAN/ULC-S102-M, Standard Test Method for Surface Burning Characteristics of Building Materials.

.3 NFPA 101 - Life Safety Code

.7 Quality Assurance

.1 Engage an experienced installer who is certified, licensed, or otherwise qualified by the firestop manufacturer as having been provided the necessary training to install manufacturer's products per specified requirements. On request the certified installer shall provide documented proof of certification from the firestop system manufacturer. A manufacturer's willingness to sell its firestop products to the Contractor or to an Installer engaged by the Contractor does not in itself confer qualification on the buyer.

.2 Retain and pay for the service of a Professional Engineer registered in the Province of [Alberta] [British Columbia] to inspect each and every mechanical fire stopping installation, and as required by the Authority having jurisdiction, and provide a report on all installations. The fire stopping engineer shall provide letters of assurance to the Owner's Consultant, in accordance with the [Alberta] [BC] Building Code.

.3 A manufacturer's direct representative (not distributor or agent) shall be on-site during the initial installation of firestop systems to train appropriate contractor personnel in correct selection and installation procedures. This will be done per manufacturer's written recommendations published in their literature and drawing details.

.4 Proposed firestop materials and methods shall conform to applicable governing codes having local jurisdiction.

.5 For those firestop applications that exist for which no ULC or cUL tested system is available through a manufacturer, a manufacturer's engineering judgment derived from similar ULC or cUL system designs or other tests will be submitted to local authorities having jurisdiction for their review and approval prior to installation. Engineer judgment drawings must follow requirements set forth by the International Firestop Council (September 7, 1994) and the Authorities having jurisdiction and be sealed by a Professional Engineer registered in the Province of [British Columbia] [Alberta].

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.

.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.

.2 Submittals:

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

1.25 Single Point Electrical Connection

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

1.26 Electrical Motors

.1 Supply mechanical equipment complete with electrical motors.

.2 Quality Assurance

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

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

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

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

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

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

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

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

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

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

.7 Provide motors complete with equipment except where indicated.

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

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

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

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

.12 Refer to electrical specifications, Section 26 05 81 - Motors, for voltage, frequency, and phase data. This shall take precedence over any reference in Divisions 21, 22, 23 and 25.

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

.14 Submittals

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

1.27 Motor Starters and Accessories

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

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

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

.4 Unless otherwise specified, starters for 3-phase motors 50 HP to 150 HP are to be reduced voltage, non-reversing, auto-transformer type starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.

.5 Unless otherwise specified, starters for 3-phase motors 150 HP and larger are to be reduced voltage, non-reversing, closed transition "wye-delta" starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.

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

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

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

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

.1 Enclosures located in sprinklered areas – Type 2;

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

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

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

.5 Enclosures except as noted above – Type 1;

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

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

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

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

1.28 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.

1.29 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.

1.30 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 [per UBC Standards].

1.31 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

1.32 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.

1.33 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.

1.34 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

1.35 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

1.36 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.

1.37 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.

1.38 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

1.39 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.

1.40 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] [C-B] for Fire Suppression.

.4 Fire Sprinkler Materials and Test Certificate.

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

.6 Schedule [C-2] [C-B] for seismic engineering.

.7 Schedule [C-2] [C-B] for fire stopping work.

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

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

.10 Fire stopping and Fire Damper test letter

.11 Vibration isolation supplier's inspection report

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

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

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

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

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

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

.18 Mechanical identification is complete.

.19 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.

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

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

.22 Record drawings have been submitted.

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

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

.25 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 until substantial performance is declared.

1.41 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 05 01 Acceptable Manufacturers.

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 Demolition

.1 Completely demolish the items scheduled and remove all materials from the premises.

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

.3 Carry out demolition in an orderly and careful manner

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

2.4 Asbestos

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

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

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

.2 Protect the site and all Contractors from the work

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

2.5 Core Drilling

.1 Clearly identify all proposed piping penetrations through existing slabs, walls etc and advise the General Contractor. Obtain x-rays of the locations to ensure penetration will avoid any existing post tension cables or reinforced steel. Advise the Structural Consultant of any conflicts as a result of the x-rays and obtain the Structural Consultant approval before any coring take place.

2.6 Firestopping and Smoke Seals

.1 Use the same product for all like applications.

.2 Use the same manufacturer throughout the project and compatible materials for restoration work.

.3 Provide fill material components for each firestopping system as needed. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.

.4 Firestopping Materials are either “cast-in-place” (integral with concrete placement) or “post installed.” Co-ordinate cast-in-place firestop devices prior to concrete placement.

.5 For penetrations through a Fire Separation wall provide a firestop system with a "F" Rating as determined by ULC or cUL as indicated below:

Fire Resistance Rating of Separation	Required ULC or cUL “F” Rating of Firestopping Assembly
30 minutes	20 minutes
45 minutes	45 minutes
1 hour	45 minutes
1.5 hours	1 hour
2 hours	1.5 hours
3 hours	2 hours
4 hours	3 hours

.6 For combustible pipe penetrations through a Fire Separation provide a firestop system with a “F” Rating as determined by ULC or cUL which is equal to the fire resistance rating of the construction being penetrated.

2.7 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.

2.8 Electrical Motors

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

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

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

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

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

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

.5 Match drive and driven sheaves.

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

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

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

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

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

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

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

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

.4 Guards:

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

.2 Guards for drives shall have:

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

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

.3 Removable side[s] for servicing.

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

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

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

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

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

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

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

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

3. EXECUTION

3.1 Painting Repairs and Restoration

.1 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. Commercialy 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, 22, 23 or 25 manufacturers to provide demonstrations and instructions.

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

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

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

3.5 Firestopping and Smoke Seals

.1 The Owner's Consultant shall conduct mandatory destructive reviews for each type of installation. Destructive testing shall be at the discretion of the Owner's Consultant and Authority having jurisdiction

.2 Allow for destructive testing of 5% of fire stopping applications. Should installations not conform to manufacturer's listed assembly, an additional 25% of installations may be destructively tested and should there be more failures, the contractor will be responsible to remove all fire stopping products and reinstall products correctly, at no additional cost to the project..

.3 Preparation:

.1 Verification of Conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.

.1 Verify penetrations are properly sized and in suitable condition for application of materials.

.2 Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, rust, laitance, release agents, water repellents, and any other substances that may affect proper adhesion.

.3 Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestop materials.

.4 Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

.5 Clean all surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

.4 Tag all penetrations and every 3 meters of joint seal with printed tags

.1 Tags shall indicate:

.1 Product.

.2 System #.

.3 Date installed.

.4 Installed by: (name and phone number of subcontractor).

.5 Re-penetrated by & Date.

.2 Tags shall state:

.1 CAUTION! FIRESTOP - DO NOT REMOVE, PUNCTURE OR DISCONTINUE UNLESS PREPARED TO RE-SEAL IMMEDIATELY WITH SPECIFIED PRODUCT

.5 Installation:

.1 Regulatory Requirements: Install firestop materials in accordance with ULC Fire Resistance Directory or UL Products Certified for Canada (cUL) Directory.

.2 Manufacturer's Instructions: Comply with manufacturer's instructions for installation of through-penetration joint materials.

.1 Seal all holes or voids made by penetrations to ensure an air and water resistant seal.

.2 Consult with mechanical engineer, project manager, and damper manufacturer prior to installation of ULC or cUL firestop systems that might hamper the performance of fire dampers as it pertains to duct work.

.3 Protect materials from damage on surfaces subjected to traffic.

.4 Where possible, use metal sleeves for floor penetrations to prevent/mitigate the consequences of leakage or flooding.

.6 Field quality control:

.1 Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.

.2 Keep areas of work accessible until inspection by applicable code authorities.

.3 Inspection of through-penetration firestop shall be performed in accordance with ASTM E 2174, “Standard Practice for On-Site Inspection of Installed Fire Stops” or other recognized standard.

.4 Use primers whenever recommended by manufacturer.

.5 Perform under this section patching and repairing of firestop caused by cutting or penetrating of existing firestop systems already installed by other trades.

3.6 Access Doors

.1 Installation:

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

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

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

.2 Location:

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

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

3.7 Electrical Motors

.1 Manufacturer’s instructions:

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

.2 Installation:

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

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

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

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

.5 Fasten securely in place.

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

.3 Setting and Alignment:

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

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

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

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

3.8 Protection

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

END OF SECTION

1. GENERAL

1.1 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	Approved Manufacturers	Note;
Access Doors - Wall	Maxam, Acudor, Milcor, Can.Aqua, Mifab, Bilco, Baucoplus	
Access doors - drywall	Baucoplus	
Actuators	Belimo, Honeywell, Siemens	
Air Separators	Armstrong, Bell & Gossett, Taco, Wheatley, Spirotherm	
Balancing Agents (BC)	KD Engineering, MDT Systems, Western Mechanical Systems, Blue Collar Group, Flotech Mechanical	
Bypass Filter (closed loop systems)	Sumco, GESL, Pace Chemicals	
Chemical Injection	LMI, Brae	
Chemical Pot Feeder	Axiom Industries	
Chillers - Air-Cooled	Trane,	Airmec, Daiken, Smard brand air cooled chillers may be considered as an alternate, if the proposed alternate chiller's efficiency and acoustical performance is equal or better than the specified (design base) TRANE Chiller. Please find the design base air cooled chiller section, end of this specification section
Coils - Heating and Cooling	Trane, Aerofin, Engineered Air, Colmac, Rosemex, Ventrol	
Commissioning Agents	KD Engineering, Blue Collar Group, Airmec, MDT Systems	
Controls Contractors - Vancouver	Energrated (Delta),	Base Building Control's Contractor
Expansion Fittings - Flexible Hoses	Metraflex, Anvilstar, 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	
Filters - Air - Mechanical	Cambridge, AAF, Pacific, FARR, Viledon	
Filters - Heating Water - Side Stream	Axiom Industries, AMF Cuno, Guthrie, Summit	
Firestopping	Hilti, 3M, Tremco, AD Firebarrier	
Flexible Connectors - Piping	Flexonics, Tube Turn, Atlantic, Hyspan, Hydroflex, Metraflex, United Flexible, Mason, Techniquip, United Flexible, Triflex, Victaulic, Anvilstar, Unisource	
Gauges - Air	Dwyer, Magnehelic	
Gauges - OWG Pressure	Trerice, Marsh, Ashcroft, Weiss, Moeller, Miljoco, Weksler, Winders	
Gauges - Differential Pressure	Dywer	

Type of Equipment	Approved Manufacturers	Note;
Grooved Mechanical Pipe Couplings/Valves/Fittings	Victaulic, Shurjoint, Gruvlok	
Insulation - Vapour Barrier Jacket Adhesive	Bakor, Epolux, Nacan, Foster, Childers	
Insulation - Fabric adhesive, coatings	Robson, Bakelite, Childers, Epolux, Foster	
Insulation - Canvas jacket	Robson, Fattal, Tai-Can	
Insulation - PVC jacket	Speedline, Proto, Zeston, Sure-Fit, Belform, Proto	
Insulation - Low temp preformed pipe insulation	Armacel, Therma-Cel, Kingspan	
Insulation - Low to intermediate temp pipe insulation	Knauf, Owens Corning, Roxul, Johns Manville	
Louvres and Roof Hoods	Airolite, Penn, Airstream, West Vent, Nailor, Ruskin, CS Louvre (Exhaust Use Only), Alumavent	
Meters - HVAC / Plumbing	Marsh, Weiss, Marshalltown, Taylor, Trerice	
Piping - Insulation sheilds	Klo-Shure	
Pipe Restraints	Trelleborg	
Piping Hangers and Saddles	Grinnell, Myatt	
Pipe and valve Identification		
Pump Accessories - Triple Duty Valves	Victaulic, B&G, Armstrong	
Pump Accessories - Suction Diffusers	Victaulic, B&G, Armstrong, Grundfos	
Pumps - Base Mounted	Grundfos, Bell & Gossett, Armstrong, Taco	
Tanks - Expansion	Amtrol, Armstrong, Bell & Gossett, Taco, Watts, Steelcraft, Wheatley, State, Sparco	
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 - Auto Balance	Tour and Anderson	
Valves - Ball	Watts, KVC, Red&White, Kitz, Apollo, Crane/Jenkins, Victaulic, Gruvlok	
Valves - Butterfly	Jenkins, Keystone, DeZurik, Centreline, Monotight, Dresser, Lunkenheimer, Crane, Bray, Toyo, Grinnell, Kitz, Red & White, Victaulic, Apollo, Mueller Locxend, KVC, Watts	
Valves - Check - Silent	Val-matic, APCO, StreamFlo, Victaulic, Gruvlok	
Valves - Check - Spring Loaded	Victaulic, Mueller Locxend, Moygro	
Valves - Circuit Balancing	Armstrong, Bell & Gossett, Wheatley, Tour and Anderson, Preso	
Valves - Drain, Radiator	Jenkins,Dahl, Crane, Toyo, Kitz	
Valves - Pressure	Watts, Armstrong, Bell & Gossett,	

Type of Equipment	Approved Manufacturers	Note;
Reducing	Taco, Crosby, Sarco, Clayton, Singer, Zurn, Wilkins, BCA, Cash Acme, Braukman	
Valves - Relief	Armstrong, Bell & Gossett, Taco, Wheatley, Watts, Farris, Singer, Lonergan	
Variable Frequency/Speed Drives	ABB,	
Vibration - Neoprene washer bushing	Korfund, Vibro-Accoustics	
Vibration - Neoprene pad	Korfund, Vibro-Accoustics	
Vibration - Rubber floor mounts	Korfund, Vibro-Accoustics	
Vibration - Spring floor mounts	Korfund, Vibro-Accoustics	
Vibration - Spring hangers	Korfund, Vibro-Accoustics	
Vibration - Restained air springs	Korfund, Vibro-Accoustics	
Vibration - Seismic snubbers	Korfund, Vibro-Accoustics	
Vibration Isolation	Mason, Korfund, Vibro-Accoustics	
Water Treatment Agents	Pace Chemicals, IPAC Chemicals, Enercon	

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

Air-Cooled Stealth (TM)

Job Information

Guildford chiller replacement
Vancouver Main Office
(P76)Ivan Holdo

Tag	RTAE-1	Nominal tonnage	150 ton
Model number	RTAE150		
Quantity	1	TOPSS version number	209

General Data

Refrigeration capacity	132.3 tons	IPLV.IP	16.95 EER (Btu/W-h)
Cooling efficiency	11.67 EER (Btu/W-h)	NPLV.IP	16.52 EER (Btu/W-h)

Evaporator Information

Evaporator application	Standard cooling (40-65F)	Evaporator configurations	3 pass evaporator
Evap fouling factor	0.000100 hr-sq ft-deg F/ Btu	Evaporator fluid type	Propylene glycol
Leaving fluid evap	41.00 F	Evap fluid concentration	30.00 %
Entering fluid evap	55.35 F	Evap fluid freeze point	9.19 F
Flow evap	234.0 gpm	Saturated evap temp - ckt 2	35.2 F
Fluid pressure drop evap	18.8 ft H2O	Saturated evap temp - ckt 1	34.5 F
Flow switch	Flow switch other - 15 cm/s		

Condenser Information

Ambient air temp	85.0 F	Saturated cond temp - ckt 1	118.8 F
Elevation	0.000 ft	Saturated cond temp - ckt 2	119.2 F
Condenser fin options	Aluminum fins with slits	RLA - condenser fan (each)	2.70 Each
Number of condenser fans	8.00 Each	Unit application	Wide ambient
Fan power	6.330 kW		

Electrical Information

Compressor starter	AFD3	RLA - comp A - AFD input	124.00 A
Incoming power line connection	Single point power	RLA - comp B - AFD input	124.00 A
Unit voltage	575.0 volt 3 phases	Short circuit current rating	25000.00 A
Unit hertz	60.0 hertz	Short circuit withstand rating	High amp
Total power	136.0 kW	Single point power MCA	246.00 A
Compressor power	129.3 kW	Single point power MOP	350.00 A
Transformer	Factory installed transformer	Power line connection type	CB high fault rated

Physical Information

Length	283.625 in	Refrig (HFC-134a) - ckt 1	172.0 lb
Width	87.813 in	Refrig (HFC-134a) - ckt 2	172.0 lb
Height	95.750 in	Oil charge - ckt 1	3.00 gal
Operating weight	14438.0 lb	Oil charge - ckt 2	3.00 gal
Shipping weight	14292.0 lb	Drive cooling charge - ckt 1	1.30 gal
		Drive cooling charge - ckt 2	1.67 gal

Air-Cooled Stealth (TM)

Job Information

Guildford chiller replacement
Vancouver Main Office
(P76)Ivan Holdo

Tag	**RTAE-1**	Nominal tonnage	**150 ton**
Model number	**RTAE150**		
Quantity	**1**	TOPSS version number	**209**

Acoustical Performance

Unit sound package	**Ultimate**	Fan speed	**700**
A-weighted sound power	**91 dBA**	A-weighted sound pressure *	**63 dBA**
A-weighted 75% sound power	**90 dBA**	A-weighted 75% sound pressure	**62 dBA**
A-weighted 50% sound power	**83 dBA**	A-weighted 50% sound pressure	**55 dBA**
A-weighted 25% sound power	**81 dBA**	A-weighted 25% sound pressure	**52 dBA**

Note: * At 30 feet in free field.

This unit complies with the efficiency requirements of all versions of ASHRAE Standard 90.1 and CANS/CSA C743.

Certified in accordance with the AHRI Air-Cooled Water-Chilling Packages Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Unit contains freeze protection fluids in the evaporator with a leaving chilled fluid temperature above 32°F [0°C] and is certified when rated per the Standard with water. Certified units may be found in the AHRI Directory at www.ahridirectory.org.

AHRI CERTIFIED® www.ahridirectory.org
Air-Cooled Water Chilling Packages
AHRI Standards 550/590 and 551/591

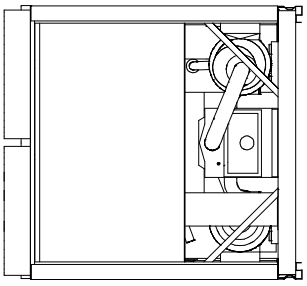
Information for LEED Projects

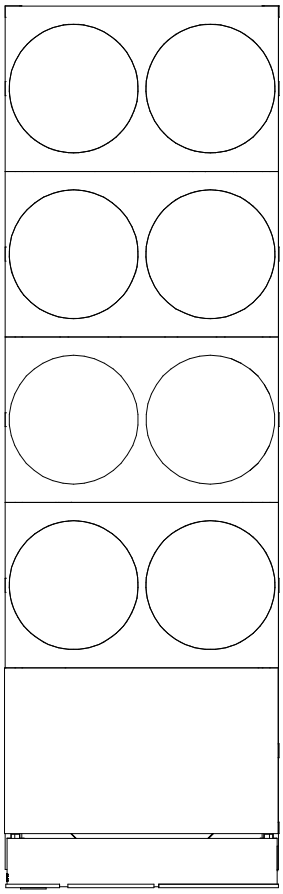
ASHRAE 90.1/CSA compliance	**ASHRAE 90.1 - all versions up to 2016**	Cooling efficiency	**11.67 EER (Btu/W-h)**
Refrig (HFC-134a) - ckt 1	**172.0 lb**	IPLV.IP	**16.95 EER (Btu/W-h)**
Refrig (HFC-134a) - ckt 2	**172.0 lb**	Compressor power	**129.3 kW**
Rated refrigeration capacity (AHRI)	**142.7 tons**	Fan power	**6.330 kW**
Rated cooling efficiency (AHRI)	**10.75 EER (Btu/W-h)**		

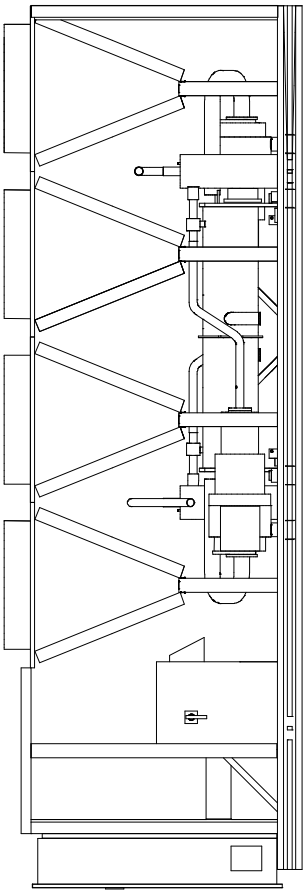
Note: This product meets the minimum efficiency requirements of ASHRAE Standard 90.1 and CANS/CSA C743 for all versions (which are based on AHRI standard rating conditions) and, therefore, also meets the LEED "Minimum Energy Performance" prerequisite in the Energy and Atmosphere section. Refer to the product catalog for performance at AHRI standard rating conditions.

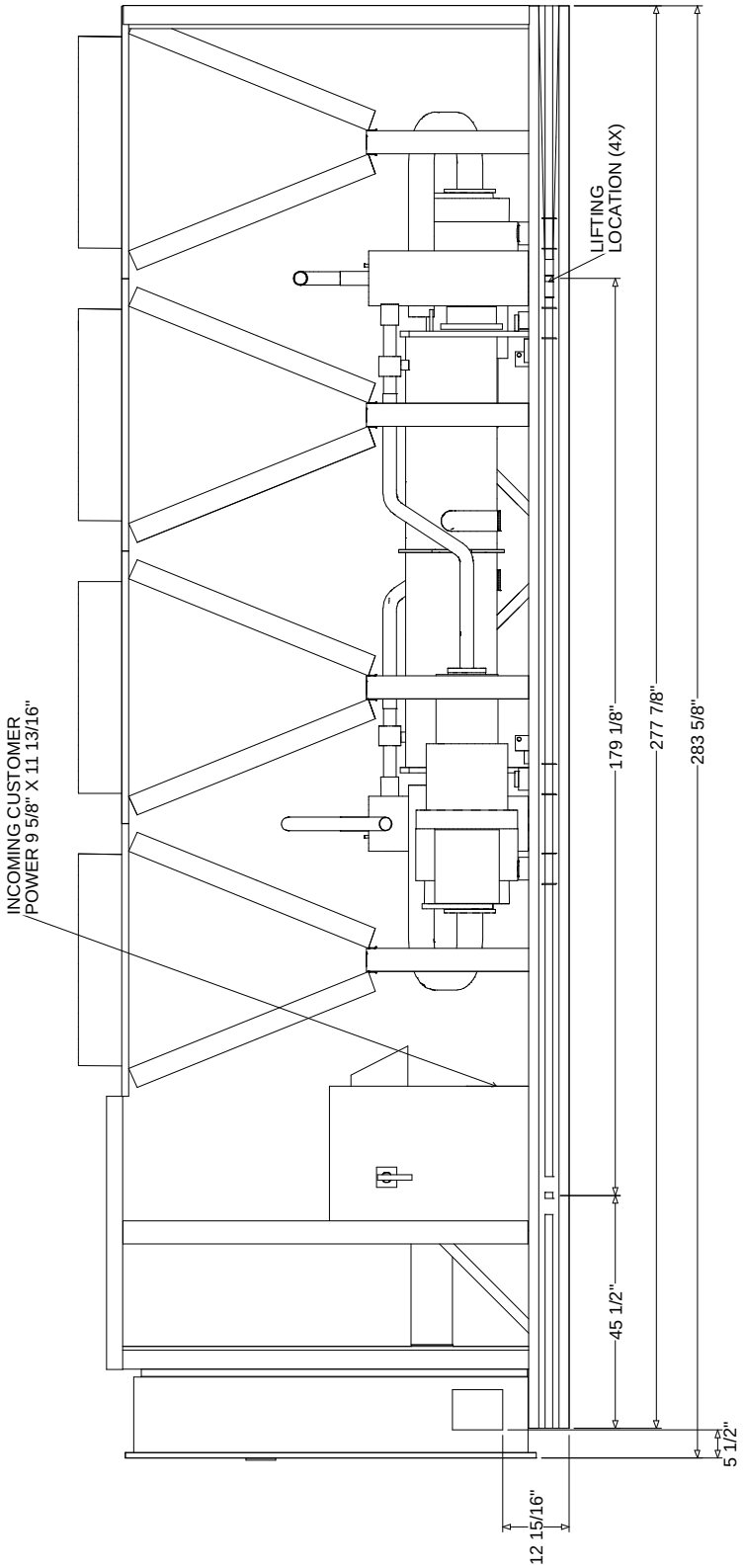
The LEED Green Building Rating System™, developed by the U.S. Green Building Council, provides independent, third-party verification that a building project meets green building and performance measures.

NOMINAL TONS	WATER CONNECTION DIAMETER (INLET/OUTLET)	WATER VOLUME
150	4" (100mm)	4044 in3

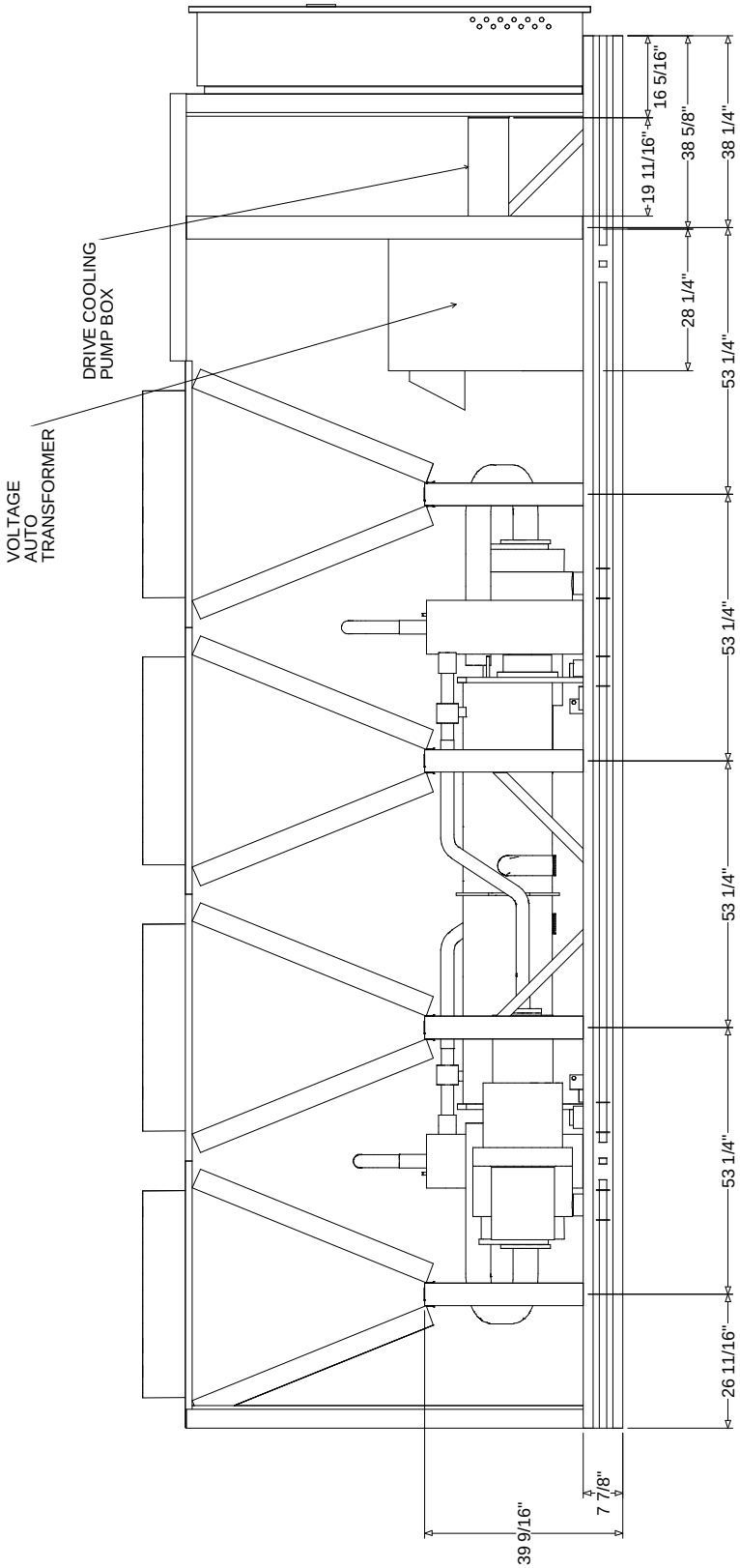




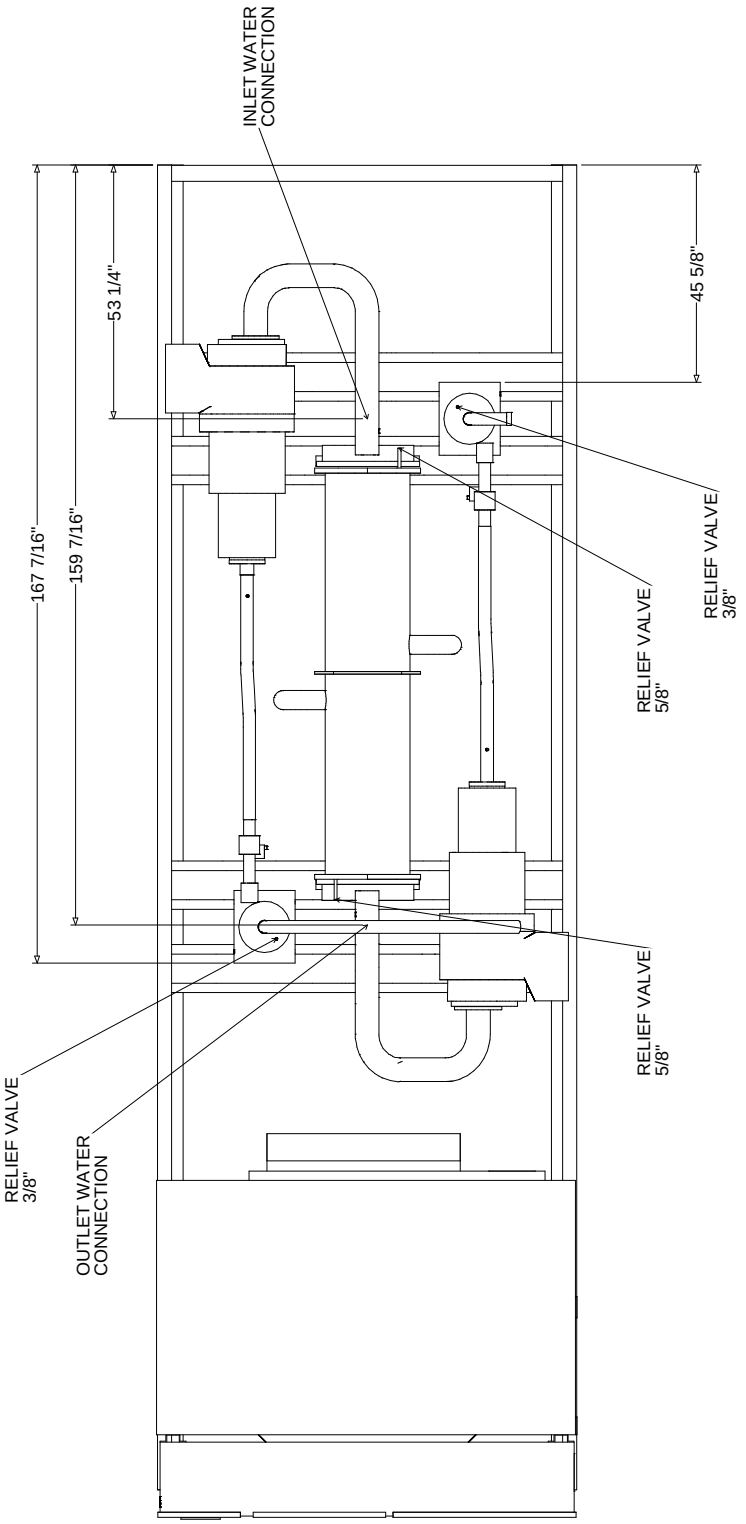




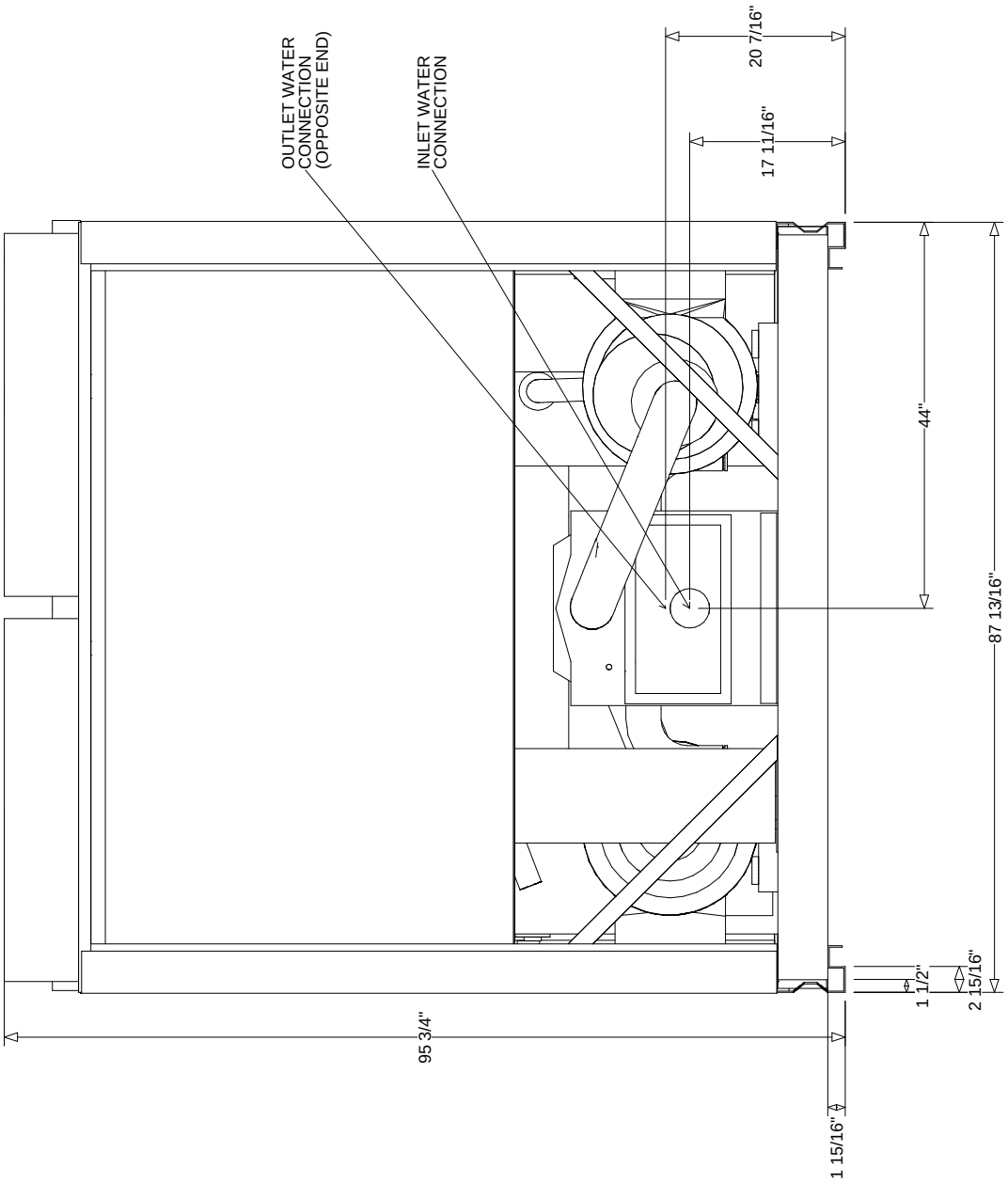
RIGHT SIDE VIEW



LEFT SIDE VIEW



TOP VIEW
(CONDENSER REMOVED FOR CLARITY)



END VIEW
NON CONTROL PANEL END

ADD 1/8" PER SIDE
TO WIDTH OF UNIT FOR
LOUVER PANEL OPTION.

LIFT 1 WEIGHT	LIFT 2 WEIGHT	LIFT 3 WEIGHT	LIFT 4 WEIGHT
4249.7 lb	3362.6 lb	2920.0 lb	3759.8 lb

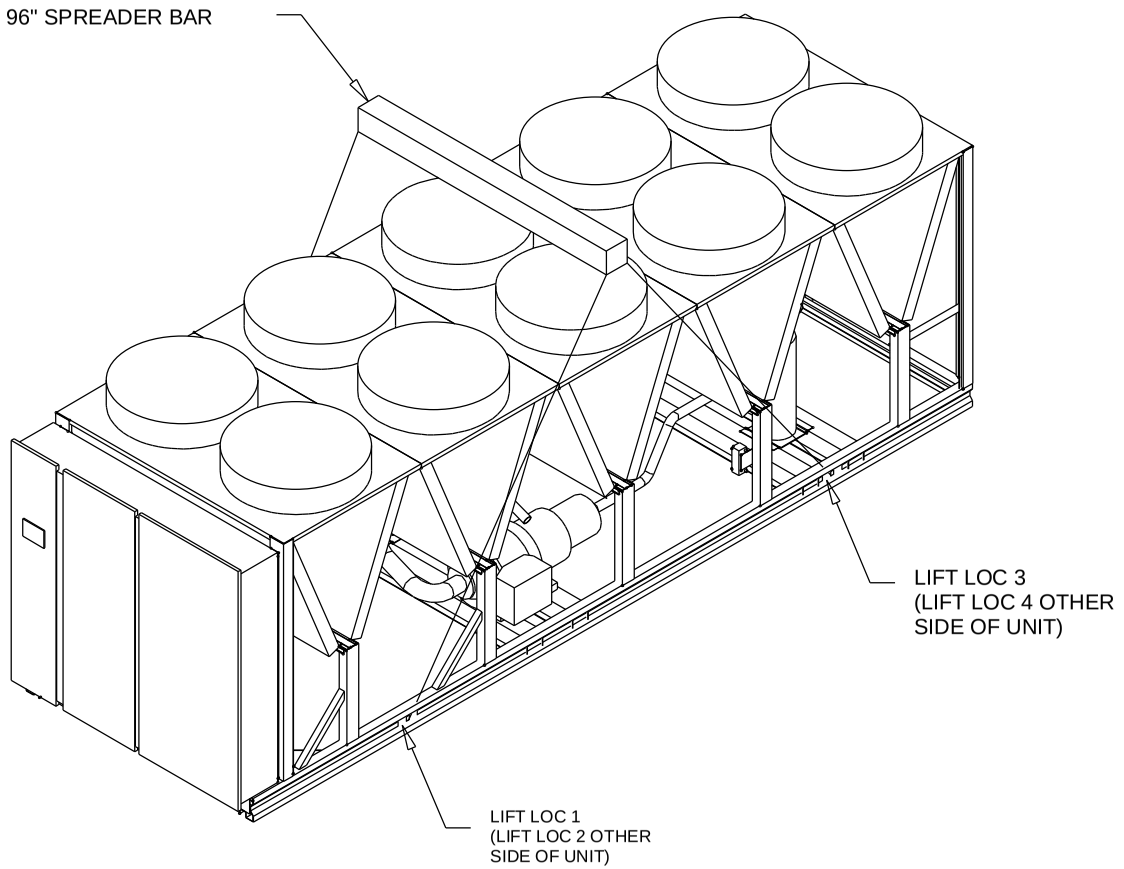
TOTAL SHIPPING WEIGHT
14292.0 lb

NOTES:
1. LIFTING CHAINS/CABLES WILL NOT BE THE SAME LENGTH. ADJUST TO KEEP UNIT LEVEL WHILE LIFTING.
2. DO NOT FORK LIFT UNIT.
3. WEIGHTS ARE TYPICAL FOR UNITS WITH R-134A CHARGE.
4. WEIGHTS ARE TYPICAL FOR UNITS WITHOUT LOUVER PANELS.
5. ADD 800.0 lb TO TOTAL WEIGHT FOR ULTRA LOW NOISE OPTION.

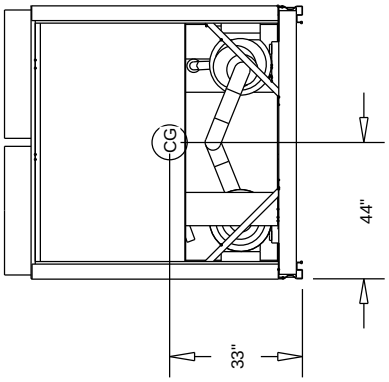
WARNING
LIFTING AND MOVING INSTRUCTIONS!
Use the spreader bar as shown in diagram. Refer to installation instructions located inside control panel for further rigging information.

Other lifting arrangements could result in death, serious injury or equipment damage.

DO NOT ALLOW LIFTING STRAPS TO CONTACT UNIT DURING LIFT!

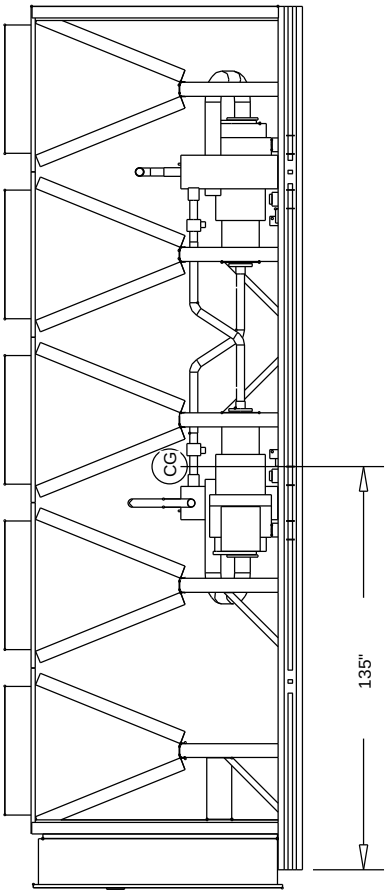


END VIEW (NON CONTROL PANEL)

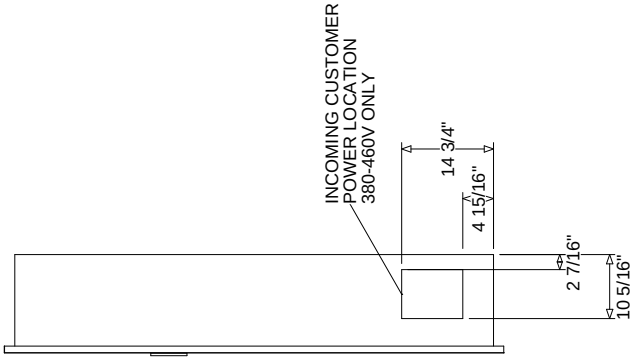


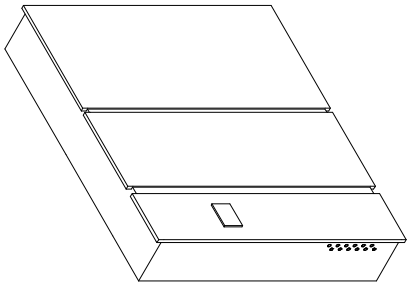
CENTER OF GRAVITY

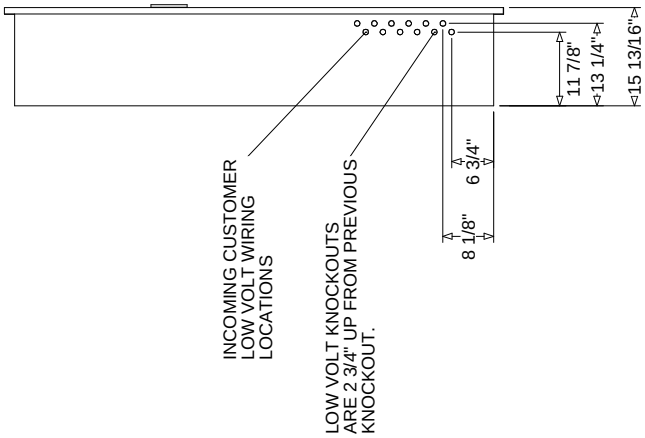
RIGHT SIDE VIEW

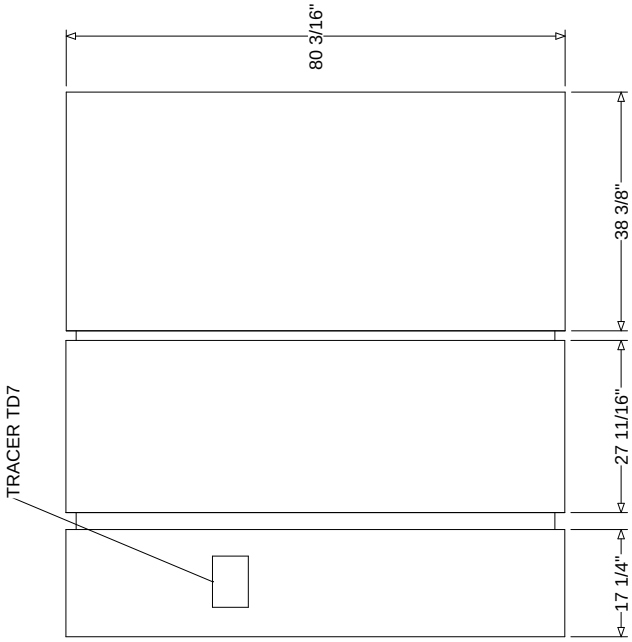


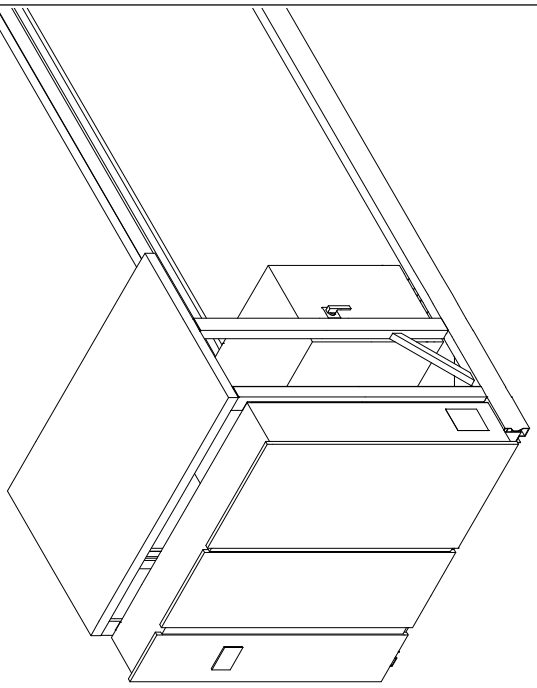
CUSTOMER WIRE SELECTION TABLE	
POWER WIRE CONNECTION TO CIRCUIT BREAKER	65kA
CIR 1 & 2 (SINGLE POINT POWER) LUG WIRE SIZE RANGE (PER PHASE)	SHORT CIRCUIT RATING
(3) MAX CONDUCTORS PER PHASE 3/0 AWG - 500MCM	

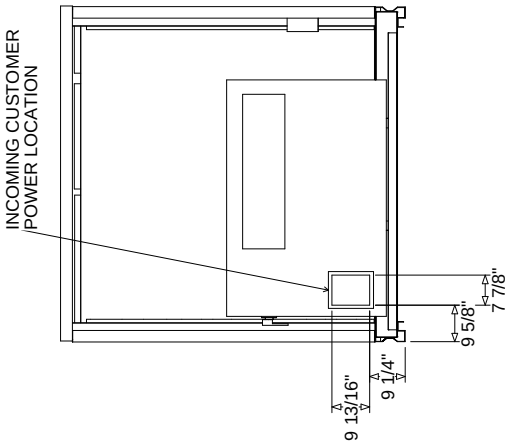




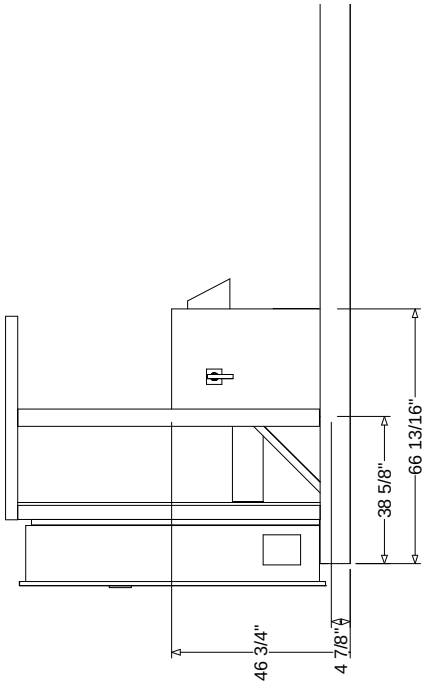




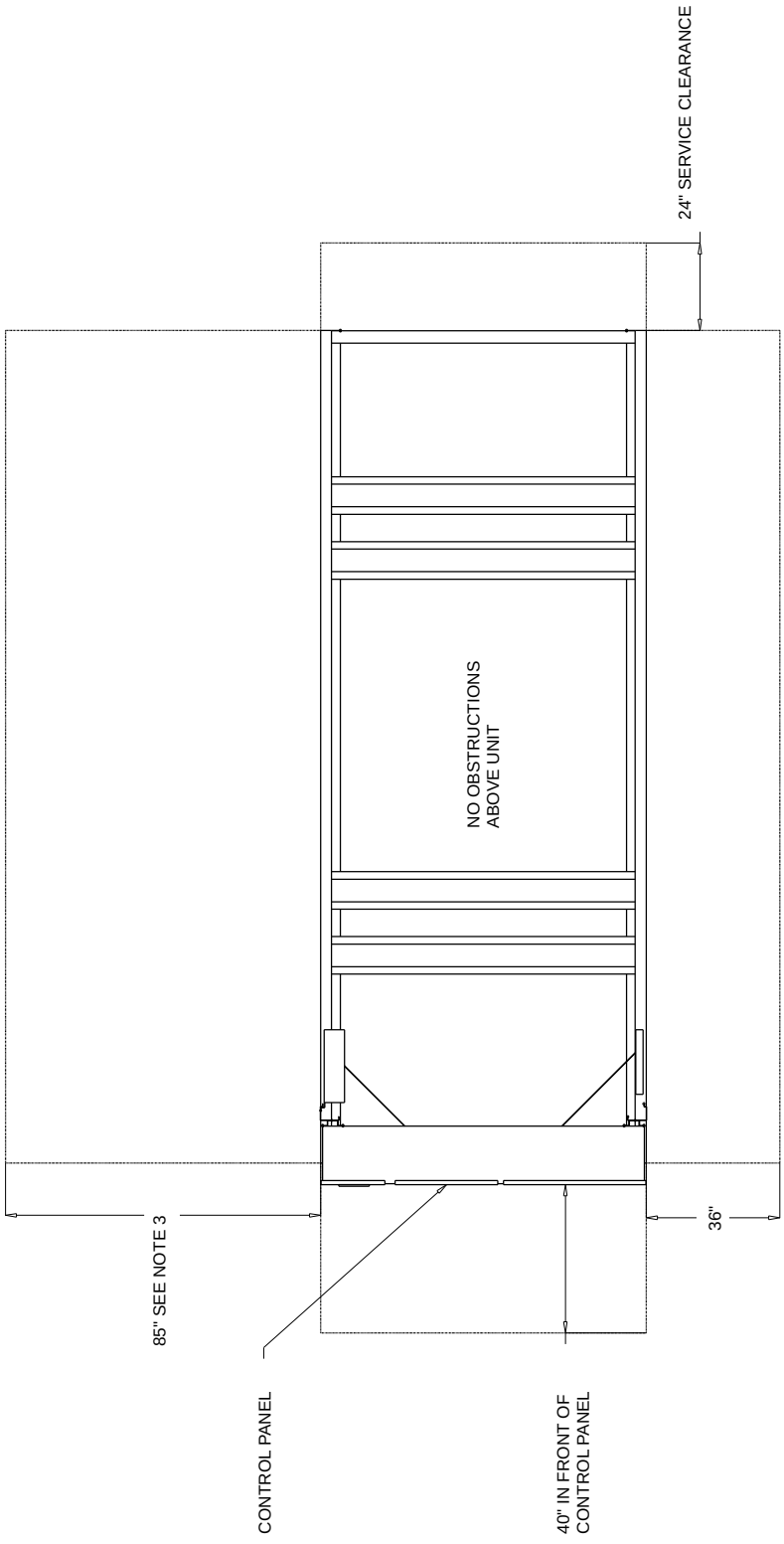




VOLTAGE AUTO-TRANSFORMER
(USED WITH 200, 230 AND 575 VOLT UNITS)



UNIT CLEARANCE

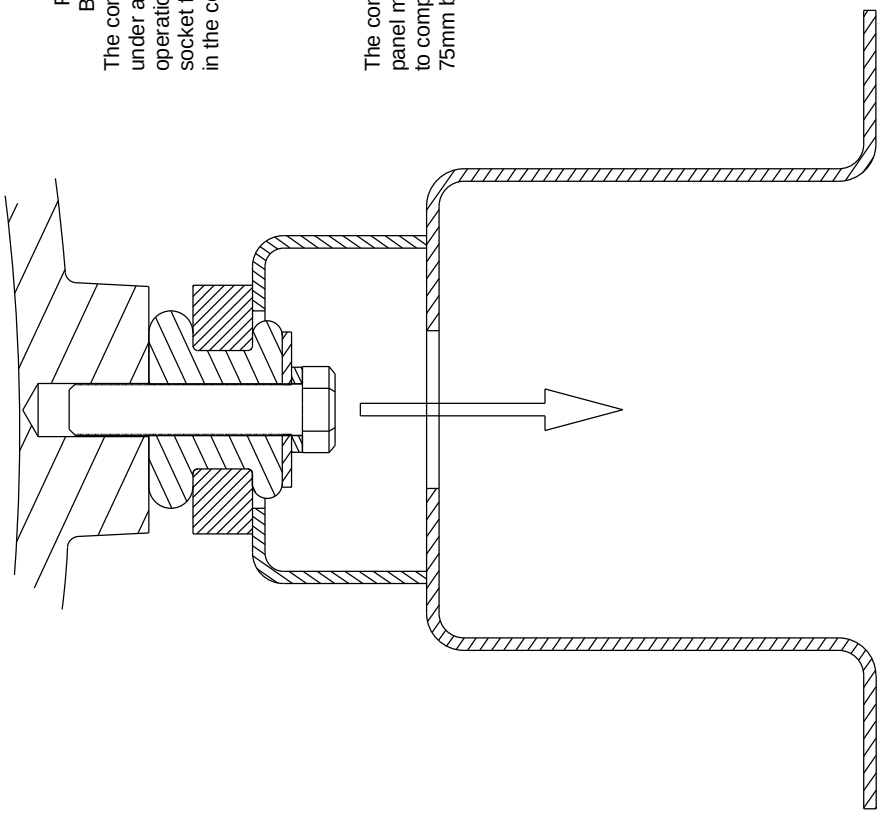


TOP VIEW

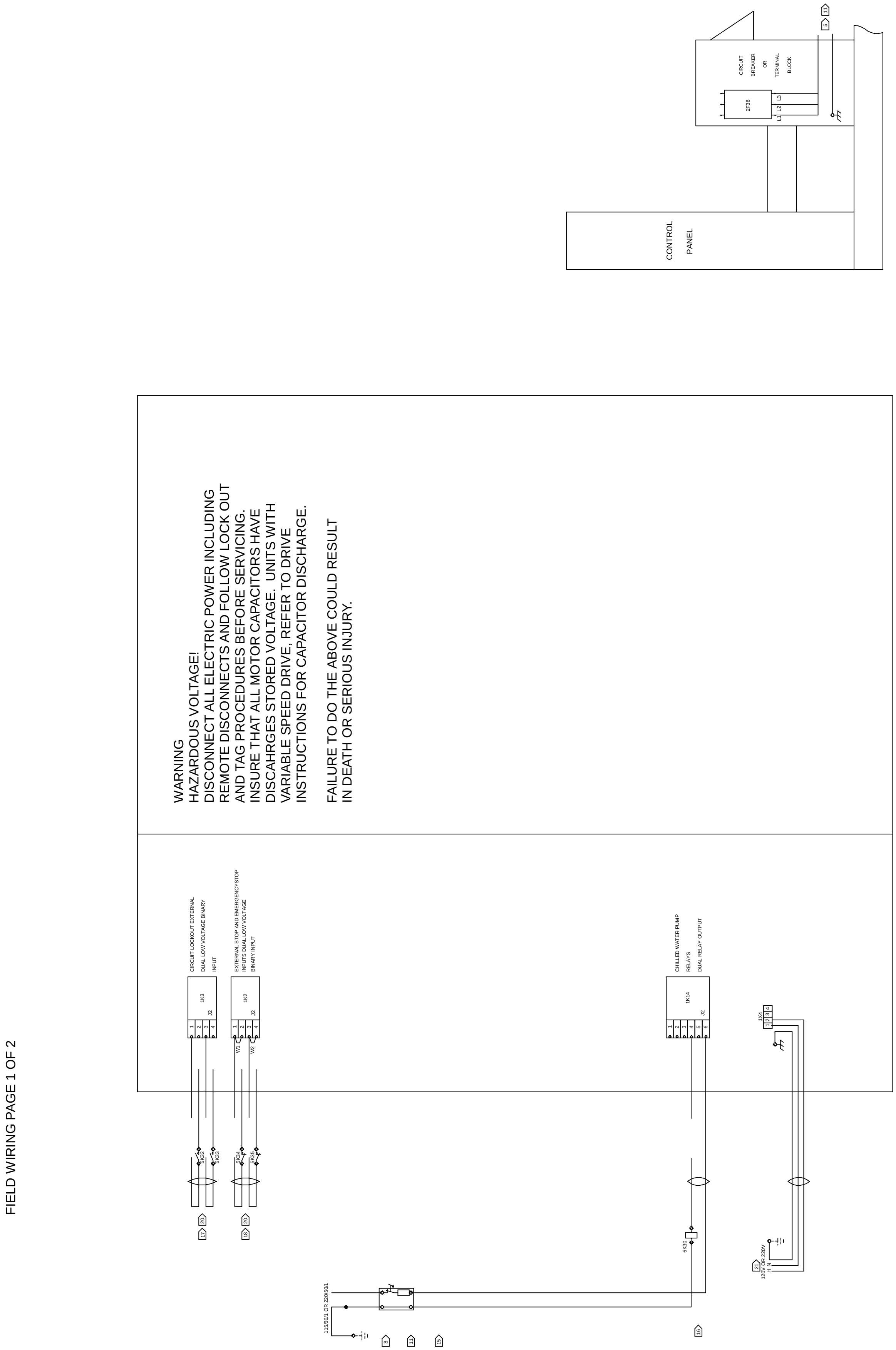
NOTES:
1. AREA ABOVE UNIT REQUIRED FOR OPERATION, MAINTENANCE, ACCESS PANEL AND AIR FLOW. NO OBSTRUCTIONS ABOVE UNIT.
2. FOR OBSTRUCTIONS OR MULTIPLE UNITS, REFER TO THE CLOSE SPACING BULLETIN.
3. CLEARANCE OF 85" ON THE SIDE OF THE UNIT IS REQUIRED FOR COIL REPLACEMENT. PREFERRED SIDE FOR COIL REPLACEMENT IS SHOWN (LEFT SIDE OF UNIT, AS FACING CONTROL PANEL), HOWEVER EITHER SIDE IS ACCEPTABLE.

NOTICE
REMOVE COMPRESSOR SHIPPING
BOLTS BEFORE CHILLER OPERATION
The compressor shipping bolts must be removed from under all three compressor feet prior to chiller operation to assure maximum low noise. Use a 24mm socket for the M16 x 75mm bolts. Store the bolts in the control panel for future use.

INSTALL COMPRESSOR SHIPPING
BOLTS BEFORE COMOPRESSOR
REMOVAL
The compressor shipping bolts that are stored in the control panel must be installed under all three compressor feet prior to compressor removal. Use a 24mm socket for the M16 x 75mm bolts.



LOW NOISE COMPRESSOR BOLTS


FIELD WIRING PAGE 1 OF 2
CIRCUIT BREAKER OR TERMINAL BLOCK
2F36
L1 L2 L3
CONTROL PANEL
WARNING
HAZARDOUS VOLTAGE!
DISCONNECT ALL ELECTRIC POWER INCLUDING
REMOTE DISCONNECTS AND FOLLOW LOCK OUT
AND TAG PROCEDURES BEFORE SERVICING.
INSURE THAT ALL MOTOR CAPACITORS HAVE
DISCAHRGES STORED VOLTAGE. UNITS WITH
VARIABLE SPEED DRIVE, REFER TO DRIVE
INSTRUCTIONS FOR CAPACITOR DISCHARGE.
FAILURE TO DO THE ABOVE COULD RESULT
IN DEATH OR SERIOUS INJURY.
CIRCUIT LOCKOUT EXTERNAL DUAL LOW VOLTAGE BINARY INPUT
1K3
EXTERNAL STOP AND EMERGENCY STOP INPUTS DUAL LOW VOLTAGE BINARY INPUT
1K2
CHILLED WATER PUMP RELAYS DUAL RELAY OUTPUT
1K14
1X4
115/60/1 OR 220/50/1
120V OR 220V

FIELD WIRING PAGE 2 OF 2

GENERAL NOTES

1. CAUTION-DO NOT ENERGIZE THE UNIT UNTIL CHECK OUT AND STARTUP PROCEDURES HAVE BEEN COMPLETED.

2. ALL MOTORS ARE PROTECTED FROM PRIMARY SINGLE PHASE FAILURES.

3. CAUTION-TRANE PUMP CONTROL MUST BE USED TO PROVIDE PUMP CONTROL. EVAPORATOR CHILLED WATER PUMP MUST BE CONTROLLED BY THE CHILLER OUTPUT. FAILURE TO COMPLY WITH THIS REQUIREMENT MAY RESULT IN DAMAGE OT THE UNIT.

<4> SINGLE SOURCE POWER IS PROVIDED AS STANDARD ON THESE PRODUCTS, FIELD CONNECTIONS ARE MADE TO 1F1.

WIRING REQUIREMENTS

5. RECOMMENDED FIELD WIRING CONNECTIONS ARE SHOWN BY DASHED LINES

6. DO NOT RUN LOW VOLTAGE CONTROL WIRING (30 VOLTS OR LESS) IN CONDUIT WITH 110 VOLT OR HIGHER WIRING. DO NOT EXCEED THE FOLLOWING MAXIMUM RUN LENGTH FOR A GIVEN SIZE: 14 AWG, 5000 FT; 16 AWG, 2000 FT; 18 AWG, 1000 FT.

<8> CUSTOMER SUPPLIED POWER 115/60/1PH OR 220/50/1PH TO POWER RELAYS. MAX. FUSE SIZE IS 20 AMPS. GROUND ALL CUSTOMER SUPPLIED POWER SUPPLIES AS REQUIRED BY APPLICABLE CODES. GREEN GROUND SCREWS ARE PROVIDED IN UNIT CONTROL PANEL.

<11> ALL FIELD WIRING MUST BE IN ACCORDANCE WITH NATIONAL ELECTRIC CODE AND LOCAL REQUIREMENTS.
CONTACT RATINGS AND REQUIREMENTS

CONTACT RATINGS AND REQUIREMENTS

<15> ALL CUSTOMER CONTROL CIRCUIT WIRING MUST BE COPPER CONDUCTORS ONLY AND HAVE A MINIMUM INSULATION RATING OF 300 VOLTS. EXCEPT AS NOTED, ALL CUSTOMER WIRING CONNECTIONS ARE MADE TO CIRCUIT BOARD MOUNTED BOX LUGS WITH A WIRE RANGE OF 14 TO 18 AWG OR DIN RAIL MOUNTED SPRING FORCE TERMINALS.

<16> UNIT PROVIDED DRY CONTACTS FOR THE CONDENSER/CHILLED WATER PUMP CONTROL. RELAY CONTACT RATINGS AT 120VAC: 7.2 AMPS RESISTIVE, 2.88 AMPS PILOT DUTY, OR 1/3 HP, 7.2 FLA. CONTACTS ARE RATED FOR 5 AMPS GENERAL PURPOSE DUTY 240 VOLTS.

<17> CUSTOMER SUPPLIED CONTACTS FOR ALL LOW VOLTAGE CONNECTIONS MUST BE COMPATABLE WITH DRY CIRCUIT 24 VOLTS DC FOR A 12 mA RESISTIVE LOAD. SILVER OR GOLD PLATED CONTACTS RECOMMENDED.

<18> THE CONTACTS FOR AUTO STOP AND EMERGENCY STOP SWITCHES ARE JUMPERED AT THE FACTORY BY JUMPERS 1W1 & 1W2 TO ENABLE UNIT OPERATION. IF REMOTE CONTROL IS DESIRED, REMOVE THE JUMPERS AND CONNECT TO THE DESIRED CONTROL CIRCUIT.

19. SOLID OVALS REPRESENT MAX NUMBER OF CONDUITS AND/OR CABLE GLANDS USED.

<20> CONNECTIONS ARE INTENDED FOR CLASS 2 ONLY.

<21> CIRCUIT 3 REQUIRES 15A PROTECTION AT 120V..

<22> CIRCUIT 4 REQUIRES 15A PROTECTION.

Engineering Bulletin

Sound Data and Application Guide
Stealth™ Chiller (Model RTAE)
150 to 300 Tons

⚠ SAFETY WARNING

Only qualified personnel should install and service the equipment. The installation, starting up, and servicing of heating, ventilating, and air-conditioning equipment can be hazardous and requires specific knowledge and training. Improperly installed, adjusted or altered equipment by an unqualified person could result in death or serious injury. When working on the equipment, observe all precautions in the literature and on the tags, stickers, and labels that are attached to the equipment.

November 2014 **RLC-PRB035C-EN**

Introduction

Read this manual thoroughly before operating or servicing this unit.

Warnings, Cautions, and Notices

Safety advisories appear throughout this manual as required. Your personal safety and the proper operation of this machine depend upon the strict observance of these precautions.

The three types of advisories are defined as follows:

⚠WARNING Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠CAUTION Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It could also be used to alert against unsafe practices.

NOTICE Indicates a situation that could result in equipment or property-damage only accidents.

Important Environmental Concerns

Scientific research has shown that certain man-made chemicals can affect the earth's naturally occurring stratospheric ozone layer when released to the atmosphere. In particular, several of the identified chemicals that may affect the ozone layer are refrigerants that contain Chlorine, Fluorine and Carbon (CFCs) and those containing Hydrogen, Chlorine, Fluorine and Carbon (HCFCs). Not all refrigerants containing these compounds have the same potential impact to the environment. Trane advocates the responsible handling of all refrigerants-including industry replacements for CFCs such as HCFCs and HFCs.

Important Responsible Refrigerant Practices

Trane believes that responsible refrigerant practices are important to the environment, our customers, and the air conditioning industry. All technicians who handle refrigerants must be certified. The Federal Clean Air Act (Section 608) sets forth the requirements for handling, reclaiming, recovering and recycling of certain refrigerants and the equipment that is used in these service procedures. In addition, some states or municipalities may have additional requirements that must also be adhered to for responsible management of refrigerants. Know the applicable laws and follow them.

⚠WARNING

Proper Field Wiring and Grounding Required!

Failure to follow code could result in death or serious injury. All field wiring MUST be performed by qualified personnel. Improperly installed and grounded field wiring poses FIRE and ELECTROCUTION hazards. To avoid these hazards, you MUST follow requirements for field wiring installation and grounding as described in NEC and your local/state electrical codes.

⚠WARNING

Personal Protective Equipment (PPE) Required!

Installing/servicing this unit could result in exposure to electrical, mechanical and chemical hazards.

- **Before installing/servicing this unit, technicians MUST put on all PPE required for the work being undertaken (Examples; cut resistant gloves/sleeves, butyl gloves, safety glasses, hard hat/bump cap, fall protection, electrical PPE and arc flash clothing). ALWAYS refer to appropriate Material Safety Data Sheets (MSDS)/Safety Data Sheets (SDS) and OSHA guidelines for proper PPE.**
- **When working with or around hazardous chemicals, ALWAYS refer to the appropriate MSDS/SDS and OSHA/GHS (Global Harmonized System of Classification and Labelling of Chemicals) guidelines for information on allowable personal exposure levels, proper respiratory protection and handling instructions.**
- **If there is a risk of energized electrical contact, arc, or flash, technicians MUST put on all PPE in accordance with OSHA, NFPA 70E, or other country-specific requirements for arc flash protection, PRIOR to servicing the unit. NEVER PERFORM ANY SWITCHING, DISCONNECTING, OR VOLTAGE TESTING WITHOUT PROPER ELECTRICAL PPE AND ARC FLASH CLOTHING. ENSURE ELECTRICAL METERS AND EQUIPMENT ARE PROPERLY RATED FOR INTENDED VOLTAGE.**

Failure to follow instructions could result in death or serious injury.

Copyright

Trademarks

All trademarks referenced in this document are the trademarks of their respective owners.

Revision History

RLC-PRB035C-EN (11 Nov 2014)

Added single circuit unit information, and Appendix B sound pressure octave band information.

RLC-PRB035B-EN (01 Jul 2014)

Updated sound power and pressure data tables.

Table of Contents

Introduction

Stealth™ Chiller – Model RTAE

Acoustical sound reduction was integrated during every development step for the Stealth™ air-cooled chiller. The efficient methods utilized for RTAE not only control sound but also reduce sound sources (mainly compressor and fan noise) and isolate them from radiating components, such as refrigerant lines.

The compressor has been designed to minimize sound at its point of creation. Gas pulsation of the compressor is controlled by fully integrating a patented discharge muffler into its design. Using state-of-the-art acoustic and fluid simulation tools, this muffler's interconnecting chambers block the refrigerant discharge gas pulsation tones inherent in screw compressors, without impeding refrigerant flow or compromising performance. Additionally, the transmitted vibration is minimized by conducting finite element analysis on the compressor housing to find areas that would amplify the frequencies generated from compression. These areas were then redesigned to reduce sound transmission.

With the discharge pulsations controlled at the compressor, the vibration transmitted from compressor to refrigerant was also contained. On units with InvisiSound™ Ultimate options, unique bellows-style flexible couplers at the compressor suction and discharge line connections were developed which minimize vibration transmission from the compressor to the unit and, ultimately, to the building.

Moreover, the refrigerant components and piping have been optimized to reduce vibration and sound propagation throughout the system.

Condenser fan sound power can be as much as half of the overall unit sound power levels. Careful consideration was taken when designing and selecting the next generation condenser fans to be engineered into the Stealth chiller. The sound levels achieved on the Stealth represent the lowest sound levels ever on Trane® air-cooled screw compressor water chillers.

When installing any chiller, forethought should be given to the chiller and its relationship with the structure. Issues such as sound and vibration should be considered and factored into the building design and chiller location within a given structure. These issues are not unique to chillers but should be considered when any mechanical device is located in or on a structure.

This bulletin is not intended to be a replacement for a sound consultant, but rather a tool to advise owners, engineers and contractors of useful tips when designing and installing chiller installations. This engineering bulletin provides guidelines for addressing both unit location and airborne sound when installing air-cooled Stealth chillers.

InvisiSound Noise Reduction Options

InvisiSound Standard Unit

Each rotary screw compressor will have a muffler as standard and each condenser fan will be low noise as standard.

InvisiSound Superior Unit

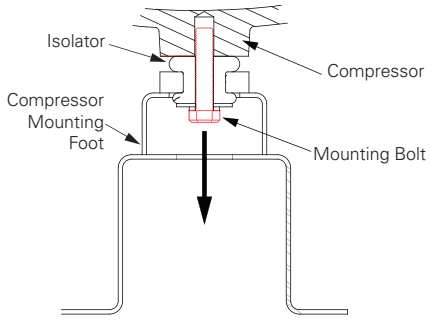
In addition to the sound reducing features on the standard unit, superior unit adds insulating sound material to the suction and discharge lines of each refrigerant circuit and reduces the maximum speed of each condenser fan.

InvisiSound Ultimate Unit

In addition to the sound reducing features on the standard and superior unit, this option adds a flexible, metallic connection at the suction and discharge of each compressor, a pre-formed sound box encapsulating each compressor and reduces the maximum speed of each condenser fan. The customer can set the fan speed at the jobsite from 100% to 60% with a schedule if desired.

Important: *For chillers built with InvisiSound Ultimate option, compressor mounting bolts must be removed to assure minimum noise during operation. Use a 24mm socket to remove (3) M15 x 75mm mounting bolts for each compressor. They are located under compressor mounting feet. See Figure 1.*

Figure 1. Compressor mounting bolt removal



Important:

- *DO NOT DISCARD MOUNTING BOLTS. Store bolts in the control panel for future use.*
- *All mounting bolts MUST be reinstalled prior to compressor removal or unit move.*

NOTICE:

Equipment Damage!

Do not remove compressor or move unit without reattaching compressor mounting bolts. Failure to reinstall bolts could cause shifting of parts and result in equipment damage.

Unit Location

Outdoor HVAC equipment must be located to minimize noise and vibration transmission to the occupied spaces of the building structure it serves. Also, the equipment must be located to prevent objectionable noise levels at adjacent property lines or building structures. When choosing a location for the equipment, consider the following application material for both ground level and roof mounted equipment. An additional concern for the designer is the resulting noise level at adjacent property lines. When commercial size equipment is installed near a residential lot line, there is potential for a sound problem. In this situation, the problem is not the commercial equipment but rather locating the equipment too close to a quiet zone! For equipment operating adjacent to residential areas, zone ordinances often require maximum lot line dBA levels of 50-55/45 (day/night). In commercial areas 60-65/55-60 (day/ night). In industrial areas typical levels mandated by local code authorities are 65-70/65-70 (day/night). The reader is cautioned that the foregoing values listed are those typically seen across major cities of the U.S. The requirements vary by locality so **the designer is cautioned to always check the criteria and local requirements before selecting equipment locations**

Ground Level Equipment

- If the equipment must be located in close proximity to a building, it should be placed next to an unoccupied space such as a storage room, mechanical room, switch gear/electrical room or other typically unoccupied space. It is not recommended to locate the equipment near occupied, sound sensitive areas of the building or near windows. Also, do not locate the equipment adjacent to other building walls or large objects which may reflect the sound back to the sound sensitive receiver.
- Seal all piping and electrical conduit penetrations in the building envelope with an approved fire safe sealant. Utilize insulated, dielectrically compatible sleeves at wall penetrations to properly support the piping and provide vibration damping. Provide flexible couplings and vibration isolators for the water circulating pump and connections to prevent the transmission of sound throughout the building.
- Install the unit on a pad isolated from the building or install the unit with proper vibration isolation underneath the unit to prevent machine vibrations from being transmitted to the structure of the building.

Roof Mounted Equipment

Roof Location

- The single most effective recommendation to prevent sound problems within a building is to locate the unit over non-critical areas such as copy rooms, restrooms, storage rooms, and other similar non-occupied areas of the building. It is not recommended to locate a unit directly over or in close proximity to sound sensitive areas such as conference rooms, executive office spaces, libraries, etc.
- It is not recommended to locate the equipment near occupied, sound sensitive areas of the building or near window glass. Also, do not locate the equipment adjacent to other building walls or large objects which may reflect the sound back to the sound sensitive receiver.

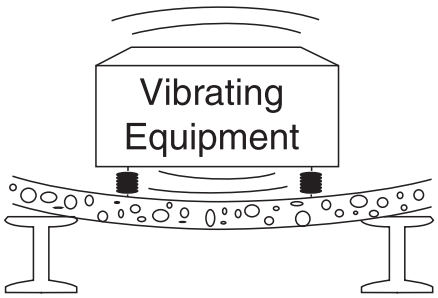
Building Structure

When mounting the chiller on the roofline, it is not recommended to locate the unit on a beam or structure at mid-span of the column grid. Rather, directly support the unit over columns. Nor is it recommended to locate the unit in the middle of a horizontal beam. Try to avoid large column spans. This will minimize the roof deflection vibration transmission.

Building Support

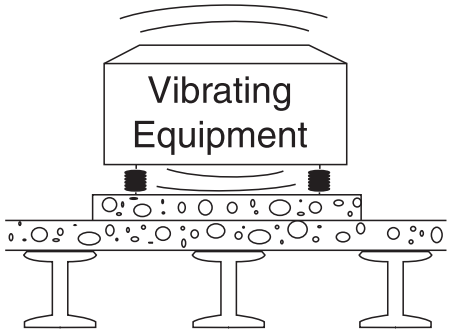
Poor. Concentration of equipment weight between beams causes excessive roof deflection and vibration transmission, even for isolated equipment. See Figure 2.

Figure 2. Building support - poor



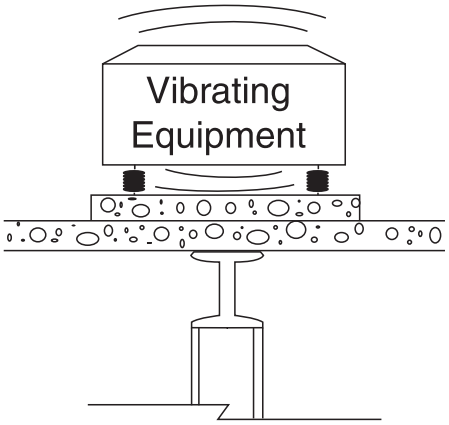
Good. Further addition of housekeeping pad and additional beams add mass and stiffness to roof. See Figure 3.

Figure 3. Building support - good



Very Good. A column directly under the equipment gives the roof a very high local stiffness, but some equipment vibration still enters the roof slab. See Figure 4.

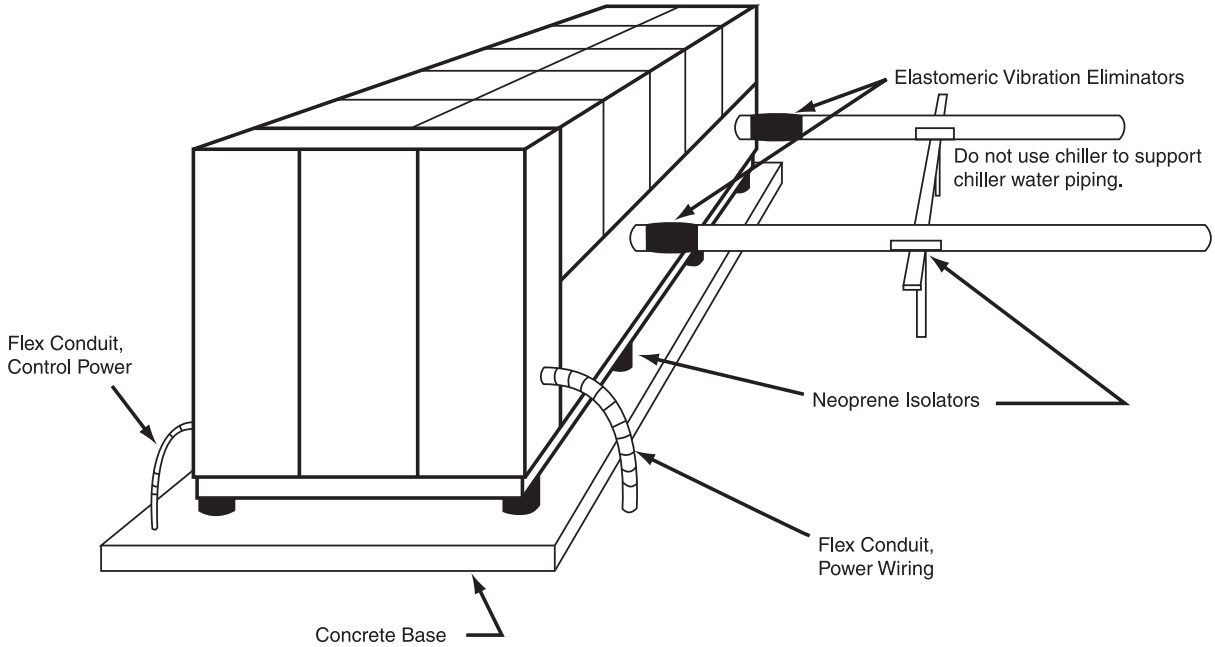
Figure 4. Building support - very good



Vibration Elimination Methods

When directly mounting chillers on I-beams that are above the roofline and mounted to the building support columns, there exists the potential for a resonant frequency at which higher than normal vibration may be transmitted to the rest of the building. Be cognizant of this application. A consultant may be required for evaluation.

Figure 5. Vibration elimination methods



Base

- It is not recommended to bolt down vibrating equipment directly to foundation without using isolators.
- Install the unit upon an inertia base or concrete pad structure with vibration isolation to match the characteristics of the roof structure. Beware of lightweight roof structures which are difficult to isolate from vibration.
- Use an inertia base or solid concrete pad as a base for the chiller. This mass, properly supported, will maximize vibration dampening and help prevent noise from penetrating through the roof directly below the unit. Floors and ceiling should be concrete slabs.

Isolators

- Isolate chiller on ELASTOMERIC isolators. Originally intended for reciprocating compressors, spring isolators are not as effective at absorbing movement and vibration on air-cooled Stealth chiller installations. This is because Stealth chillers have higher frequency vibration (900 Hz) than reciprocating chillers (less than 125 Hz).
- Isolate the unit on elastomeric isolators selected to match the characteristics of the roof structure. It is not recommended that equipment be applied to buildings

with a lightweight roof structure unless column supports are provided which are independent of the roof structure.

Chilled Water Piping

- Provide flexible couplings and vibration isolators for the water circulating pump connections to prevent the transmission of sound throughout the building.
- Isolate chilled water piping from the chiller with ELASTOMERIC vibration eliminators. Metal braided eliminators have proven to be much less effective than elastomeric isolators in reducing vibration transmission to the building through the piping.
- Isolate pipe hangers with ELASTOMERIC isolators. This reduces vibration transmission to the building. Do not let the chiller support the weight of the chilled water piping. Isolating pipe hangers this way reduces vibration transmission to the building.

Electrical

- Electrical connections to the chiller should be in flex conduit. Hard electrical conduit is another vibration path that should be eliminated in chiller installations.

Sealing Penetrations

- Seal all piping and electrical conduit penetrations in the building envelope with an approved fire safe sealant. Utilize insulated, dielectrically compatible sleeves at wall penetrations to properly support the piping and provide vibration damping.
- Acoustically treat all wall penetrations (piping, conduit, duct, outdoor vents, etc.)

Sound Pressure

Table 1 gives the overall A-weighted sound pressure levels for the air-cooled Stealth™ chiller. Information given in this bulletin along with the data in Table 1 may be used to estimate the sound pressure levels of common installations. Estimations made using this bulletin are considered typical of what may be measured in a free field with a hand-held sound meter, in the absence of a nearby reflective surface.

Table 1. Sound pressure levels (Lp, in dBA)[a]- 10m from center of broad sides of chiller

Unit Size[b]	InvisiSound[c] Option					
	Std	Superior	Ultimate			
	920 rpm	825 rpm	700 rpm	650 rpm	600 rpm	920 rpm
AHRI Rating Point - 100% Load						
150S	72	68	63	62	60	70
165S	74	69	65	64	63	71
150	72	68	63	61	60	70
165	74	70	63	62	60	71
180	73	69	63	62	60	71
200	72	70	64	62	60	70
225	72	69	64	62	60	72
250	73	70	64	63	61	72
275	74	70	66	65	64	73
300	75	71	66	65	63	73
AHRI Rating Point - 75% Load						
150S	66	65	62	60	59	64
165S	68	65	63	62	60	63
150	66	66	62	60	58	64
165	65	64	63	61	59	63
180	66	65	63	61	59	64
200	69	66	63	62	59	63
225	67	66	64	62	59	66
250	69	68	64	62	60	67
275	68	67	64	62	60	66
300	69	67	65	63	62	66
AHRI Rating Point - 50% load						
150S	62	58	55	55	55	55
165S	64	60	55	55	55	55
150	59	57	55	55	55	55
165	59	57	54	54	54	54
180	60	58	55	55	55	55
200	61	61	54	54	54	54
225	59	58	57	57	57	57
250	64	60	58	58	58	58
275	64	61	58	58	58	58
300	64	61	57	57	57	57
AHRI Rating Point - 25% Load						
150S	61	57	52	52	52	52
165S	64	60	53	53	53	53
150	57	55	52	52	52	52
165	57	56	51	51	51	51
180	59	57	52	52	52	52
200	60	57	51	51	51	51
225	59	56	53	53	53	53
250	60	58	55	55	55	55
275	59	59	57	57	57	57
300	64	60	54	54	54	54

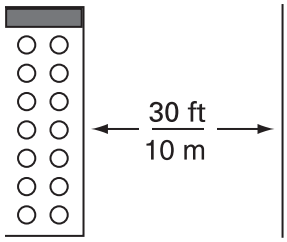
(a) A-weighted sound pressure level, dBA, ref 20 micro Pa. Measurement at 30 ft (10m) distance from unit.
(b) Data for 150S and 165S units are estimates.
(c) Sound option is indicated in Model Number digit 12. Standard Unit Digit 12 = 1. InvisiSound Superior Digit 12 = 2. InvisiSound Ultimate Digit 12 = 3.

For reference, sound pressure information presented in octave bands is listed in "Appendix B — Sound Pressure Octave Band Data," p. 18.

Sound power octave band data are given in "Appendix A — Sound Power Octave Band Data," p. 14. Acoustical consultants may require the data in Appendix A to perform a detailed acoustical analysis. Acoustical analysis may also be done using the Trane Acoustics Program (C.D.S.).

Note: *The sound power data in Appendix A cannot be compared directly to SOUND PRESSURE data shown in Table 1.*

Figure 6. Sound measurement



Note: *Sound measurements taken closer than 30 ft (10m) may be greatly distorted due to the large chiller lengths and multiple noise sources within the chiller.*

Noise Control - Stealth™ Chillers

Three techniques are available for taking full advantage of the sound properties of the air-cooled Stealth chiller and minimizing the potential for noise problems. These are:

- Unit orientation
- Distance factor
- Sound attenuation through use of barrier walls

Unit Orientation

Stealth sound is directional in nature, allowing the contractor/engineer to position the unit to minimize potential noise problems. The chiller may be oriented such that the control box end or end opposite the control box faces the direction where a noise problem is expected. See Figure 7.

Figure 7. Orientation of chiller to minimize noise problems

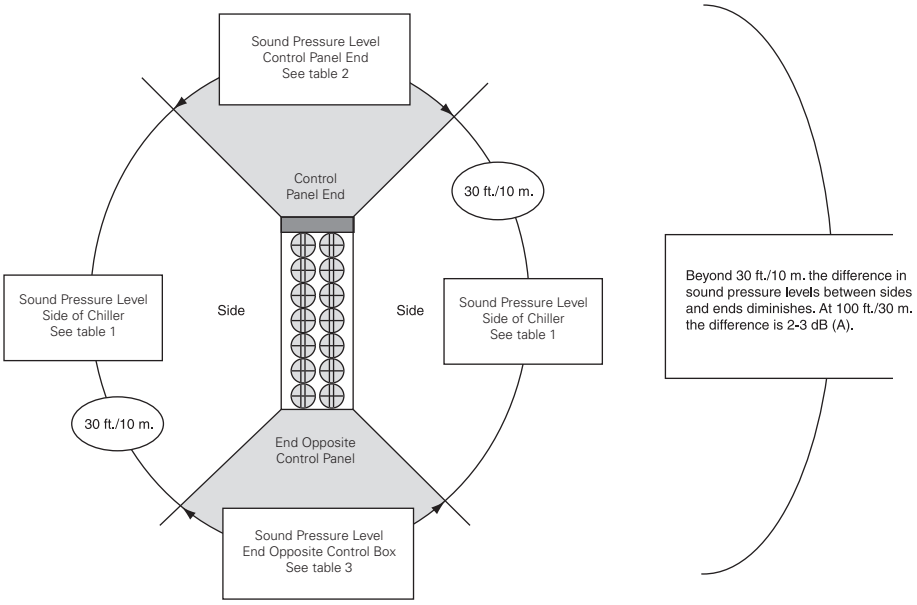


Table 2. Sound pressure levels (Lp, in dBA)[a]- 10 m from center of control panel end of chiller

Unit Size[b]	InvisiSound[c] Option					
	Std	Superior	Ultimate			
	920rpm	825rpm	700rpm	650rpm	600rpm	920rpm
AHRI Rating Point - 100% Load						
150S	64	60	55	54	52	63
165S	65	62	57	56	55	64
150	64	60	55	53	52	63
165	65	62	56	54	52	63
180	65	61	56	54	52	64
200	65	62	57	55	53	63
225	65	62	57	55	53	64
250	66	62	57	55	54	64
275	66	63	59	58	57	65
300	67	63	58	57	56	66
AHRI Rating Point - 75% Load						
150S	59	57	55	53	52	57
165S	60	58	56	55	53	56
150	58	58	55	53	50	57
165	58	57	56	54	52	56
180	58	58	56	54	52	57
200	62	59	56	54	52	56
225	59	59	56	54	52	58
250	63	61	57	55	53	60
275	61	61	57	55	53	59
300	61	59	58	56	55	59
AHRI Rating Point - 50% load						
150S	55	51	48	48	48	48
165S	57	53	48	48	48	48
150	52	50	48	48	48	48
165	52	50	47	47	47	47
180	53	51	48	48	48	48
200	53	52	47	47	47	47
225	52	51	50	50	50	50
250	58	53	51	51	51	51
275	58	55	52	52	52	52
300	57	54	50	50	50	50
AHRI Rating Point - 25% Load						
150S	54	50	45	45	45	45
165S	57	53	47	47	47	47
150	50	49	46	46	46	46
165	50	48	45	45	45	45
180	52	49	45	45	45	45
200	52	49	45	45	45	45
225	52	49	47	47	47	47
250	54	52	48	48	48	48
275	52	53	50	50	50	50
300	57	53	47	47	47	47

(a) A-weighted sound pressure level, dBA, ref 20 micro Pa. Measurement at 30 ft (10m) distance from unit.
(b) Data for 150S and 165S units are estimates.
(c) Sound option is indicated in Model Number digit 12. Standard Unit Digit 12 = 1. InvisiSound Superior Digit 12 = 2. InvisiSound Ultimate Digit 12 = 3.

Table 3. Sound pressure levels (Lp, in dBA)[a]- 10m from center of end opposite control panel

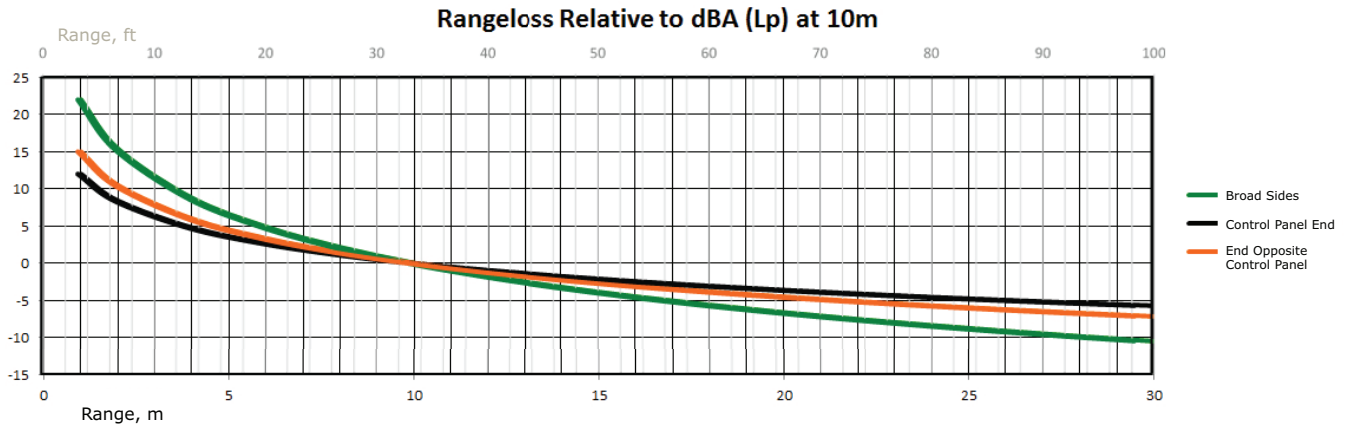
Unit Size[b]	InvisiSound[c] Option					
	Std	Superior	Ultimate			
	920rpm	825rpm	700rpm	650rpm	600rpm	920rpm
AHRI Rating Point - 100% Load						
150S	67	63	58	57	55	65
165S	68	64	60	59	58	66
150	68	63	58	57	56	65
165	68	64	59	57	55	66
180	68	64	59	57	55	66
200	67	65	59	57	56	66
225	68	64	59	58	56	67
250	69	66	60	59	57	67
275	69	66	61	60	59	68
300	70	66	61	60	58	68
AHRI Rating Point - 75% Load						
150S	62	60	58	56	54	60
165S	63	60	59	57	56	59
150	61	61	57	55	53	59
165	60	59	58	56	54	58
180	61	60	58	56	54	60
200	63	61	58	57	55	58
225	62	62	59	57	55	61
250	65	63	59	57	55	63
275	64	63	60	58	56	62
300	64	62	61	59	57	61
AHRI Rating Point - 50% load						
150S	57	54	51	51	51	51
165S	59	56	51	51	51	51
150	55	53	50	50	50	50
165	55	52	50	50	50	50
180	55	53	51	51	51	51
200	56	54	50	50	50	50
225	55	54	52	52	52	52
250	60	56	54	54	54	54
275	60	57	54	54	54	54
300	60	56	53	53	53	53
AHRI Rating Point - 25% Load						
150S	57	53	48	48	48	48
165S	60	56	49	49	49	49
150	52	51	48	48	48	48
165	52	51	47	47	47	47
180	56	53	48	48	48	48
200	54	51	47	47	47	47
225	55	52	50	50	50	50
250	56	54	50	50	50	50
275	55	55	53	53	53	53
300	60	56	50	50	50	50

(a) A-weighted sound pressure level, dBA, ref 20 micro Pa. Measurement at 30 ft (10m) distance from unit.
(b) Data for 150S and 165S units are estimates.
(c) Sound option is indicated in Model Number digit 12. Standard Unit Digit 12 = 1. InvisiSound Superior Digit 12 = 2. InvisiSound Ultimate Digit 12 = 3.

Distance Factor

The distance between a source of sound and the receiver or place of sound measurement plays an important part in minimizing potential noise problems. Figure 8 gives the reductions in sound pressure level, dBA based on increasing distance from the chiller. Sound levels at a specific location can be minimized by correctly orienting the chiller (see Figure 7, p. 9) and placing the chiller as far away from the location as possible (see Figure 7, p. 9).

Figure 8. Sound attentuation due to distance



Notes:

- *Sound measurements taken closer than 30 ft (10m) may be greatly distorted when compared to an estimation made using Table 1, p. 8 and Figure 8 due to large chiller lengths and multiple noise sources within the chiller.*
- *Beyond 100 ft (30m), the sound pressure will continue to decrease 5dBA for each doubling of the distance from the unit to the place of measurement. For example, the sound pressure at 200 ft will be 5 dBA lower than the sound pressure at 100 ft.*

Sound Attenuation Using Barrier Walls

Reciprocating chillers are characterized by a low frequency pounding sound that is typically difficult to attenuate. The direct drive Stealth compressor and condenser fans have a medium and high frequency characteristic that may be attenuated with simple, inexpensive barrier walls.

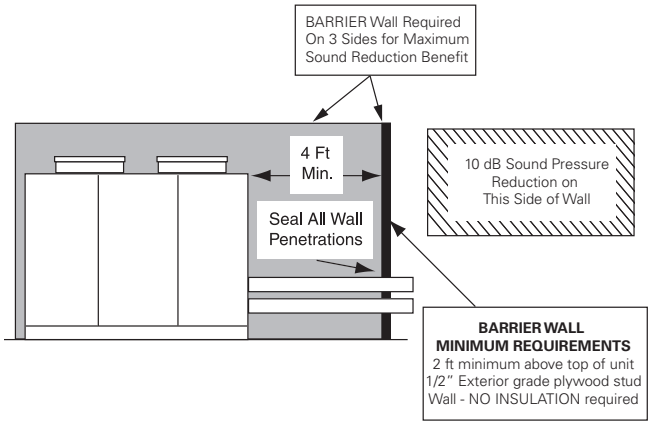
A barrier wall constructed to only ½ inch exterior grade plywood gives a dramatic 10 dBA reduction in sound. See Figure 9 for minimum wall requirements. Solid walls of brick or other more robust outdoor materials are

equally acceptable and can be expected to give better attenuation. Masonry block walls with special sound absorbing cavities should be considered for critical applications.

A minimum distance of 4 ft is recommended, but the chiller may be placed closer than 4 ft to a barrier wall. Some loss of performance will occur. SeeTrane engineering bulletin RLC-PRB004-EN.

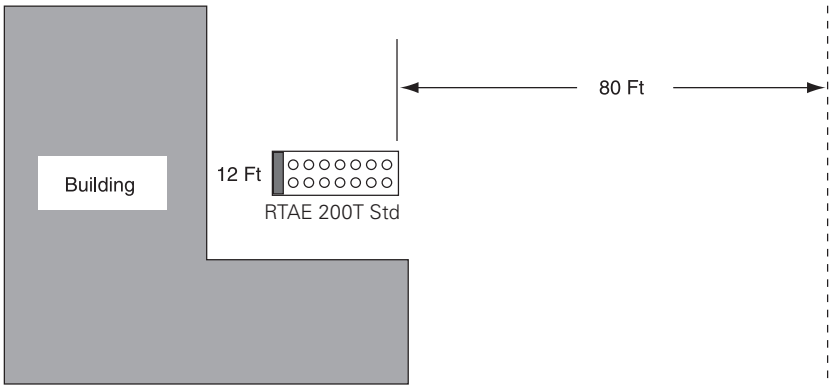
Louvered panels or decorative walls with any amount of open area should not be used to attenuate sound. They have little or no sound reflecting or attenuating benefit. Also, an insulated sheet metal box covering the compressors alone will provide minimal sound attenuation and is not recommended.

Figure 9. Suggested barrier wall for sound attentuation



Example

Figure 10. Installation example



An example will demonstrate how to use the preceding information to minimize potential problems for noise sensitive installations. See Figure 10 for representation of this installation example.

The objective is to design an installation that will yield 65 dBA or less at the lot line.

The estimation of sound pressure at the lot line is made as follows:

- 73 dBA – fromTable 1, p. 8, sound pressure @ 30 ft for RTAE 200 Std
- - 4 dBA – See Figure 7, p. 9. Deduct 4 dBA for chiller orienation at 80 ft..
- - 5 dBA –See Figure 8, p. 11. Deduct 5dBA because of 80 ft distance of chiller from lot line.
- +3 dBA – Addition of 3 dBA due to sound reflection of building wall 12 ft from chiller

  Note: A building wall in close proximity to the unit, 15 ft or less, reflects the sound towards the lot line. In effect this causes the building to act like a second sound source raising the measured sound at the lot line by as much as 3 dBA.
- 67 dBA – Estimated Sound Pressure at the lot line (with no barrier wall)
- 67dBA exceeds the requirement of 65 dBA at the lot line. An acoustical barrier wall as shown in Figure 9, p. 11 will reduce the sound pressure an additional 10 dBA, to 57 dBA, thus meeting the requirement.
- 69 dBA – Estimated sound power at the lot line with no barrier wall
- -10 dBA – Reduction due to acoustical barrier wall
- 57 dBA – Estimated Sound Pressure at the lot line with a barrier wall.

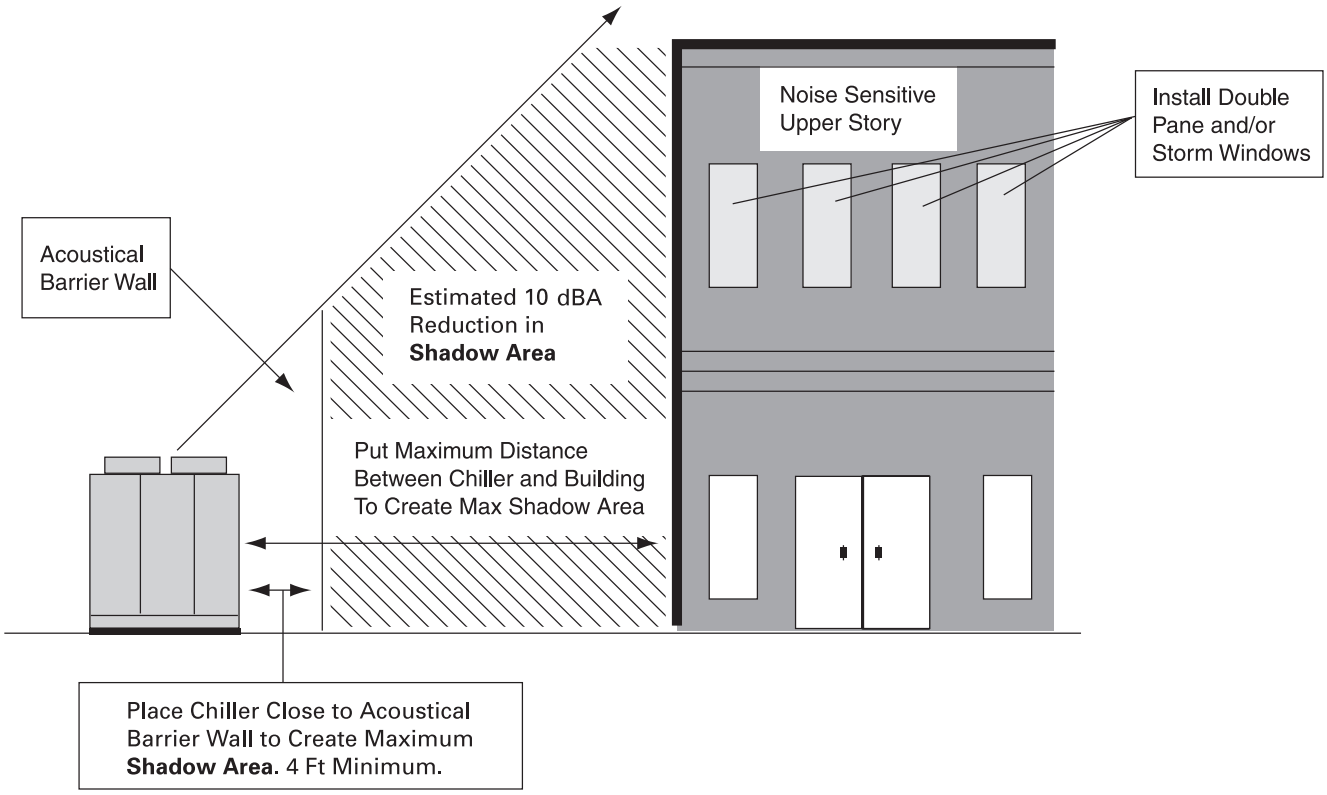
Building Upper Story Sound Problems

Air-cooled chillers are sometimes installed adjacent to and below the occupied space of larger buildings, where the noise sensitivity of the upper stories of the building may be a concern. Once again, use of an acoustical barrier wall can be very effective. See Figure 11, p. 13.

The acoustical barrier wall placed as shown in Figure 11, p. 13 attenuates both compressor and fan noise and will yield an estimated 10 dBA sound pressure reduction in the “shadow” area created by the wall. In order to create the largest possible “shadow” area, the acoustical barrier wall should be as tall as possible, with the unit placed as close as possible to the barrier wall and the unit placed as far from the building as possible. The unit should be located a minimum of 15 ft from the building to minimize the potential for reflected sound. Also seal any electrical or water assemblies that penetrate the barrier wall to avoid “sound leaks” towards the building.

See Figure 9, p. 11 for minimum construction requirements of barrier walls.

Figure 11. Attenuation for upper story building sound problems



Acoustical Fan Discharge Stacks

Use of acoustical fan discharge stacks by themselves will produce only marginal sound attenuating benefits. It is important to remember that both the compressors and the fans contribute to the sound of the air-cooled Stealth™ chiller. Compressor noise is not attenuated by a fan discharge stack and a locally built and installed acoustical “box” around the compressors is not an effective means of compressor sound attenuation.

However, acoustical fan discharge stacks can be used with an acoustical barrier wall. Selection and installation of acoustical fan discharge stacks must be done by a competent acoustical engineer in order to be effective.

Please note that chiller performance is adversely affected by the use of acoustical fan discharge stacks. The length and open area of acoustical fan discharge stacks must be designed to produce no more than 0.5 inch of additional static pressure on the condenser fans. Also note that care must be taken to properly support discharge fan stacks against severe cross winds.

Appendix A — Sound Power Octave Band Data

Sound power octave band data can be used for purposes of describing the basic acoustical properties of the air-cooled Stealth chiller. However, there are two cautionary notes. First, if the engineer is using the data as a criteria in a bid evaluation, make sure that the data from all competitors is on an equal basis. Insist that all competitors present data terms of **SOUND POWER (not sound pressure),** in a consistent format, according to AHRI Standard 370.

Important: *Sound **power** data CANNOT be compared directly to sound **pressure** data.*

Second, the sound power data does not provide sufficient information to correctly position the chiller or attenuate its sound to take full advantage of the characteristics of the air-cooled Series R chiller. Unlike most reciprocating chillers that exhibit a low frequency, pounding sound, the air-cooled Series R chiller sound is directional in nature and has a higher frequency characteristic that is more easily attenuated. The specific application information given in the preceding parts of this bulletin can be used to create a significant competitive advantage over competitive air-cooled reciprocating chillers.

Note: *Sound Power Rating data given in Table 4 through Table 9, p. 17 may vary ± 3dB in any specific octave band due to normal variations in chiller construction.*

Table 4. Octave band sound power levels — InvisiSound Standard[a] unit— fan 920 rpm

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	94	100	97	96	96	88	82	74	99
165S	95	101	98	97	98	90	84	76	100
150	94	100	97	95	98	89	82	75	100
165	95	101	98	96	98	91	83	76	100
180	95	101	98	97	97	90	83	77	100
200	95	101	98	97	96	89	85	77	100
225	95	102	99	98	97	89	83	75	100
250	96	102	99	98	100	90	84	76	102
275	96	102	100	98	99	90	85	76	101
300	97	103	100	99	99	91	85	77	102
AHRI Rating Point - 75% Load									
150S	91	95	93	95	90	82	76	68	95
165S	91	94	93	97	91	83	77	70	97
150	91	95	92	90	91	83	77	67	94
165	91	94	93	90	89	83	75	67	93
180	91	95	93	90	90	83	76	69	93
200	91	94	91	89	93	82	76	70	95
225	93	97	95	94	91	84	77	70	95
250	93	98	96	100	93	86	80	71	99
275	93	97	95	98	92	85	79	71	98
300	93	97	95	97	92	84	79	71	98
AHRI Rating Point - 50% Load									
150S	86	89	86	93	83	77	68	65	92
165S	86	89	87	96	86	80	70	68	95
150	86	89	85	91	82	74	65	59	89
165	86	89	86	89	84	74	65	60	89
180	87	89	90	90	84	76	67	61	90
200	86	89	86	88	86	76	69	61	90
225	88	91	88	88	83	78	70	68	88
250	89	92	90	97	84	79	71	68	95
275	88	91	88	98	85	80	73	68	95
300	88	91	89	96	86	80	71	68	95
AHRI Rating Point - 25% Load									
150S	83	86	84	93	84	77	67	65	92
165S	84	86	86	96	87	80	70	68	95
150	83	86	84	86	82	72	63	58	87
165	83	86	82	84	82	72	64	59	86
180	83	86	86	89	86	74	64	60	90
200	83	86	83	86	84	76	68	61	87
225	85	88	85	87	85	77	70	68	89
250	85	89	86	92	81	77	69	68	91
275	85	89	85	88	85	77	70	68	89
300	85	88	87	96	87	80	70	68	95

(a) Model Number Digit 12 = 1
(b) Data for 150S and 165S units are estimates.

Table 5. Octave band sound power levels — InvisiSound Superior[a] unit— fan 825 rpm

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	92	97	94	93	92	85	80	74	95
165S	93	98	95	95	93	87	82	76	97
150	93	97	94	92	93	85	79	72	96
165	93	98	95	93	94	87	80	74	97
180	94	98	95	93	93	87	80	75	97
200	94	99	96	94	94	86	82	76	97
225	94	99	96	95	93	86	80	76	97
250	94	99	96	95	96	88	81	76	98
275	95	99	97	96	96	88	82	77	98
300	95	100	97	96	95	88	83	77	98
AHRI Rating Point - 75% Load									
150S	91	95	92	92	88	82	76	72	93
165S	91	94	92	93	88	82	76	75	93
150	91	95	92	91	92	82	76	68	94
165	91	94	92	89	88	82	75	67	92
180	92	95	93	90	89	82	76	68	93
200	91	94	91	89	91	80	76	68	93
225	93	97	95	93	90	83	77	76	94
250	93	97	95	97	91	85	78	76	97
275	93	97	95	97	91	84	78	75	97
300	93	97	94	94	90	84	78	75	95
AHRI Rating Point - 50% Load									
150S	86	89	86	88	81	76	68	71	88
165S	86	89	87	91	82	78	70	74	90
150	87	89	85	86	81	73	70	60	86
165	86	89	85	85	81	73	70	60	86
180	87	89	89	85	82	75	70	61	87
200	87	89	86	82	85	74	70	61	87
225	88	91	88	85	81	77	70	75	87
250	89	92	89	90	82	78	71	75	90
275	88	91	88	93	82	78	71	74	92
300	88	91	89	91	83	78	71	74	91
AHRI Rating Point - 25% Load									
150S	83	86	84	88	79	75	68	71	88
165S	84	86	85	91	82	78	70	74	90
150	84	86	83	84	80	71	69	59	85
165	84	86	82	84	80	71	69	59	85
180	84	86	86	85	85	72	69	60	87
200	84	86	84	82	81	72	69	60	84
225	85	88	85	84	79	76	69	74	85
250	85	90	86	89	79	76	70	74	88
275	85	88	85	92	80	77	70	74	90
300	85	88	86	91	82	78	70	74	90

(a) Model Number Digit 12 = 2
(b) Data for 150S and 165S units are estimates.

Appendix A — Sound Power Octave Band Data

Table 6. Octave band sound power levels — InvisiSound Ultimate[a] unit— fan 700 rpm

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	90	93	91	88	87	81	75	69	91
165S	91	94	92	90	88	83	77	71	92
150	91	93	90	88	89	79	74	67	91
165	91	94	91	89	87	80	75	68	91
180	92	94	91	89	87	80	76	68	91
200	91	95	92	90	88	81	77	69	92
225	92	95	92	90	88	81	76	69	92
250	92	95	92	90	89	82	77	69	92
275	92	96	93	91	91	83	78	71	94
300	93	96	94	91	90	84	78	72	94
AHRI Rating Point - 75% Load									
150S	90	93	91	89	86	79	73	65	91
165S	91	94	92	91	87	80	75	67	92
150	90	93	90	88	86	79	73	64	90
165	92	94	91	89	87	80	73	65	91
180	92	94	91	89	87	80	74	65	91
200	92	94	91	89	87	80	74	66	91
225	92	95	93	90	88	81	74	66	92
250	92	95	93	90	88	81	75	67	92
275	92	96	93	91	88	82	75	67	93
300	93	96	94	92	89	82	76	68	94
AHRI Rating Point - 50% Load									
150S	86	89	86	82	78	73	66	59	84
165S	87	89	86	83	78	74	67	61	84
150	86	89	85	82	78	72	65	56	83
165	86	89	86	81	78	71	65	56	83
180	87	89	86	82	79	72	65	57	84
200	87	89	86	82	77	71	65	56	83
225	88	91	88	84	80	75	67	60	85
250	89	91	88	85	81	76	69	61	87
275	89	92	89	86	81	76	69	61	87
300	89	91	88	84	80	75	68	61	86
AHRI Rating Point - 25% Load									
150S	84	86	83	80	75	71	64	58	81
165S	85	86	84	82	76	73	66	61	83
150	84	86	82	81	75	68	61	53	81
165	84	86	82	82	74	68	60	53	81
180	84	86	83	82	77	68	62	55	82
200	84	86	83	82	74	68	62	55	82
225	85	88	85	81	76	73	65	59	83
250	86	89	86	82	77	73	66	60	84
275	86	88	85	88	79	74	66	60	87
300	86	88	85	82	77	74	66	61	83

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 7. Octave band sound power levels — InvisiSound Ultimate[a] unit— fan 650 rpm

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	89	92	89	86	85	80	74	68	89
165S	90	93	90	88	87	82	76	71	91
150	90	92	89	86	88	77	73	66	90
165	90	93	90	87	85	79	74	67	89
180	91	93	90	87	85	79	74	67	89
200	90	94	90	88	86	80	76	69	90
225	91	94	91	88	86	80	74	68	90
250	91	94	91	88	87	81	76	69	91
275	92	94	92	89	90	82	77	70	92
300	92	95	92	89	88	83	77	71	92
AHRI Rating Point - 75% Load									
150S	89	92	89	88	84	77	71	64	89
165S	90	93	90	90	85	79	73	67	91
150	89	92	89	86	84	77	71	62	88
165	91	93	90	87	85	78	71	63	89
180	91	93	90	87	85	78	72	63	89
200	92	94	91	88	86	79	72	65	90
225	91	94	91	88	85	79	72	65	90
250	91	94	91	89	85	79	73	65	90
275	91	94	91	89	86	80	74	66	91
300	92	95	92	91	87	80	74	67	92
AHRI Rating Point - 50% Load									
150S	86	89	86	82	78	73	66	59	84
165S	87	89	86	83	78	74	67	61	84
150	86	89	85	82	78	72	65	56	83
165	86	89	86	81	78	71	65	56	83
180	87	89	86	82	79	72	65	57	84
200	87	89	86	82	77	71	65	56	83
225	88	91	88	84	80	75	67	60	85
250	89	91	88	85	81	76	69	61	87
275	89	92	89	86	81	76	69	61	87
300	89	91	88	84	80	75	68	61	86
AHRI Rating Point - 25% Load									
150S	84	86	83	80	75	71	64	58	81
165S	85	86	84	82	76	73	66	61	83
150	84	86	82	81	75	68	61	53	81
165	84	86	82	82	74	68	60	53	81
180	84	86	83	82	77	68	62	55	82
200	84	86	83	82	74	68	62	55	82
225	85	88	85	81	76	73	65	59	83
250	86	89	86	82	77	73	66	60	84
275	86	88	85	88	79	74	66	60	87
300	86	88	85	82	77	74	66	61	83

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 8. Octave band sound power levels — InvisiSound Ultimate[a] unit— fan 600 rpm

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	88	90	88	85	84	79	73	68	88
165S	89	92	89	87	86	81	76	71	90
150	89	90	87	84	87	76	72	66	89
165	89	91	88	85	84	77	72	67	88
180	90	91	88	86	83	77	73	67	88
200	89	92	89	86	84	78	75	68	88
225	90	92	89	86	84	79	73	68	89
250	90	92	90	86	86	80	75	68	89
275	91	93	90	87	89	80	76	70	91
300	91	93	91	88	87	82	76	71	91
AHRI Rating Point - 75% Load									
150S	88	90	88	87	82	76	70	63	88
165S	89	91	89	90	83	77	72	66	90
150	88	90	87	84	82	75	69	61	86
165	90	91	88	85	83	76	70	61	87
180	91	92	88	85	82	76	70	62	87
200	91	92	89	86	84	77	71	64	88
225	90	92	90	86	83	77	70	64	88
250	90	92	90	88	83	77	71	64	89
275	90	93	90	88	84	78	72	65	89
300	91	93	91	90	85	79	73	66	91
AHRI Rating Point - 50% Load									
150S	86	89	86	82	78	73	66	59	84
165S	87	89	86	83	78	74	67	61	84
150	86	89	85	82	78	72	65	56	83
165	86	89	86	81	78	71	65	56	83
180	87	89	86	82	79	72	65	57	84
200	87	89	86	82	77	71	65	56	83
225	88	91	88	84	80	75	67	60	85
250	89	91	88	85	81	76	69	61	87
275	89	92	89	86	81	76	69	61	87
300	89	91	88	84	80	75	68	61	86
AHRI Rating Point - 25% Load									
150S	84	86	83	80	75	71	64	58	81
165S	85	86	84	82	76	73	66	61	83
150	84	86	82	81	75	68	61	53	81
165	84	86	82	82	74	68	60	53	81
180	84	86	83	82	77	68	62	55	82
200	84	86	83	82	74	68	62	55	82
225	85	88	85	81	76	73	65	59	83
250	86	89	86	82	77	73	66	60	84
275	86	88	85	88	79	74	66	60	87
300	86	88	85	82	77	74	66	61	83

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 9. Octave band sound power levels — InvisiSound Ultimate[a] unit— fan 920 rpm

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	94	100	97	95	94	87	81	73	98
165S	95	101	98	96	95	88	82	75	98
150	94	100	97	95	95	87	81	73	98
165	95	101	98	96	95	87	82	74	98
180	95	101	98	96	95	88	82	74	99
200	95	101	98	96	95	87	82	74	98
225	96	102	99	97	96	89	83	75	100
250	96	102	99	97	96	89	83	75	100
275	96	102	100	98	97	89	84	76	100
300	97	103	100	98	97	90	84	77	101
AHRI Rating Point - 75% Load									
150S	91	95	92	91	88	81	75	67	92
165S	91	94	92	91	87	80	75	67	92
150	91	95	92	90	88	81	75	66	92
165	92	94	91	89	87	80	73	65	91
180	93	95	92	90	88	81	75	66	92
200	92	94	91	89	87	80	74	66	91
225	91	90	83	76	68	94	5	5	95
250	93	98	95	93	92	84	78	70	95
275	93	97	94	92	90	83	77	69	94
300	93	97	94	93	90	83	77	69	94
AHRI Rating Point - 50% Load									
150S	86	89	86	82	78	73	66	59	84
165S	87	89	86	83	78	74	67	61	84
150	86	89	85	82	78	72	65	56	83
165	86	89	86	81	78	71	65	56	83
180	87	89	86	82	79	72	65	57	84
200	87	89	86	82	77	71	65	56	83
225	88	91	88	84	80	75	67	60	85
250	89	91	88	85	81	76	69	61	87
275	89	92	89	86	81	76	69	61	87
300	89	91	88	84	80	75	68	61	86
AHRI Rating Point - 25% Load									
150S	84	86	83	80	75	71	64	58	81
165S	85	86	84	82	76	73	66	61	83
150	84	86	82	81	75	68	61	53	81
165	84	86	82	82	74	68	60	53	81
180	84	86	83	82	77	68	62	55	82
200	84	86	83	82	74	68	62	55	82
225	85	88	85	81	76	73	65	59	83
250	86	89	86	82	77	73	66	60	84
275	86	88	85	88	79	74	66	60	87
300	86	88	85	82	77	74	66	61	83

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Appendix B — Sound Pressure Octave Band Data

Side of Chiller

Table 10. Sound pressure levels (Lp, in dB) InvisiSound Standard[a], max fan 920rpm 10m from center of broad sides of chiller

Unit Size [b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	64	69	65	63	70	62	55	46	72
165S	65	69	65	64	72	64	56	48	74
150	64	69	65	62	70	64	55	46	72
165	65	69	65	62	73	66	56	48	74
180	65	70	66	63	72	64	56	49	73
200	65	69	65	64	70	63	57	49	72
225	65	71	66	64	70	64	56	47	72
250	65	71	66	64	72	64	56	47	73
275	66	71	67	65	72	65	57	48	74
300	67	72	68	66	74	65	58	49	75
AHRI Rating Point - 75% Load									
150S	61	63	60	62	64	57	49	40	66
165S	61	61	60	64	65	57	50	42	68
150	61	63	60	57	64	57	49	39	66
165	61	61	60	57	63	57	48	39	65
180	61	63	60	57	64	58	49	40	66
200	61	61	59	56	68	57	48	41	69
225	63	64	62	61	64	58	50	43	67
250	63	66	63	66	66	60	53	43	69
275	63	65	62	65	65	59	52	43	68
300	63	64	62	64	66	59	51	43	69
AHRI Rating Point - 50% Load									
150S	57	54	54	60	57	52	41	37	62
165S	57	53	55	63	60	54	43	40	64
150	57	56	53	57	55	48	38	31	59
165	57	53	54	56	56	49	38	32	59
180	57	54	57	57	57	50	39	33	60
200	57	53	54	55	60	50	42	33	61
225	58	57	55	54	56	51	43	40	59
250	59	58	57	64	57	53	44	40	64
275	59	57	56	64	58	55	45	40	64
300	59	55	56	63	60	54	44	40	64
AHRI Rating Point - 25% Load									
150S	54	50	51	60	57	51	40	37	61
165S	54	51	53	63	60	54	43	40	64
150	54	52	50	53	54	47	36	30	57
165	54	49	49	51	56	47	36	31	57
180	54	50	54	56	57	49	37	32	59
200	54	49	50	53	58	51	41	33	60
225	55	56	52	54	56	51	43	40	59
250	56	58	53	59	54	50	42	40	60
275	56	56	52	54	56	51	43	40	59
300	56	52	54	63	60	54	43	40	64

(a) Model Number Digit 12 = 1
(b) Data for 150S and 165S units are estimates.

Table 11. Sound pressure levels (Lp, in dB) InvisiSound Superior[a], max fan 825 rpm 10m from center of broad sides of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	62	65	62	60	66	60	52	46	68
165S	63	66	63	61	67	62	54	48	69
150	62	65	62	59	66	60	52	44	68
165	64	66	63	60	68	62	52	45	70
180	64	66	63	60	68	61	53	46	69
200	64	67	64	61	68	61	54	47	70
225	64	67	64	61	67	61	53	49	69
250	64	67	64	61	68	62	54	48	70
275	65	68	64	62	68	62	54	49	70
300	65	68	65	63	69	63	55	49	71
AHRI Rating Point - 75% Load									
150S	61	63	60	58	62	56	48	45	65
165S	61	61	59	59	62	57	49	47	65
150	61	63	60	57	64	57	49	39	66
165	61	61	59	56	62	57	48	39	64
180	62	63	60	57	63	57	49	40	65
200	61	61	59	55	65	55	48	40	66
225	63	64	62	59	64	57	50	48	66
250	63	65	63	63	65	59	51	48	68
275	63	65	62	64	64	59	51	48	67
300	63	64	62	61	64	58	50	47	67
AHRI Rating Point - 50% Load									
150S	57	54	54	55	55	49	41	43	58
165S	57	53	55	58	56	51	43	46	60
150	57	57	53	53	54	48	43	32	57
165	57	53	53	52	54	48	43	32	57
180	57	54	56	52	55	49	43	32	58
200	57	53	53	49	60	49	43	33	61
225	58	58	55	52	54	50	43	47	58
250	59	58	56	57	56	51	44	48	60
275	59	57	55	60	55	52	44	46	61
300	59	55	56	58	57	52	44	46	61
AHRI Rating Point - 25% Load									
150S	54	50	51	55	53	49	40	44	57
165S	54	50	53	58	55	51	43	47	60
150	54	53	50	51	53	46	42	30	55
165	54	49	50	50	54	46	42	31	56
180	54	50	53	51	56	47	42	31	57
200	55	49	52	49	55	47	42	32	57
225	55	57	52	51	52	48	42	47	56
250	56	59	53	56	53	49	42	46	58
275	56	53	52	58	53	51	42	46	59
300	56	52	54	58	55	52	43	47	60

(a) Model Number Digit 12 = 2
(b) Data for 150S and 165S units are estimates.

Table 12. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 700 rpm 10m from center of broad sides of chiller

Unit Size [b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	60	60	58	55	61	55	47	41	63
165S	62	61	59	56	63	57	49	43	65
150	61	60	58	54	61	54	47	38	63
165	61	61	59	55	61	55	47	39	63
180	62	61	59	56	61	55	48	39	63
200	62	62	60	56	62	56	49	40	64
225	62	62	60	57	62	56	48	41	64
250	62	62	60	56	62	57	49	41	64
275	63	63	60	57	64	57	50	43	66
300	63	63	61	58	64	58	50	44	66
AHRI Rating Point - 75% Load									
150S	60	60	58	56	60	53	46	37	62
165S	61	61	59	58	61	55	47	39	63
150	60	60	58	54	60	53	46	35	62
165	62	61	59	55	61	54	46	36	63
180	62	61	59	55	61	55	46	36	63
200	62	61	59	55	61	54	46	37	63
225	62	62	60	56	61	55	47	38	64
250	62	62	60	57	61	55	47	38	64
275	62	63	60	57	62	56	48	39	64
300	63	63	61	59	63	57	49	40	65
AHRI Rating Point - 50% Load									
150S	57	54	53	49	52	47	38	30	55
165S	57	53	54	49	52	48	39	32	55
150	57	55	53	48	52	46	38	28	55
165	57	53	53	48	51	45	37	27	54
180	57	54	54	49	52	46	38	28	55
200	57	53	54	49	51	45	37	28	54
225	59	57	55	50	53	49	40	31	57
250	59	57	56	52	55	50	41	32	58
275	59	61	57	53	54	50	41	32	58
300	59	56	55	51	54	49	40	32	57
AHRI Rating Point - 25% Load									
150S	54	50	51	46	49	45	36	29	52
165S	55	51	52	48	49	47	38	32	53
150	54	53	49	48	49	42	34	25	52
165	55	49	49	49	47	42	33	25	51
180	55	50	51	49	49	43	35	26	52
200	55	49	51	49	47	43	35	26	51
225	56	55	52	48	50	47	38	30	53
250	56	56	53	49	51	47	39	30	55
275	56	55	52	55	52	48	39	31	57
300	56	52	53	49	50	47	39	32	54

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 13. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 650 rpm 10m from center of broad sides of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	60	58	56	53	59	54	46	40	62
165S	61	59	58	55	61	56	49	43	64
150	60	58	56	52	59	52	45	37	61
165	61	59	57	53	59	53	46	38	62
180	62	59	57	54	59	53	47	38	62
200	61	60	58	54	60	54	48	40	62
225	61	60	58	55	59	54	47	40	62
250	61	60	58	55	60	55	48	41	63
275	62	61	59	56	63	56	49	42	65
300	63	61	60	56	62	57	49	43	65
AHRI Rating Point - 75% Load									
150S	59	58	56	55	58	52	44	36	60
165S	60	59	58	57	59	53	46	38	62
150	60	58	56	52	57	51	44	34	60
165	61	59	57	53	59	52	44	34	61
180	61	59	57	54	58	53	45	34	61
200	62	60	58	54	59	53	45	36	62
225	61	60	59	54	59	53	45	36	62
250	61	60	58	56	59	53	46	37	62
275	62	61	59	56	60	54	46	38	62
300	62	61	59	58	61	55	47	39	63
AHRI Rating Point - 50% Load									
150S	57	54	53	49	52	47	38	30	55
165S	57	53	54	49	52	48	39	32	55
150	57	55	53	48	52	46	38	28	55
165	57	53	53	48	51	45	37	27	54
180	57	54	54	49	52	46	38	28	55
200	57	53	54	49	51	45	37	28	54
225	59	57	55	50	53	49	40	31	57
250	59	57	56	52	55	50	41	32	58
275	59	61	57	53	54	50	41	32	58
300	59	56	55	51	54	49	40	32	57
AHRI Rating Point - 25% Load									
150S	54	50	51	46	49	45	36	29	52
165S	55	51	52	48	49	47	38	32	53
150	54	53	49	48	49	42	34	25	52
165	55	49	49	49	47	42	33	25	51
180	55	50	51	49	49	43	35	26	52
200	55	49	51	49	47	43	35	26	51
225	56	55	52	48	50	47	38	30	53
250	56	56	53	49	51	47	39	30	55
275	56	55	52	55	52	48	39	31	57
300	56	52	53	49	50	47	39	32	54

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Appendix B — Sound Pressure Octave Band Data

Table 14. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 600 rpm 10m from center of broad sides of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	59	56	55	51	58	53	45	40	60
165S	60	57	56	53	60	56	48	43	63
150	59	56	54	50	58	50	44	36	60
165	60	57	55	51	58	52	45	38	60
180	61	57	55	52	57	52	46	38	60
200	60	58	56	53	58	52	47	39	60
225	60	58	57	53	57	53	46	40	60
250	60	58	57	53	59	54	47	40	61
275	61	59	57	54	62	55	48	42	64
300	62	59	58	54	61	56	48	43	63
AHRI Rating Point - 75% Load									
150S	58	56	55	54	56	50	43	35	59
165S	59	57	56	57	57	52	45	38	60
150	59	56	55	51	55	49	42	32	58
165	60	57	56	51	56	50	42	33	59
180	61	57	56	52	56	51	43	33	59
200	61	58	56	52	57	51	43	35	59
225	60	58	58	52	57	51	43	35	59
250	60	58	57	54	57	52	44	36	60
275	61	59	57	54	58	52	45	37	60
300	61	59	58	57	59	53	46	38	62
AHRI Rating Point - 50% Load									
150S	57	54	53	49	52	47	38	30	55
165S	57	53	54	49	52	48	39	32	55
150	57	55	53	48	52	46	38	28	55
165	57	53	53	48	51	45	37	27	54
180	57	54	54	49	52	46	38	28	55
200	57	53	54	49	51	45	37	28	54
225	59	57	55	50	53	49	40	31	57
250	59	57	56	52	55	50	41	32	58
275	59	61	57	53	54	50	41	32	58
300	59	56	55	51	54	49	40	32	57
AHRI Rating Point - 25% Load									
150S	54	50	51	46	49	45	36	29	52
165S	55	51	52	48	49	47	38	32	53
150	54	53	49	48	49	42	34	25	52
165	55	49	49	49	47	42	33	25	51
180	55	50	51	49	49	43	35	26	52
200	55	49	51	49	47	43	35	26	51
225	56	55	52	48	50	47	38	30	53
250	56	56	53	49	51	47	39	30	55
275	56	55	52	55	52	48	39	31	57
300	56	52	53	49	50	47	39	32	54

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 15. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 920 rpm 10m from center of broad sides of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	64	69	65	62	68	61	54	45	70
165S	65	70	65	63	69	63	55	47	71
150	64	69	65	62	68	61	54	44	70
165	65	69	65	62	69	62	54	45	71
180	65	70	66	63	69	62	55	46	71
200	65	69	65	62	68	62	54	45	70
225	65	71	66	64	70	63	56	47	72
250	65	71	66	64	70	63	56	47	72
275	66	71	67	64	71	64	57	48	73
300	67	72	68	65	71	64	57	48	73
AHRI Rating Point - 75% Load									
150S	61	63	60	58	62	55	48	39	64
165S	61	61	59	58	61	55	47	39	63
150	61	63	60	56	62	55	48	37	64
165	62	61	59	55	61	54	46	36	63
180	63	63	60	57	62	56	48	38	64
200	62	61	59	55	61	54	46	37	63
225	63	64	62	58	63	57	49	39	66
250	63	66	63	60	65	59	51	41	67
275	63	65	62	59	64	58	50	40	66
300	63	64	62	60	63	57	49	41	66
AHRI Rating Point - 50% Load									
150S	57	54	53	49	52	47	38	30	55
165S	57	53	54	49	52	48	39	32	55
150	57	55	53	48	52	46	38	28	55
165	57	53	53	48	51	45	37	27	54
180	57	54	54	49	52	46	38	28	55
200	57	53	54	49	51	45	37	28	54
225	59	57	55	50	53	49	40	31	57
250	59	57	56	52	55	50	41	32	58
275	59	61	57	53	54	50	41	32	58
300	59	56	55	51	54	49	40	32	57
AHRI Rating Point - 25% Load									
150S	54	50	51	46	49	45	36	29	52
165S	55	51	52	48	49	47	38	32	53
150	54	53	49	48	49	42	34	25	52
165	55	49	49	49	47	42	33	25	51
180	55	50	51	49	49	43	35	26	52
200	55	49	51	49	47	43	35	26	51
225	56	55	52	48	50	47	38	30	53
250	56	56	53	49	51	47	39	30	55
275	56	55	52	55	52	48	39	31	57
300	56	52	53	49	50	47	39	32	54

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Control Panel End of Chiller

Table 16. Sound pressure levels (Lp, in dB) InvisiSound Standard[a], max fan 920 rpm 10m from center of control panel end of chiller

Unit Size [b]	Octaves 63	125	250	500	1000	2000	4000	8000	Overall A Wtd
AHRI Rating Point - 100% Load									
150S	64	68	61	58	61	53	47	37	64
165S	65	68	62	60	63	54	49	38	65
150	64	68	61	57	61	54	47	37	64
165	65	68	62	58	63	55	48	38	65
180	66	69	62	59	63	54	48	39	65
200	65	68	62	59	62	54	49	40	65
225	66	69	63	60	62	54	48	38	65
250	66	69	63	60	63	55	49	38	66
275	67	70	64	60	63	55	49	39	66
300	67	71	64	61	64	56	50	40	67
AHRI Rating Point - 75% Load									
150S	62	61	57	56	55	47	41	31	59
165S	62	60	57	58	56	48	42	33	60
150	62	61	56	52	56	48	42	30	58
165	62	60	57	52	55	47	40	30	58
180	62	61	57	52	55	48	41	31	58
200	62	60	55	51	61	47	41	32	62
225	63	63	59	56	56	48	42	33	59
250	64	65	60	62	57	51	45	34	63
275	64	63	59	60	57	49	44	33	61
300	64	63	59	59	57	49	43	33	61
AHRI Rating Point - 50% Load									
150S	57	52	50	55	48	42	34	28	55
165S	58	52	51	58	50	44	36	31	57
150	57	55	49	53	46	39	31	22	52
165	57	51	50	51	47	39	30	22	52
180	58	52	53	51	48	41	32	23	53
200	58	51	50	50	51	40	34	24	53
225	59	56	52	50	47	41	36	30	52
250	60	57	54	58	48	43	36	30	58
275	60	56	52	60	49	45	38	31	58
300	60	54	52	58	51	44	36	31	57
AHRI Rating Point - 25% Load									
150S	54	49	48	55	48	42	33	27	54
165S	55	49	49	58	51	44	35	30	57
150	54	51	48	48	45	37	28	20	50
165	54	47	45	46	47	37	28	21	50
180	55	48	50	51	48	40	29	22	52
200	55	47	47	47	50	41	34	23	52
225	56	55	49	49	47	41	35	30	52
250	56	57	50	54	45	41	35	30	54
275	57	55	49	49	47	41	35	30	52
300	57	50	50	58	51	44	35	30	57

(a) Model Number Digit 12 = 1
(b) Data for 150S and 165S units are estimates.

Table 17. Sound pressure levels (Lp, in dB) InvisiSound Superior[a], max fan 825 rpm 10m from center of control panel end of chiller

Unit Size[b]	Octaves 63	125	250	500	1000	2000	4000	8000	Overall A Wtd
AHRI Rating Point - 100% Load									
150S	63	64	58	55	57	50	45	36	60
165S	64	65	60	57	58	52	46	39	62
150	63	64	58	54	57	50	44	34	60
165	64	65	59	55	59	52	45	36	62
180	65	65	59	55	59	52	45	37	61
200	65	66	60	56	60	51	46	38	62
225	65	66	60	57	58	51	45	39	62
250	65	66	60	57	59	53	46	39	62
275	65	67	61	57	60	53	46	39	63
300	66	67	61	58	60	53	48	39	63
AHRI Rating Point - 75% Load									
150S	62	61	57	53	54	47	41	35	57
165S	62	60	56	54	53	47	41	37	58
150	62	61	56	53	56	47	42	30	58
165	62	60	56	51	54	47	40	29	57
180	62	61	57	52	54	47	41	30	58
200	62	60	55	51	57	45	40	30	59
225	63	63	59	55	55	48	42	39	59
250	64	64	59	59	56	50	44	38	61
275	64	63	59	58	56	49	43	38	61
300	64	63	59	56	55	49	43	38	59
AHRI Rating Point - 50% Load									
150S	57	52	50	50	46	40	33	33	51
165S	58	52	51	53	47	42	35	36	53
150	58	55	49	48	45	38	35	22	50
165	58	51	49	47	46	38	35	22	50
180	58	52	52	47	47	40	35	23	51
200	58	51	49	44	51	39	35	24	52
225	59	57	51	47	46	40	36	38	51
250	60	57	52	52	47	41	36	38	53
275	60	55	52	56	47	42	36	37	55
300	60	54	52	53	48	42	36	36	54
AHRI Rating Point - 25% Load									
150S	55	49	47	50	44	40	33	34	50
165S	55	49	49	53	46	42	35	37	53
150	55	51	47	46	44	37	34	21	49
165	55	47	46	45	45	36	34	21	48
180	55	48	49	46	47	37	34	22	49
200	55	47	48	44	46	37	34	22	49
225	56	56	49	46	43	38	35	37	49
250	57	58	49	50	44	39	35	37	52
275	57	52	49	54	45	41	35	36	53
300	57	50	50	53	47	42	35	37	53

(a) Model Number Digit 12 = 1
(b) Data for 150S and 165S units are estimates.

Appendix B — Sound Pressure Octave Band Data

Table 18. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 700 rpm 10m from center of control panel end of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	61	59	55	50	52	46	40	31	55
165S	62	60	56	52	54	48	42	34	57
150	61	59	54	50	52	44	39	28	55
165	62	60	55	51	53	46	40	30	56
180	63	60	55	51	52	45	40	30	56
200	62	61	56	52	53	46	41	31	57
225	63	61	56	52	53	46	41	31	57
250	63	61	56	52	54	47	41	32	57
275	63	61	57	53	56	48	42	33	59
300	64	62	58	53	55	49	43	34	58
AHRI Rating Point - 75% Load									
150S	61	59	55	51	51	44	38	28	55
165S	62	60	56	53	52	45	40	30	56
150	61	59	54	50	51	44	38	26	55
165	62	60	55	51	52	45	38	27	56
180	63	60	55	51	52	45	39	27	56
200	63	60	55	51	52	45	39	27	56
225	63	61	57	52	53	46	39	28	56
250	63	61	57	53	53	46	40	29	57
275	63	61	57	53	54	46	40	30	57
300	64	62	58	54	54	47	41	31	58
AHRI Rating Point - 50% Load									
150S	58	52	50	44	44	38	31	20	48
165S	58	52	50	45	44	38	32	22	48
150	57	53	49	44	44	37	31	18	48
165	58	51	49	43	43	36	30	18	47
180	58	52	50	44	44	37	31	19	48
200	58	51	50	44	43	36	30	18	47
225	59	55	51	45	45	40	33	21	50
250	60	56	52	47	47	40	34	22	51
275	60	60	53	48	46	40	34	23	52
300	60	54	52	46	46	39	33	22	50
AHRI Rating Point - 25% Load									
150S	55	49	47	42	40	35	29	19	45
165S	56	49	48	43	41	36	31	22	47
150	55	52	45	43	40	33	26	15	46
165	55	48	46	44	39	32	25	15	45
180	55	48	47	44	40	33	27	17	45
200	56	48	47	44	39	33	27	17	45
225	57	53	48	43	41	37	30	20	47
250	57	55	50	44	43	37	31	21	48
275	57	53	49	50	44	38	31	21	50
300	57	51	49	44	42	37	31	22	47

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 19. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 650 rpm 10m from center of control panel end of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	60	57	53	48	50	45	38	31	54
165S	62	58	54	50	52	47	41	34	56
150	61	57	53	48	51	42	37	27	53
165	61	58	54	49	51	44	38	29	54
180	62	58	54	49	51	44	39	29	54
200	62	58	54	50	51	44	40	30	55
225	62	59	55	50	51	45	39	31	55
250	62	59	55	50	52	46	40	31	55
275	63	59	55	51	55	46	41	33	58
300	63	60	56	51	53	48	41	34	57
AHRI Rating Point - 75% Load									
150S	60	57	53	50	49	42	36	26	53
165S	61	58	54	52	50	43	38	29	55
150	60	57	53	48	49	42	36	24	53
165	62	58	54	49	50	43	36	25	54
180	62	58	54	49	50	43	37	25	54
200	62	59	54	50	51	44	37	27	54
225	62	59	55	50	51	44	37	27	54
250	62	59	55	51	51	44	38	27	55
275	62	59	55	51	51	45	39	28	55
300	63	60	56	53	52	45	39	29	56
AHRI Rating Point - 50% Load									
150S	58	52	50	44	44	38	31	20	48
165S	58	52	50	45	44	38	32	22	48
150	57	53	49	44	44	37	31	18	48
165	58	51	49	43	43	36	30	18	47
180	58	52	50	44	44	37	31	19	48
200	58	51	50	44	43	36	30	18	47
225	59	55	51	45	45	40	33	21	50
250	60	56	52	47	47	40	34	22	51
275	60	60	53	48	46	40	34	23	52
300	60	54	52	46	46	39	33	22	50
AHRI Rating Point - 25% Load									
150S	55	49	47	42	40	35	29	19	45
165S	56	49	48	43	41	36	31	22	47
150	55	52	45	43	40	33	26	15	46
165	55	48	46	44	39	32	25	15	45
180	55	48	47	44	40	33	27	17	45
200	56	48	47	44	39	33	27	17	45
225	57	53	48	43	41	37	30	20	47
250	57	55	50	44	43	37	31	21	48
275	57	53	49	50	44	38	31	21	50
300	57	51	49	44	42	37	31	22	47

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 20. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 600 rpm 10m from center of control panel end of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	59	55	51	47	49	44	38	31	52
165S	61	56	53	49	51	46	40	34	55
150	60	55	51	46	49	40	36	27	52
165	60	55	52	47	49	43	37	28	52
180	62	55	52	48	49	42	38	28	52
200	61	56	53	48	50	43	39	30	53
225	61	57	53	48	49	43	38	30	53
250	61	56	53	48	50	45	39	31	54
275	62	57	54	49	55	45	40	32	57
300	62	58	54	50	52	47	41	34	56
AHRI Rating Point - 75% Load									
150S	59	55	51	49	47	40	35	26	52
165S	60	56	53	51	49	42	37	28	53
150	59	55	51	46	47	40	34	23	50
165	61	56	52	47	48	41	34	23	52
180	61	56	52	47	48	41	35	24	52
200	62	56	53	48	49	41	36	25	52
225	61	56	54	48	48	42	36	25	52
250	61	56	53	50	48	42	37	26	53
275	61	57	54	50	49	43	37	28	53
300	62	58	54	52	50	43	38	29	55
AHRI Rating Point - 50% Load									
150S	58	52	50	44	44	38	31	20	48
165S	58	52	50	45	44	38	32	22	48
150	57	53	49	44	44	37	31	18	48
165	58	51	49	43	43	36	30	18	47
180	58	52	50	44	44	37	31	19	48
200	58	51	50	44	43	36	30	18	47
225	59	55	51	45	45	40	33	21	50
250	60	56	52	47	47	40	34	22	51
275	60	60	53	48	46	40	34	23	52
300	60	54	52	46	46	39	33	22	50
AHRI Rating Point - 25% Load									
150S	55	49	47	42	40	35	29	19	45
165S	56	49	48	43	41	36	31	22	47
150	55	52	45	43	40	33	26	15	46
165	55	48	46	44	39	32	25	15	45
180	55	48	47	44	40	33	27	17	45
200	56	48	47	44	39	33	27	17	45
225	57	53	48	43	41	37	30	20	47
250	57	55	50	44	43	37	31	21	48
275	57	53	49	50	44	38	31	21	50
300	57	51	49	44	42	37	31	22	47

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 21. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 920 rpm 10m from center of control panel end of chiller

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	64	68	61	57	60	52	46	36	63
165S	65	68	62	58	60	53	47	37	64
150	65	68	61	57	60	52	46	35	63
165	65	68	62	58	60	52	47	36	63
180	66	69	62	58	60	53	47	36	64
200	65	68	62	58	60	52	47	36	63
225	66	69	63	59	61	53	48	37	64
250	66	69	63	59	61	54	48	37	64
275	67	70	64	60	62	54	49	38	65
300	67	71	64	60	63	55	49	39	66
AHRI Rating Point - 75% Load									
150S	62	61	56	53	53	46	40	29	57
165S	62	60	56	53	52	45	40	30	56
150	62	61	56	52	53	46	40	28	57
165	62	60	55	51	52	45	38	27	56
180	63	61	57	52	53	46	40	28	57
200	63	60	55	51	52	45	39	27	56
225	63	63	58	53	55	48	41	30	58
250	64	65	59	55	57	49	43	32	60
275	64	63	58	54	55	48	42	31	59
300	64	63	58	55	55	48	42	31	59
AHRI Rating Point - 50% Load									
150S	58	52	50	44	44	38	31	20	48
165S	58	52	50	45	44	38	32	22	48
150	57	53	49	44	44	37	31	18	48
165	58	51	49	43	43	36	30	18	47
180	58	52	50	44	44	37	31	19	48
200	58	51	50	44	43	36	30	18	47
225	59	55	51	45	45	40	33	21	50
250	60	56	52	47	47	40	34	22	51
275	60	60	53	48	46	40	34	23	52
300	60	54	52	46	46	39	33	22	50
AHRI Rating Point - 25% Load									
150S	55	49	47	42	40	35	29	19	45
165S	56	49	48	43	41	36	31	22	47
150	55	52	45	43	40	33	26	15	46
165	55	48	46	44	39	32	25	15	45
180	55	48	47	44	40	33	27	17	45
200	56	48	47	44	39	33	27	17	45
225	57	53	48	43	41	37	30	20	47
250	57	55	50	44	43	37	31	21	48
275	57	53	49	50	44	38	31	21	50
300	57	51	49	44	42	37	31	22	47

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

End Opposite Control Panel

Table 22. Sound pressure levels (Lp, in dB) InvisiSound Standard[a], max fan 920 rpm 10m from center of end opposite control panel

Unit Size[b]	Octaves 63	125	250	500	1000	2000	4000	8000	Overall A Wtd
AHRI Rating Point - 100% Load									
150S	63	67	62	62	63	59	48	38	67
165S	64	67	63	63	65	61	49	40	68
150	63	67	62	62	65	62	47	38	68
165	64	67	63	62	65	61	48	40	68
180	65	68	63	63	65	61	48	41	68
200	64	67	63	63	64	61	50	41	67
225	65	68	64	64	64	61	49	39	68
250	65	68	64	64	67	62	49	39	69
275	65	69	65	65	66	62	50	40	69
300	66	70	65	65	66	62	51	41	70
AHRI Rating Point - 75% Load									
150S	60	60	57	59	57	54	42	32	62
165S	60	59	57	61	58	55	42	34	63
150	60	60	57	56	58	55	42	31	61
165	60	59	58	56	56	53	40	31	60
180	61	60	57	56	57	55	42	33	61
200	61	59	56	55	62	54	41	33	63
225	62	62	60	59	58	55	43	35	62
250	63	64	61	64	60	58	45	35	65
275	62	62	60	62	59	56	44	35	64
300	63	62	59	62	59	56	44	35	64
AHRI Rating Point - 50% Load									
150S	56	51	51	57	51	48	34	29	57
165S	56	51	51	60	53	50	36	32	59
150	56	54	49	55	49	46	31	23	55
165	56	50	50	53	51	46	31	24	55
180	56	51	54	53	51	48	32	25	55
200	56	51	51	52	53	47	35	25	56
225	58	55	52	53	50	48	36	32	55
250	58	56	54	60	51	50	37	32	60
275	58	55	53	62	52	51	38	32	60
300	58	53	53	60	53	51	36	32	60
AHRI Rating Point - 25% Load									
150S	53	48	48	58	51	48	33	29	57
165S	53	48	50	61	54	51	35	32	60
150	53	50	48	50	49	44	29	22	52
165	53	47	46	48	50	44	29	23	52
180	53	48	50	54	53	47	30	24	56
200	53	47	47	49	51	47	34	25	54
225	55	54	49	52	51	48	35	32	55
250	55	56	50	56	48	47	35	32	56
275	55	54	50	52	51	48	35	32	55
300	55	50	51	61	54	51	36	32	60

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 23. Sound pressure levels (Lp, in dB) InvisiSound Superior[a], max fan 825 rpm 10m from center of end opposite control panel

Unit Size[b]	Octaves 63	125	250	500	1000	2000	4000	8000	Overall A Wtd
AHRI Rating Point - 100% Load									
150S	62	63	59	59	59	57	45	38	63
165S	63	64	60	60	60	58	47	40	64
150	62	63	59	59	60	57	44	36	63
165	63	64	60	59	61	58	45	37	64
180	63	64	60	60	61	58	46	38	64
200	63	65	61	60	61	58	47	39	65
225	63	65	61	61	61	58	46	41	64
250	63	65	61	61	63	59	46	40	66
275	64	66	62	62	63	60	47	41	66
300	65	66	62	62	62	60	48	41	66
AHRI Rating Point - 75% Load									
150S	60	60	57	57	56	54	41	37	60
165S	60	59	57	57	55	54	41	39	60
150	60	60	57	56	59	54	42	31	61
165	60	59	57	55	55	53	41	31	59
180	61	60	57	56	56	54	42	32	60
200	61	59	56	55	58	52	41	32	61
225	62	62	60	58	57	55	43	40	62
250	62	63	60	62	59	57	44	40	63
275	62	62	59	61	58	56	43	40	63
300	63	62	59	59	58	56	43	39	62
AHRI Rating Point - 50% Load									
150S	56	51	51	53	48	47	34	35	54
165S	56	51	51	55	49	48	36	38	56
150	56	54	50	50	48	45	35	24	53
165	56	50	49	49	49	45	35	24	52
180	57	51	53	51	49	47	35	24	53
200	56	51	50	47	53	45	36	25	54
225	58	56	52	51	48	47	36	39	54
250	58	56	53	54	50	48	37	40	56
275	58	55	52	57	49	49	36	38	57
300	58	53	53	55	50	49	36	38	56
AHRI Rating Point - 25% Load									
150S	53	48	48	53	47	46	33	36	53
165S	54	48	50	55	49	49	36	39	56
150	53	50	47	48	47	43	35	23	51
165	53	47	46	48	48	43	34	23	51
180	54	48	50	50	51	44	34	23	53
200	54	47	49	47	48	43	34	24	51
225	54	55	49	49	46	45	35	39	52
250	55	57	50	53	46	46	35	38	54
275	55	51	50	56	47	48	35	38	55
300	55	50	50	55	49	49	36	39	56

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 24. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 700 rpm 10m from center of end opposite control panel

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	60	58	55	54	54	52	40	33	58
165S	61	59	57	56	56	54	42	36	60
150	60	58	55	54	56	51	39	30	58
165	61	59	56	55	55	52	40	31	59
180	61	59	56	55	55	52	41	31	59
200	61	60	57	56	55	53	42	33	59
225	61	60	57	56	55	53	41	33	59
250	61	60	57	56	56	54	42	33	60
275	62	61	58	57	58	55	43	35	61
300	63	61	58	57	57	55	43	36	61
AHRI Rating Point - 75% Load									
150S	59	58	55	55	53	51	38	29	58
165S	60	59	56	56	54	52	40	31	59
150	60	58	55	54	53	51	38	27	57
165	61	59	56	55	54	51	39	28	58
180	61	59	56	55	54	52	39	28	58
200	61	59	56	55	54	51	39	29	58
225	61	60	58	56	55	52	40	30	59
250	61	60	57	56	55	52	40	30	59
275	62	61	58	57	56	53	41	31	60
300	62	61	58	58	56	54	41	32	61
AHRI Rating Point - 50% Load									
150S	56	52	50	48	46	44	31	22	51
165S	57	51	51	49	46	45	32	24	51
150	56	53	49	48	46	43	31	20	50
165	56	50	50	47	45	42	30	19	50
180	57	51	50	48	46	44	31	20	51
200	57	51	51	48	45	42	30	20	50
225	58	54	52	50	47	46	33	23	52
250	59	55	53	51	49	47	34	24	54
275	58	59	53	51	48	47	34	24	54
300	58	53	52	50	47	46	33	24	53
AHRI Rating Point - 25% Load									
150S	53	48	48	46	42	41	29	21	48
165S	54	49	49	48	43	43	31	24	49
150	53	51	46	46	42	39	27	17	48
165	54	47	46	47	41	39	26	17	47
180	54	48	47	47	43	40	27	18	48
200	54	47	48	47	41	39	27	18	47
225	55	52	49	47	43	43	31	22	50
250	56	54	50	48	45	43	31	22	50
275	55	52	50	52	47	44	31	23	53
300	56	50	50	48	44	43	32	24	50

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 25. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 650 rpm 10m from center of end opposite control panel

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	59	56	54	52	53	51	39	32	57
165S	60	57	55	54	54	53	42	35	59
150	59	56	53	52	55	49	38	29	57
165	60	57	54	53	53	51	39	30	57
180	61	57	54	53	53	50	40	30	57
200	60	58	55	54	53	51	41	32	57
225	60	58	56	54	53	51	40	32	58
250	60	58	56	55	55	53	41	33	59
275	61	59	56	56	57	53	42	34	60
300	62	59	57	55	56	54	42	35	60
AHRI Rating Point - 75% Load									
150S	58	56	54	53	51	49	37	28	56
165S	60	57	55	55	52	50	39	30	57
150	59	56	53	52	51	48	36	26	55
165	60	57	54	53	52	50	37	26	56
180	61	57	54	53	52	50	37	27	56
200	61	58	55	54	53	50	38	28	57
225	60	58	56	54	53	50	38	28	57
250	60	58	56	55	53	51	38	29	57
275	61	58	56	55	54	51	39	30	58
300	61	59	57	56	54	52	40	31	59
AHRI Rating Point - 50% Load									
150S	56	52	50	48	46	44	31	22	51
165S	57	51	51	49	46	45	32	24	51
150	56	53	49	48	46	43	31	20	50
165	56	50	50	47	45	42	30	19	50
180	57	51	50	48	46	44	31	20	51
200	57	51	51	48	45	42	30	20	50
225	58	54	52	50	47	46	33	23	52
250	59	55	53	51	49	47	34	24	54
275	58	59	53	51	48	47	34	24	54
300	58	53	52	50	47	46	33	24	53
AHRI Rating Point - 25% Load									
150S	53	48	48	46	42	41	29	21	48
165S	54	49	49	48	43	43	31	24	49
150	53	51	46	46	42	39	27	17	48
165	54	47	46	47	41	39	26	17	47
180	54	48	47	47	43	40	27	18	48
200	54	47	48	47	41	39	27	18	47
225	55	52	49	47	43	43	31	22	50
250	56	54	50	48	45	43	31	22	50
275	55	52	50	52	47	44	31	23	53
300	56	50	50	48	44	43	32	24	50

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Appendix B — Sound Pressure Octave Band Data

Table 26. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 600 rpm 10m from center of end opposite control panel

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	58	54	52	51	51	50	38	32	55
165S	59	55	54	52	53	53	41	35	58
150	58	54	51	50	54	47	37	28	56
165	59	55	52	51	51	50	38	30	55
180	60	55	52	51	51	48	39	30	55
200	59	55	53	52	51	50	40	31	56
225	59	56	54	52	51	50	39	32	56
250	59	56	54	53	53	52	40	33	57
275	60	56	55	54	56	52	41	34	59
300	61	57	55	54	54	53	41	35	58
AHRI Rating Point - 75% Load									
150S	57	54	52	52	49	47	35	27	54
165S	59	55	53	54	51	48	37	30	56
150	58	54	52	50	49	46	35	24	53
165	60	55	53	51	50	47	35	25	54
180	60	55	53	51	50	48	36	25	54
200	60	56	53	52	51	48	36	27	55
225	59	56	55	52	50	48	36	27	55
250	59	56	54	53	51	49	37	28	55
275	60	56	55	53	51	50	37	29	56
300	60	57	55	55	52	50	38	30	57
AHRI Rating Point - 50% Load									
150S	56	52	50	48	46	44	31	22	51
165S	57	51	51	49	46	45	32	24	51
150	56	53	49	48	46	43	31	20	50
165	56	50	50	47	45	42	30	19	50
180	57	51	50	48	46	44	31	20	51
200	57	51	51	48	45	42	30	20	50
225	58	54	52	50	47	46	33	23	52
250	59	55	53	51	49	47	34	24	54
275	58	59	53	51	48	47	34	24	54
300	58	53	52	50	47	46	33	24	53
AHRI Rating Point - 25% Load									
150S	53	48	48	46	42	41	29	21	48
165S	54	49	49	48	43	43	31	24	49
150	53	51	46	46	42	39	27	17	48
165	54	47	46	47	41	39	26	17	47
180	54	48	47	47	43	40	27	18	48
200	54	47	48	47	41	39	27	18	47
225	55	52	49	47	43	43	31	22	50
250	56	54	50	48	45	43	31	22	50
275	55	52	50	52	47	44	31	23	53
300	56	50	50	48	44	43	32	24	50

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

Table 27. Sound pressure levels (Lp, in dB) InvisiSound Ultimate[a], max fan 920 rpm 10m from center of end opposite control panel

Unit Size[b]	Octaves								Overall A Wtd
	63	125	250	500	1000	2000	4000	8000	
AHRI Rating Point - 100% Load									
150S	63	67	62	62	62	59	47	37	65
165S	64	68	63	62	63	60	48	39	66
150	63	67	62	62	62	58	47	37	65
165	64	67	63	62	62	59	47	37	66
180	64	68	63	63	63	59	48	38	66
200	64	67	63	62	62	59	47	37	66
225	65	68	64	63	63	60	48	39	67
250	65	68	64	63	64	61	49	39	67
275	66	69	65	64	65	61	49	40	68
300	66	70	65	65	65	62	50	40	68
AHRI Rating Point - 75% Load									
150S	60	60	57	57	55	53	40	31	60
165S	60	59	56	56	54	52	40	31	59
150	61	60	57	56	56	53	40	29	59
165	61	59	56	55	54	51	39	28	58
180	62	61	57	56	56	53	40	30	60
200	61	59	56	55	54	51	39	29	58
225	62	62	59	58	57	54	42	32	61
250	63	64	60	59	59	56	44	33	63
275	63	62	59	58	58	55	42	33	62
300	63	62	59	58	57	54	42	33	61
AHRI Rating Point - 50% Load									
150S	56	52	50	48	46	44	31	22	51
165S	57	51	51	49	46	45	32	24	51
150	56	53	49	48	46	43	31	20	50
165	56	50	50	47	45	42	30	19	50
180	57	51	50	48	46	44	31	20	51
200	57	51	51	48	45	42	30	20	50
225	58	54	52	50	47	46	33	23	52
250	59	55	53	51	49	47	34	24	54
275	58	59	53	51	48	47	34	24	54
300	58	53	52	50	47	46	33	24	53
AHRI Rating Point - 25% Load									
150S	53	48	48	46	42	41	29	21	48
165S	54	49	49	48	43	43	31	24	49
150	53	51	46	46	42	39	27	17	48
165	54	47	46	47	41	39	26	17	47
180	54	48	47	47	43	40	27	18	48
200	54	47	48	47	41	39	27	18	47
225	55	52	49	47	43	43	31	22	50
250	56	54	50	48	45	43	31	22	50
275	55	52	50	52	47	44	31	23	53
300	56	50	50	48	44	43	32	24	50

(a) Model Number Digit 12 = 3
(b) Data for 150S and 165S units are estimates.

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1. GENERAL

1.1 Section Scope

.1 Materials and installation for:

.1 Flexible braided hose.

.2 Flexible pipe connectors.

.3 Expansion joints.

.4 Expansion compensators.

.5 Pipe alignment guides.

.6 Pipe anchors.

.7 Expansion loops.

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 13 – Hydronic Piping.

1.3 References

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

.1 ASTM A53/A53M- [02], Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

.2 ASTM A105/A105M- [03], Standard Specification for Carbon Steel Forgings, for Piping Applications.

.2 American Society of Mechanical Engineers:

.1 ASME B31.9 - Building Services Piping.

.2 ASME Section IX - Boiler and Pressure Vessel Code -Welding and Brazing Qualifications.

1.4 Design Requirements:

.1 It is the Contractor`s responsibility to retain the services of a qualified professional engineer to design the pipe expansion system for the actual installed layout of all piping systems covered by this specification section.

.2 The Contractor is required to review the mechanical, structural, and architectural documents for the identification of any seismic joints for seismic separations within the building structure that affects the installation of any mechanical systems. At each of these locations, the contractor shall allow for the design, supply, and installation of applicable mechanical system flexible connections along with support of these systems on each side of the seismic joint or separation. This applies to all piping systems as well as ductwork systems.

.3 Special attention should be given to straight pipe runs, pipe shaft installations and non-metallic pipe installations. As a minimum on hot piping, provide expansion compensation on every other floor of a non-metallic pipe riser in a shaft and every third floor for metallic pipe risers in a shaft.

1.5 Submittals

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

.2 Submit data on all materials.

.3 Shop Drawings:

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

.2 Submit shop drawings sealed by a professional engineer.

.4 Product Data:

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

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

.5 Design Data:

.1 Indicate criteria and show calculations.

.2 Submit sizing methods calculations sealed by a professional engineer.

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

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

.8 Welders' Certificate: Provide welders' certificate.

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

.10 Operation and Maintenance Data:

.1 Submit adjustment instructions.

1.6 General Requirements

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

.2 Provide expansion compensation for all closed piping systems including but not limited to: chilled water and all other closed piping systems that operate at varying temperatures.

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

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

.5 Expansion Compensation Design Criteria:

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

.2 Chilled Water: 5°C (42°F).

.3 Safety factor: 30%.

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

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

1.7 Warranty

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

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Flexible Metal Hose

.1 Steel Piping:

.1 Inner Hose: Stainless Steel convoluted bellows.

.2 Exterior Sleeve: Double braided stainless steel.

.3 Suitable for system operating temperatures and pressures.

.4 Joints: As specified for pipe joints.

.5 Size: Use pipe-sized units.

.6 Maximum offset: 20mm (3/4”) on each side of installed center line per linear 300mm (12”) of flexible connector length.

.7 Application: Steel piping ½ NPS to 14 NPS.

2.3 Flexible Pipe Connectors

.1 Restrained Double Sphere Elastomer Type:

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

.2 Reinforced with an external ring between spheres.

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

.4 Bridge bearing quality Neoprene or EPDM.

.5 Suitable for outdoor installation.

.6 Suitable for system operating temperatures and pressures.

.7 Joints: As specified for flanged pipe joints.

.8 Size: Use pipe-sized units.

.9 Cable or control rods require washer bushings to absorb a thrust of 6,800kPa (1,000psi).

.10 Control rods shall be used on all flexible pipe connectors when not anchored on both sides of the connector.

.11 Application: Chilled water and condenser systems only. Steel piping 2 NPS to 12 NPS.

2.4 Expansion Joints

.1 Stainless Steel Bellows Type:

.1 Corrugated, packless.

.2 Stainless steel guide sleeves.

.3 Cover over external surfaces.

.4 Suitable for system operating temperatures and pressures.

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

.6 Maximum Extension: 6mm (1/4”).

.7 Joint: As specified for piping system.

.8 Size: Use pipe sized units.

.9 Accessories: limit stops.

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

.2 External Ring Controlled Stainless Steel Bellows Type:

.1 Suitable for system operating temperatures and pressures.

.2 External cast iron control rings.

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

.4 Maximum Extension: 9mm (3/8”).

.5 Maximum Offset: 3mm (1/8”).

.6 Joint: As specified for flanged pipe joints.

.7 Size: Use pipe sized units.

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

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

.3 Groove End Type:

.1 Slip type.

.2 Packless, gasketed, telescoping body and slip pipe section.

.3 Suitable for system operating temperatures and pressures.

.4 Size: Use pipe sized units.

.5 Consists of a series of grooved end pipe nipples joined in tandem with Victaulic Style 77 flexible couplings.

.6 Application: Axial movements. Steel piping 2 NPS and larger.

2.5 Expansion Compensators.

.1 Steel Pipe Expansion Compensator:

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

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

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

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

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

.6 Joint: As specified for piping system.

.7 Size: Use pipe sized units.

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

2.6 Pipe Alignment Guides.

.1 Heavy gauge pressed steel with precision drilled bolting.

.2 Black enamel paint coated.

.3 The interface with the copper tube shall be coated with a permanent dielectric material.

.4 Accommodate specified insulation thickness.

.5 Vapour barriers, jackets to remain uninterrupted.

.6 Suitable for system operating temperatures.

.7 Application: Copper or steel piping 1 NPS and larger.

.8 Provide as per manufactures instructions.

2.7 Pipe Anchors.

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

2.8 Expansion Loops

.1 Provide expansion loops as required.

.2 The three legs of the expansion loop shall be equal unless indicated otherwise.

.3 Cold springing of the expansion loop up to 50% of the expansion travel is allowable.

3. EXECUTION

3.1 General

.1 Install to manufacturer's instructions.

.2 Provide all piping systems with provision for expansion.

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

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

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

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

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

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

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

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

3.2 Flexible Metal Hose

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

.2 Protect the hose from torque damage during installation.

3.3 Expansion Joints

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

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

.3 Locate expansion joints centrally between anchors.

.4 Bellows Type:

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

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

.5 Sleeve Type:

.1 Provide structure for base mounted units.

.2 Pack joints after installation.

3.4 Pipe Alignment Guides

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

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

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

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Materials and installation for meters, thermometers and pressure gauges in piping systems.

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 09 00 – Instrumentation and Control for HVAC

1.3 References

.1 The latest revisions of the following standards shall apply

.2 American Society of Mechanical Engineers (ASME).

.1 ASME B40.100 Pressure Gauges and Gauge Attachments.

.2 ASME B40.200 Thermometers, Direct Reading and Remote Reading.

.3 Canadian Standards Association

.1 CSA C22.2 No. 61010-1 Electrical Equipment for Measurement, Control and Laboratory Use; Part 1: General Requirements

.2 CAN/CSA-C22.2 No. 157 Intrinsically Safe and Non-incendive Equipment for Use in Hazardous (Classified) Locations.

.3 CSA C22.2 No. 213 Non-incendive Electrical Equipment for use in Class I, Div. 2 Hazardous Locations.

1.4 Submittals

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

.2 Submit manufacturer's product data for following items:

.1 Pressure gauges.

.2 Pressure gauge taps

.3 Thermometers.

.4 Wells.

.5 Test plugs

.6 Test thermometer

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

.1 Select thermometers and pressure gauges so that their operating range falls in the middle half of the scale range.

2.3 Pressure Gauges

.1 Case & Ring: 115 mm (4½"), cast aluminum, black steel or stainless steel case with stainless steel or chrome plated face ring.

.2 Lens: Shatter-proof acrylic.

.3 Dial: Aluminum with white finish and black markings, both IP and metric graduations.

.4 Pointer: Adjustable type, aluminum with black finish.

.5 Movement: Rotary type bushed movement, silicone dampened to prevent pointer oscillation.

.6 Pressure Element Assembly: Phosphor bronze bourdon tube.

.7 Connection: Brass, 6 mm (1/4") NPT, bottom-outlet.

.8 Accuracy: Plus or minus one percent of entire range (ASME B40.1 Grade A).

.9 Scale: Dual units, Kilopascal and psig.

.10 Listing:

.1 Registered with Provincial Boiler and Pressure Vessel Safety Branches with CRN number.

.11 Accessories:

.1 Install a needle valve ahead of each gauge.

.2 Install a pressure snubber ahead of each gauge.

.3 Install an anti-syphon loop (suitable for steam pressure) ahead of each gage on steam systems.

2.4 Differential Pressure Gauges

.1 Magnehelic: 90 mm (3½") diameter dial in case, diaphragm actuated, black figures on white background, front recalibration adjustment, (inclined type manometer and tubing, static pressure tips, and mounting assembly.

2.5 Pressure Gauge Taps

.1 Needle Valve: Brass, 6mm (1/4") NPT for minimum 2068 kPa (300 psi).

.2 Ball Valve: Brass 6mm (1/4") NPT for 1724 kPa (250 psi).

.3 Pulsation Damper: Pressure snubber, brass with 6mm (1/4") NPT connections

2.6 Thermometers – Piping

.1 Case: cast aluminum alloy with anodized, powder coat or baked enamel finish.

.2 Lens: Clear glass or heat resistant acrylic window.

.3 Scale:

.1 225 mm (9 inch) scale length.

.2 White background with temperature range in black

.3 Dual Celsius and Fahrenheit scale.

.4 Tube: non-toxic organic filled (non-mercury).

.5 Adjustable Fitting: 180° adjustment in vertical plane and 360° adjustment in horizontal plane.

.6 Connection: 30mm (1 1/4") threaded brass coupling nut.

.7 Stem: Aluminum, tapered to fit standard thermowells, packed with heat transfer paste to provide maximum temperature response.

.8 Accuracy: plus or minus one percent of full scale.

2.7 Thermometer Wells

.1 Material:

.1 Copper Pipe: Copper or bronze.

.2 Steel Pipe: Brass.

.2 Size: 20 mm (3/4") NPT.

.3 Brass separable sockets for thermometer stems with or without extensions, and with cap and chain. Provide extensions as required.

.4 Registered with Provincial Boiler and Pressure Vessels Safety Branch with CRN number.

2.8 Test Plugs for Pressure / Temperature

.1 6 mm (1/4") NPT solid brass test plug fitting and cap for receiving 3 mm (⅛") O.D. pressure or temperature probe.

.2 Dual seal core, Nordel EPDM, suitable for temperature of 177°C (350°F) and rated for zero leakage from vacuum to 6895 kPa (1000 psi).

.3 Provide one (1) master test kit containing:

.1 One (1) gauge adaptor, 3 mm (1/8") O.D. probe.

.2 Two (2) test pressure gauge of suitable range

.3 Two (2) stem pocket testing thermometers of suitable range.

2.9 Test Thermometer

.1 Hand over a test thermometer in protective case to the Owner during the Owner's Demonstration and Instruction Period. Provide the same make and type as the permanently installed thermometers suitable for use with pipe mounted wells. Range 0°C to 115°C. (30°F to 240°F).

.2 Obtain two signed receipts from the Owner certifying that the test thermometer has been received. Hand one over to the Owner's Consultant.

3. EXECUTION

3.1 Application

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

3.2 Installation

.1 Install thermometers and gauges so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.

.2 Install between equipment and first fitting or valve.

.3 Install engraved lamacoid nameplates as specified in Section 23 05 23 – Identification, identifying medium.

.4 Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

3.3 Pressure Gauges

.1 Install pressure gauges with pulsation dampers for liquid service. Provide gauge cock or needle valve to isolate each gauge. Extend nipples to allow clearance from insulation.

.2 Provide one compound pressure gauge per pump. Install taps on pump suction, pump discharge and before strainer. Pipe to gauge with needle valve on each tap.

.3 Use extensions where pressure gauges are installed through insulation.

.4 Provide positive pressure gauges as indicated on the drawings and in the following locations:

.1 Expansion tanks.

.2 Pressure reducing valves – both sides.

.5 Provide compound pressure gauges as indicated on the drawings and in the following locations:

.1 Pumps.

3.4 Differential Pressure Gauges

.1 Provide filter differential pressure gauges as indicated on the drawings

3.5 Thermometers

.1 Install in wells on piping. Provide heat conductive material inside well.

.2 Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 65 mm (2½") for installation of thermometer sockets. Ensure sockets allow clearance from insulation.

.3 Install thermometers in air duct systems on flanges.

.4 Install thermometer sockets adjacent to control systems thermostat, transmitter, or sensor sockets.

.5 Use extensions where thermometers are installed through insulation.

.6 Provide stem type thermometers as indicated on the drawings and in the following locations:

.1 Headers to central equipment.

.2 Coil banks at inlet and outlet.

.3 Chillers at inlet and outlet.

.7 Provide dial type thermometers as indicated on the drawings and in the following locations:

.1 After coils in air systems.

3.6 Thermometer Wells

.1 Install wells for balancing purposes.

.2 Install wells where indicated for use with test thermometers.

.3 Provide thermometer wells as indicated on the drawings and in the following locations:

.1 All lines to three-way control valves.

.2 Individual return lines from cooling coils.

3.7 Pressure / Temperature Ports

.1 Install pressure/temperature ports into threaded pipe nipples welded to wall of pipe. Locate fittings in accessible spaces.

.2 Provide one pressure / temperature port test kit.

.3 Coordinate locations with the balancing agent to ensure all ports are provided as required for testing and balancing services.

.4 Install pressure / temperature ports in the following locations:

.1 Both sides of two-way control valves.

.2 All lines to three-way control valves.

.3 Cooling coils: At common inlet and outlet of each coil.

.4 Chiller: At inlet and outlet of chilled water and condenser water.

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 Piping

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

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

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

1.4 Submittals

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

.1 Submit shop drawings for:

.1 Bases, hangers and supports.

.2 Connections to equipment and structure.

.3 Structural assemblies.

.2 Certificates:

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

.3 Manufacturers' Instructions:

.1 Provide manufacturer's installation instructions.

1.5 General Requirements

.1 Plumbing piping: to BC Plumbing Code

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

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

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

.5 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.

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

.7 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.

.8 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 49 - Seismic Restraint for HVAC Piping and Equipment.

.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 HVAC.

.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 hot 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 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.

2.6 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.

2.7 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

2.8 Equipment Supports

.1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel. Submit calculations with shop drawings.

2.9 Equipment Anchor Bolts and Templates

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

2.10 Other Equipment Supports

.1 Fabricate equipment supports from structural grade steel

.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)		

3.4 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 and equipment.

.2 Equipment isolation bases.

.3 Flexible piping connections.

.4 Seismic restraints for isolated equipment.

.5 Seismic restraints for non-isolated equipment.

.6 Certification of seismic restraint designs and installation supervision.

.7 Certification of seismic attachment of housekeeping pads.

1.2 Related Requirements

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

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

1.3 References

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

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

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

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

.1 VISCMA – Installing Seismic Restraints for Mechanical Equipment.

1.4 Submittals

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

.1 Consultant Assurance of Professional Design and Commitment for Field Review Schedule B and Assurance of Professional Field Review and Compliance Schedule C-B 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 British Columbia

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

1.5 General Requirements

.1 All mechanical equipment, piping 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.

.3 Responsibilities:

.1 The Contractor shall retain the services of a qualified professional seismic engineer (Seismic Engineer) registered in the Province of British Columbia. The Seismic Engineer shall design and review the installation of all seismic restraints as well as mechanical equipment and mechanical system supports. The restraints and supports shall be specifically designed to fasten to the structure indicated in the contract documents and installed in the field. The complete design for these systems shall comply with all applicable building code requirements.

.2 Seismic Engineer shall provide and submit to the Owner's Consultant Assurance of Professional Design and Commitment for Field Review Schedule B and Assurance of Professional Field Review and Compliance Schedule C-B for seismic engineering.

.3 Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

.1 Determine vibration isolation and seismic restraint sizes and locations.

.2 Provide vibration isolation and seismic restraints as scheduled or specified.

.3 Provide calculations and materials if required for restraint of non-isolated equipment.

.4 Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

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

.5 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.

.6 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.

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

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

.9 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.

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

.11 Use ductile materials in all vibration isolation equipment.

.12 Isolators:

.1 Provide neoprene isolators for deflections 6mm ($^1/_4$") 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.

.13 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 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.

.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.

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 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.

2.4 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.

2.5 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.

2.6 Spring Floor Mounts

.1 Spring isolators built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of 6mm ($^1/_4$") travel in all directions before contacting the resilient snubbing collars.

.2 Molded neoprene cup or $^1/_4$" (6mm) neoprene acoustical friction pad between the baseplate and the support.

.3 All mountings shall have leveling bolts that must be rigidly bolted to the equipment.

.4 Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

2.7 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.

2.8 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.

2.9 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.

2.10 Spring Hangers

.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 Colour coded springs, rust resistant, painted box type hangers.

2.11 Neoprene Hanger Isolators

.1 Neoprene double deflection rod isolators with steel housing and hanger rod bushing, selected for a minimum 4 mm (0.15") static deflection unless otherwise specified.

2.12 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 All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three leveling valves to maintain leveling within plus or minus 3mm (⅛").

.4 Suitable for outdoor installation.

2.13 Seismic Snubbers

.1 All 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.

2.14 Pipe Riser Anchor

.1 Telescoping all direction acoustical pipe anchors consisting of two concentric steel tubes separated by 12 mm (½") thick neoprene isolation material.

.2 Provide hot application isolators as required.

2.15 Bases – 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").

2.16 Bases – 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").

2.17 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.

2.18 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.

2.19 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

2.20 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.

2.21 Anchor Bolts

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

2.22 Flexible Piping Connections

.1 Flexible piping connectors are to be supplied with seismic restraint materials. Where flexible connections are not specified with piping in other Sections they are to be equal to Mason Industries twin sphere, non-metallic connectors with hose lengths pre-set in strict accordance with manufacturer's instructions and to approval of Seismic Consultant, each rated for continuous operation at 1725 kPa at 87.7°C (250 psi at 190°F) or 1380 kPa at 121°C (200 psi at 250°F), and complete with:

.1 Nylon tire cord reinforced EPDM body;

.2 Ductile iron reinforcing ring and ductile iron screwed or flanged connections as required and to suit piping system operating pressure.

2.23 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.

.5 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

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	
Glycol Tanks	SCR	4	Attach to removable steel strap yoke
Chillers			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
On roof curb	BTRC	4	Roof curb bolted to roof.
Piping	SCR TSR	As required	As per Specification

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

.6 Seismic restrain all piping as follows:

.1 Seismically restrain all piping as follows:

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

.2 All other piping 2 ½ NPS and larger.

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

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

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

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

.8 Unless otherwise specified, vibration isolation products are to be product of one manufacturer.

.9 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.

.10 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").

.11 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;

.7 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").

.8 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.

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

.10 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.

.11 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.

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

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

.14 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.

.15 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.

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

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

.18 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. 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. 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.

.19 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.

3.2 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.

3.3 Rubber Floor Mounts

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

.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.

3.4 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.

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

3.5 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.

3.6 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 except use rubber floor mounts for slab on grade installations.

3.7 Seismic Snubbers

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

3.8 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").

3.9 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.

3.10 Flexible Piping Connectors

.1 Supply flexible piping connectors for connections (including plumbing) to seismically restrained equipment. Hand connectors to appropriate piping trade at site for installation.

3.11 Flexible Duct Connectors

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

3.12 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).

3.13 Field Quality Control

.1 Seismic Engineer:

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

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

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

.2 Manufacturer's Field Services:

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

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

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

.2 Upon completion of installation.

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

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

END OF SECTION

1. GENERAL

1.1 Section Scope

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

1.2 Related Requirements

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

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

1.3 References

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

.2 Canadian General Standards Board (CGSB):

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

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

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

1.4 Submittals

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

.1 Submit data on all materials.

1.5 General Requirements

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

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

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

.4 Submit list of system and component labels to be 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 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.

.4 Extent of background colour marking:

.1 To full circumference of pipe or insulation.

.2 Length to accommodate pictogram, full length of legend and arrows.

.5 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).

.6 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
Chilled Water Supply	Blue	CHILLED SUPPLY CHWS
Chilled Water Return	Blue	CHILLED RETURN, CHWR
Make Up Water	Yellow	MAKE UP WTR

2.6 Valves, Controllers Identification

.1 Provide valve identification and secure with non-ferrous chain or "S" hooks suitable for the system temperature.

.2 Identification tags shall be of brass, aluminum, metalphoto, lamicoid or fiberglass, stamped or engraved with 12mm (½") high identifier markings.

.3 Tag the following valves as a minimum:

.1 Valves on main piping circuits.

.2 Valves on major branch lines.

.3 Valves on minor branch lines in horizontal or vertical service spaces and mechanical rooms.

.4 Drain valves and hose bibbs on systems containing glycol.

.5 Control valves.

.4 Do not tag the following valves:

.1 Valves on control valve stations.

.2 Valves on steam trap stations.

.3 Plumbing fixture stops or hose bibbs.

.4 System drain valves.

.5 Provide a valve tag schedule. Include in the identification of each tagged item, valve type, service, function, normal position and location of tagged item.

.6 Provide a flow diagram for each system, reference applicable charts and schedules.

2.7 Controls Components Identification

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

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

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

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

.5 All BMS wire and cable shall be identification tagged. Wire/cable shall be identification tagged at every termination location. Wire/cable and tubing terminating at distributed control panels (DCP) and application specific controllers (ASC) shall be tagged with the DCP/ASC controller termination number. Wire/cable and tubing terminating at field devices shall be tagged with both the DCP/ASC number and the DCP/ASC termination number. At any splices or terminal strips between the field device and DCP/ASC, the wiring shall be tagged on both sides of the termination point the same as for a field device termination.

2.8 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 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 HVAC to be numbered H-1, H-2, H-3…

END OF SECTION

1. GENERAL

1.1 Section Scope

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

.2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.

.3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges and document results.

1.2 Related Requirements

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

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

.3 Section 23 08 00 – Commissioning for HVAC.

1.3 References

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

.2 Associated Air Balance Council (AABC)

.1 National Standards for Total System Balance, MN-1.

.3 National Environmental Balancing Bureau (NEBB)

.1 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

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

.1 HVAC Systems – Testing, Adjusting and Balancing.

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

.1 ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality.

1.4 General Requirements

.1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.

.2 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this section.

1.5 Approved TAB Agencies

.1 Refer to Section 21 05 01 – Common Work Results for Mechanical - Acceptable Manufacturers These are listed under 23 05 01.

1.6 Qualifications of TAB Personnel

.1 Employ an approved independent testing and balancing agency to test and balance the following systems.

.2 Submit names of personnel to perform TAB to the Owner's Consultant within 15 days of award of contract. Provide documentation confirming qualifications, years of direct field testing and balancing experience and successful experience. Provide a list of a minimum of ten comparable projects successfully completed by all key members of the balancing team and the Standard under which the projects were completed.

.3 TAB shall be performed in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved:

.1 AABC – National Standards for Total System Balance, MN-1

.2 NEBB – Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

.3 SMACNA -HVAC Systems – Testing, Adjusting and Balancing

.4 Recommendations and suggested practices contained in the TAB Standard are mandatory.

.5 Use TAB Standard provisions, including checklists, and report forms to satisfy the Contract requirements.

.6 Where the instrument manufacturer's calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.

.7 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.

.1 For systems or system components not covered in TAB Standard, use TAB procedures developed by the TAB Specialist.

.2 Where new procedures, and requirements, are applicable to the Contract requirements, procedures shall have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), requirements and recommendations contained in these procedures and requirements are mandatory.

1.7 Exceptions

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

1.8 Submittals

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

.2 Preliminary TAB Report

.1 Submit for checking and approval of the Owner's Consultant, prior to submission of formal TAB report, sample of rough TAB sheets. Include:

.1 Details of instruments used.

.2 Details of TAB procedures employed.

.3 Calculations procedures.

.4 List of air and liquid systems to be TAB

.5 Summaries.

.3 TAB Report

.1 Format in accordance with referenced standards.

.2 TAB report to show results in SI units and to include:

.1 Project record drawings.

.2 System schematics.

.3 Date of test, Name and address of building and balancing technician's name.

.4 Range of outdoor air temperature during the balancing period.

.5 Main branch duct traverses. Maximum and minimum outdoor air quantities.

.6 Static pressure across each component in an air handling system at full flow.

.7 Static pressure across each fan.

.8 Fans: Tag, service and location, motor speed, fan specified and actual capacity. Fan motor size, starting time, amps and voltage.

.9 Pumps: Tag, service, location, manufacturer, model and size. Specified and actual flow and head pressure. Motor size, speed, amps and voltage.

.10 Cooling Coils: Tag, service and location. Specified and actual capacity, flow, fluid pressure drop, liquid entering and leaving temperatures, air-side entering and leaving temperatures and air flow.

.11 Chillers: Tag, location, manufacturer, model and size. Specified and actual capacity, fluid flow rates (condenser & evaporator), entering & leaving temperatures (condenser & evaporator), pressure drop (condenser & evaporator) & amps and voltage of compressor(s).

.12 Terminal cooling elements: Entering and leaving liquid temperatures, and flow rates

.13 Provide fan performance curve for each new air handling system and pump performance curve for each new pump system.

.3 Submit copies of TAB Report to the Owner’s Consultant for verification and approval.

1.9 Co-ordination

.1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule to ensure completion before acceptance of project.

.2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.10 Pre-TAB Review

.1 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

.2 Ensure devices are accessible and maintainable. Advise the installing Contractor of omissions or conflicts affecting the scope of this section.

.3 Review contract documents before project construction is started and confirm in writing to Consultant the adequacy of provisions for TAB and that other aspects of design and installation are pertinent to the success of TAB.

.4 Review specified standards and report to Consultant in writing describing any proposed procedures which vary from the standard.

1.11 Start-up

.1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.

.2 Follow special start-up procedures specified elsewhere in Divisions 21, 22, 23 and 25

2. PRODUCTS

2.1 Instruments

.1 Prior to TAB, submit to the Owner's Consultant a list of instruments used together with serial numbers.

.2 Calibrate in accordance with requirements of most stringent of referenced standards for applicable system.

.3 Calibration shall be within 6 months of TAB. Provide certificate of calibration to the Owner's Consultant.

3. EXECUTION

3.1 Start of TAB

.1 Notify the Consultant 7 days prior to start of TAB.

.2 Start TAB when building is essentially completed, including:

.1 Pressure, leakage, other tests specified elsewhere Division 23.

.2 Provisions for TAB installed and operational.

.3 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:

.1 Proper thermal overload protection in place for electrical equipment.

.2 Air systems:

.1 Filters in place, clean.

.2 Duct systems clean.

.3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.

.4 Correct fan rotation.

.5 Fire, smoke, volume control dampers installed and open.

.6 Coil fins combed, clean.

.7 Access doors, installed, closed.

.8 Outlets installed, volume control dampers open.

.3 Fluid systems:

.1 Flushed, filled, vented.

.2 Correct pump rotation.

.3 Strainers in place, baskets clean.

.4 Isolating and balancing valves installed, open.

.5 Calibrated balancing valves installed, at factory settings.

.6 Chemical treatment systems complete, operational.

3.2 Tolerances

.1 Application Tolerances:

.1 Do TAB to following tolerances of design values:

.1 Laboratory/Healthcare HVAC systems: plus 10%, minus 0%.

.2 General HVAC systems: plus or minus 5%.

.3 Hydronic systems: plus or minus 10%.

.2 Accuracy Tolerances:

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

.3 Site Tolerances:

.1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.

.2 Leakage tests on following systems not to exceed specified leakage rates.

.3 Small duct systems up to 250Pa (1”WC): leakage 2%.

.4 Large low pressure duct systems up to 500Pa (2”WC): leakage 2 %.

.5 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

3.3 Testing

.1 Test ducts and piping before installation of insulation or other forms of concealment. Do not externally insulate or conceal work until tested and approved.

.2 Test after seals have cured.

.3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.

.4 Conduct tests in presence of the Owner’s Consultant or Owner’s representative.

.5 Bear costs including retesting and making good.

.6 Refer to Piping Sections for specific test requirements.

.7 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.

3.4 Air System Procedure

.1 Perform balancing, adjusting and testing with building doors and windows in their normal operation position.

.2 Perform drop test on all fire dampers and reset to open position.

.3 The following procedure shall be adopted for central systems:

.1 Ensure dampers or volume control devices are in fully open position.

.2 Balance central apparatus to ±10% air flow.

.3 Balance branches, mains to ±10% air flow.

.4 Recheck central apparatus.

.5 Balance all terminal air outlets to ±10%.

.6 Rebalance central apparatus to ±5%.

.7 Recheck all air outlets.

.8 Perform acoustical measurements.

.9 Perform building pressurization tests and measurements at minimum and maximum outdoor air damper positions of the main air unit(s).

.4 When balancing air outlets:

.1 Rough balance furthest outlets and then balance sequentially back to source.

.2 Fine balance furthest outlet back to source.

.5 Take static pressure readings and air supply temperature readings at 10 points on each air system.

.6 Make air quantity measurements in ducts by "Pitot Tube" traverse of entire cross sectional area. If readings are inconsistent across duct, relocate to two duct *diameters *widths and re-do traverse.

.7 Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control only by duct internal devices such as dampers and splitters.

.8 Vary total system air quantities by adjustment of fan speeds. Vary branch air quantities by damper regulation.

.9 The final balanced condition of each area shall include testing and adjusting of pressure conditions. Test and record building pressurization levels in the aquatic space throughout full range of fan delivery rates, under both clean & dirty filter conditions. Document abnormal building leakage conditions noted.

.10 Complete balancing to achieve positive building pressure with respect to lobby. A positive pressure relative to outside of 10 Pa minimum and 20 Pa maximum shall be achieved, measured with negligible outside wind velocity.

.11 Adjust building zones to achieve the following pressure differentials:

.1 Aquatic space to be negative to lobby.

.2 Aquatic to be neutral to change rooms.

.3

3.5 Balancing of Hydronic Systems

.1 Open all (except pressure bypass must be closed) valves to fully open position including balancing valves, isolation valves, and control valves.

.2 Execute air balance prior to initiating hydronic balance (if coils are provided).

.3 Set pumps to deliver 10% excess flow if possible.

.4 Adjust flows through each boiler or chiller to ensure equal flow.

.5 Check and adjust flows and temperatures at inlet side of coils.

.6 Position and mark all automatic valves, hand valves and balancing cocks for design flow through all coils, connectors and all items in system requiring circulation of chilled water or glycol.

.7 Upon completion of flow readings and coil adjustments, mark setting and record data.

.8 Coordinate shaving of impellor to operating condition on pumps larger than 1.5 kW. (2 Hp).

.9 Ensure all bypass valves are tightly closed.

.10 After making all terminal unit adjustments, re-check settings at pumps. Re-adjust as required.

.11 Calibrate all pressure and temperature gauges.

.12 Install pressure gauges on each coil then read pressure drop through coil and set flow rate on call for full flow through coil. Set pressure drop across bypass valve to match coil full flow pressure drop.

.13 For all parallel pumping systems, check all flows through boiler, chiller, heat exchanger, and pumps under the following situations.

.1 With two pumps operating.

.2 With one pump operating - repeat for each pump.

.3 With controls demanding no cooling.

.14 For each pump, plot maximum and minimum flows on curve.

3.6 Verification

.1 Reported results subject to verification by the Owner's Consultant.

.2 Provide personnel and instrumentation to verify up to 30% of reported results.

.3 Number and location of verified results as directed by the Owner's Consultant.

.4 Pay costs to repeat TAB as required to satisfaction of the Owner's Consultant.

3.7 Settings

.1 After TAB is completed to satisfaction of the Owner's Consultant, replace drive guards, close access doors, lock devices in set positions, ensure sensors are at required settings.

.2 Permanently mark settings to allow restoration at any time during life of facility. Do not eradicate or cover markings.

3.8 Completion of TAB

.1 TAB is considered complete when final TAB Report received and all results are accepted by the Owner's Consultant.

END OF SECTION

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

.8 Declare – Living Building Challenge (LBC), Red List

1.4 Submittals

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

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

.2 Manufacturer's installation instructions.

1.5 General Requirements

.1 The Installation firm shall be a current member of the Thermal Insulation Association of Canada (TIAC).

.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 Pumps (chilled)

.3 Expansion Tanks

.4 Air Eliminators

.5 Engine silencer and exhaust

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.

.9 Products shall be either Declare LBC Red List free or LBC compliant.

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 (55°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 Fastenings, Adhesives and Coatings

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

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

.2 All openings, joints and seams shall be sealed with self adhesive vapor retardant tape. Insulation shall be fitted neatly to all contours without voids.

3.4 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 a 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.

3.5 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		
Chiller components subject to condensation	25	1	A-6	TIAC 1503-C
expansion tanks - chilled water	50	2	C-2	TIAC 1503-C
pumps - chilled water	25	1	A-6	TIAC 1503-C
Expansion joints ①	50	2	C-2	TIAC 1503-H
condensate - flash tank	50	2	A-2 or C-2	TIAC 1503-H
Chiled Water Coil Frames	50	2	C-1 or C-2	TIAC 1503-H
Removable insulated cover type application				

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

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

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Thermal insulation and jacketing for HVAC piping and HVAC piping accessories.

1.2 Related Requirements

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

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

1.3 References

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

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

.3 National Energy Code of Canada for Buildings [2011][2015].

.4 ASHRAE 90.1 – 2010 Energy Standard for Buildings Except Low Rise Residential Buildings.

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

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

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

.8 ASTM C547 – Standard Specification for Mineral Fibre Pipe Insulation.

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

.10 Declare – Living Building Challenge (LBC), Red List.

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

.2 Manufacturer's installation instructions.

.3 Manufacturer’s declaration that products are either Declare – Living Building Challenge (LBC), Red List free or LBC compliant.

1.5 General Requirements

.1 The Installation firm shall be a current member of the Thermal Insulation Association of Canada (TIAC).

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

.3 Definitions:

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

.2 "EXPOSED" will mean not concealed.

.3 “K” value means Thermal Conductivity.

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

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

.6 SSL: Self-Sealing Lap.

.7 FSK: Foil Scrim Kraft; jacketing.

.8 PSK: Poly Scrim Kraft; jacketing.

.9 PVC: PolyVinyl Chloride.

.4 Insulate Chilled water piping, refrigerant piping, fittings and valves shall be insulated and vapour sealed unless noted otherwise. This includes:

.1 Chilled water supply and return.

.5 Provide removable Insulation c/w vapour seal the following fittings, if the pipe is insulated:

.1 Elbows, tees, reducers.

.2 Valves, (bodies and bonnets) except check valve covers.

.3 Strainers.

.4 Flanges.

.5 Unions.

.6 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.

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

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

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

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

.3 Thermal conductivity ("k" factor) not to exceed specified values when tested in accordance with ASTM C547

.4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88 and NFPA 90A

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

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

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

.8 Products shall be either Declare LBC Red List free or LBC compliant.

2.3 Preformed Pipe Covering

.1 Low Temperature Thermal Insulation

.1 Piping service temperature -40°C to 5°C (-40°F to 41°F)

.2 Complying with ASTM C534

.3 Preformed and pre-slit flexible foamed elastomeric insulation with self-adhesive self seal or lap seal joints:

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

.4 Preformed flexible closed cell insulation:

.1 Maximum “K” value at 24°C (75°F) = 0.036 W/m.°C (0.24 Btu.in/hr.ft2.°F)

.5 Phenolic closed cell preformed rigid insulation with all service jacket vapour retarder (ASJ). ASJ shall be re-enforced with glass fibre, factory applied with pressure sensitive lap closure.

.1 Maximum “K” value at 24°C (75°F) = 0.019 W/m.°C (0.13 Btu.in/hr.ft2.°F)

.2 Low to Intermediate Temperature Thermal Insulation

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

.2 Preformed insulation, mineral glass wool pipe insulation with all service jacket vapour retarder (ASJ). ASJ shall be re-enforced with glass fibre, factory applied with pressure sensitive lap closure.

.3 Complying with ASTM C547.

.4 ASJ vapour transmission rate 0.02 perms maximum

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

2.4 Fastenings, Adhesives and Coatings

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

.2 Jacket Fastenings:

.1 Thermocanvas and All Service Jacket:

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

.2 Metal Jackets:

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

.3 PVC Jacket and Fitting Covers:

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

.3 Adhesives:

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

.4 Coatings:

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

2.5 Finish Jackets

.1 Jackets:

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

.2 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.

.4 Stainless Steel: 0.25m thick [304][316] [smooth] [corrugated] [stucco embossed] longitudinal slip and circumferential slip joints with 0mm lasp, 19mm wide metal banding, 0.5mm thick, 300mm spacing

.2 Preformed Fitting Covers:

.1 PVC Fitting Covers pre-moulded one piece covers, white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02") thick.

.2 Aluminum Fitting Covers: Die shaped components with factory applied protective liner on interior surface, 0.51 mm (22 ga.) thick,

3. EXECUTION

3.1 General

.1 Install in accordance with 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 Install hangers, supports outside vapour retarder jacket.

.7 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

.8 Ensure insulation is continuous through inside walls. Pack around pipes with fire proof self-supporting insulation material, properly sealed.

.9 Insulate piping, fittings and valves. Provide removable Insulation for unions, flanges (except on flanged valves), “victaulic” couplings, strainers, flexible connections and expansion joints. Terminate insulation neatly with plastic material trowelled on a bevel.

.10 Locate insulation or cover seams in least visible locations. Locate seams on piping in ceiling spaces on the underside of the pipe.

.11 Terminate insulation 75 mm (3") back from all uninsulated fittings to provide working clearance. Terminate insulation at 90°, finish with reinforced scrim cloth and vapour barrier mastic system or use vapour barrier mastic and pre-formed fitting cover over.

.12 On vertical pipes over 3 NPS provide insulation supports welded or bolted to pipe, directly above the lowest pipe fitting. Provide supports on 4.5 m (15’) centres.

.13 Where insulation is not specified:

.1 Cold Piping: Coat exposed cold pumps, pipes, and fittings, connecting surfaces of thermometers, pressure gauges, flow switches, controllers, etc. with a No Sweat paint product to prevent condensation.

3.2 Installation Cold and Chilled Water Application - (5°C to 15°C) TIAC 1501-C

.1 Piping: Apply pipe insulation with integral vapor retarder jacket to piping and hold in place by securing the jacket flap. Seal all flaps and butt strips with vapor retarder adhesive. Pipe insulation with integral self-sealing vapor retarder jacket will not require additional fastening.

.2 Screwed or welded fittings: Insulate fittings with section of the pipe insulation mitered to fit tightly. All seams shall be sealed using vapor retarder tape.

.3 Valves, Strainers: Insulate valve bodies, bonnets and strainers with fitted pipe insulation or mitered blocks all to thickness of adjacent pipe insulation, then seal all seams of vapor retarder with vapor retarder tape.

.4 Flanged and grooved fittings: Insulate with oversized pipe insulation or mitered blocks to the thickness of the adjacent pipe insulation, then seal all seams of vapor retarder jacket with vapor retarder tape.

3.3 Finishes

.1 Concealed piping shall be left as factory finished, TIAC standard CPF/2.

.2 Exposed Piping Indoor (Canvas) CPF/1

.1 The factory applied integral all service jacket shall be neatly applied to receive the fabric jacket. Apply a jacket with a fire resistive lagging coating. Apply a finishing coat of fire resistive lagging coating

.3 Exposed Piping Indoor (PVC Jacket) CPF/4:

.1 Apply PVC jacketing using necessary fastenings on approximately 300mm centers, or bond using an adhesive recommended by the manufacturer to provide continuous seal. Overlap each section a minimum 75mm (3”). Cover longitudinal and circumferential joints with finishing tape neatly applied. On hot piping tacks may be used to secure jacket laps. Tacks are to be applied on 100mm (4”) centres.

.2 Over insulated fittings, valve bodies, valve bonnets, strainers and flanges apply PVC jacket or preformed PVC fitting covers to provide a complete jacket system. Secure with appropriate fastenings and jacket finishing tape.

.4 Exposed Piping Outdoor - Aluminum CPF/3

.1 Apply aluminum jacketing with a 60mm overlap at 3 o'clock using necessary fastenings on approximately 150mm centers.

.2 Over insulated fittings, valve bodies, valve bonnets, strainers and flanges apply aluminum jacket or preformed metal fitting covers to provide a complete jacket system. Secure with necessary fastenings.

.5 Exposed Piping Outdoor (Mastic) CPF/5

.1 On glass mineral wool style insulation, apply a coat (minimum 1 litre per 1.5 m) of weather coating over the insulated surfaces. While still wet, embed a layer of reinforcing membrane and finish with a final coat (minimum 1 liter per 1.5 m) of weather coating.

.2 On elastomeric style insulation provide two (2) coats of Armaflex WB finish or equivalent weather resistant coating. Coverage shall be a per manufacturers recommendations.

3.4 Application Design Operating Temperatures

.1 Chilled Water 7°C (44°F)

3.5 Piping Insulation Minimum Thickness Schedule

Type Of System	Design Operating Temperature Range °C (°F)	Thermal Conductivity of Insulation		Nominal Pipe Diameter NPS				
		Conductivity Range W/m.°C	Mean Rating Temperature °C (°F)	Runouts ≤ 1	1 to 1.25	1.5 to 3	4 to 6	≥ 8
				Minimum Thickness of Piping Insulation (mm)				
Cooling Systems (Chilled Water, Refrigeration)	5-13 (41-55)	0.033-0.039	24 (75)	25	25	25	25	25
	<5 (41)	0.029-0.037	10 (50)	25	25	25	25	40

Note: Where the thermal conductivity of a proposed insulation is greater than the range specified above, the thickness will be increased by the ratio of *U2/U1*.

U2 = proposed insulation "k" value at the table mean rating temperature.

U1 = upper range limit "k" value from the table above.

Note: Where thermal conductivity of proposed insulation is less than the range specified above, the thickness may be decreased by the ratio of U2/U1.

U2 = proposed insulation "k" value at the table mean rating temperature.

U1 = lower range limit "k" value from the table above.

3.6 Piping Finish Schedule

.1 Conform to the following:

Duty	Type	TIAC Code
Indoors, Concealed	Factory	CPF/2
Indoors, Exposed in Mechanical Room and Utility Areas	Canvas Jacket	CPF/1
Indoors, Exposed in Parkade and Elsewhere	PVC Jacket	CPF/4
Outdoors	Aluminum Jacket	CPF/3

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Section includes commissioning process requirements for HVAC&R 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 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 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 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 Division 25 Section “25 08 00 Commissioning of Integrated Automation” and “Sequence of Operations of HVAC Controls.”

.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 [oil] [gas] [steam] [chilled water] [hot-water] [and] [solar] 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. 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 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.

3.6 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 **20** 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 Sound or vibration sensitive neighborhood buildings

.7 Each space with a noise criterion of RC or NC 25 or lower.

.8 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.

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 29 – Hangers and Supports for HVAC Piping and Equipment

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

.5 Section 23 07 19 – HVAC Piping Insulation.

.6 Section 23 05 53 – Mechanical Identification.

.7 Section 23 25 00 – HVAC Water Treatment.

.8 Section 23 05 16 – Expansion Fittings and Loops for HVAC Piping.

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 B1.20.1, Pipe Threads, General Purpose.

.2 ASME B16.1, Cast Iron Pipe Flanges and Flanged Fittings.

.3 ASME B16.3, Malleable Iron Threaded Fittings.

.4 ANSI/ASME B16.4, Gray-Iron Threaded Fittings.

.5 ASME B16.5, Pipe Flanges and Flanged Fittings.

.6 ASME B16.9, Factory-Made Wrought Butt welding Fittings.

.7 ANSI/ASME B16.15, Cast Bronze Threaded Fittings.

.8 ANSI/ASME B16.18, Cast Copper Alloy, Solder Joint Pressure Fittings.

.9 ANSI/ASME B16.22, Wrought Copper and Copper-Alloy Solder Joint Pressure Fittings.

.10 ASME B18.2.1, Square and Hex Bolts and Screws

.11 ASME B18.2.2, Square and Hex Nuts.

.12 ASME B31.1, Power Piping.

.13 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 B242, Groove and Shoulder Type Mechanical Pipe Couplings.

.4 CSA W47.1, Certification of Companies for Fusion Welding of Steel.

.5 CSA W117.2, Safety in Welding, Cutting, and Allied Processes.

.6 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 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.

1.5 Quality Assurance

.1 All components, products and fabrication techniques shall be provided in compliance with the Regulations and Requirements of the Province of British Columbia "Power Engineers Boiler and Pressure Vessel Safety Act and Regulations".

.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 [the Regulations and Requirements of the Province of British Columbia "Power Engineers Boiler and Pressure Vessel Safety Act and Regulations"] [Alberta Boiler Saftey 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 B31.9 Code and the British Columbia Boiler and Pressure Vessel Act.

.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 coupling, fitting, and valve (body and component) castings shall 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.

.5 All grooved joint products shall comply with CSA B242.

1.6 Regulatory Requirements

.1 Comply with ASME B31.9, 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 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

.1 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, chemical feed, relief valve vents.

.3 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.

.1 Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.

.2 Rigid Type Coupling: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 121°C (250°F).

.1 Victaulic Style 107 or Victaulic Zero-Flex Style 07.

.3 Flexible Type Coupling: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 121°C (250°F). For use in locations where vibration attenuation and stress relief are required.

.1 Victaulic Style 77 or 177

.4 NPS 14 to 24: 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 121°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 A

.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.

.4 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 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 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

.4 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)

.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 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.

2.5 Automatic Flow Control Valves

.1 General: Devices shall automatically control the required flow quantity between differential pressure ranges of 14 to 310 kPa (2 to 45 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.

2.6 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.

2.7 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.

2.8 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.

2.9 Combination Balance/Check Valves

.1 Combination Balance/Check Valves are not acceptable.

2.10 Needle Valves

.1 Bronze body, screwed, globe type with cadmium plated steel stem.

.2 ANSI Class 400 (2760 kPa).

2.11 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.

2.12 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

2.13 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

2.14 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

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, 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 fittingsis 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 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.

3.6 Roll Groove Piping

.1 Use lubricant supplied 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.

3.7 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]. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

3.8 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.

3.9 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 Provide a piped drain connection for each low point in buried or encased ductwork. The duct drain (1/2`` dia. Type K copper tube with soldered fittings) shall be trapped and piped to an indirect waster fitting to the nearest floor drain. If the drain line can be terminated within a heated accessible space but not connected to a gravity drained system, a shutoff valve and downturned elbow shall be provided. If the low point drain cannot be piped to an indirect waste or a heated accessible space, the drain trap is to be 50 mm (2") diameter cast iron primed, vented, and connected to the sanitary waste system.

.4 Drains from drain pans shall be DWV copper NPS 1-1/4 minimum size.

.5 Drain and vent piping shall be of the same material as the piping system to which it is connected, except where otherwise specified.

3.10 Expansion of Piping

.1 Install all piping systems with due regard and provision for expansion avoiding strain or damage to equipment and building. Pay particular attention to piping running horizontal across building expansion joints and provide adequate expansion and contraction for all such piping.

.2 It is the contractor's responsibility to retain the services of a qualified professional engineer to design the thermal pipe expansion system for the actual installed layout of all piping systems covered by this specification section.

.3 The contractor is also required to review the architectural, structural and mechanical documents for the identification of ay seismic joints or seismic separations within the building structure that affects the installation of any mechanical systems. At each of these locations, allow for the design, supply, and installation of applicable mechanical system flexible connections along with support of these systems on each side of the seismic joint or separation. Refer to Section 23 05 16 Expansion Fittings and Loops for HVAC Piping.

.4 Install flexible piping connections to all equipment that contains rotating components including but not limited to: hydronic coils within fan powered terminal units, isolated boilers, entrance heaters that are externally isolated, air handling units that are externally isolated, isolated pumps, isolated pump packages, cooling towers, chillers, heat pumps, and all compressorized equipment. Refer to Section 23 05 48 Vibration Isolation for HVAC Piping & Equipment.

.5 Install at least three (3) elbows in all branch connections. Where space does not permit 3 elbows, install braided flexible pipe connectors in accordance with manufacturer's recommendations. Three (3) elbow branch connections shall have sufficient developed length to ensure that excessive stresses are not generated in the piping and in no case less than 900 mm (36").

3.11 Valves

.1 General

.1 Install all valves in accordance with manufacturer's recommendations.

.2 Install valves in accessible locations with stems upright or angled 45° above horizontal unless approved otherwise. Valves must be accessible without removing adjacent piping.

.3 Provide valves suitable to connect to adjoining piping as specified for pipe joints. Use line sized valves unless specifically noted otherwise.

.4 Remove interior parts before soldering.

.5 Provide stem extensions on all insulated valves.

.6 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.

.7 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 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]. [UBC projects only]

.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.

.5 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.

.6 Needle Valves:

.1 Install needle valves where petcocks or manual vents are indicated.

.7 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 ait 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 Dieletric Couplings

.1 Provide dielectric couplings, of suitable pressure rating for the system, where dissimilar metals are joined.

.2 NPS 2 and under: provide isolating unions or bronze valves.

.3 NPS 2-1/2 and larger: provide isolating flanges.

.4 Dielectric waterway fittings may be used in lieu of unions or flanged connections. Waterways shall be grooved and/or threaded end(s), with inert thermoplastic lining.

3.14 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.

3.15 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.

3.16 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.

3.17 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 and 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 331.3 process piping (if high pressure piping used)

.4 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.

3.18 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.

3.19 Filling of System

.1 Refill system with clean water adding water treatment as specified.

3.20 Chemical Treatment

.1 Chemically treat water systems in accordance with Section 23 25 00 HVAC Water Treatment.

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

1.1 Section Scope

.1 The provision of:

.1 Expansion tanks

.2 Air vents

.3 Air separators

.4 Pipe line strainers

.5 Suction guides,

.6 Relief valves

.7 Flexible hoses.

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 13 – Hydronic Piping

1.3 References

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

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

.2 American Society of Mechanical Engineers (ASME)

.1 ANSI/ASME B31 Standards of Pressure Piping

.2 ANSI/ASME Boiler and Pressure Vessel Code (BPVC), Section IV Heating Boilers.

.3 ANSI/ASME Boiler and Pressure Vessel Code (BPVC), Section VIII Pressure Vessels

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

.1 ASTM B62 Standard Specification for Composition Bronze or Ounce Metal Castings

.2 ASTM A278M Standard Specification for Gray Iron Castings for Pressure Containing Parts for Temperatures Up to 650°F (350°C)

.3 ASTM A536 Standard Specification for Ductile Iron Castings

.4 Canadian Standards Association (CSA International).

.1 CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.

.2 CSA B214 Installation Code for Hydronic Heating Systems.

1.4 Submittals

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

.1 Shop drawing data for:

.1 Expansion tanks

.2 Air vents

.3 Air separators

.4 Suction guides

.5 Relief valves

.6 Flexible hoses

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Diaphragm Type Expansion Tank – ASME Rated

.1 Provide ASME rated expansion tanks for systems with a working pressure exceeding 207 kPa (30 psig) or with a diameter exceeding 610 mm (24").

.1 Construction: Steel

.2 Finish: Red Oxide Primer

.3 Diaphragm: Replaceable Butyl/EPDM bladder

.4 Air Valve: Schrader Valve w/EPDM Seats

.5 Factory Pre-charge: 82 kPa (12 PSIG)

.6 Maximum Operating Temperature: 115°C (240°F)

.7 Maximum Working Pressure: 861 kPa (125 PSIG)

.8 Saddles for horizontal installation or base mount for vertical installation.

.9 Factory seismic restraint ring or factory welded anchor points

.10 Warranty: 1 Year

2.3 Automatic Air Vent

.1 Provide automatic float-type valves:

.1 Brass body, polypropylene float, nitrile disc

.2 NPS 1/8 or 1/2 connection

.3 Maximum Operating Temperature: 99°C (210°F)

.4 Maximum Working Pressure: 861 kPa (125 PS)

2.4 Manual Air Vents

.1 Provide manual air vents with NPS 1 or line diameter pipe, whichever is greater, to form air collection chamber 150 mm high.

.2 Provide a NPS ½ globe valve, bronze body union bonnet, threaded ends, stainless steel trim, plug type disc.

2.5 Manual Coin Vent

.1 Bronze or chrome plate steel body, screwed, hygroscopic cellulose discs

.2 Manual screwdriver operator.

.3 Internal ball check.

.4 Maximum Operating Temperature: 115°C (240°F)

.5 Maximum Working Pressure: 861 kPa (125 PS)

2.6 Air Separators

.1 Provide vertical, line size vortex type separator as scheduled on the drawings.

.2 NPS 3 and smaller screwed ends

.3 NPS 4 and larger flanged.

.4 Welded steel vessel to ASME Section VIII, Division 1

.5 Separator to include brass conical shaped air venting chamber, stainless steel strainer, automatic air vent at top of unit and bottom blowdown valve.

.6 Maximum working pressure: 860 kPa (125 PSIG)

.7 Maximum operating temperature: 115 °C (240 °F).

2.7 Pipe Line Strainer

.1 NPS 2 and smaller:

.1 Bronze body to ASTM B62

.2 Screwed connections

.3 Y pattern.

.2 NPS 2 ½ and larger:

.1 Cast ductile iron body to ASTM A536, Grade 65-45-12, grooved ends.

.2 Cast steel body to ASTM A278M, Class 30, flanged connections.

.3 Blowdown connection: NPS 1.

.4 Screen: stainless steel with 1.19 mm thru 3.2 mm perforations.

.5 Maximum working pressure: 2065 kPa (300psig).

2.8 Suction Guides

.1 Provide suction guides on the pump suction as scheduled on the drawings.

.2 NPS 1-1/2 and larger:

.1 Cast Iron body with ANSI 125 flanged ports.

.2 For 300 psig flanged pipe system: Ductile Iron body and ANSI 250 flanged ports.

.3 For grooved pipe system: Ductile Iron body with Grooved inlet and ANSI 125 flanged outlet connections.

.3 Outlet flow stabilizing guide vanes

.4 Removable Stainless Steel Strainer and Fine Mesh Start-up Strainer.

.5 NPS 1 blowdown connection.

.6 Pressure gauge tapings.

.7 Adjustable support leg or base support boss.

2.9 Combination Valve (Triple Duty Valve)

.1 Alternatively to individual components provide a single combination valve on the discharge of vertical inline and base mounted pumps.

.2 The combination valve shall include:

.1 Isolation valve

.2 Spring closure type silent non slam check valve

.3 Flow control and flow measurement device

.3 NPS 2-1/2 to 12

.1 Cast Iron body with ANSI 125 flanged ports.

.2 For 300 psig flanged pipe system: Ductile Iron body and ANSI 250 flanged ports.

.3 For grooved pipe system: Ductile Iron body with grooved inlet and outlet connections.

.4 The body shall have brass pressure and temperature metering ports, with Nordel check valves and gasketed caps and two other connections to be supplied with brass drain plugs.

.5 Metering ports are to be interchangeable with drain ports to allow for measurement flexibility when installed in tight locations.

.6 The valve disc shall be bronze plug & disc type with high impact resin seat.

.7 Stainless steel valve stem.

.4 Each valve shall be furnished with a pre-formed removable PVC insulation jacket to meet a flame spread rating of 25 and a smoke development rating of 50. Insulation shall meet ASHRAE 90.1

2.10 Pressure Relief Valves

.1 NPS ¾ to NPS 2

.1 Provide an ASME Section IV certified pressure relief valve as indicated in the contract drawings.

.2 Raised seat and non-mechanical disc alignment.

.3 Spring loaded, lever operated, non adjustable, factory set.

.4 Bronze or iron body with expanded outlets.

2.11 Flexible Hose Assemblies

.1 Provide flexible hose connections for connecting to air valve reheat coils, fan coil units etc.

.2 EPDM rubber inner core, stainless steel exterior braid, steel crimp ferrules and brass or bi-chromate steel threaded ends.

.3 Fixed male NPT one end and swivel male NPT other end.

.4 Minimum length: 600mm (24”)

.5 Maximum operating temperature 110^{o}C (230^{o}F).

.6 Maximum operating temperature: 115 °C (240 °F).

2.12 3 in 1 Hydraulic, Air and Dirt Separator

.1 Provide hydraulic separators where shown on the drawings to separate primary and secondary circuits in combination with air and dirt separation.

.2 Combination Air, Hydraulic and Dirt Separators: Provided with an epoxy resin painted steel body, 300 series stainless steel internal coalescing mesh, and a brass blow down drain valve on the bottom of the separator with particle separation capacity to 5 microns (0.2 mil). 100% air removal to microbubble level. Max. connection velocity 4 feet per second (1.2 m/s). All models provided with air vent isolated manually using a shut off ball valve.

.3 Up to 4inches (100mm) - ANSI B16.5 Class 150 RF flanged, 2 inches to 4 inches with pre-formed insulation, rigid closed cell expanded polyurethane foam.

.1 Maximum working pressure: 150 psi (10 bar).

.2 essel working temperature range w/ insulation: 32 degrees F to

.3 220 degrees F (0 degrees C to 105 degrees C).

.4 Vessel working temperature range w/o insulation: 32 degrees F to

.5 270 degrees F (0 degrees C to 132 degrees C).

.6 Suitable fluids: water or 50 percent maximum glycol solution.

.7 Flow rates: 37.3 gallons per minute to 149 gallons per minute (2.3 liters per second to 9.4 liters per second).

.4 ASME Registered up to 4 inces (100mm) - designed and built in accordance Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code and tagged and registered with the National Board of Boiler and Pressure Vessel Inspector, and CRN registered, and stamped for 150 psi (10 bar) working pressure, with ASME U stamp. ANSI B16.5 Class 150 RF flanged, 2 inches to 4 inches with pre-formed insulation, rigid closed cell expanded polyurethane foam.

.1 Maximum working pressure: 150 psi (10 bar).

.2 Vessel working temperature range w/ insulation: 32 degrees F to

.3 220 degrees F (0 degrees C to 105 degrees C).

.4 Vessel working temperature range w/o insulation: 32 degrees F to

.5 270 degrees F (0 degrees C to 132 degrees C).

.6 Suitable fluids: water or 50 percent maximum glycol solution.

.7 Flow rates: 37.3 gallons per minute to 149 gallons per minute (2.3 liters per second to 9.4 liters per second).

3. EXECUTION

3.1 General

.1 Comply with manufacturers written recommendations, including product technical bulletins, catalogue installation instructions and product carton installation instructions.

.2 Ensure adequate clearances are maintained for service and maintenance.

3.2 Automatic Air Vent

.1 Install automatic air vents at each high point in the piping systems and where shown on the drawings.

.2 Install on tees and not on horizontal pipe runs or elbows.

.3 Install a minimum NPS 1/2 isolation valve ahead of each air vent, unless air vent has an integral shut-off valve.

.4 Fit all vents on top of an air-collecting chamber.

.5 Pipe all air vent discharge connections, (except for glycol) separately, to the nearest building drain, using NPS 1/4 hard drawn copper tube. Label ends with permanent labels.

.6 Pipe all air vent discharge connections from the glycol circuit, separately back to the glycol mixing tank, using NPS 1/4 hard drawn copper tube.

3.3 Manual Air Vents

.1 Install manual air vents at high points in the piping systems and where shown on the drawings.

.2 Install on tees and not on horizontal pipe runs or elbows.

.3 Install an isolation valve ahead of each air vent.

3.4 Manual Coin Vent

.1 Provide manual coin vents on the return side of each water heating/cooling terminal element installed above the connection mains piping.

.2 Install air vents so that screwdriver slots are easily accessible.

.3 DO NOT USE on glycol systems.

3.5 Air Separators

.1 Provide air separators on the suction-side of the heating circulator(s).

.2 Make direct connection to suspended expansion tanks. Connection to floor mounted expansion tanks shall be made to the piping directly downstream of the air separator.

.3 Maintain a minimum of five (5) pipe diameters of straight run piping to the inlet and outlet connections of the air separator.

3.6 Pipe Line Strainer

.1 Provide isolation valves on either side of the strainer to facilitate cleaning without system drain down.

.2 Provide blow down connections as follows:

.1 Cold services: all sizes, plug

.2 Hot services: NPS 2 and under, nipple and cap

.3 Hot services: NPS 2-1/2 and larger, nipple, globe valve and nipple.

3.7 Suction Guides

.1 Provide suction guides on all pumps with an inlet size NPS 2-1/2 and larger.

.2 Maintain service space for strainer removal.

.3 Provide a blow-down globe valve.

.4 Remove the fine mesh start-up strainer after a short running period. (24 hours maximum).

3.8 Relief Valves

.1 Provide relief valves on pressure tanks, low pressure side of reducing valves, heating convertors, expansion tanks, boilers and where indicated elsewhere in the contract documents.

.2 Pipe all relief valve discharge connections, (except for glycol) separately, to the nearest building drain.

.3 Pipe all relief valve discharge connections from the glycol circuit, separately back to the glycol mixing tank or collection tank. Do not drain waste glycol to floor drains.

.4 System relief valve capacity shall equal make-up pressure reducing valve capacity.

.5 Equipment relief valve capacity shall exceed input rating of connected equipment.

.6 Equipment relief valve pressure rating shall be below the equipment maximum operating pressure rating.

.7 Where one vent serves several relief valves, the cross sectional areas shall exceed the sum of the individual vent areas.

3.9 Flexible Hose Assemblies

.1 Provide flexible hose assemblies for connections to air valve reheat coils, fan coil units, misaligned connections and where indicated elsewhere in the contract documents.

3.10 Flexible Hoses - Heat Pumps

.1 Provide flexible hoses on the supply and return loop piping connections to each heat pump.

.2 Provide unions and connections

.3 Utilize the flexible hoses to bypass heat pumps during pipe cleaning.

3.11 Hydraulic Separators

.1 Install hydraulic separators where shown on the drawings and as per manufacturer's installation instructions.

.2 Ensure that separator is independently supported if suspended from the structure otherwise separator shall be properly secured to a 100mm high housekeeping pad if complete with floor mounting supports.

.3 Separators to be provided with manufacturer supplied pre-formed shell insulation.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 The provision of heating water and chilled water circulation pumps

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 14 - Variable Frequency Drives.

.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 21 16 – Hydronic Piping Specialties.

.7 Division 26 – Electrical.

1.3 References

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

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

.2 ASHRAE Standard 90.1- 2010, Energy Standard for Buildings Except Low-Rise Residential Buildings.

.3 CAN/CSA-B214, Installation Code for Hydronic Heating Systems.

.4 Electrical Equipment Manufacturers Association of Canada (EEMAC).

.5 National Electrical Manufacturers' Association (NEMA) MG 1, Motors and Generators.

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 Manufacturer's Catalog Data, including specific model, type, and size for all pumps including:

.2 Pump connections, piping and fittings, valves, strainers, triple duty valves, suction guides, control assemblies and ancillaries, identifying factory and field assembled.

.3 Wiring as assembled and schematics.

.4 Dimensions, construction details, recommended installation and support, mounting bolt hole sizes and locations and point loads.

.2 Operators manual and service manual.

.3 Exploded parts list.

.4 List indicating manufacturer recommend service tasks and intervals.

1.5 General Requirements

.1 Provide pumps as specified in the project’s equipment schedules.

.2 Pump motors and guards shall comply with the motor and guard requirements specified under Section 21 05 01 Common Work Results for Mechanical.

.3 Variable Frequency Drives shall comply with the requirements specified under Section 23 05 14 Variable Frequency Drives.

.4 Provide correctly sized load and line reactors. Reactors shall be shipped with each drive for all supply voltages, (No exceptions).

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Split Coupled Vertical In-Line Pump (7.5 hp and up)

.1 Type: Cast iron, radially split, with tapped openings for venting, draining and gauge connections, with ANSI 125 flanged suction and discharge connections.

.1 Maximum operating pressure: 690 kPa. (100psi).

.2 Maximum operating temperature: 149°C (300°F).

.2 Pump impeller: Bronze, fully enclosed type. Impeller shall be dynamically balanced.

.3 Shaft: Stainless steel.

.4 Seal assembly: Mechanical seal, stainless steel spring with carbon against silicone carbide faces, secondary Viton seal, factory installed flush line with manual vent.

.5 Coupling: Rigid spacer type.

.6 Motor: to NEMA MG 1, drip proof, sleeve bearing, 1750 rpm, high efficiency motor.

.7 Capacities and electrical requirements as scheduled on the drawings.

3. EXECUTION

3.1 General

.1 Install to manufacturer's instructions.

.2 Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

.3 Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 102 mm (4 inches) and over.

.4 Provide line sized shut-off valve and strainer or pump suction fitting on pump suction, and line sized soft seat check valve and balancing valve or combination pump discharge valve on pump discharge.

.5 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

.6 Provide drains for bases and seals, piped to and discharging into floor drains.

.7 Install close coupled and base mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to Division 3 Cast In Place Concrete.

.8 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.

.9 Install volute venting pet cock in accessible location.

.10 Install pressure gauge test cocks.

.11 Provide spacer at inlet and outlet on vertical in-line pumps complete with screen diffuser.

.12 Triple duty valves are not allowed. [for UBC jobs only]

.13 Provide vibration isolation and seismic restraint in accordance with Section 23 05 48 Vibration and Seismic Control for Mechanical.

.14 Install spool piece of discharge of vertical line pumps in accordance with manufacturer's instructions. In absence of instructions, spool pieces shall be as follows:

.1 2" – 3" pump outlet: 6" spool piece

.2 4" - 6" pump outlet: 12" spool piece

.3 8" and up pump outlet: 18" spool piece

.15 Provide flexible pipe connections on all pumps with inlets/outlets 2" and up to isolate pump from piping.

3.2 Before Start-Up

.1 In accordance with manufacturer's recommendations and the following:

.1 Verify that electric power is available and of the correct characteristics.

.2 Check rotation prior to start-up.

.3 Check and align pumps prior to start-up.

.4 Lubricate pumps before start-up.

3.3 Start-Up

.1 In accordance with manufacturer's recommendations and the following:

.1 After starting pump, check for proper, safe operation.

.2 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.

.3 Check base for free-floating, no obstructions under base.

.4 Run-in pumps for 12 continuous hours.

.5 Verify operation of over-temperature and other protective devices under low- and no-flow condition.

.6 Eliminate air from scroll casing.

.7 Adjust water flow rate through water-cooled bearings.

.8 Adjust flow rate from pump shaft stuffing boxes to manufacturer's recommendation.

.9 Adjust alignment of piping and conduit to ensure true flexibility at all times.

.10 Eliminate cavitation, flashing and air entrainment.

.11 Adjust pump shaft seals, stuffing boxes, glands.

.12 Measure pressure drop across strainer when clean and with flow rates as finally set.

.13 Replace seals if pump used to degrease system or if pump used for temporary heat.

.14 Verify lubricating oil levels.

3.4 Variable Frequency Drives

.1 Comply with Section 23 05 14 Variable Frequency Drives.

.2 Coordinate location of Variable Frequency Drive, mounting and support with all trades.

.3 Ensure adequate clearance is allowed per code requirements.

.4 Provide wiring between Variable Frequency Drive and pump in compliance with Division 26 requirements and pump motor manufacturer requirements.

3.5 Performance Verification (PV)

.1 Comply with Section 23 08 00 Commissioning of HVAC and in addition the following:

.2 Exclusions: This paragraph does not apply to small in-line circulators.

.3 Assumptions: these PV procedures assume that:

.1 Manufacturer's performance curves are accurate.

.2 Valves on pump suction and discharge provide tight shut-off.

.4 Net Positive Suction Head (NPSH):

.1 Application: measure NPSH for pumps which operate on open systems and with water at elevated temperatures.

.5 Multiple Pump Installations - Series and Parallel:

.1 Repeat PV procedures specified above for pump performance and pump BHP for combinations of pump operations.

.6 Record of point(s) of actual performance and design performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.

END OF SECTION

GENERAL

1.1 Section Scope

.1 Materials, components, equipment and chemicals for cleaning, water treatment and maintenance for the following wet side hydronic systems and equipment:

.1 Chilled water system (closed loop)

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 13 – Hydronic Piping

.4 Section 23 21 16 – Hydronic Piping Specialties

1.3 References

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

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

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

.1 ASTM E202 Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

.3 American Society of Mechanical Engineers (ASME)

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

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

.1 Material Safety Data Sheets (MSDS).

1.4 Submittals

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

.1 Submit shop drawings with complete description of proposed chemicals, quantities, calculations, procedures, test kits and equipment to be supplied. Along with product shop drawings, provide copies of data sheets, procedure instructions and analysis reports to be used on this project.

.2 Material Safety Data Sheets (MSDS) for all chemicals to be used.

.3 Provide written reports containing procedure of system cleaning and degreasing, giving times, dates, conditions of water, and problems and actions encountered.

.4 Submit written reports to the mechanical contractor and Consultant containing results of tests taken every seven days after completion of chemical treatment. Reports shall be done every seven days for a minimum time period of 35 days.

.2 Provide seasonal site visits (4 minimum) within the warranty year to check the treatment, take samples, analyze and recommend proper addition of treatment. Provide written reports to the owner after each visit with a copy to the Consultant.

1.5 General

.1 Equipment, chemicals, testing and service shall be provided by one supplier.

.2 Chemical treatment agency shall provide equipment, chemicals and site supervision so as to fully comply with all requirements and their intent contained within this specification section.

.3 Perform the cleaning, degreasing operation and initial water treatment and submit written reports on all situations found, actions taken and final results. Reports shall be signed by the commissioning coordinator, and chemical treatment agency. Inform the Consultant and commissioning agency fifteen (15) working days prior to commencing of work.

.4 Provide chemical treatment as specified herein and provide written reports. Reports shall be signed by the chemical treatment agency, mechanical contractor and commissioning agency.

.5 Chemical treatment agency shall provide directive and assistance to the mechanical contractor in the degreasing, cleaning and chemical treatment of all piping systems. Use of the permanent mechanical systems for pumping or heating of cleaning and dilution solutions is not permitted. Permanent systems shall be isolated and portable pumps and boilers utilized for the duration of the cleaning process. Permanent equipment shall be flushed, degreased and chemically treated independent of the piping systems.

.6 Confirm chemical treatment products are compatible with piping materials, seals and gaskets used on this project prior to use.

2. PRODUCTS

2.1 Acceptable Manufacturers

.1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

.1 Provide sufficient chemicals for the Owner to treat and test the systems for one year from the time of substantial completion of the building.

.2 Materials which may contact finished areas shall be colourless and non-staining.

.3 Chemicals used must comply with environmental and health standards applicable to the usage on this project.

.4 Chemicals must be approved by governing authorities for release into Municipal sewer system.

2.3 Existing Treatment System

.1 Owner has a contract with a treatment chemical supplier to maintain proper levels of chemical in building systems. New chemicals and/or treatment delivery hardware are to be supplied by this supplier. Obtain supplier’s name during bidding process and obtain required pricing information.

2.4 Characteristics of Control Chemicals:

.1 Chemicals must be non-toxic when released to atmosphere, noncorrosive and non-staining if a leak occurs. Chemicals shall be compatible with all system components so that operation or life expectancy of the components is not affected by the application of the chemical treatment.

.2 System Cleaner:

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

.3 Close System Treatment:

.4 Sequestering agent to reduce deposits and adjust pH, with a Chromate free, nitrite/borate type corrosion inhibitor suitable for use with both ferrous and non-ferrous metals.Open System Treatment

.1 "Performax Millennium" Series #2395 corrosion inhibitor and deposit control in a drum type container;

.2 "Biocide T" slime control agent in a pail type container;

.3 "Biosphere 250" for control of bacteria, fungi, and algae, and supplied in pail or drum type containers as required.

.5 Dispersant/Purging compound:

.1 As recommended by the Chemical Water Treatment company. Compounds shall not cause odours.

2.5 Cleaning Solutions:

.1 Tri-sodium phosphate: 0.40 kg per 100 L water in system.

.2 Sodium carbonate: 0.40 kg per 100 L water in system.

.3 Low-foaming detergent: 0.01 kg per 100 L water in system

2.6 Propylene Glycol

.1 Provide a USP grade inhibited propylene glycol in sufficient quantity to charge the glycol heating system to the percentage scheduled in the contract drawings.

.2 Ethylene glycol is not acceptable.

.3 Provide sufficient product to charge the system, the system feeder storage tank and the Owners stock of two (2) spare 20L pails of propylene glycol.

2.7 Hydronic System Feeder

.1 System shall be a factory assembled and tested complete package with the following minimum criteria:

.1 Non-metallic storage/mixing tank with cover, 208 litre (55 US gallon) capacity

.2 Pump suction hose with inlet strainer.

.3 Pressure pump with thermal cut-out, 120V/1/60 with electrical cord and plug suitable for plug in to a standard electrical outlet.

.4 Integral pressure switch and check valve

.5 Low level pump cut-out.

.6 Pre-charged accumulator tank with EPDM diaphragm;

.7 Manual diverter valve for purging air and agitating contents of storage tank

.8 Pressure regulating valve adjustable 35 – 380 KPa (5 – 55 psig) complete with pressure gauge; built-in check valve and union connection

.2 Provide a minimum NPS ½ flexible braided hose connection 900mm (36”) long from package to system connection.

.3 Pressure pump shall be capable of running dry without damage.

.4 Unit shall be CSA approved.

2.8 Chemical Pot Feeder

.1 Provide chemical pot feeder enamelled steel or cast iron by-pass feeders minimum 10 L capacity, 2060 kPa (300 psi) rated and complete with 20 mm (¾") diameter NPT pipe connection tappings, and a screw-on cast iron cap with "Buna N" "O" ring seal, one pot feeder per system, located as shown on system schematics and floor plans. If location is in question obtain clarification from the Consultant prior to installation.

2.9 Side Stream Filter Housing

.1 Side stream filter housing of steel or stainless steel construction, EPDM O-rings, brass drain valve using a 250 mm x DOE 5 micron filter cartridge, with a minimum flow rate of 35 l/s (9gpm).

.2 Provide a sight flow indicator with stainless steel impeller, tempered borosilicate glass window, 304 SS cage installed in conjunction with the side stream filter, isolation valves and balancing valve. Connections shall be NPS 3/4 NPT and all isolating valves shall be installed as per manufacturer's instructions.

2.10 Corrosion Coupon and Holder Assembly

.1 Mild steel corrosion coupon

.2 Holder, NPS ¾ or 1 NPT male connection.

.3 Provide malleable or cast iron cross, NPS ¾ or 1 NPT male connection.

2.11 Test Kits

.1 Provide test kits as required to determine proper system treatment consisting of, but not limited to the following:

.1 Glycol systems treatment test kits to determine proper concentration and glycol inhibitor, this shall include a hydrometer type tester.

.2 Provide test kits for hardness and chlorides in addition to those listed above.

.3 Provide an electronic pH meter complete with three different calibration standard solutions.

.4 All test kits shall be provided with adequate chemicals and reagents for one year of testing.

.5 Turn test kits over to Owner at substantial completion.

2.12 Shipping/Feeding Chemical Containers

.1 High density moulded polyethylene, with liquid level graduations, reusable cover.

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 Chemical Feed Piping

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

3.3 Cleaning of Mechanical System

.1 Systems shall be operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.

.2 Retain a qualified water treatment specialist to perform system cleaning.

.3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.

.4 Ensure that heat exchangers, coils, boilers, chillers and other equipment are isolated / bypassed during the flushing and cleaning process. Only after the piping system is substantially clean, shall water be allowed to circulate through equipment. Demonstrate system cleanliness to Consultant.

.5 Cleaning procedures:

.1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report shall include:

.1 Cleaning procedures, flow rates, elapsed time.

.2 Chemicals and concentrations used.

.3 Inhibitors and concentrations.

.4 Specific requirements for completion of work.

.5 Special precautions for protecting piping system materials and components.

.6 Complete analysis of water used to ensure water will not damage systems or equipment.

.6 Conditions at time of cleaning of systems:

.1 Systems shall be free from construction debris, dirt and other foreign material.

.2 Control valves shall be operational, fully open to ensure that terminal units can be cleaned properly.

.3 Strainers shall be clean prior to initial fill.

.4 Install temporary filters on pumps not equipped with permanent filters.

.5 Install pressure gauges on strainers to detect plugging.

.7 Report on Completion of Cleaning:

.1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.

3.4 Hydronic System Start Up

.1 Fill system with water, ensure air is vented from system.

.2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 35 kPa (does not apply to diaphragm type expansion tanks).

.3 Use water metre to record volume of water in system to +/- 0.5%.

.4 Add chemicals under direct supervision of chemical treatment supplier.

.5 Closed loop systems: circulate system cleaner at 60°C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.

.6 Flush with velocity the system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.

.7 Add chemical solution to system.

.8 Establish circulation, raise temperature slowly to 82°C minimum. Circulate for 12 h, ensuring flow in all circuits. Remove heat; continue to circulate until temperature is below 38°C. Drain as quickly as possible. Refill with clean water. Circulate for 6 h at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).

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

3.5 Closed Loop Hydronic Water and Glycol Systems

.1 Provide by-pass side stream filters complete with flow indicators and 5 micron filter cartridges between the supply and return of hot water heating and glycol heating circuits.

.2 Provide sufficient filter elements for replacement once per week from commissioning to date of acceptance.

.3 Provide one pot feeder for each individual system.

.4 Install complete with isolating and drain valves and necessary piping. Install as indicated on schematics.

.5 Treat closed systems with closed systems treatment introduced through pot feeder when required or indicated by test.

.6 Provide one side stream 5 micron cotton wound filter cartridge per main circulation pump system, c/w isolation valves, unions.

.7 Supply and add the chemical scale and corrosion inhibitor to the closed circuit heating or chilled water piping system under the direction of and according to the concentration recommended by the chemical water treatment company.

3.6 Commissioning

.1 Commissioning Agency shall supervise water treatment sub-contractor.

.2 Commence water treatment commissioning:

.1 After start-up deficiencies rectified.

.2 After start-up and before TAB of connected systems.

.3 Pre-commissioning verification Inspections:

.1 Presence of test equipment, reagents, chemicals, details of specific tests performed, and operating instructions.

.2 Suitability of logbook.

.3 Required quality of treated water.

.4 Commissioning procedures - applicable to Water Treatment Systems:

.1 Establish, adjust as necessary and record automatic controls and chemical feed rates.

.2 Monitor performance continuously during commissioning of connected systems and until acceptance of project.

.3 Establish test intervals, regeneration intervals.

.4 Record on approved report forms commissioning procedures, test procedures, dates, times, quantities of chemicals added, raw water analysis, treated water analysis, test results, instrument readings, adjustments made, results obtained.

.5 Establish, monitor and adjust automatic controls and chemical feed rates as necessary.

.6 Visit project at specified intervals after commissioning is satisfactorily completed to verify that performance remains as set during commissioning.

.5 Commissioning procedures - Closed Circuit Hydronic Systems:

.1 Analyze water in system.

.2 Record types, quantities of chemicals applied.

.6 Training:

.1 Commission systems, perform tests in presence of, and using assistance of, assigned O&M personnel.

3.7 Owners Stock

.1 Provide 1 year supply of each chemical for the Owner.

.2 Provide 12 replacement DOE 5 micron cotton wound filter cartridges.

.3 Provide two (2) spare 20L pails of propylene glycol

.4 Obtain a receipt from the Owner and give one copy to the Consultant.

3.8 Testing

.1 Chemical water treatment company shall provide a laboratory test report as required.

.1 Provide laboratory test reports confirming the correct chemical concentrations have been achieved.

3.9 Monitoring

.1 Provide laboratory test reports and treatment recommendations for treated water samples taken by the Owner's operating personnel.

.2 They will be sent to the chemical water treatment company monthly for the first three months, and once every three months thereafter for one year following the initial test.

.3 Each analysis shall provide concentrations of significant components of each water sample. At minimum, these shall be:

Item	Reports Units (ppm)
Total Suspended Solids	ppm.
Total Hardness	ppm.
Total Dissolved Solids	ppm as calcium carbonate.
pH	
Magnetite	ppm.

.4 The cost of the testing is to be borne by the Contractor.

.5 The Chemical Water Treatment Company shall send to the Owner on a scheduled bases, properly identified sample bottles for each of the systems to be tested as required.

.6 Test reports shall be sent as they occur to the owner.

3.10 Reports

.1 A copy of all reports shall be sent to the Consulting Engineer.

.2 Provide three (3) copies of written instructions for the chemical testing and treatment specific to this project for insertion into the operating and maintenance manuals.

.3 Email electronic copy of all reports to the Owners maintenance department.

END OF SECTION

GENERAL

1.1 Section Scope

.1 The supply and installation of:

.1 Hydronic cooling coils.

1.2 Related Requirements

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

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

.3 Section 23 05 01 – Acceptable Manufacturers.

.4 Section 23 07 19 - HVAC Piping Insulation.

.5 Section 23 31 00 - HVAC Ducts and Casings.

1.3 References

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

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

.2 ANSI/AHRI Standard 410.

.3 ASTM B88 Standard Specification for Seamless Copper Water Tube.

.4 Canadian Electrical Code (CEC) C22.1

1.4 Submittals

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

.1 Shop Drawings: Indicate coil and frame configurations, dimensions, materials, rows, fin spacing, connections, and rough in dimensions. Certify that coil capacities, hydronic flow rates and temepratures, air and water pressure drops, and selection procedures meet or exceed specified requirements.

.2 Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

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

1.5 Warranty

.1 Provide one year manufacturer warranty for coil leakage.

2. PRODUCTS

2.1 Acceptable Manufacturers

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

2.2 Hydronic Cooling Coils

.1 Allow for split coils and coil banks to easy installation and also minimize the structural disturbances.

.2 Tubes: 16 mm (5/8") OD seamless copper or brass arranged in staggered pattern, expanded into full length fin collars, brazed joints. Manufacturer shall optimize tube size to maintain a minimum of 0.76 m/s (2.5 fps) fluid velocity in tubes at 60% of design flow rate.

.3 Fins: Aluminum continuous plate type with full fin collars or individual helical finned tube type wound under tension.

.4 Casing: Galvanized steel frame with extruded tube sheet holes. Provide tube supports for coils longer than 1000 mm (40").

.5 Headers: Seamless copper tube with silver brazed joints to ASTM B88.

.6 Testing: Factory tested to a minimum of 2070 kPa (300 psi) dry air under water.

.7 Configuration: Drainable, with threaded plugs in headers for drain and vent; threaded plugs in return bends and in headers opposite each tube.

.8 Rows and Fin Spacing: 4, 6 or 8 rows and fin spacing 2.1mm to 3.1mm (8 to 12 fins per inch) to meet the performance scheduled on the drawings.

.9 Certified under ARI Standard 410 Certified

3. EXECUTION

3.1 General

.1 Install to manufacturers written instructions.

.2 Install in ducts and casings to SMACNA HVAC Duct Construction Standards, Metal and Flexible.

.3 Support coil sections independent of piping on steel channel or double angle frames and secure to casings.

.4 Provide common frames for a maximum three coil sections.

.5 Provide airtight seal between coil and duct or casing.

.6 Refer to Section 23 33 00 Duct Accessories for coil end covers.

.7 Protect coils to prevent damage to fins and flanges. Comb out damaged or bent fins.

.8 Make connections to coils with unions or flanges.

.9 Insulate headers located outside air flow as specified for piping. Refer to Section 23 07 19 HVAC Piping Insulation.

3.2 Hydronic Coils

.1 Pipe hydronic coils in a counterflow arrangement i.e. Connect hydronic supply to leaving air side of coil.

.2 Provide an isolation valve on the supply line and lockshield balancing valve with memory stop on the return line.

.3 Install supply piping connection at the bottom of a coil header and install return piping connection at top of a coil header.

.4 Provide manual air vents at high points complete with stop valve.

.5 Install cleanable/drainable tube coils with 1:50 pitch.

.6 Ensure water coils are drainable and provide drain connection at low points.

.7 Install cleanable/drainable tube coils with 1:50 pitch.

.8 Make connections to coils with unions or flanges.

3.3 Hydronic Cooling Coils

.1 Arrange coil supports to avoid piercing drain pans.

.2 Provide moisture eliminators of 0.7 mm (24 gauge) galvanized steel, where air velocity exceeds 2.5 m/sec (500 ft/min).

.3 Provide drain pan and drain connection.

.4 Unless noted otherwise in equipment specifications fabricate drain pans from 1.0 mm (20 gauge) [epoxy painted galvanized steel][stainless steel]. Extend 75 mm (3”) from entering air coil face and 150 mm (6”) from the coil face leaving air side or 100 mm (4”) beyond the face of eliminators.

.5 Pipe drain pans individually to floor drain with minimum 75mm (3”) deep water seal trap. Increase trap seal depth, for fan static pressures in excess of 500Pa (2”WC) proportionally.

END OF SECTION

1. GENERAL

1.1 General

.1 This Section specifies general conditions for Divisions 25 and is to be read, interpreted and coordinated with all other sections of Division 25 and Section 21 05 01 – Common Work Results for Mechanical.

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 and Division-1 Specification Sections apply to work specified in this section.

.3 Section 23 05 53 - Identification for HVAC Piping and Equipment.

.4 Section 23 08 00 – Commissioning of HVAC.

.5 Division 26 – Electrical.

1.3 References

.1 Work, materials, and equipment shall comply with the most restrictive of local, provincial and National authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

.2 British Columbia Codes:

.1 British Columbia Electrical Code

.2 British Columbia Safety Authority

1.4 General Scope

.1 'Provide' shall mean 'supply and install'.

.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 to provide: service access, maintain service clearances and for ease of maintenance.

.6 Connect to equipment specified in other Sections and to equipment supplied and installed by other Contractors or by the Owner.

1.5 Coordination of Work

.1 Products furnished but not installed under this division

.1 Division 23 – Heating, Ventilation and Air Conditioning

.1 Control Valves

.2 Flow Switches

.3 Pressure and Temperature Sensor Wells and Sockets

.4 Energy meters

.5 Terminal Unit Controls

.2 Products not furnished or installed under but integrated with the work of this division

.1 Division 23 – Heating, Ventilation and Air Conditioning

.1 Chiller controls

.2 Variable frequency drives

1.6 Submittals

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

.2 Provide submittals on all hardware, software, and installation. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent. Provide drawings as files on optical disk (file format: .dwg, .dxf, pdf, or comparable). When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall include a complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data and the following:

.1 BAS Hardware:

.1 Manufacturer's description and technical data, performance curves, product specification sheets, and installation/maintenance instructions for:

.1 Control Panels

.2 Transducers/Transmitters

.3 Sensors (including accuracy data)

.4 Actuators

.5 Valves

.6 Relays/Switches

.7 Operator Interface Equipment

.8 Wiring

.9 Other relevant items

.2 Wiring diagrams and layouts for each control panel. Show all termination numbers.

.3 Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.

.2 Central System Hardware and Software:

.1 Controls contractor to provide required additional control panels to accommodate controls of the chiller replacement project on the existing control system

.3 Controlled Systems

.1 A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.

.2 A schematic wiring diagram for each BAS. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the BAS schematic, it shall be labeled with the same name. All terminals shall be labeled.

.3 An instrumentation list for each controlled system. Each element of the BAS shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

.4 A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.

.5 A point list for each system controller including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device. Software flag points, alarm points, etc.

.4 Quantities of items submitted shall be reviewed but are the responsibility of the Division 25 Contractor.

.5 A description of the proposed process along with all report formats and checklists to be used in Section 25 08 00 “Commissioning of Integrated Automation “BAS Demonstration” and “BAS Acceptance.”

.6 Instrumentation and Data Point Summary Table. Contractor shall submit in table format with the following information for each instrument and data point. The table is to be reviewed and approved by the owner’s representative prior to hardware and software installation and programming.

.1 Point name

.2 Point description: provide building designation, system type, equipment type, engineering units, and functionality; include a description of its physical location

.3 Expected range (upper and lower limit)

.4 Instrumentation (as applicable): manufacturer, model number, range, and accuracy specification

.5 Type

.1 AI: analog input

.2 BI: binary input

.3 NAI: network analog input

.4 NBI: network binary input

.5 CP: Configuration Property

.6 P: Programmed (e.g., soft or virtual point in control sequence such as a PID input or output)

.7 C: Calculated value; a soft or virtual point. If calculated value, provide logic diagrams or code and any constants used in formula. If time-based integrated values are required, provide time periods: minutes, daily, weekly, monthly, and yearly. Also indicate if it is a running average.

.6 Input resolution

.7 Graphic display resolution

.8 Data trend interval

.3 Schedules:

.1 Within one month of contract award, provide a schedule of the work indicating the following:

.1 Intended sequence of work items.

.2 Start dates of individual work items.

.3 Duration of individual work items.

.4 Planned delivery dates for major material and equipment and expected lead times.

.5 Milestones indicating possible restraints on work by other trades or situations.

.2 Provide monthly written status reports indicating work completed, revisions to expected delivery dates, etc. An updated project schedule shall be included.

.4 Provide Record drawings and maintenance data in compliance with Division 01 - Closeout Submittals and the following:

.1 Submit project record documents upon completion of installation. Co-ordinate quantity to suit number of O&M manuals required. The documents shall be submitted for approval prior to final completion and shall include:

.2 Project Record Drawings. As-built versions of the submittal shop drawings provided as files on optical media and as 11” x 17” prints.

.3 Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Section 25 08 00 Commissioning of Integrated Automation “BAS Demonstration” and “BAS Acceptance”.

.4 Operation and Maintenance (O & M) Manual.

.5 As-built versions of submittal product data.

.6 Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.

.7 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 set points and variables.

.8 Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

.9 Graphic files, programs, and database on magnetic or optical media.

.10 List of recommended spare parts with part numbers and suppliers.

.11 Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

.12 Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

.13 Licenses, guarantees, and warranty documents for equipment and systems.

.14 Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

.5 Training Materials. Provide course outline and manual for each class at least six weeks before first class. The BAS designer will modify course outlines and manuals if necessary to meet Owner's needs. The BAS designer will review and approve course outlines and manuals at least three weeks before first class.

1.7 Acceptable Control System Primary Manufacturers

.1 Refer to Section 23 05 01 for acceptable manufacturers list.

Manufacturer	Company	Product Line
Delta Controls	Energrated Systems Corp Island Temperature Control	Orca

Quality Assurance

.2 Installer and Manufacturer Qualifications

.1 Installer shall have an established working relationship with BAS Manufacturer of not less than three years.

.2 Installer shall have successfully completed BAS control system training. Upon request, Installer shall present certification of completed training including hours of instruction and course outlines.

1.8 Identification

.1 All components of the Building Management System shall be identification tagged. Comply with Section 23 05 53 - Identification for HVAC Piping and Equipment.

1.9 Warranty

.1 Warrant work as follows:

.1 Warrant labor and materials for specified BAS free from defects for a period of 12 months after final acceptance. BAS failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

.2 Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

.3 Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

.4 Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of BAS designer's acceptance.

.2 Special warranty on instrumentation:

.1 All instrumentation shall be covered by manufacturer's transferable [one-year] "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

1.10 Substantial & Total Performance

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

.2 A certificate of Substantial Performance will not be granted unless the controls systems have been commissioned and are capable of operation with alarm controls functional and automatic controls in operation. Commissioning checklists must be submitted prior to the request by the Contractor to have a substantial completion inspection.

1.11 Ownership of Proprietary Material

.1 Project-specific software and documentation shall become Owner's property. This includes, but is not limited to graphics, record drawings, database, application programming code and documentation.

2. PRODUCTS

2.1 Not used

3. EXECUTION

3.1 Examination

.1 The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Consultant for resolution before rough-in work is started.

3.2 Co-ordination

.1 Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

.2 Coordinate final graphics floor plans, room names and numbering with Architectural drawings including any changes made during construction. These graphics should be provided to the Engineers and the Owner for sign off before the graphics are completed.

.3 The contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.

.4 Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the BAS specified in this section. These controls shall be integrated into the system and coordinated by this Contractor as follows:

.1 Each supplier of a controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.

.2 The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.

.3 The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.

.4 The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.3 General Workmanship

.1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

.2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

.3 Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

.4 Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

.5 All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

.6 All work, materials, and equipment shall comply with the rules and regulations of applicable local, provincial, and federal codes and ordinances as identified in Part 1 of this specification.

3.4 Existing Equipment

.1 Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the Consultant is to be notified immediately.

.2 All redundant wiring and equipment as a result of this project, that is not identified for either salvage or reuse, shall be removed and become the property of the contractor, unless otherwise noted.

.3 The mechanical system must remain in operation based on the Owner requirements within the building (ie between the hours of 6 a.m. and 6 p.m., Monday through Friday).Any interruptions to the operation of existing building systems must be co-ordinated with the Owner and the design team in advance of any interruptions.

.4 The scheduling of fans through existing or temporary time clocks or BAS shall be maintained throughout the BAS installation.

.5 Modify existing starter control circuits, if necessary, to provide hand/off/auto control of each starter controlled. If new starters or starter control packages are required, these shall be included as part of this contract.

3.5 Training

.1 Provide training sessionsperiod for personnel designated by the Owner.The number of training sessions required should be agreed with the Engineers and Owner prior to commencement of training

.2 Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be one day in length and must be coordinated with the building owner.

.3 Train the designated staff of the owner to enable them to do the following:

.1 Day-to-day Operators:

.1 Proficiently to operate the system

.2 Understand BAS architecture and configuration

.3 Understand BAS system components

.4 Understand system operation, including BAS control and optimizing routines (algorithms)

.5 Operate the workstation and peripherals

.6 Log on and off the system

.7 Access graphics, point reports, and logs

.8 Adjust and change system set points, time schedules, and holiday schedules

.9 Recognize malfunctions of the system by observation of the printed copy and graphical visual signals

.10 Understand system drawings and Operation and Maintenance manual

.11 Understand the job layout and location of control components

.12 Access data from BAS controllers and ASCs

.13 Operate portable operator's terminals

.2 Advanced Operators:

.1 Make and change graphics on the workstation

.2 Create, delete, and modify alarms, including annunciation and routing of these

.3 Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals

.4 Create, delete, and modify reports

.5 Add, remove, and modify system's physical points

.6 Perform BAS field checkout procedures

.7 Perform BAS unit operation and maintenance procedures

.8 Perform workstation and peripheral operation and maintenance procedures

.9 Perform BAS diagnostic procedures

.10 Maintain, calibrate, troubleshoot hardware

.11 Adjust, calibrate, and replace system components

.3 System Managers/Administrators:

.1 Maintain software and prepare backups

.2 Interface with job-specific, third-party operator software

.3 Add new users and understand password security procedures

.4 These objectives will be divided into three logical groupings. Participants may attend one or more of these, depending on level of knowledge required.

.5 Provide course outline and materials. The instructor(s) shall provide one copy of training material per student.

.6 The instructor(s) shall be factory-trained instructors experienced in presenting this material.

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 25 05 00 – Common Work Results for Integrated Automation.

1.3 General

.1 This is a chiller replacement project and the control sequences shall be developed with the controls contractor during the shop drawing phase of the project.

.2 In addition to replacing the existing chiller with the new one, the followings will also be done within this project scope of work that will require controls:

.1 Replacing the existing constant flow chilled water pumps with new VFD controlled chilled water pumps.

.2 Controls for the new VFDs serving the chilled water pumps

.3 Replacing existing DX coils of the couple of AHU with new chilled water coils

.4 Controls for the couple of new chilled water coils. Modulating two way controls valves.

.5 New differential pressure sensor installation for pump speed control via VFDs

.6 Control graphic updates.

END OF SECTION