



**Mechanical
Specification**
FOR

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Issued for Tender
November 12, 2024

NORR ONBL22-0011
HHA #2222219

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MECHANICAL GENERAL REQUIREMENTS 20 01 01

1 GENERAL

1.1 General Contract Documents

- .1 Comply with General Conditions of the Contract, Supplementary Conditions of the Contract, and Division 01 - General Requirements.
- .2 Where content in this Specification section duplicates requirements in various Division 01 Specification sections, this section and the applicable Division 01 sections are to be read together and the most stringent requirements apply.

1.2 Work Included

- .1 Work to be done under Divisions 20, 21, 22, 23 and 25 to include furnishing of labour, materials and equipment required for installation, testing and putting into proper operation complete mechanical systems as shown, as specified, as intended, and as otherwise required. Complete systems to be left ready for continuous and efficient satisfactory operation.
- .2 Read drawings and specifications together as a whole and in conjunction with other such documents included under the Construction Contract.

1.3 Document Organization

- .1 Applicable Divisions for Mechanical Work:
 - .1 Division 20 - Common Work for Mechanical
 - .2 Division 21 - Fire Protection
 - .3 Division 22 - Plumbing and Drainage
 - .4 Division 23 - Heating, Ventilation and Air Conditioning (HVAC)
 - .5 Division 25 - Building Automation System
- .2 For clarity, any reference in the Contract Documents to Division 20 includes Divisions 21, 22, 23 and 25.
- .3 The Specifications for these Divisions are arranged in sections for convenience. It is not intended to recognize, set or define limits to any subcontract or to restrict Contractor in letting subcontracts.
- .4 Contractor is responsible for completion of work whether or not portions are sublet.

1.4 Division 20, as it applies to Divisions 21, 22, 23 and 25

- .1 Division 20 contains common work requirements that are applicable as necessary to the Work of Divisions 21 to 25 and apply as if written in full within those Divisions.

1.5 Language

- .1 The specification is written as a series of instructions addressed to the Contractor, and by implication to subcontractors and to suppliers. For clarity and brevity, use is made of numbered lists and bulleted lists. Where a list follows a semi-colon (;) the punctuation is for clarity. Where a list follows a colon (:) the punctuation is to be read as a short-hand form of the verb "to be" or "to have" as context requires.
- .2 It is not intended to debate with the Contractor the reasons for these instructions, and words associated with justification for an instruction or restatement of anticipated performance have been omitted to avoid possible ambiguities.

1.6 Definitions and Abbreviations

- .1 Specification section 20 01 13 *Definitions and Abbreviations – Mechanical* contains general definitions and abbreviations that apply to one or more specification sections of this Division of the Work. Other specification sections of the mechanical Divisions of the Work may also include additional specific definitions and/or abbreviations that apply to that specification section.
- .2 The following general terms apply to Divisions 20 to 25 of the Work:
 - .1 The words "indicated", "shown", "noted", "listed" or similar words or phrases used in this Specification, mean that material or item referred to is "indicated", "shown", "listed" or "noted" on Drawings or in Specification.
 - .2 Wherever the word "listed" is used in conjunction with a product and a product certification standard (including but not limited to CSA, ULC, CGSB, BNQ, UL), it shall be understood to mean that the product is "listed" by an accredited 3rd party testing laboratory as being certified to the referenced product standard.
 - .3 Wherever the words "approved", or similar words or phrases are used in the Specification they shall be understood, unless the context otherwise provides, to mean that material or item referred to shall be "approved by" the Owner.
 - .4 Wherever the words "satisfactory", "as directed", "submit", "permitted", "reviewed", or similar words or phrases are used in the Specification they shall be understood, unless the context otherwise provides, to mean that material or item referred to shall be "satisfactory to", "as directed by", "submitted to", "permitted by", or "reviewed by" the Consultant.
 - .5 Instructions using any form of the word:
 - (a) "install" means to place in position and activate for service or use,
 - (b) "supply" means to procure and deliver materials to the place of the Work, or to make available labour or services for the stated purpose,
 - (c) "provide" means to supply material, labour and services to install the referenced item.
 - .6 The term "building code" means the edition of the applicable building code at the time of obtaining a building permit.
 - .7 Wherever manufacturers or manufacturer's products are identified in lists under the phrase "Standard of Acceptance", these are manufacturers and/or products which meet the project standards in regard to performance, quality of material and workmanship.

1.7 Examination

- .1 Examine any existing buildings, local conditions, building site, the specifications and drawings, and report any condition, defect or interference that would prevent execution of the work.
- .2 No allowance will be made for any expense incurred through failure to make these examinations of the site and the documents prior to Tender or on account of any conditions on site or any growth or item existing there which was visible or known to exist at time of Tender.
- .3 Before commencing work under this Division, examine the work of other Divisions of the Work and report any defect or interference.

1.8 Design Services

- .1 Provide specialty design services for elements of the Work where specified in other sections of Division 20. Drawings and specifications prepared by such specialty design service providers shall be sealed by a professional engineer licensed in the jurisdiction of the Work.

1.9 Product Substitutions

- .1 The use of a substitute article or material which the manufacturer represents to be of at least equal quality and of the required characteristics for the purpose intended may be permitted, subject to the following provisions:
 - .1 a substitution will not be considered for reasons of meeting the construction schedule unless the contractor can demonstrate to the satisfaction of the Consultant they made all reasonable efforts to procure the specified product or material in a timely fashion,
 - .2 the manufacturer must advise the Consultant of this intention to use an alternative article or material before doing so,
 - .3 the burden of proof as to the quality and suitability of alternatives to be upon the manufacturer and they shall supply all information necessary as required by the Consultant at no additional costs to the contract,
 - .4 the Consultant shall be the sole judge as to the quality and suitability of alternative materials and their decision to be final,
 - .5 where use of an alternative material involves redesign or changes to other parts of the work, the costs and the time required to effect such redesign or changes will be considered in evaluating the suitability of the alternative materials,
 - .6 no test or action relating to the approval of substitute materials is to be made until the request for substitution has been made in writing by the manufacturer and has been accompanied by complete data as to the quality of the materials proposed. Such request to be made in ample time to permit appropriate review without delaying the work, taking into consideration that such a substitution request may be rejected and require providing the product or material as originally specified,
 - .7 whenever classification, listing, or other certification by a recognized standards body is a part of the specifications for any material, proposals for use of substitute materials is to be accompanied by reports from the equivalent body indicating compliance with the requirements of the specifications,
 - .8 the costs of all testing required to prove equality of the material proposed to be borne by the manufacturer.

2 SHIPPING, HANDLING AND STORAGE

2.1 Shipping

- .1 Provide adequate protection of equipment during shipping and handling so as to provide equipment at the Work site in ex-works condition when handled by commercial carrier systems.
- .2 Provide, as necessary, removable bracing of the internal components in each item of equipment so that the equipment can be moved on its side or back, without sustaining damage.
- .3 Where removeable internal bracing has been provided, the equipment to be provided with warning labels to call for the removal of the shipping bracing prior to energization.
- .4 Any component that is packaged or shipped separately is to be individually crated and tagged with unit number and the equipment number of the assembly to which it belongs.
- .5 Provide each "shipping section" with a permanently-attached, readily-visible identification tag bearing the equipment number of the assembly of which it is a part.

2.2 Storage

- .1 Store equipment and materials at the worksite to protect them from any damage until placed into its final location. Maintain similar protection of installed equipment and materials to protect against damage until they are turned over to the Owner. Make good any damage to equipment or materials up to the time of ready for takeover.
- .2 Store equipment in accordance with the manufacturer's instructions and not less than:
 - .1 stored in a dry, clean location,
 - .2 cover with polyethylene plastic sheeting,
 - .3 include a desiccant material under the protective sheeting to absorb moisture, or provide heated ventilated air.
- .3 Provide adequate ventilation and temporary heating to prevent condensation of moisture within the equipment.

2.3 Provisions for Handling and Field Erection

- .1 For equipment that will require hoisting on site, provide removable side panels, lifting angles or lifting plates to accommodate the use of slings or crane hooks, for each shipping section.
- .2 For floor mounted equipment, provide on each shipping section removable steel channel base plates to permit use of pipe rollers or dollies without damaging the equipment.

3 OWNER'S SPECIAL REQUIREMENTS FOR EXISTING SITES

- .1 The following special requirements are in addition to the requirements of Division 01 of the Work.
- .2 Provide a written list of names for employees and sub-trades entering the building, advising which areas they need access to at least 48 hours prior to expected time of arrival. This lead time is required to prearrange security passes.
- .3 Security passes must be visibly worn at all times by all employees.
- .4 Trades people to strictly adhere to owner's building security procedures otherwise entrance into the building will be denied.
- .5 Trades people are to enter the entrance identified by the Owner.
- .6 Park vehicles in designated areas. Do not block driveways.
- .7 Use only the freight elevator to transport tools and material. Freight elevator door must be shut immediately after exiting the cab.
- .8 Do not disable or activate any electrical or mechanical system without prior approval by the Owner's Project Manager. Also, prior to disabling or activation of any electrical or mechanical system, obtain approval from Building Operations and Building Security.
- .9 Submit prior notification to Building Security Staff before any construction activity commences which will result in heat, smoke, dust or fumes, such as welding, saw cutting, soldering, spray painting, which might affect sensitive fire detection and protection equipment.
- .10 Provide at least 48 hours prior notification to Building Operations for any fire system isolation requests.
- .11 Schedule work and meet with sub-trades daily on site, to show trades people the work areas and work to be done.
- .12 Trades-people are to supply and use their own tools. No tools, ladders or equipment, etc. will be loaned by the Owner.

- .13 Provide environmental cleaning of the job site daily during construction and upon completion. This includes above ceilings. Do not store materials or garbage on the loading dock.
- .14 Provide special care, attention and protection when transporting equipment and materials to prevent accidental damage to fire protection equipment, finishes, furnishings and fixtures.
- .15 "No Smoking" – this is a smoke-free building. Violators will be asked to leave and may be denied reentry. Smoking is not allowed on the roof.
- .16 A security escort will be required for any work being done in secured areas, e.g. raised floor, computer room and mechanical/electrical rooms.
- .17 If Building Operations deems that work on a particular system requires security escort, allow 48 hours to make appropriate arrangements.
- .18 For any open flame work, provide fire extinguishers and security fire watch.
- .19 Obtain the approval of the Building Manager for the storage of materials on site.
- .20 Perform a daily cleanup prior to leaving the site.
- .21 Secure oxygen and acetylene cylinders at all times and capped nightly.
- .22 Restore operating and redundant systems to their normal condition at the end of each work day unless otherwise approved by the Owner
- .23 At the conclusion of each work day, the Contractor's superintendent/supervisor is to advise the Building Manager on the day's activities and plans for the next day's work.

4 PROGRESS PAYMENT PROCEDURE

4.1 Schedule of Values

- .1 Provide schedule(s) of values for progress payments in accordance with this part.
- .2 Prepare and submit a schedule of values ("SOV") for the Division 20 Work.
- .3 Each SOV is to be in the sample format shown in Article "Attachments", specifically that the SOV is to include four sections for:
 - .1 Contract price work element breakdown, which includes:
 - (a) detailed breakdown by work element as agreed with the Consultant,
 - (b) line items for coordination drawings, as-built documents and operating manuals,
 - (c) a summary line item for authorized Cash Allowance disbursements (if applicable),
 - (d) line items for each Itemized Price (if applicable),
 - (e) line items for each Separate Price (if applicable and included in the Contract Price)
 - (f) a line item for the total of the original contract work element values,
 - (g) a summary line item for approved change instructions,
 - .2 Cash Allowance disbursement authorization, with separate work elements for each cash allowance,
 - .3 Approved Change Instructions, with separate work elements for each change instruction,
 - .4 Outstanding Change Instructions which are either not quoted or not yet approved.
- .4 Each work element in the SOV sections (except Outstanding Change Instructions) is to include:
 - .1 the original contract value and the percent of original contract total value (Contract Price section only),
 - .2 the completed to date amount and percent of original work element contract value,

- .3 the previously billed amount and percent of original work element contract value,
 - .4 the current billing (payment request) amount and percent of original work element contract value, and
 - .5 the balance to complete amount and percentage of original work element contract value.
- .5 The required Contract Price work element breakdown will be determined by the Consultant, with the level of breakdown appropriate to the project such as
- .1 by trade,
 - .2 by specification section or portion thereof,
 - .3 by labour vs material,
 - .4 by location in the building,
 - .5 or any combination of the above.
- .6 Submit a draft SOV for review and approval by the Consultant at least three weeks before the first request for progress payment. Do not submit requests for progress payments until the SOV has been reviewed and there are no outstanding comments from the Consultant.
- .7 Make requests for progress payments using the values on the reviewed SOV.
- .8 When a change in the Work has been approved by the Owner, include the approved changes on the SOV for the next payment application, whether or not payment is requested in full or in part for that change in that payment request period.
- .9 For each SOV, include a line item "Interference & Coordination Drawings" and include a value that is the greater of:
- .1 the value of the work or,
 - .2 5% of the Division 20 contract price.

Payment of the indicated amount will not be made until satisfactory evidence of completion of this work element has been received by the Consultant. Where satisfactory documents are not received, a Change Order will be issued to delete this work element and the amount from the Contract Price. If coordination drawings are not provided, all interferences will be resolved at the contractor's cost.

- .10 For each SOV, include a line item "As-Built & Operating Manuals" and includes a value that is the greater of:
- .1 the value of the work or,
 - .2 2% of the Division 20 contract price.

Payment of the indicated amount will not be made until satisfactory documents have been received by the Consultant. Where satisfactory documents are not received, a Change Directive will be issued to delete this work element and the amount from the Contract Price.

5 CONSTRUCTION CHANGES

5.1 General

- .1 The valuation method to be used for a change instruction to the Work is to be determined by the Consultant from the following methods:
- .1 by labour and material when the change instruction is by a Change Directive;
 - .2 by unit prices set out in the Contract or subsequently agreed upon for other change instructions;
 - .3 by a detailed quotation for other change instructions; or

- .4 by a Cash Allowance Disbursement instruction.

5.2 Definitions

- .1 The following definitions apply to this section

- .1 **Allpricer** – the material pricing guide/service provided by Allpricer Limited.
- .2 **MCAA manual** – the Mechanical Contractors Association of America publication *Labor Estimating Guide for Service* for labour units.
- .3 **Base wage rate** – the hourly rate actually paid to the trades person, determined in accordance with applicable collective bargaining agreement, or in their absence the actual gross wages paid to the worker.
- .4 **Job Site Impact Multiplier** – a multiplier expressed as a decimal number that is included in the Labour Rate to account for special job site conditions that affect labour availability, labour productivity, procurement of materials, and materials management, that are specific to the project and site conditions.
- .5 **Indirect labour** – any labour that is neither journeyman labour that directly performs the work nor labour that directly supervises journeyman(s).
- .6 **Labour Rate** – the actual fully burdened labour cost per hour of labour consumed by a trades person including statutory and regulatory burden, collective bargaining burden, and other project related burden. For greater clarity, the labour rate includes but is not limited to the following:
- (a) base wage rate,
 - (b) vacation and statutory holiday pay,
 - (c) union deductions and additional union charges,
 - (d) Legislated burdens including EHT, WSIB, EI, CPP, RST on H/W
 - (e) wage-based taxes,
 - (f) job site impact multipliers,
 - (g) expendable small tools charge,
 - (h) project insurance,
 - (i) financing of payroll,
 - (j) estimating,
 - (k) rest breaks and idle time,
 - (l) safety including training, safety meetings, WHMIS, fall protection, personnel protection equipment, and safety committees,
 - (m) preparation and handling of shop drawings and other submittals,
 - (n) preparation of as-built documents, including operation and maintenance manuals,
 - (o) labour warranties,
 - (p) site facilities,
 - (q) clean-up,
 - (r) parking.
- .7 **Foreperson** – a first level supervisory position having direct control over the work performed by journeymen.
- .8 **Journeyman** – a person working in a skilled construction trade which may be prescribed by regulation, and includes apprentices.
- .9 **Labour Unit** – the number of journeyman labour hours or part thereof, required to perform a specific construction task, and includes but is not limited to:

- (a) receiving, unloading, stockpiling, distribution and handling of materials and equipment,
 - (b) rigging or erecting of materials or equipment,
 - (c) fitting and joining of materials,
 - (d) pressure testing of piping and ductwork systems,
 - (e) testing of equipment and systems.
- .10 **Line materials** – components that make up a distribution network for fluid, power, or electronic/digital information, and includes:
- (a) piping, pipe fittings, valves (of all kinds), pipe strainers and other pipe mounted equipment,
 - (b) ducting, duct fittings, duct balancing dampers and other duct mounted equipment,
 - (c) conduit, cable tray, cable, conductors, and wiring,
 - (d) supports, hangers and restraints,
 - (e) vibration isolators and seismic restraints associated with line materials,
 - (f) instrumentation including gauges and sensors/transmitters,
 - (g) electrical, pneumatic, and hydraulic actuators for valves and dampers, and
 - (h) any coatings or other protective elements applied thereto including insulation and painting.
- .11 **Overhead** – administrative expenses of the Contractor's business and the project which are not included in a Labour Rate or Labour Unit. For greater clarity, overhead includes but is not limited to the following:
- (a) company office, storage, and fabrication spaces, and associated maintenance, utilities, and expenses,
 - (b) project site office, fabrication and storage spaces, washrooms, break rooms, and associated maintenance, utilities, and expenses,
 - (c) company office equipment, furniture and supplies,
 - (d) project site office equipment, furniture and supplies,
 - (e) labour time for project managers and project assistants,
 - (f) project site security,
 - (g) project site clean-up, recycling and waste disposal,
 - (h) materials management,
 - (i) property taxes, business licenses, and auto insurance,
 - (j) dues and subscriptions,
 - (k) postage and courier,
 - (l) advertising, telephone, IT services and equipment,
 - (m) legal and accounting fees and expenses,
 - (n) sales and marketing,
 - (o) salaries and benefits for company indirect labour including company management, sales force, dispatchers, estimators, clerical staff, and at-office general (non-trades) labour.
 - (p) all other indirect labour.
- .12 **Senior Foreperson** – the second (and subsequent) level supervisory position having direct control over one or more Forepersons, where the number of Forepersons supervised is in accordance with local regulatory requirements or collective bargaining agreements. ("Superintendent" or "Supervisor" has the same meaning).

5.3 Change Directive Method

- .1 Except where otherwise determined in the Construction Contract or Division 01 specification, the valuation of changes by the Change Directive method shall comply with the following:
 - .1 the form of presentation of costs and methods of measurement shall be agreed to by Consultant and Contractor before proceeding with the change,
 - .2 the adjustment in the Contract Price for a change carried out by way of Change Directive shall be determined on the basis of the cost of the Contractor's actual expenditures and savings attributed to the Change Directive. For clarity and by example, savings for deductions of similar materials, equipment, labour or services shall be valued at the same amount as for expenditures for additions of same.
 - .3 labour costs will be determined based on actual time spent and the agreed labour rate, the actual cost of installed line materials and equipment, and the agreed fee for overhead and profit,
 - .4 if the change results in a net decrease in Contract cost, the contract price will be decreased by the net decrease in the cost, without adjustment for the Contractor's percentage fee for overhead and profit,
 - .5 the Contractor shall keep accurate records, in an agreed upon form, of time, quantities and invoiced costs and present an account of the cost of the change in the Work, together with vouchers, material receipts and invoices,
 - .6 this time and material method shall be used until such time as a total cost estimate of the change is agreed between the Owner and the Contractor, at which time all payments made under this time and material method will be credited against the agreed total cost for the change.

5.4 Unit Price Method

- .1 Costing of changes by the Unit Price method:
 - .1 Costs for work identified by agreed unit costs shall be charged at those rates, unless the Owner agrees to other rates.

5.5 Proposed Changes; Other Change Instructions Method

- .1 For proposed changes to the Work or other similar instructions, submit a detailed quotation for approval.
- .2 The adjustment in the Contract Price for a change carried out by way of proposed change or other similar instruction shall be determined on the basis of the cost of the Contractor's actual expenditures and savings attributed to the Proposed Change. For clarity and by example, savings for deductions of similar materials, equipment, labour or services shall be valued at the same amount as for expenditures for additions of same.
- .3 Costs are to be approved by the Owner before the proposed change to the Work proceeds. The quotation for the change to the Work is to include a summary of charges made up of three components: labour charges, material costs and fees.
- .4 Labour Charges:
 - .1 The labour unit hour estimates are to be based on the current MCAA estimating manual unless otherwise agreed by the Consultant;
 - .2 The labour cost is to be determined using the agreed labour rates.
 - .3 Labour rates for Foreperson and Senior Foreperson shall be as per agreement, or in absence of such agreement shall be 1.15 times the journeyman labour rate. The maximum allowable labour hours for supervision are not to exceed:
 - (a) for a Foreperson, a maximum of 10% of the total calculated journeyman hours on a change, and

(b) for a Senior Foreperson of all levels, a maximum combined amount of 3% of the total calculated journeyperson hours on a change.

(c) no other supervisory hours will be permitted.

.5 Material Charges:

.1 Material costs for line materials and installed equipment are to be net of trade discounts. The discount to be applied to list prices for items included in Allpricer manual shall not be less than:

(a) 20% for line materials, and

(b) 10% for equipment that is not line material.

.6 Fees:

.1 The Contractor and any sub-contractor is allowed a combined overhead and profit fee of 15% for work to be performed by their own forces,

.2 The Contractor and any sub-contractor is allowed a combined overhead and profit fee of 5% for work performed by a sub-contractor (in the case of the Contractor) or a sub-sub-contractor (in the case of work performed for a sub-contractor),

.3 For clarity, the allowable fees on direct work and on sub-contracted work apply to a sub-sub-contractor of any tier.

5.6 Cash Allowances; Contingency Allowances

.1 Instructions for changes to the Work to be performed under a cash allowance or contingency allowance ("Allowance") included in the contract price shall be authorized by a Cash Allowance Disbursement instruction.

.2 Except as described below, the determination of costs for Work performed under an Allowance shall be in accordance with the procedure for proposed changes unless otherwise instructed to proceed with the work, in which case the cost of such work shall be valued in accordance with the procedures for Change Directive.

.3 The contract price, not the Allowance, includes the overhead and profit fee for the value of the Allowance.

.4 Except where otherwise specified in the Construction Contract, where the cost of the Work performed under a Cash Allowance Authorization;

.1 is less than the Allowance value, the contract price includes the overhead and profit for the contractor and any sub-contractors. A change order will be issued for a credit for the balance of the Allowance, but shall not include the associated overhead and profit fee.

.2 exceeds the Allowance value, a Change Order will be issued for the amount in excess of the Allowance, and the excess amount is to include the agree fee for overheat and profit.

6 SUBMITTALS

6.1 Shop Drawings and Product Data Sheets

.1 Submit shop drawings, manufacturers product data and samples in accordance with the requirements of Specification sections of Division 01, this Part, and as further required in other Specification sections of Division 20.

.2 Submit shop drawings in the same unit of measure as are used on the drawings. Both metric and U.S. customary units may be included.

.3 Submit shop drawings by email to: shopdrawings@hhangus.com, except where a project document management web-service is used.

- .4 Include a H.H. Angus shop drawing cover sheet form prepared for this project for each shop drawing submittal (refer to part "Attachments" for an example of this form);
 - .1 Information required on each submission:
 - (a) Client/Architect name,
 - (b) Project Name,
 - (c) H.H. Angus project number,
 - (d) Date,
 - (e) Contractor name,
 - (f) Contractor reference No.,
 - (g) Manufacturer name,
 - (h) Product type,
 - (i) Specification section number,
 - (j) Contractor trade category: architectural, structural, conveying equipment, user equipment, mechanical, electrical, telecommunications, civil or other.
 - (k) If a re-submission, the Consultant's previous submittal reference number.
- .5 Submit shop drawings in PDF format except as follows;
 - .1 if the Consultant agrees to a shop drawing to be submitted in hardcopy format, submit in 8.5 x 11 or 11 x 17 size, black and white originals of graphic quality suitable for photocopying and digital scanning. Allow one additional week for processing of shop drawings submitted in hardcopy format.
- .6 Manufacturer's letter sized product data sheets for standard items are acceptable in place of shop drawings provided that physical characteristics are identified and are related to specification references.
- .7 Submit with manufacturers data sheets, typed schedules listing manufacturer's and supplier's name and catalogue model number.
- .8 For plumbing fixtures and other permeant fixtures, submit fixture sheets with catalogue numbers. Identify and arrange fixture sheets in the same sequence and using the same identification number as shown in specification fixture lists.
- .9 Shop drawings and/or product data sheets to show;
 - (a) dimensioned outlines of equipment and construction details,
 - (b) equipment weights and center of gravity,
 - (c) performance ratings,
 - (d) dimensioned details showing service connection points,
 - (e) elevations illustrating locations of visible equipment such as gauges, pilot lights, breakers and their trip settings, windows, meters, and access doors,
 - (f) description of operation,
 - (g) single line diagrams,
 - (h) general routing of bus ducts and connecting services,
 - (i) mounting and fixing arrangements,
 - (j) operating and maintenance clearances,
 - (k) access door swing spaces, and
 - (l) where products are required to be certified to a published standard, the mark of the testing organization who certified the product and the standard reference number to which it is certified.

- .10 Shop drawings and product data to be accompanied by;
 - (a) detailed drawings of bases, supports and anchor bolts,
 - (b) sound power data, where applicable, and
 - (c) performance curve for each piece of equipment marked with point of operation.
- .11 Shop drawing and data sheet submission is taken as certification that the products are;
 - .1 from the manufacturer's current production, and
 - .2 in compliance with applicable codes, standards, and regulations.
- .12 For standard catalogued (non-custom) products, do not submit drawings showing internal construction details, component assemblies or interior piping and wiring diagrams. Such information may be necessary to understand correct functioning of equipment and are to be submitted with operating and maintenance data.
- .13 Check and stamp each shop drawing as being correct before submission. Shop drawings without such stamps will be rejected and returned.
- .14 Keep one copy of each reviewed shop drawing and product data sheet on site and have them available for reference purposes.
- .15 Where equipment is delivered without reviewed shop drawings, equipment will be condemned and is to be removed from site and replaced with new equipment after shop drawings have been submitted and reviewed.

6.2 Coordination, Fabrication, or Installation Drawings

- .1 Contractor coordination, fabrication, installation and/or sleeving drawings are to be provided in accordance with specification Section 20 01 03 *Mechanical Coordination and Installation Design Services*.
- .2 Contractor's coordination, fabrication, installation, and/or sleeving drawings will not be reviewed as shop drawings. If submitted as a shop drawing, a transmittal only will be returned identifying the submitted drawings have not been reviewed as a shop drawing.
- .3 Maintain a copy on site of such drawings for reference by the Consultant.
- .4 The Consultant reserves the right to request selected Contractor's coordination, fabrication, or installation drawings for review.

6.3 Effect of Consultants Review of Submittals

- .1 Consultant's review of shop drawings is performed on a sampling basis only, to confirm to Consultant's satisfaction that the Contractor understands the Work to be performed and is interpreting the design documents correctly, and such reviews are performed for the benefit of the Owner.
- .2 For greater certainty, the review of shop drawings by Consultant does not constitute a quality control function for the benefit of Contractor, nor does such a review relieve Contractor of their responsibility for complying with the Contract documents.

7 APPLICABLE CODES, STANDARDS AND REGULATIONS; PERMITS

7.1 Codes, Standards and Regulations

- .1 Where a published product standard or installation code is adopted by statute or regulation by an applicable AHJ, the applicable edition of the standard or code is the one that has been adopted
 - .1 at the time of obtaining a permit for the applicable portion of the Work, or

- .2 in the absence of a requirement for a permit, the start date of construction.
- .2 Where a published product standard or installation code is not adopted by statute or regulation, then the most current edition of that standard or code at the start date of construction applies.
- .3 Install mechanical and electrical systems in accordance with the applicable requirements adopted by the AHJ in the jurisdiction of the Work.
- .4 Where requirements of the Specifications exceed those of applicable codes, standards, and regulations the requirements of the Specifications is to govern.
- .5 In the event of a conflict between codes, bulletins, regulations, or standards, or where work shown is in conflict with these documents, obtain interpretation before proceeding. Failure to clarify any ambiguity will result in an interpretation requiring application of the most demanding requirements.

7.2 Confined Spaces

- .1 Unless otherwise prescribed by the Constructor's / Owner's workplace safety program, treat spaces not designed and constructed for continuous human occupancy as confined spaces in accordance with applicable health and safety legislation, including but not limited to:
 - .1 horizontal and vertical service spaces, shafts, and tunnels,
 - .2 inside of equipment which permits entry of the head and/or whole body, and
 - .3 ceiling spaces which are identified as containing a hazardous substance.

7.3 Permits, Tests and Certificates

- .1 Arrange and pay for permits, tests, and Certificates of Inspection required by the AHJ applicable to the element of the Work.
- .2 Submit applications requiring Owner's signature before commencing work.
- .3 Obtain and submit applicable AHJ Inspection certificates or reports including but not limited to:
 - (a) Electrical inspection,
 - (b) Plumbing and drainage inspection,
 - (c) HVAC inspection,
 - (d) Pressure Vessel Inspection.
 - (e) Piping and Boiler Inspection.
 - (f) Fuel safety Inspection.
- .2 Renew certificates or reports so as to remain in force through the warranty period.
- .4 Co-ordinate and perform testing required by an AHJ in accordance with the Part on Testing in this Section.

8 COMMON PRODUCT REQUIREMENTS

8.1 Standard of Material and Equipment

- .1 Provide materials and equipment in accordance the requirements of Specification section of Division 01 and as follows.
- .2 Materials and equipment:
 - .1 new and of uniform pattern throughout work,
 - .2 of Canadian manufacture where obtainable,
 - .3 standard products of approved manufacture,

- .4 labeled or listed (certified) to applicable standards in accordance with Specification sections of the Work and as required by authorities having jurisdiction,
 - .5 registered in accordance with the requirements of the applicable provincial pressure vessels regulation and registered in accordance with CSA B51 for Canadian Registration Numbers, as applicable,
 - .6 in compliance with Standards and Regulations including but not limited to;
 - (a) chemical and physical properties of materials,
 - (b) design,
 - (c) performance characteristics, and
 - (d) methods of construction and installation.
 - .7 identical units of equipment to be by the same manufacturer. ,
 - .8 identical component parts of same manufacturer in similar units of equipment, but various component parts of each unit need not be from one manufacturer.
- .3 Materials and equipment are described to establish standards of construction and workmanship. Where manufacturers and/or products are listed under "Standard of Acceptance", select manufacturers and or products from these lists. Use of manufacturers or products other than as listed are subject to specification requirements concerning requests for substitution.
- .4 Include items of material and equipment not specifically noted on Drawings or mentioned in Specifications but which are required to make a complete and operating system.
- .5 Confirm capacity or ratings of equipment being provided, when based on ratings of equipment being provided under other trade Sections, before such items are purchased.
- .6 Factory fabricated control panels and component assemblies are to be listed for electrical safety requirements.
- .7 Select materials and equipment in accordance with manufacturer's recommendations and these Specifications, and install same in accordance with manufacturer's instructions and these Specifications.
- .8 Materials and equipment not satisfying these selection criteria will be condemned. Remove condemned materials from job site and provide properly selected and approved materials.

8.2 Manufacturers Nameplates

- .1 Provide manufactured equipment with metal nameplate with raised or recessed lettering, mounted on each piece of equipment. On insulated equipment, mechanically fasten plates on metal stand-off bracket arranged to clear insulation.
- .2 Manufacturer's nameplate to indicate equipment size, capacity, model designation, manufacturer's name, serial number, voltage, cycle, phase and power rating of motors, and approval listings.
- .3 Certified products are to clearly show the mark of the certification agency when in the final installed state.

8.3 Factory Applied Painting

- .1 Protect factory finished equipment during construction, and clean at completion of work.
- .2 Touch-up factory painted prime and/or final coats damaged during construction, with colour matching paint recommended by the equipment manufacturer.
- .3 Use heat resistant paint where conditions require.

8.4 Factory Applied Prime Painting

- .1 Factory-prime paint other equipment fabricated from iron or steel, including equipment supports and hangers, access platforms, access doors, registers, grilles, diffusers, dampers, metal radiation enclosures and fire hose cabinets where separate product specifications do not require a factory applied final coat.

8.5 Field Painting

- .1 After equipment has been installed and piping and insulation is completed, clean rust and oil from exposed iron and steel work provided under this Division, whether or not it has been factory prime painted.
- .2 In "occupied" areas of building touch up any damage to prime coat resulting from shipping or installation and leave ready for final decorative painting under Finishes, Division 9.
- .3 In addition, apply prime and/or final paint coats to equipment and materials where specifically detailed in other Sections of these Divisions.

8.6 Provision for Future

- .1 Where space is indicated as reserved for future equipment or for future extension to building, leave such space clear and install piping, raceways and equipment so that connections can be made to future apparatus or building.
- .2 Identify provisions and service terminations for future on Record Drawings.

8.7 Maintenance of Bearings

- .1 Turn-over rotating equipment at least once a month from delivery to site until start-up.
- .2 Run-in sleeve type bearings in accordance with manufacturer's written recommendation. After "run-in", drain, flush out and refill with new charge of oil or grease.
- .3 Protect bearings, shafts and sheaves against damage, corrosion and dust accumulation during building construction.

8.8 Pre-purchased Equipment; Damage and Ownership

- .1 At time of receipt of pre-purchased or pre-tendered equipment at the job site by the installing mechanical contractor, provide the services of the manufacturer/distributor/supplier's technical representative to:
 - .1 inspect the equipment prior to unloading,
 - .2 witness the unloading and advise the contractor on the appropriate method for handling the equipment in order to avoid damage during the unloading, moving and setting in place phase of the equipment, and
 - .3 report any damage to the Consultant.
- .2 In the event the equipment has been found to be damaged before unloading, it is to be returned immediately to the factory for repairs and/or replacement by the manufacturer/supplier.
- .3 In the event of damage occurring at any time during unloading and until the equipment is accepted by the Owner, the installing contractor is responsible for repairs and/or replacement of the damaged equipment to the satisfaction of the Owner.

9 OFFICE AND STORAGE; TOOLS

9.1 Office and Storage

- .1 Provide temporary office, washroom and lunchroom facilities, workshop, and tools and material storage space. Facilities may be site trailers or as otherwise approved by the General Contractor/Construction Manager.
- .2 Assume responsibility for security of these facilities.
- .3 Provide heat, light and telephone and Internet service
- .4 Owners cafeteria is off limits

9.2 Tools, Temporary Equipment and Materials

- .1 Provide tools, equipment, scaffolding, extension cords, lamps and miscellaneous consumable materials, required to carry out the Work.

10 COORDINATION; INSTALLATION DRAWINGS

10.1 Coordination

- .1 Consultant drawings are diagrammatic and illustrate the general location of equipment, and intended routing of ductwork, piping, etc. and do not show every structural detail. In congested areas drawings at greater scale may be provided to improve interpretation of the Work. Where equipment or systems are shown as "double line", they are done so either to improve understanding of the Work, or simply as a result of the use of a CAD drawing tool, and in either case such drawings are not represented as fabrication or installation drawings.
- .2 Lay out and coordinate Work to avoid conflict with work under other Divisions.
- .3 Make good damage to Owner's property or to other trade's work caused by inaccurate layout or careless performance of work of this Division.
- .4 When equipment provided under other Sections connects with material or equipment supplied under this Section, confirm capacity and ratings of equipment being provided.
- .5 Take information involving accurate measurements from dimensioned Architectural Drawings or at building.
- .6 Install services and equipment which are to be concealed, close to building structure so that furring is kept to minimum dimensions.
- .7 Location of pipes, ductwork, raceways and equipment may be altered without extra cost provided instruction is given or approval is obtained, in advance of installation of items involved. Changes will be authorized by site instructions and are to be shown on Record Drawings.
- .8 Location of floor drains, hub drains, combination drains, plumbing fixtures, convectors, unit heaters, diffuser, registers grilles and other similar items may be altered without extra cost provided instruction is given prior to roughing in. No claim will be paid for extra labour and materials for relocating items up to 3 m (10 ft) from original location nor will credits be anticipated where relocation up to 3 m (10 ft) reduces material and labour.
- .9 Include incidental material and equipment not specifically noted on Drawings or mentioned in Specifications but which is needed to complete the work as an operating installation.

10.2 Field, Fabrication, and Installation Drawings

- .1 Prepare field, fabrication, and/or installation drawings to show location of equipment and relative position of services, and to demonstrate coordination with the work of other trades;

- .1 drawing scale: minimum 1:50 (1/4"=1'-0")
 - .2 use information from manufacturer's shop drawings for each trade and figured dimensions from latest Architectural and Structural Drawings,
 - .3 layout equipment and services to provide access for repair and maintenance,
- .2 Circulate drawings to other trades involved in each area, and conduct coordination meetings with those trades.

11 ANCHORS AND INSERTS

- .1 Supply anchor bolts and locating templates for installation in advance of concrete pouring.

12 CUTTING, PATCHING AND REMEDIAL WORK

12.1 General

- .1 Assume responsibility for prompt installation of work in advance of concrete pouring, masonry, roofing, finishing trades and similar work. Should any cutting or repairing of either unfinished or finished work be required because such installation was not done, employ the particular trade whose work is involved to do such cutting and patching and pay for any resulting costs.
- .2 Neatly cut or drill holes required in existing building elements to accommodate building services including ductwork, piping, cable, raceways, bus duct or cable tray.
- .3 Arrange and pay for all cutting and patching as required for the Work. Before cutting, drilling, or sleeving structural load bearing elements, obtain the Consultant's approval of location and methods in writing. Employ original installer or expert in the finishing of material required to perform cutting or patching for weather-exposed, moisture-resistant elements or sight-exposed surfaces.

12.2 Structure Scanning and Cutting

- .1 Layout cutting of structural elements, such as floors slabs, walls, columns or beams and obtain approval before starting work. Conduct an initial electromagnetic scan of reinforcing rods and electrical conduit, and review with structural engineering Consultant.

Standard of Acceptance

- Hilti - fig. PS 300 Ferroscan

- .1 Based on the preceding results, arrange and pay for supplemental radiographic examination where necessary to improve on locating concrete reinforcement, conduits and other embedment's.
 - .1 submit radiographic results to the structural engineer and obtain comments before starting work,
- .2 Based on the preceding results, provide two-dimensional ground penetrating radar scans to locate concrete reinforcement, conduits and other embedments. Scanners to be operated by personnel trained by the measurement device manufacturer.

Standard of Acceptance

- Hilti PS1000 X-SCAN

- .3 Relocate core drilling location if steel or conduit is found in the proposed location and repeat procedure. Reroute any circuits damaged by core drilling.
- .4 Scan for all shots and anchors in floors, walls, and ceilings.

13 PROTECTION OF PERSONNEL, WORK, AND PROPERTY

13.1 Personnel Protection

- .1 Without limiting the Contractor's responsibilities regarding occupational health and safety requirements at the construction site, provide specific personnel protection as follows:
 - .1 protect exposed live equipment during construction for personnel safety,
 - .2 shield and mark live parts "LIVE 120 VOLTS", or with appropriate voltage,
 - .3 arrange for installation of temporary doors for rooms containing electrical distribution equipment. Keep these doors locked except when under direct supervision of electrician,
 - .4 do not leave conduit, wires, cables, tools, equipment or materials in such a way that they constitute a hazard,
 - .5 provide toe guards around openings in the roof or floor to prevent materials or debris from dropping down to a lower level,
 - .6 remove loose equipment and tools from overhead areas before leaving each day,
 - .7 cut off bolts at floor level to eliminate a possible tripping hazard.

13.2 Protection During Construction

- .1 Provide protection required to enable existing building and equipment to remain in continuous and normal operation.
- .2 Take the necessary precautions to protect equipment, existing building and service from damage during the Work. Accept responsibility for any damage and make good without cost to the Owner.
- .3 Protect existing surfaces and items so that they are not damaged in any way whatsoever by the work of all trades. Take precautions as necessary to prevent damage to walls, floors, ceilings, windows, doors, door frames, moldings, finishes, piping, ductwork, light fixtures, etc. Provide protection, hoarding, tarpaulins, dust sleeves etc., as required. Any damage caused because of lack of adequate protection to be made good at no cost to the Owner.
- .4 Take care when working above or around equipment that must remain in service.
- .5 Take care to eliminate dust in equipment areas.
- .6 Protect switchgear fronts from accidental breaker trips when working around or above them. Provide an extended shield constructed of 12 mm (½") fire retardant plywood a minimum of 450 mm (18") from board front to allow access to board.

13.3 Core Drilling

- .1 Wherever core drilling is required, provide temporary dust proof screens.
- .2 In areas where core drilling through a slab in an operating facility is necessary, clearly mark out the areas to be drilled on the underside of slab. Owner's representative to be notified at least 1 week prior to core drilling operation. Provide tarping of equipment supervised by the Owner.
- .3 During core drilling operations, station at least one person directly below the area of drilling with a large plastic container pressed to underside of slab to capture and hold core and water upon completion of operations.

- .4 Continuously use a wet/dry commercial quality vacuum at location of drilling operation to remove all excess water from the area.

13.4 Temporary Dust Proof Screens

- .1 Comply with Division 01 for temporary dust proof screens and infection control procedures.

13.5 Protection of Floors During Equipment Installation

- .1 Provide protection of floor finishes during installation or removal of equipment, and at any other time when moving or installing heavy equipment.
- .2 Install 19mm (¾") plywood over 6 mil plastic over finished floor areas when moving heavy equipment that could damage floor finish, or when installing equipment or line materials overhead.
- .3 Repaint or re-tile any floors or walls damaged or scratched during construction.

13.6 Housekeeping

- .1 Maintain a high level of cleanliness.
- .2 Remove scrap and refuse from the work area daily.
- .3 Whenever possible, clean up immediately following completion of work.
- .4 Deposit oily and waste solvent rags in approved containers to minimize the fire hazard.
- .5 Sweep and damp mop daily.

14 WORK IN EXISTING BUILDING

14.1 General

- .1 Comply with Division 01 for restrictions on working in existing occupied buildings and as follows.
- .2 During the tender period, the Contractor shall perform a site inspection of the place of work and surroundings including the accessible ceiling spaces and other areas where access could be considered reasonable. Make a thorough investigation of as-built conditions to determine scope of renovation or demolition work required prior to submitting tender.
- .3 The Work includes changes to existing building. Route pipes, ducts, conduits and other services to avoid interference with existing installation.
- .4 Perform core drilling after-hours or on weekends depending on the schedule of the impacted spaces. Coordinate with Owner for specific times.
- .5 Relocate existing pipes, ducts, conduits, bus ducts and any other equipment or services required for proper installation of new work, including as required for temporary removal and re-installation to suit new installation work.
- .6 Remove existing plumbing fixtures, lighting fixtures, piping, ductwork, wiring, and equipment to suit new construction. Cut back and cap drain, vent and water outlets, conduits and electrical outlets, not being used.
- .7 Unless noted otherwise removed materials and equipment become the property of the Contractor and are to be taken from the site and disposed of appropriately.
- .8 On completion of relocations, confirm relocated equipment are in proper working order.

- .9 Where Owner wishes to take over renovated areas ahead of project completion date and these areas are to be fed from new distribution systems, make temporary connections to existing services in these areas. Reconnect to permanent services, at later date, when new distribution systems are available.

14.2 Continuity of Services

- .1 Keep existing buildings in operation with minimum length of shutdown periods.
- .2 Make connections to existing systems at approved times.
- .3 Obtain written approval recording times when connections can be made.
- .4 Arrange work so that physical access to existing buildings is not unduly interrupted.
- .5 Be responsible for and make good any damages caused to existing systems when making connections.
- .6 Provide premium time labour to tie-in to services at night or on weekends.
- .7 For piping systems, make connections to existing piping by draining down the existing piping system. Use of hot-tapping or freezing of piping is only permitted where approved by the Owner and a specification section for such work has been included in the project specifications.
- .8 Provide temporary services to drain down existing piping systems which convey liquids or steam condensate, including provision of temporary hoses, etc., and provide services to perform the drain down of these systems, except where the Owner elects to perform such drain-downs.
- .9 For piping systems conveying liquids, after completion of new work to existing piping systems, refill the existing and new piping systems including provision of cleaning of new piping and addition of chemical treatments, as applicable, in accordance with the requirements of other sections of Division 20. Include for addition of replenishing chemical treatment for existing piping systems in accordance with the Owner's existing chemical treatment program, or in the absence of such, in accordance with the chemical water treatment requirements specified in other Sections of Division 20.

15 MOVING AND SETTING IN PLACE OF OWNER-SUPPLIED PRODUCTS

15.1 General

- .1 The requirements of this Part applies to;
 - .1 Division 20 equipment that has been directly purchased by the Owner, and
 - .2 other Owner-supplied products or equipment (i.e. process equipment) that has building services requirements.
- .2 Comply with the requirements of Division 01 and as specified herein.

15.2 Owner-Supplied Products (Supplied by Owner Equipment – "SBO")

- .1 Items marked SBO on drawings are to be;
 - .1 purchased by the Owner,
 - .2 received, checked, and stored by the Contractor, and
 - .3 subsequently unpacked, uncrated, assembled and located in its final location by the Contractor, and installed in accordance with the manufacturer instructions,
 - .4 participate in the start-up and testing of the equipment and placing into service.
- .2 Provide mechanical and electrical services to SBO equipment in accordance with the SBO equipment manufacturer's instructions and as otherwise shown.

15.3 Existing Owners Equipment to be Relocated (E.R. or Ex. Rel.)

- .1 Applies to owners existing equipment which has mechanical and electrical services, and marked on the drawings as E.R. Ex.Rel. or otherwise so identified.
- .2 Items so marked on drawings are to be moved from their present location and reinstalled by the Contractor.
- .3 Disconnect and reconnect mechanical and electrical services to accommodate this equipment relocation.

16 TEMPORARY HEATING

16.1 During Construction

- .1 Temporary heating required while building is under construction will be provided under Division 01.
- .2 Permanent heating system may be used for temporary heating, when this equipment is installed in its permanent location and the building is closed-in and Contractor under Division 1 provides staff for operation and maintenance whenever permanent heating system is being used for temporary heating.
- .3 Hot water boilers may not be used unless heating units, radiation, pumps and piping are complete, the piping system has been pressure tested, cleaned, and final chemical water treatment is in operation.
- .4 Permanent heating equipment used for temporary heating to be thoroughly cleaned and put in first class operating condition and appearance at completion of the Work, as approved by the Owner.

17 FINAL CLEANING AND ADJUSTMENTS

17.1 Final Cleaning

- .1 Conduct final cleaning in accordance with Division 01 requirements and as specified herein.
- .2 Perform final cleaning after construction activities that create dust have been completed.
- .3 Thoroughly clean exterior surface of exposed piping, and vacuum external surfaces of exposed ducts and interior surfaces of air handling units. Clean strainers in piping systems and install clean filters in air handling systems immediately prior to handover of the building to the Owner.
- .4 HEPA vacuum the top and interiors of motor controllers, VFDs, control panels, and control cabinets followed by a thorough HEPA vacuuming of the service room floors. Thoroughly wash floors with wet mop and clean water. Control access to the room after cleaning. Provide temporary filter media on air supply ducts to these rooms to prevent re-contamination from other areas of construction.
- .5 Remove tools and waste materials on completion of work and leave work in clean and perfect condition.

17.2 Final Adjustments

- .1 Calibrate components and controls and check function and sequencing of systems under operating conditions.
- .2 Supply lubricating oils and greases for proper operation of equipment and systems until work has been accepted.

18 RECORD DRAWINGS

18.1 Record Drawings

- .1 Maintain record drawings in accordance with Division 01 during the course of the Work and as follows.

- .2 A set of design drawings in AutoCad, Revit, or PDF format (as determined by the Consultant) will be provided by the Consultant. Record changes in actual installation as the Work progresses by the following method:
 - .1 make sets of white prints for each phase of Work and mark-up the print drawings, or
 - .2 revise the AutoCad or Revit file directly, and identify all changes made.
- .3 Mark-up these record drawings to provide dimensioned locations of drains, pipes, ductwork, conduit, manholes, foundations and similar buried items within the building, with respect to building column centres. Mark level with respect to an elevation which will be provided.
- .4 Retain on-site the survey information from excavation and backfill of site services, and after approval, transfer this information to the record documents.
- .5 Retain these drawings and make available to Consultant for periodic review.
- .6 At 50%, 75% and 90% project completion, scan marked-up drawings to PDF format and submit copy to the Consultant, or to the project on-line document management service if one is used.

18.2 As-Built Drawings

- .1 Prior to testing, balancing and adjusting, transfer site record drawing information to a copy of the computer aided drafting/design program ("CAD") files, in the same software format used for the Consultants design drawings, to record final as-built condition.
- .2 Obtain a current set of CAD files from the Consultant. The Consultant's CAD files may not reflect all or any construction changes.
- .3 Drawings are to remain set to and follow Consultants CAD Standards - do not alter drawing scales, reference files, colours, layers or text styles,
- .4 Where items have been deleted, moved, renumbered or otherwise changed from contract drawings, revise the CAD files to record these changes. "Bubble" these revisions, and place these annotations on a separate and easily identified drawing layer.
- .5 Show on mechanical as-built drawings final location of piping, ductwork, switches, starters, Motor Control Centres, thermostats, and equipment.
- .6 Show on site services as-built drawings survey information provided by an accredited land surveying service.
- .7 Identify each drawing in lower right hand corner in letters at least 12 mm (½ in) high with a note as follows:

<p>AS-BUILT DRAWINGS. This drawing has been revised to show systems as installed (Signature of Contractor) (Date).</p>
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- .8 The site services drawings are to include the signature and stamp of the accredited surveyor adjacent to the note.
- .9 Submit one (1) set of white prints of the draft as-built CAD files for Consultant's review.
- .10 Once "AS BUILT DRAWINGS" white prints are reviewed, transfer Consultant's comments to the CAD files. Return CAD files modified to "As Built" condition to Consultants electronically by removable mass storage device or by electronic file transfer as designed by the Consultant.
- .11 Submit three (3) sets of white prints and one (1) electronic copy of CAD files with Operating and Maintenance Manuals to the Owner.

19 OPERATING AND MAINTENANCE INSTRUCTIONS

19.1 Operating and Maintenance Manuals

- .1 Provide operating and maintenance manuals in accordance with Division 01 and as follows.
- .2 Provide operation and maintenance data bound in vinyl covered, hard back, three-ring covers, nominally 50 mm (2 in) thick, suitable for paper size of 210 mm x 300 mm (8½ in x 11 in);
 - .1 organize material in volumes, generally grouped by Trade section;
 - (a) Table of Contents,
 - (b) General Information,
 - (c) Sub-contractors (list),
 - (d) Site services,
 - (e) Fire Protection,
 - (f) Plumbing,
 - (g) Heating and Cooling Plant and Distribution,
 - (h) Air Handling Equipment and Distribution,
 - (i) Building automation, Controls and Instrumentation,
 - (j) Testing Reports,
 - (k) As-Built Drawings,
 - (l) Warranties.
 - .2 Title sheet in each volume to be labeled "Operating and Maintenance Manual" and to bear;
 - (a) Project Name,
 - (b) Project Number,
 - (c) Date,
 - (d) Trade Section,
 - (e) List of Contents.
 - .3 Provide three hard-copies to Owner.
- .3 In addition, provide PDF files for each document, produced from original direct-to-digital file creations;
 - .1 organize documents into separate PDF files for each Trade Section identified above, and apply PDF Bookmarks to create a Table of Contents for each file.
- .4 Operating data to include;
 - .1 control schematics for each system,
 - .2 description of each system and associated control elements,
 - .3 control operating sequences at various load conditions, reset schedules and anticipated seasonal variances,
 - .4 operating instructions for each system and each component,
 - .5 description of actions to be taken in event of equipment failure,
 - .6 valve schedules and flow diagrams,
 - .7 service piping identification charts.
- .5 Maintenance data to include;

- .1 manufacturer's literature covering servicing, maintenance, operating and trouble-shooting instructions for each item of equipment,
 - .2 fault locating guide,
 - .3 manufacturer's parts list,
 - .4 reviewed shop drawings,
 - .5 equipment manufacturer's performance sheets,
 - .6 equipment performance verification test results,
 - .7 voltage and ampere rating for each item of electrical equipment,
 - .8 spare parts list and an itemized cost,
 - .9 name and telephone numbers of service organization and technical staff that will provide warranty service on the various items of equipment.
- .6 Approval procedure;
- .1 submit one set of first draft of Operating and Maintenance Manuals for approval at least one month prior to planned substantial performance date,
 - .2 make corrections and resubmit for a final review,
 - .3 review contents of Operating and Maintenance Manuals with Owner's operating staff or representative to ensure thorough understanding of each item of equipment and its operation.
 - .4 hand-over two (2) hard-copies and one (1) PDF copy on removable storage device of the Operating and Maintenance Manuals to the Owner's operating staff and obtain written confirmation of delivery. Provide a copy of the delivery record to the Consultant.

19.2 Operating and Maintenance Training

- .1 Provide operating and maintenance training in accordance with Division 01 and as follows.
- .2 Provide training to Owners operations staff to thoroughly explain operation and maintenance of each system, incorporating specialized instruction by manufacturers as described under other Sections in these Divisions. Include classroom instruction and hands-on instruction, delivered by competent instructors.
- .3 Develop the proposed training plan, and submit an outline of the training program for review, adjustment and approval by the Owner.
- .4 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, utilizing the services of the manufacturers' representative as required.
- .5 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each training topic, separated by approximately one week each. Develop the proposed training plan and obtain approval from the Owner before commencing training.
- .6 All training to be scheduled and provided between the hours of 7 am to 5 pm, Monday to Friday. Where training is required to be performed outside of these hours due to availability of Owners operations personnel, if the trainers are paid for overtime outside of these hours, the overtime portion only is eligible to be paid by the Owner as an extra cost.
- .7 Complete the training as close to Substantial Performance as possible, so that the operations staff are prepared to operate the systems after Substantial Performance is certified.
- .8 Organize each training sessions as follows:

- .1 Fire Protection - Division 21
- .2 Plumbing – Division 22
- .3 HVAC – Division 23
- .4 Building Management System – Division 25
- .9 Keep records of date and duration of each instruction period together with names of persons attending. Submit signed records at completion of instruction.
- .10 For each training session, include the following topics;
 - .1 general purpose of system (design intent),
 - .2 use of O&M manuals,
 - .3 review of control drawings and schematics,
 - .4 start-up, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, control set-up and programming troubleshooting, and alarms,
 - .5 interaction with other systems,
 - .6 adjustments and optimizing methods for energy conservation,
 - .7 health and safety issues,
 - .8 special maintenance and replacement sources,
 - .9 occupancy interaction issues, and
 - .10 system response to different operating conditions.
- .11 Develop and provide training material, including printed documents and electronic presentation aids (e.g. MS PowerPoint) for each session. Submit three (3) copies of materials in both hardcopy and PDF format, in accordance with article on Operating and Maintenance Manuals.
- .12 Sessions may be video recorded by the Owner as an aid to ongoing training of Owners staff.

20 CARE, OPERATION AND START-UP

- .1 Provide all labour and materials as necessary to perform start-up and testing of equipment and systems.
- .2 Arrange and pay for services of manufacturer's factory service technician to supervise start-up of the installation, check, adjust, balance and calibrate components and equipment as specified in the specification sections of Division 20.
- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with every aspect of the operation, care and maintenance thereof.
- .4 Arrange and pay for services of applicable manufacturer's factory service engineer or certified independent testing organization to supervise initial start-up of specialized portions of installation and to check, adjust, balance and calibrate components including related wiring and controls. Provide these services for such periods, and for as many visits as may be necessary to put applicable portion of the installation in complete working order. Provide a certificate indicating that the equipment is free and clear of deficiencies.

21 TESTING

21.1 General

- .1 The following describes the general requirements for testing of mechanical systems; refer to additional testing requirements in applicable sections of Division 20 of the Work.
- .2 Conduct tests during progress of Work and at its completion to verify equipment and systems meet the contract documents. Submit details of test methods in writing and obtain approval before commencing work.
- .3 Supply test equipment, apparatus, gauges, meters and data recorders, together with skilled personnel to perform tests and log results.
- .4 Submit written notice 24 hours in advance of each test series, setting out the time, place and nature of the tests, to the Inspection Authority and personnel witnessing tests.
- .5 The Owner reserves the right to witness any test; any such witnessing activity shall not be construed as acceptance of the system or equipment by the Owner.
- .6 Conduct tests before application of external insulation and before any portion of pipes, ducts or equipment is concealed.
- .7 Do not subject expansion joints, flexible pipe connections, meters, control valves, convertors, and fixtures, to test pressures greater than the stated working pressure of equipment. Isolate or remove equipment or devices during tests when prescribed test pressure is greater than working pressure of any piece of equipment or device.
- .8 Should section of pipe, duct, or electrical cable fail under test, replace faulty piping, duct, or cable with new fittings, pipe, duct or cable and then retest. Do not repair threaded pipe joints by caulking nor welded joints by peening. Repeat tests until results are satisfactory.
- .9 Where it is necessary to test portions of piping, ductwork or electrical cable system before system is complete, overlap successive tests so that no joint or section of duct or pipe is missed in testing.
- .10 Upon completion of work and testing of same, submit logs to demonstrate that tests have been carried out satisfactorily. Repeat any tests if requested.

21.2 Testing of Integrated Life Safety and Fire Protections Systems

- .1 Conduct testing of integrated life safety and fire protection systems in accordance with specification Section 20 08 11 *Testing of Integrated Electrical Life Safety and Fire Protection Systems*.

21.3 Testing - Potable Water Piping

- .1 Except where otherwise specified in other sections of Division 22, test potable water systems with water or air as required by the plumbing code in effect at the location of the Work.
- .2 For water service pipes 100 mm (4") and larger, disinfect the pipe with chlorine ("hyper-chlorinate") from the street valve to the first shut-off valve inside the building. At completion of disinfection, take water samples just before the utility meter and pay for the samples to be tested by an accredited testing laboratory. Test the water samples for contaminants and to measure the residual chlorine concentration and provide test certificate confirming water contaminates are below the threshold values proscribed by applicable legislation.
- .3 Where stainless steel piping is used in the domestic water system, between the entry point in the building and the utility water meter, after taking the water sample for laboratory testing, immediately drain down the incoming service piping up to the utility meter and then flush with clean city water until a site test of the drain water shows a residual chlorin level not greater than the incoming city water supply.

- .4 Where stainless steel piping is used in potable water piping inside the building (i.e. downstream of the utility meter), do not allow any hyper-chlorinated water used for disinfection of piping to come into contact with the stainless steel piping.

21.4 Testing - Other Piping

- .1 Except where otherwise specified in other sections of Divisions 21, 22 or 23, hydraulically pressure test other water piping systems at 1½ times system design pressure (relief valve setting) or 1000 kPa (150 psi), whichever is greater, for 10 minutes then reduce the test pressure and hold for 24 hours. Pressure must remain essentially constant throughout test period without pumping. Make allowance for correction of pressure readings for variations in ambient temperature between start and finish of test.
 - .1 Alternatively, hold the pressure at the design pressure and testing all joints with a soap test.
- .2 Test natural gas system in accordance with CSA B149.1 *Natural Gas and Propane Piping Code*.
- .3 Test fuel oil systems in accordance with CSA B139 *Installation Code for Oil Burning Equipment*.
- .4 Test drainage, waste and vent piping for tightness and grade as required by the plumbing code in effect at the location of the Work.
- .5 Test special service piping as detailed in other sections of Divisions 21, 22 and 23.

21.5 Testing - Ventilation

- .1 Pressure test ductwork in accordance with section 23 31 13 *Ductwork*, or other applicable sections of Division 23.

21.6 Testing - Electrical

- .1 Make tests of equipment and wiring. Test wiring systems in accordance with section 20 05 12 *Wiring Requirements for Mechanical*.
- .2 Replace defective equipment and wiring with new material.

22 COMMISSIONING

- .1 Participate in commissioning of equipment and systems in accordance with Section 20 08 15 *Mechanical Commissioning*.
- .2 Equipment supplied on this project will be subject to detailed factory inspection and/or on-site testing and commissioning prior to being placed in service. The electrical contractor, their major system and equipment suppliers, and the Independent Testing Agent (ITA) will be required to participate in special commissioning meetings to review progress and status of the commissioning program.
- .3 Include in Bid amount for licensed electricians to participate in the commissioning program, to undertake temporary power connections, operation of equipment, opening and closing of panel boards and switchboards, testing of power and control wiring, and assisting the ITA and the equipment suppliers' field personnel in the startup and testing of the equipment.
- .4 The contractor and equipment suppliers to include in the Bid amount the costs to accommodate and undertake factory and site testing.

23 TEMPORARY AND TRIAL USAGE

- .1 Temporary and trial usage by Owner of any mechanical or electrical device, machinery, apparatus, equipment or any other work or materials before final completion and written acceptance is not to be construed as evidence of acceptance by Owner.
- .2 Owner to have privilege of such temporary and trial usage, as soon as that said work is claimed to be completed and in accordance with Contract Documents, for such reasonable length of time as is sufficient for making complete and thorough test of same.

- .3 No claims will be considered for damage to or failure of any parts of such work so used which may be discovered during temporary and trial usage, whether caused by weakness or inaccuracy of structural parts or by defective materials or workmanship of any kind whatsoever.
- .4 Defects in workmanship and materials identified during temporary and trial usage are to be rectified under warranty.

24 SPECIAL TOOLS AND SPARE PARTS

24.1 Spare Parts

- .1 Prior to application for Substantial Performance, furnish spare parts as follows;
 - .1 one set of mechanical seals for one pump of each model size,
 - .2 one pump casing joint gasket for each model size,
 - .3 one head gasket for each shell-and-tube heat exchanger with removable heads,
 - .4 one glass for each gauge glass,
 - .5 one set of V-belts for each drive of the same model size,
 - .6 one set of filter cartridges for each filter or filter bank installed.
- .2 Maintain an inventory record and delivery receipt record of spare parts delivered to the Owner, and include them in the Operating and Maintenance manuals.

25 CONSULTANT REVIEWS

25.1 General

- .1 Consultant's attendance at site including but not limited to site meetings, demonstrations, site reviews and any resulting reports are for the sole benefit of the Owner and as required by the local authority have jurisdiction. It is the Contractor's responsibility to ensure that the Work is complete and constructed in accordance with the design documents.

25.2 Site Reviews

- .1 General reviews and progress reviews do not record deficiencies during the course of the Work until such time as a portion or all of the work is declared complete. In some instances, before the work is completed, readily noticeable deficiencies may be recorded by the Consultant where the deficient item is indicative of issues such as poor workmanship, incorrect materials or installation methods, or may be difficult to correct at a later date. Any such reported items, or lack thereof, shall not be relied on in any way as part of the Contractor's quality assurance program nor relieve the Contractor in the performance of the Work, specifically in identification and rectification of deficiencies or incomplete Work.
- .2 Deficiency reviews conducted by the Consultant are performed on a sampling basis, and any deficiency item is to be interpreted as being indicative of similar locations elsewhere in the Work, unless otherwise shown.

25.3 Milestone Reviews

- .1 Specific milestone reviews may be conducted at key stages by the Consultant, including;
 - .1 before backfilling of buried drainage,
 - .2 before closing of shafts,
 - .3 before closing of ceilings,

- .4 before closing of walls,
 - .5 equipment demonstration,
 - .6 Substantial Performance deficiency review,
 - .7 Total Performance deficiency review.
- .2 Coordinate with the Consultant the type and quantity of milestone reviews required by the Consultant and incorporate these requirements in the construction schedule.
 - .3 Notify the Consultant in writing seven (7) calendar days in advance of work to be concealed to arrange a site review prior to the Work being concealed where required by the Consultant. Any noted deficiencies are to be corrected before being concealed. Failure to provide notification can result in the Work being exposed for review at the Contractor's cost.

25.4 Partial Occupancy Reviews

- .1 Where the Work is planned to include occupancy by the Owner of a part of the Work but not the entire Work ("partial occupancy"), the procedures specified for Substantial Performance Review will apply to the portion of the Work being considered for partial occupancy.

25.5 Substantial Performance Review

- .1 At the time of applying for project Substantial Performance, submit to Consultant a comprehensive list of items to be completed or corrected.

25.6 Final Review

- .1 At project completion submit written request for final review of mechanical and electrical systems. Refer to section 20 08 19 *Project Close-Out*.
- .2 Include with the request a written certification that:
 - .1 reported deficiencies have been completed,
 - .2 systems have been balanced and tested and are ready for operation,
 - .3 completed maintenance and operating data have been submitted and approved,
 - .4 equipment/line material tags are in place and equipment identification is completed,
 - .5 cleaning is finished in every respect,
 - .6 all mechanical equipment surfaces have been touched up with matching paint, or re-finished as required,
 - .7 spare parts and replacement parts specified have been provided and receipt acknowledged,
 - .8 As-built and Record drawings are completed and approved,
 - .9 Owner's operating personnel have been instructed in operation and maintenance of systems,
 - .10 fire protection verification is 100% completed and Verification Certificates have been submitted and accepted.

26 CONTRACTOR INSPECTIONS

26.1 General

- .1 The Division 20 contractor shall assign one person responsible for ensuring that Work from all mechanical trades is complete prior to:
 - .1 closing in wall, ceilings or burying of services,

- .2 partial-occupancy reviews, and
 - .3 substantial performance reviews.
- .2 In conjunction with the Contractor's Mechanical and Electrical sub-contractors, the Contractor shall walk the site and thoroughly inspect that the work is complete, in good workmanship and installed according to the contract documents and derived documents therefrom. The Contractor shall then submit a report attesting to the completed state of the Work (the "Statement of Completion" report, as detailed later in this part).
- .3 In the case of Contractor inspections for partial-occupancy or substantial performance, submit the Statement of Completion report at least 24 hours prior to the scheduled review by the Consultant.

26.2 Concealed Space Digital Image Records

- .1 Where services are to be concealed behind walls, ceilings, or buried, the Contractor shall make a digital photo or digitally scanned record of the Work, and assemble these digital records in a logical file structure, organized by floor or department, with each record filename including the room number, so as to form a comprehensive documentation of the completed services.
- .2 The digital files and folders are to be turned over to the Consultant for review prior to the Consultant's reviews for partial- occupancy or substantial performance.
- .3 As part of the request for substantial performance of the Work, submit two (2) copies of the digital record on separate removable storage devices to the Owner for their use. These records are in addition to other construction records including as-built documentation.

26.3 Contractor Inspections for Partial Occupancy and Substantial Performance

- .1 In preparation for the Consultants general review for partial-occupancy and/or substantial performance of the Work, the Contractor shall perform a comprehensive inspection of the Work to ensure that their contractual obligations are met before requesting a Consultant's review of the Work. In performing this inspection, the Contractor shall create a Statement of Completion report which is to include;
 - .1 date and time of the Contractor's inspection, signed by the person who conducted the inspection,
 - .2 names of the mechanical contractor's personnel who participated in the inspection,
 - .3 confirmation that previously noted deficiencies have been completed,
 - .4 confirmation that the work is 100% complete, tested, balanced and free of deficiencies, or include a list of outstanding deficiencies and incomplete Work with;
 - (a) a reason why the Work has not been completed (i.e. another trade has to complete their work)
 - (b) a plan of action to complete the Work, and
 - (c) a commitment date for completion of the Work including rectification of all deficiencies.
- .2 The format of the Statement of Completion shall be approved by the Consultant.
- .3 The Consultant shall review and sign-off the Statement of Completion Report and return a copy to the Contractor. The Contractor shall retain on-site a log of all signed off Statement of Completion reports.
- .4 If a required Statement of Completion report is not received, the Consultant reserves the right to withhold conducting a review for partial-occupancy or substantial performance.
- .5 After receipt of the Contractor's Statement of Completion report, if upon entering an area of the work covered by the Statement of Completion report the Consultant determines, in its sole opinion, that the applicable Work is not ready for review, the Consultant may elect to cancel the review of the Work or the affected portion of the Work, and shall assume no responsibility for any damages or losses as a result of cancellation of the review. The Contractor shall remedy the incomplete work and request

another review with 72 hours prior written notice, and shall resubmit the revised Statement of Completion at least 24 hours prior to the new review.

27 CORRECTION AFTER COMPLETION

- .1 At completion, submit a written warranty undertaking to remedy defects in work for a period of one year from date of substantial performance of the Work. This warranty is not to supplant other warranties of longer period called for on certain equipment or materials.
- .2 Warranties are to encompass replacement of defective parts, materials or equipment, and to include incidental fluids, gaskets, lubricants, supplies, and labour for removal and reinstallation of the corrected Work.
- .3 Submit similar warranties for one year from date of acceptance for any part of work accepted by Owner, before completion of the whole Work.

28 ATTACHMENTS

28.1 Schedule of Values Form

- .1 Attached sample of the Schedule of Values form layout.

28.2 Shop Drawing Submittal Form

- .1 Attached sample of shop drawings submittal form.

SCHEDULE OF VALUES

Project Name: <<name of project>>
 Owner Name: <<owner name>>
 Contractor Name: <<name of trade contractor: mechanical, electrical, etc>>
 Division(s) of the Work: <<i.e. 20, 21, 22...>>
 For the billing period ending: dd-mmm-yyyy

This sheet is an example of a required schedule of values to be developed by the Contractor, to be submitted with each progress payment request.
 Specific level of detail for each work element to be approved by the Consultant.

Item	Base Contract Element	Contract Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
1.1	<<work element>>	1,000,000.00	65.9%	400,000.00	40.0%	225,000.00	22.5%	175,000.00	17.5%	600,000.00	60.0%
1.2	<<work element>>	250,000.00	16.5%	30,000.00	12.0%	5,000.00	2.0%	25,000.00	10.0%	220,000.00	88.0%
1.3	<<work element>>	125,000.00	8.2%	50,000.00	40.0%	22,000.00	17.6%	28,000.00	22.4%	75,000.00	60.0%
X.X	Itemized Price No. 1	25,000.00	1.6%	0.00	0.0%	0.00	0.0%	0.00	0.0%	25,000.00	100.0%
X.X	Separate Price No. 1	12,500.00	0.8%	5,000.00	40.0%	0.00	0.0%	5,000.00	40.0%	7,500.00	60.0%
CCA.1	Cash Allowance Disbursements Summary	75,000.00	4.9%	34,000.00	0.0%	8,000.00	0.0%	26,000.00	0.0%	41,000.00	0.0%
X.X	Coordination drawings	15,000.00	1.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
X.X	As-built documents and operating manuals	15,000.00	1.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
CO.1	Original Contract Values	1,517,500.00	100.0%	519,000.00	34.2%	260,000.00	17.1%	259,000.00	17.1%	968,500.00	63.8%
	Approved Changes Summary	13,400.00		5,200.00	38.8%	2,000.00	14.9%	3,200.00	23.9%	8,200.00	61.2%
	Total Current Contract Values	1,530,900.00		524,200.00	34.2%	262,000.00	17.1%	262,200.00	17.1%	976,700.00	63.8%

Reference	Cash Allowance Disbursement	CA Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
CAA_1	<<description of cash allowance>>	20,000.00		20,000.00	100.0%	8,000.00	40.0%	12,000.00	60.0%	0.00	0.0%
CAA_2	<<description of cash allowance>>	55,000.00		14,000.00	25.5%	-	0.0%	14,000.00	25.5%	41,000.00	74.5%
	Total	75,000.00		34,000.00	45.3%	8,000.00	10.7%	26,000.00	34.7%	41,000.00	54.7%

Reference	Approved Changes	Change Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
CO_01	<<description of change of work>>	5,800.00		-	0.0%	-	0.0%	0.00	0.0%	5,800.00	100.0%
CD-01	<<description of change of work>>	7,600.00		5,200.00	68.4%	2,000.00	26.3%	3,200.00	42.1%	2,400.00	31.6%
	Total	13,400.00		5,200.00	38.8%	2,000.00	14.9%	3,200.00	23.9%	8,200.00	61.2%

Reference	Unquoted/Unapproved Changes	Status	Quotation
			\$
CCN=01	<<description of change of work>>	Waiting for approval	12,000.00
CCN=02	<<description of change of work>>	Unquoted	
	Total		12,000.00



Toronto Montreal Vancouver Dallas Chicago

SHOP DRAWING SUBMITTAL

***Include this cover page with each shop drawing submission.
Submissions without this form will be returned without review.
Submit one submittal form per shop drawing; do not group under one submittal sheet***

Client/Architect: Click or tap here to enter text.

Project Name: Click or tap here to enter text.

HHA Project No: Click or tap here to enter text.

Contractor to complete the following for each submission.

Date:

Contractor Name: Ref. No:

Manufacturer Name:

Product Type/Description:

Specification section number:

Contractor Trade Category:

- | | | | |
|--|-------------------------------------|--|---|
| <input type="checkbox"/> Architectural | <input type="checkbox"/> Structural | <input type="checkbox"/> Conveying Equipment | <input type="checkbox"/> User Equipment |
| <input type="checkbox"/> Mechanical | <input type="checkbox"/> Electrical | <input type="checkbox"/> Telecommunications | <input type="checkbox"/> Civil |
| <input type="checkbox"/> Other | | | |

If this is a resubmission, check here:

Previous submission HHA reference no.:

hhangus.com



END OF SECTION

QUALIFICATIONS AND AUTHORITIES - ONTARIO 20 01 02

1 GENERAL

1.1 Scope

- .1 This specification section:
 - .1 describes the qualification requirements for tradesmen in the province of Ontario;
 - .2 defines the applicable authorities having jurisdiction related to construction in Ontario; and
 - .3 describes the responsibilities of the contractor and/or Owner for registration and inspection of systems and application for construction or installation permits.

1.2 Definitions

- .1 **TSSA:** Technical Standards and Safety Authority
- .2 **ESA:** Electrical Safety Authority

2 QUALIFICATIONS

2.1 Trades Qualification and Apprenticeship

- .1 Tradesmen to hold a a certificate of qualification or be an apprentice in accordance with the *Building Opportunities in the Skilled Trade Act, 2021*, S.O. 2021, c. 28, including but not limited to the following prescribed trades in accordance with the *Prescribed Trades and Related Matters* regulation O.Reg. 876/21:
 - .1 Construction Millwright,
 - .2 Electrician – construction and maintenance,
 - .3 Fuel and electrical systems technician,
 - .4 Heat and frost insulator,
 - .5 Information technology – hardware technician,
 - .6 Information technology – network technician,
 - .7 Network cabling specialist,
 - .8 Instrumentation and control technician,
 - .9 Plumber,
 - .10 Refrigeration and air-conditioning systems mechanic,
 - .11 Sheet metal worker,
 - .12 Sprinkler and fire protection installer,
 - .13 Steamfitter,

2.2 Work-Specific Qualification Licenses

- .1 Fabricators and installers of pressure piping and equipment which are subject to O.Reg. 220/01 *Boilers and Pressure Vessels* regulation shall hold the required license for performing such work, unless otherwise exempt by the regulation.

- .2 Contractors performing work on liquid or gaseous fuel piping systems and related equipment shall hold certificates of authorization made under O.Reg. 215/01 *Fuel Industry Certificates* to perform work within the scope of the following regulations;
- .1 Gaseous Fuels, O.Reg. 212/01
 - .2 Propane Storage and Handling, O.Reg. 211/01
 - .3 Fuel Oil, O.Reg. 213/01
 - .4 Compressed Natural Gas, O.Reg. 214/01

3 AUTHOURITIES

3.1 Authorities having Jurisdiction

- .1 When referenced in specification sections in Division 20 to 25, the authority-having-jurisdiction (“AHJ”) over regulated portions of the work are identified in the following table.

Work Element	Authority	AHJ Abbreviation
Fire Protection	Municipal Building Department or Fire Department	None
Plumbing	Municipal Building Department	None
HVAC	Municipal Building Department	None
Flammable and Combustible Liquids	Fire Department	None
Liquid fuels (for vehicle refueling)	Technical Standards and Safety Authority	TSSA
Heating Oil and Diesel Fuel	Technical Standards and Safety Authority	TSSA
Propane	Technical Standards and Safety Authority	TSSA
Pressure Piping	Technical Standards and Safety Authority	TSSA
Refrigeration	Technical Standards and Safety Authority	TSSA
Licensed Plant Operators	Technical Standards and Safety Authority	TSSA
Electrical	Electrical Safety Authority	ESA

4 PERMITS, REGISTRATION AND INSPECTION

4.1 Building Code Permits

- .1 Application for Building Permit including plumbing and HVAC has been made by the Owner. Arrange and coordinate for municipal inspections as required under the Ontario Building Code.

4.2 Other Work Permits, Registration and Inspection

- .1 Arrange, provide documentation, and pay for permits, registration, and inspection of the following work elements:

- .1 Boilers, pressure vessel and pressure piping,
 - .2 Electrical work performed under Division 20 to 25, and
 - .3 Where described elsewhere in Division 20 to 25.
- .2 Arrange, provide documentation, and pay for variance approvals and field inspections where specified elsewhere in Division 20 to 25.

END OF SECTION

MECHANICAL COORDINATION AND INSTALLATION DESIGN SERVICES 20 01 03

1 GENERAL

1.1 Scope

- .1 Provide detailed coordination, fabrication, and installation design drawings for the services provided under Division 20. Integrate the coordination drawings provided under Division 26 into the design drawings provided under Division 20.
- .2 Provide the services of an experienced mechanical and electrical coordination supervisor to manage these contractors' design services. The supervisor is responsible for leading a multi-trade coordination effort including but not limited to: detailed inspection of existing conditions, layout and finalize routing of services, setting sleeves for structural openings and sequencing of service installation.

1.2 Document Ownership

- .1 Ownership and copyright of Contractors coordination, fabrication, and installation design drawings remains with the Contractor producing these documents, subject to the requirements of the project construction contract. In the absence of any requirements in the project construction contract, the Contractor will provide the Owner with a royalty-free, transferrable, and irrevocable license to copy and use the materials for the purpose of operating and maintaining the building and building systems.

1.3 Consultant Drawings

- .1 Consultant drawings are diagrammatic and illustrate the general location of equipment, and intended routing of ductwork, piping, bus duct, etc., and do not show every structural detail. In congested areas drawings at greater scale may be provided to improve interpretation of the Work. Where equipment or systems are shown as "double line", they are done so either to improve understanding of the Work, or simply as a result of the use of a CAD drawing tool, and in either case such drawings are not represented as fabrication or installation drawings.
- .2 The use of Consultant's drawings directly for construction, without preparation of Contractor detailed coordination, fabrication, and installation design drawings, is at the Contractors risk.

1.4 Requests for Information

- .1 Requests for Information (RFI's or similar type of document) concerning coordination are to be submitted with sketch drawings indicating proposed solution for review by the Consultant. RFI's submitted without such proposals may be returned by Consultant for re-submission to include proposed resolution.

2 WORK RESTRICTIONS

- .1 [Refer to specification section 01 14 00 *Work Restrictions*.]
- .2 The following commentary describes work restrictions that may affect the Contractors construction schedule and/or means and methods of construction, and are to be taken into consideration by the Contractor when estimating the cost and duration of the Work. This commentary does not limit the scope of work nor does it address all potential risk factors associated with the Work.
 - .1 restricted access to ceiling spaces for coordination with existing services
 - .2 restricted access to confined spaces
 - .3 hidden conduit in slabs and walls

- .4 availability of existing documentation

3 INTERFERENCE CO-ORDINATION DRAWINGS

3.1 General

- .1 Take information involving accurate measurements from dimensioned Architectural Drawings or at building.
- .2 Install services and equipment which are to be concealed, close to building structure so that furring is kept to minimum dimensions. Provide necessary offsets in ducts, piping etc. to change elevation and direction as required to coordinate services in the ceiling space.
- .3 Location of equipment and associated service connections are diagrammatic and based on manufacturer information available at the time of design. Include suitable allowances for and make adjustments to installation of actual equipment, including but not limited to size of housekeeping pads, methods of support, routing of pipe, duct, conduit and other services around and to the equipment, and location of services connection points to the equipment, at no change to the Construction Price.
- .4 Location of pipes, ductwork, raceways and equipment may be altered without extra cost provided instruction is given or approval is obtained, in advance of installation of items involved. Changes will be authorized by site instructions and are to be shown on Record Drawings.
- .5 Location of floor drains, hub drains, combination drains, plumbing fixtures, convectors, unit heaters, diffuser, registers grilles and other similar items may be altered without extra cost provided instruction is given prior to roughing in. No claim will be paid for extra labour and materials for relocating items up to 3 m (10 ft) from original location nor will credits be anticipated where relocation up to 3 m (10 ft) reduces material and labour.
- .6 Include incidental material and equipment not specifically shown but which is needed to complete the work as an operating installation.
- .7 Make good damage to Owner's property or to other trade's work caused by inaccurate layout or careless performance of work of this Division.

3.2 Interference Coordination Drawings

- .1 Prepare interference coordination drawings to show location of equipment and relative position of services, and to demonstrate coordination with works of other trades. Drawings shall be prepared by a specialist firm experienced in CAD mechanical and electrical interference drawing production. Interference drawings are to include coordination with all mechanical and electrical services.
- .2 Mechanical contractor is to consult and co-operate with electrical contractor to identify electrical services which are to be incorporated into interference drawings.
- .3 Mechanical contractor shall make arrangements with the Owner to access the site and ceiling spaces immediately after award of contract to start survey and preparation of coordination drawings so drawings are coordinated before services are installed. Reasonable time for survey and coordination drawings must be included in the schedule. Contractor shall perform site survey work to document all existing mechanical and electrical services that are to remain and are to be included in the interference drawings.
- .4 Conduct weekly meetings to discuss and resolve interference issues discovered during interference drawing production.
- .5 Submit drawings to other trades involved in each area and include a note in the drawing title block as follows;

- .1 "This drawing was prepared and circulated for review and mark-up to related subcontractors as noted and initialed in the table below. Corrections and concerns identified through this coordination process have been addressed on this drawing. Areas that incorporate significant changes from layouts shown on Contract Documents have been circled for Consultants' general review"
- .2 Drawing scale to be minimum 1:50 (1/4"=1'-0").
- .3 Produce coordination drawings, preferably in 3D AutoCad MEP or Revit format, and keep a set of drawings on site for Consultant's general review.
- .4 Obtain Consultant's drawing files for background information, pending completion and return of any electronic file waiver forms.

3.3 Coordination with Other Trades

- .1 Superimpose all services (piping and conduits larger than 2" diameter) on one drawing to be installed in ceiling space or mechanical rooms from information gathered from all subcontractors on site. Lay out and coordinate Work to avoid conflict with work under other sections of this Division and other Divisions.
- .2 When equipment provided under other Sections or Divisions connects with material or equipment supplied under this Section, confirm capacity and ratings of equipment being provided.

3.4 Interconnecting Control and Power Wiring

- .1 Provide wiring block diagrams and detailed termination drawings for controls wiring connections to equipment and instrumentation, for both Building Automation System control and hard-wired interlock wiring. Provide wiring terminal numbers specific for each equipment connection.
- .2 Maintain these interconnection drawings through the course of the Work and include a final updated version with the Operating and Maintenance instructions.

3.5 Fire Alarm and Building Automation System

- .1 Provide a wiring coordination interface drawing for termination of fire alarm annunciation circuits to Building Automation System I/O equipment and/or motor starters, adjustable frequency drives, dampers, and motorized fire dampers.
- .2 Drawings to include wiring terminal numbers and description label for FAS annunciation zone.
- .3 Submit interface drawings as a shop drawing for Consultants review.
- .4 Maintain these interconnection drawings through the course of the Work and include a final updated version with the Operating and Maintenance instructions.

4 OWNERS EQUIPMENT AND RELOCATED EQUIPMENT

- .1 The service provisions shown for Owner's supplied equipment and/or relocated equipment is based on the available information at the time of design. Examine the actual service requirements for this equipment and make adjustments as necessary to connection sizes of service drops to suit. A change (increase or decrease) in one trade size for piping, tubing, electrical conductors and conduit, and a change of up to 25% in duct cross-sectional area will be provided at no change to the construction cost.
- .2 Where actual service requirements (except as described above for size) are different between the Consultant's drawings and Owner's equipment requirements, submit proposal for new or deleted services or capacities to the Consultant for review.

5 FABRICATION AND INSTALLATION DRAWINGS

- .1 On an as-needed basis, prepare fabrication, spooling, and/or installation drawings based on the completed interference coordination drawings. Such drawings are to be in accordance with Contractor's company standards.
- .2 Drawing scale: same as the interference coordination drawings or at larger scale as needed.
- .3 Use information from manufacturer's shop drawings for each trade and figured dimensions from latest Architectural and Structural Drawings.
- .4 Layout equipment and services to provide access for repair and maintenance.

END OF SECTION

DEFINITIONS AND ABBREVIATIONS - MECHANICAL

20 01 13

1 GENERAL

1.1 Scope

- .1 This specification provides definitions and abbreviations of terms which may apply to one or more specification sections under Division 20, 21, 22, 23 and 25.
- .2 Additional definitions and/or abbreviations may also be included in other specification sections where they apply only to one specification section.

1.2 Definitions

Authourity having Jurisdiction (“AHJ”): the designated government body or regulatory agency responsible for enforcement of applicable statute.

Bronze: a copper alloy with a minimum copper content of 84%.

Building Automation System (“BAS”): the building control systems as specified in Division 25.

Class XXX: a numerical pressure-temperature designation “XXX” in accordance with ANSI/ASME B16 series of standards.

Canadian Registration Number (“CRN”): as defined in accordance with CSA B51.

Certificate of competency: a license, certificate or other document which attests to the qualifications of a construction tradesperson and which is recognized and/or required under prevailing provincial, territorial or federal statutes in the location of the project as an authorization to perform such work.

Cold Working Pressure (“CWP”): the maximum non-shock cold working pressure at temperatures as stated in a MSS valve standard.

Design Criteria: criteria that states the requiree performance of equipment or a system, and is also the minimum design basis for equipment, systems and contractor’s design responsibilities.

Design Pressure: (in reference to a pressure piping system) - the maximum allowable internal pressure in a piping system at the indicated coincident Design Temperature that the piping system may be subjected under normal operating conditions and is the basis for determining the piping system hydrostatic or pneumatic test pressure requirements.

Design Temperature: (in reference to a pressure piping system) – the maximum allowable in-service temperature of the piping system.

Double Regulating Valve (“DRV”): a calibrated manual flow balancing valves with pressure test ports (also referred to as circuit balancing valve),

Dezincification Resistant (“DZR”): a brass copper alloy which by means of its alloy and method of manufacture is certified as being resistant to the process of dezincification.

Flow Limiting Regulating Valve (“FLRV”): an automatic calibrated flow control device which limits the maximum flow to a branch piping network.

Minimum Component Pressure Rating (“MCPR”): the minimum pressure at the indicated coincident temperature at which the component must be capable of withstanding, remain functional and not exceed its maximum allowable stress in accordance with its referenced standard.

National Pipe Taper (“NPT”): a pipe thread in accordance with ANSI/ASME B1.21.1

Operating Pressure: the estimated maximum expected internal operating pressure of a fluid in a pipe or equipment for the purpose of establishing a piping system Design Pressure; actual in-service gauge pressures may be lower. The operating pressure may be specified as a single value, or it may vary by location in the system. “Working pressure” has the same meaning.

Operating Temperature: the estimated maximum normal temperature of the fluid in a piping system

Potable water: has the same meaning as defined in the applicable plumbing code or building code in the jurisdiction of the project. "Domestic water" has the same meaning.

Steam Working Pressure (“SWP”): the maximum steam pressure at the indicated maximum steam temperature or it is the saturated steam pressure if a coincident temperature is not specified.

Service rooms: means a room provided in a building to contain equipment associated with building services, and which includes but is not limited to: boiler rooms; furnace rooms; incinerator rooms; garbage handling rooms; rooms to accommodate HVAC appliances, pumps, compressors and other related equipment; rooms containing electrical distribution equipment; and rooms containing telecommunications and data equipment.

Service space: means space provided in a building to facilitate or conceal the installation of building service facilities such as chutes, ducts, pipes, shafts or wires.

1.3 Abbreviations

AMCA	Air Movement and Control Association International
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineers
ASTM	ASTM International (formerly American Society for Testing and Materials)
CSA	Canadian Standards Association
FM	Factory Mutual Approvals
MCAA	Mechanical Contractors Association of America
MCAC	Mechanical Contractors Association of Canada
MSS	Manufacturers Standardization Society
NECA	National Electrical Contractors Association

NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	NSF International (formerly National Sanitary Foundation)
SMACNA	Sheetmetal and Air Conditioning Contractors' National Association
UL	Underwriters Laboratory (USA)
ULC	Underwriters Laboratory Canada

End of Section

BASIC MATERIALS AND METHODS

20 05 01

1 GENERAL

1.1 Scope

- .1 Articles that are of a general nature, and applicable to each Section of Division 20 to 25.

2 ACCESSIBILITY FOR BUILDING CONTROL DEVICES

- .1 Mount control devices, intended to be adjusted or to otherwise be operated by the occupant for the operation of building services or safety devices, as follows:
 - .1 room environmental controls, including thermostats/adjustable room temperature sensors: at 1200 (47 in) above the finished floor,
 - .2 all other controls: between 900 and 1100 mm (36 in. and 43 in.) above the finished floor.
 - .3 be positioned to have a clear space in front of and centered on the control device, of 810 x 375 mm (32 x 15 in).
 - .4 be operable using a closed fist and with a force not exceeding 22.2 N (5 lbsf).
- .2 The above requirements do not apply to control devices that are solely located and used by the building operations staff.

3 ACCESS DOORS

3.1 General

- .1 Provide access doors to be installed at locations where equipment requiring inspection, service, maintenance or adjustment is "built-in" to work of other trades.

Standard of Acceptance

- Williams Brothers – fig. GP
- Elmdor/Acorn - fig. DW
- Mifab - fig. UA

3.2 Applicable Product Standards

- .1 CAN/ULC-S104 Standard Method for Fire Testing of Door Assemblies

3.3 Construction:

- .1 Standard access door:
 - .1 1.6 mm (16 ga) carbon steel door and door-frame with white satin coat prime coat finish, with door edges turned back to frame for rigidity,
 - .2 flush mounted with 180° opening door, round safety corners, concealed hinges, plaster lock and anchor straps,
 - .3 latch: screw driver operated,
 - .4 access doors in ceilings, where acoustic tile is applied to plaster or gypsum board, to be dish type designed to receive tile insert.
 - .5 size:
 - (a) 600 mm x 600 mm (24 in x 24 in) for personnel entry,
 - (b) 300 mm x 450 mm (12 in x 18 in) for hand entry,

.2 Variations:**.1 stainless steel variant:**

(a) Type 304 stainless steel with No. 4 brush satin finish.

.2 waterproof variant:

(a) Type 304 stainless steel with No. 4 brush satin finish, with neoprene gasketed door.

.3 security access variant:

(a) keyed cylinder, with all cylinders keyed alike,

.4 fire rated variant:

(a) where access door is located in a horizontal or vertical fire separation that has a fire resistance rating of 2 hours or less,

(b) insulated door with 50 mm (2 in) fire retardant mineral wool insulation, and 0.95 mm (20 ga.) back liner,

(c) heavy duty spring for self-closing door action,

(d) rated for installation in masonry walls and fire rated shaft wall construction, or fire rated ceiling construction as applicable to the installation,

(e) listed to CAN/ULC-S104 for minimum 1.5 hour closure ratings.

.5 Submit shop drawings showing access door size, type and location.**3.4 Installation:****.1 Access doors are required at;****.1 expansion joints,****.2 dampers,****.3 fire dampers,****.4 air valves,****.5 air terminal units,****.6 isolation and control valves ,****.7 pressure reducing valves,****.8 heating or cooling coils,****.9 control wiring junction boxes.****.2 Supply access doors and make arrangements and pay for installation by Division in whose work they occur.****.3 Supply access doors with the required variations in accordance with the following table:**

Space Type	Wall or Ceiling Finish	Variants		
		Stainless Steel	Water-proof	Key lock
Service rooms, Service corridors,	Drywall	---	---	---

Space Type	Wall or Ceiling Finish	Variants		
		Stainless Steel	Water-proof	Key lock
Public spaces and corridors - more than 2.4 m (8 ft) above the floor, Private spaces, washrooms	Tile or other hard finished surfaces	Yes	---	---
Public spaces and corridors - 2.4 m (8 ft) or less above the floor, Mental health patient areas, Public washrooms	Drywall	---	---	Yes
	Tile or other Hard Surfaces	Yes	---	Yes
Shower rooms, bathtub rooms, Pools, saunas, Kitchens, laundries, Other damp, washdown or high humidity spaces	All	Yes	Yes	Yes

- .4 Provide fire rated variant in addition to the above table variants, as applicable to the wall or ceiling construction.
- .5 Size and locate access doors in applied tile, block or in glazed or unglazed structural tile to suit joint patterns.
- .6 Access doors are not required in removable ceilings. Provide coloured marking devices after completion of ceilings, at four corners of each panel below point requiring access. Colour code markers to show service or device above.
- .7 At time of instruction of owners operating staff, hand-over and obtain signed receipt for 4 sets of each type of key used for access doors with key-lock cylinders.

4 DIELECTRIC FITTINGS

- .1 Dielectric unions – NPS 2 and under:
 - .1 body and union nut material selected to suit connecting piping materials, including carbon steel/copper, carbon steel/stainless steel, and copper/stainless steel,
 - .2 flat-face union design,
 - .3 tail-piece with NFPT ends with thermobaked epoxy coating, and Teflon shoulder gasket,
 - .4 head-piece with integral O-ring, with threaded or sweat pipe ends.
 - .5 union nut,
 - .6 pressure rating: Class 3000.
 - .7 dielectric coating resistance rating: minimum 500 V/mil thickness.

Standard of Acceptance

- Hart Industrial Unions - fig. D-3136 series

- .2 Dielectric insulating flanges - NPS 2-1/2 to NPS 4;
 - .1 For connecting copper to carbon steel piping.

- .2 Ductile iron flanges, Class 125 to ANSI B16.42.
- .3 Copper tailpiece for soldered joint,
- .4 NFPT thread to AMSE B1.20.1 x copper solder joint,
- .5 BUNA-N gasket,
- .6 lead free materials to NSF 61+G.
- .7 maximum design pressure: 1200 kPa (175 psi)
- .8 maximum operating temperature: 82°C (180°F)

Standard of Acceptance

- Watts No. LF3100

- .3 Dielectric insulated flange – single face with copper tube tailpiece – NPS 2-1/2 to NPS 4;
 - .1 For connecting copper to carbon steel piping.
 - .2 Van Stone style carbon steel flange with copper tailpiece with flared flared end,
 - .3 carbon steel flange, Class 150 to ANSI B16.5, with powder coated finish.
 - .4 copper tailpiece with rolled flange face-end, and EPDM insulating gasket isolating the copper tube from the steel flange.

Standard of Acceptance

- CTS Flange Canada - fig. CTS Copper Flange Adaptor

- .4 Dielectric Insulating gaskets for flanges NPS 6 and over:
 - .1 for use with ASME Class 150 and 300 dimensional flanges.
 - .2 suitable for connecting dissimilar piping materials, including carbon steel/copper, carbon steel/stainless steel, and copper/stainless steel,
 - .3 compatible with pressure and temperature service,
 - .4 BUNA-N or EPDM gasket seals compatible with potable water
 - .5 flange bolts run in insulating sleeves with insulating washers under nuts.

Standard of Acceptance

- Advance Products and Systems

- .5 Provide dielectric isolation between pipes of dissimilar metals with suitable insulating dielectric unions, insulating flanges, or insulating gaskets between flanges;
 - .1 place dielectric isolation between steel piping and bronze or brass valves.
 - .2 do not use bronze or brass valves as dielectric fittings.

◦

5 DRAIN VALVES

- .1 Provide drain points with drain valves at low points of piping systems and at section isolating valves.
- .2 Drain valves: minimum NPS 2 straight pattern bronze with hose end male thread, cap and chain.

6 V-BELT DRIVES

6.1 Products

- .1 Provide V-belt drive for each motor driven device which is not directly connected to the motor. Keep overhung loads on prime mover shafts within manufacturer's design guidelines.
- .2 Sheaves for motors 7.5 kW (10 hp) and less, with not more than two belts:
 - .1 cast iron or steel secured to shafts with removable keys.
 - .2 adjustable pitch on motor, fixed pitch on driven device, giving plus or minus 10% speed range,
 - .3 selected to meet specified operating condition at mid position in pitch adjustment.
- .3 Sheaves for motors greater than 7.5 kW (10 hp) or drives with three or more belts:
 - .1 cast iron or steel with split tapered bushing and keyway.
 - .2 fixed pitch.
- .4 Belts:
 - .1 matched sets of 'B' section, selected for service factor of 2.0 times installed motor horsepower.
 - .2 capable of carrying load with one belt broken.
- .5 Motor slide rails:
 - .1 adjustment plates for centre line alignment
 - .2 belt tension adjusting screws.

6.2 Installation

- .1 Tension belts to manufacturer's recommendations before start-up and after first 100 hr of operation using calibrated belt tensioning gauge.
- .2 Provide replacement pulleys and belts during start-up and balancing to suit field operating conditions.

7 DRIVE AND COUPLING GUARDS

7.1 Products

- .1 Provide guards to protect belt drives, flywheels, rotating couplings on equipment and fan inlet and outlets.
- .2 Guards:
 - .1 removable for servicing,
 - .2 arranged to permit lubrication with guards in place.
- .3 Guards for belt drives:
 - .1 expanded metal screen welded to steel bar stock or angle frame,
 - .2 minimum 1.2 mm (18 ga) thick galvanized sheet metal tops and bottoms,
 - .3 40 mm (1½") diameter holes at both shaft centres for insertion of tachometer.
- .4 Flexible coupling and flywheel guards:
 - .1 Removable "U" shaped, minimum 1.6 mm (16 ga) thick galvanized mild steel or expanded metal mesh on substantial welded angle iron or round barstock frame.
- .5 Guards on unprotected fan inlets and outlets:

- .1 Minimum 20 mm ($\frac{3}{4}$ in) galvanized wire mesh or expanded metal screen with net free area of guard not less than 80% of fan opening.

7.2 Installation

- .1 Belt guards to accommodate movement of motors for belt tension adjustment.
- .2 Where equipment is installed on resiliently mounted base frame or pad, attach belt guard to this base
- .3 Belt guards and fan inlet guards may be omitted where fan and motor is installed in plenum less than 1.4 m (4 ft) high and disconnect for fan motor is mounted adjacent to and outside access door to plenum.
- .4 Fan inlet guards may be omitted where fan is fitted with inlet guide vanes.

8 SLEEVES

8.1 General

- .1 Sleeve pipes, ducts and conduits passing through masonry walls, concrete floors, and fire rated gypsum board ceilings and partitions.
- .2 Maintain fire rating integrity where pipes and ducts pass through fire rated walls, floors and partitions.

8.2 Floor and Wall Sleeves

- .1 Sleeves in fire separations:
 - .1 sized to suit fire stopping methods employed for bare pipes, conduits, insulated pipes, and bare and insulated ducts without fire dampers, and
 - .2 sized to suit conditions of approval given in manufacturers installation instructions for fire and smoke dampers.
- .2 Sleeves in other construction:
 - .1 sized to clear insulated pipes and ducts by 13 mm ($\frac{1}{2}$ in) all round, and
 - .2 sized to clear conduits, bare pipes, and bare ducts by 6 mm ($\frac{1}{4}$ in) all round.
- .3 Sleeves for pipes, conduits and ducts smaller than 0.4 m² (4 sq ft) through solid walls and floors:
 - .1 Schedule 40 steel pipe or 1 mm (20 ga) (minimum) sheet metal, lapped and spot welded.
 - .2 Sleeves for pipes, conduits and ducts smaller than 0.4 m² (4 sq ft) through gypsum board partitions:
 - (a) 1 mm (20 ga) minimum sheet metal, lapped and spot welded with 20 mm ($\frac{3}{4}$ in) lip flange at one end.
- .4 Sleeves for ducts 0.4 m² (4 sq ft) and larger through walls and floors:
 - .1 1.6 mm (16 ga) minimum sheet metal, lapped and spot welded with 20 mm ($\frac{3}{4}$ in) lip flange at one end.
- .5 Manufactured floor sleeves with integral fire stopping:
 - .1 floor sleeve with integrated firestopping, for insulated and non-insulated metal pipes, and plastic pipes,
 - .2 for installation in concrete floors and metal deck/concrete floors,
 - .3 adaptors for support or pipe riser clamps,
 - .4 listed to CAN/ULC-S115.

Standard of Acceptance

- Hilti - fig. CP 680 series

8.3 Waterproof Sleeves - Indoors

- .1 Applications:
 - .1 where pipes and ducts pass through floors in areas subject to water, in mechanical rooms, in kitchens, in washing areas and in slabs over electric and telephone rooms.
- .2 Waterproof sleeves for pipes and conduits:
 - .1 Schedule 40 pipe, with 75 mm (3 in) wide annular water bar continuously welded at midpoint, hot dip galvanized to ASTM A123 after fabrication.
- .3 Waterproof sleeves for ducts less than 0.4 m² (4 sq ft):
 - .1 1 mm (20 ga) galvanized steel, with 40 mm (1½ in) flange at midpoint.
- .4 Waterproof sleeves for ducts 0.4 m² (4 sq ft) and larger and openings with multiple ducts:
 - .1 1.6 mm (16 ga) galvanized steel, with 40 mm (1½ in) flange at midpoint, or,
 - .2 form opening with wood (removed after concrete is set) and trim opening with welded steel angle frame 75 mm (3 in) high, bolted to slab and caulked, or,
 - .3 trim opening with 75 mm x 75 mm (3 in x 3 in) continuous concrete curb doweled to slab.
- .5 Modifications for existing construction:
 - .1 annular fins and flanges attached to sleeve at point equivalent to surrounding floor level or curb.

8.4 Installation

- .1 Place and secure sleeves in concrete form work.
- .2 Supply sleeves to be set in concrete and masonry walls with installation detail drawings.
- .3 Regular sleeves;
 - .1 terminate flush with surfaces of concrete and masonry walls.
- .4 Waterproof sleeves in new construction;
 - .1 extend 75 mm (3 in) above finished floor.
 - .2 with flange embedded within concrete floor.
- .5 Sleeves in existing concrete and masonry walls and floors;
 - .1 installed in neatly cut or drilled holes in existing construction,
 - .2 cutting and drilling of structural elements, such as floors, slabs, walls, columns, or beams to be carried out in accordance with procedure set out in Article "Cutting and Patching" below.
 - .3 terminate sleeves flush with surfaces of concrete and masonry walls,
 - .4 extend waterproof sleeves 75 mm (3 in) above finished floor with flange, countersunk, and bolted down flush into floor surface,
 - .5 fill opening between sleeve and wall or floor with 2 hour fire rated fire-stopping sealant with water barrier.
- .6 Roof sleeves for pipe and conduit:
 - .1 install manufactured roof flashing sleeves in accordance with manufacturer instructions, specifically in accordance with requirements applicable to the type of roofing membrane requirements,

- .2 where limestone ballast is used, apply asphalt or similar protective coating onto flashing sleeve to a height of 50 mm (2 in) above ballast layer,
- .7 Fill future-use sleeves with weak concrete, gypsum plaster or similar material.
- .8 Coat exposed exterior surfaces of un-galvanized ferrous sleeves with heavy application of zinc rich paint
- .9 At fire separations and smoke separations, pack and seal void between sleeve and pipe, duct without fire damper, conduit, or insulation in accordance with Article "Fire Stopping and Smoke Seals" in this Section.
- .10 At other locations, pack void between sleeve and pipe, conduit, duct or insulation for full depth of sleeve, with mineral wool and seal with silicone-free caulking compound.
- .11 Install fire dampers in accordance with conditions of approval given in manufacturer's instructions.

9 FIRE STOPPING AND SMOKE SEALS

9.1 General

- .1 Provide fire stopping and smoke seals where ducts, pipes or conduits penetrate fire separations.
- .2 Fire stop materials to be impervious to water when installed in a horizontal separation, including waterproof service sleeves.
- .3 Firestop material manufacturer or their designated service representative to provide the following services:
 - .1 selection of listed fire stopping assemblies for each applicable service penetration and fire separation assembly/rating,
 - .2 provide training of contractor's staff for proper installation of fire stopping assembly; create and maintain a log of those personnel who obtain training,
 - .3 inspect the completed installation of all penetrations and submit a written report to the Consultant, including photo record of randomly selected instances of each fire stopping method. Where deficiencies are discovered, note the deficiencies in the report and provide remedial instructions to the contractor to correct the deficiency. After deficiencies are corrected, re-inspect the deficiencies to conform their correction, update and resubmit the report to the Consultant.
- .4 Submit a complete fire stopping and smoke seal shop drawing schedule to the Consultant for review. Include details, cut sheets, system description and location for each proposed fire stopping and smoke sealing application.

9.2 Products

- .1 Materials to form ULC listed or cUL listed/classified assemblies.

Standard of Acceptance

- Hilti Firestop Systems
 - 3M
 - Nelson Firestop Products
 - Eastern Wire + Conduit (Royal Quickstop)
- .2 Other manufacturers having products with explicitly similar characteristics, listings or classifications and approvals are acceptable.

9.3 Installation

- .1 Install firestopping and smoke seals in accordance with the manufacturer's recommendations and in accordance with its listing.
- .2 Firestopping and smoke seals to be installed only by personnel trained by the manufacturer on the installation of such systems.
- .3 Seal space between penetrating service and sleeve or opening in in fire rated floors and walls with a firestop and smoke sealing system.
- .4 Select thickness and arrangement of back-up materials to suit size of service, length of sleeve and anticipated movement.
- .5 At time of application of materials, surfaces to be clean, dry and free from dust, oil, grease, loose or flaking paint and foreign materials.
- .6 Select firestopping system to allow insulation and vapour barrier to pass un-broken through assembly.
- .7 Do not apply fire stopping materials to fire or smoke dampers.

10 WALL AND FLOOR PLATES

10.1 General

- .1 Provide finishing plates fitted to ducts, pipes, and electrical services provided under Division 20 of the Work which pass through walls, floors and ceilings in finished areas.

10.2 Products

- .1 Escutcheons for small diameter piping and small diameter electrical conduit:
 - .1 manufactured chrome plated two-piece split type with hinge and set-screw.
- .2 Finishing plates for ducts, larger pipes, larger electrical conduits and electrical cables:
 - .1 finishing plate (ring) fabricated from minimum 0.9 mm (20 ga) thick T304 stainless steel with No. 4 brushed finish, with minimum 25 mm (1 in) high collar ring,
 - .2 mounting holes drilled at not less than three (3) symmetrically location positions around the ring to allow mechanical fastening,
 - .3 plate diameter to be sufficiently sized to overlap the wall, floor or ceiling opening by not less than 25 mm (1 in) all around the opening.

10.3 Installation

- .1 Escutcheons;
 - .1 secure escutcheons to pipe and electrical conduit with mechanical fastener.
- .2 Finishing plates:
 - .1 set finishing plates flat against the finished surfaces, and secure to the surface with stainless steel pan-head mechanical fasteners. Provide insert anchor plugs in the finished surface as necessary to secure the fasteners.

11 PIPE SUPPORTS, EQUIPMENT SUPPORTS, AND TRENCH COVERS

11.1 General

- .1 Design and fabricate supplementary supporting steel for piping, ductwork and equipment supports from steel plate and sections. For clarity, the contractor under these Division 20 to 25 of the Work is responsible for design, fabrication and installation of such materials.

- .2 Concrete housekeeping bases for mechanical and electrical equipment which are in direct contact with floor slab, are to be provided by this Division 20.
- .3 Concrete for equipment supported on vibration isolated inertia bases is to be provided by this Division 20.
- .4 Work to be done by firms specializing in these fields.
- .5 Submit shop drawings for steel and concrete work, prepared by Professional Engineers licensed in the jurisdiction of the Work.

11.2 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Building Code,
 - .2 R.R.O. 1990, Reg. 851 Industrial Establishments
- .2 Installation codes and standards:
 - .1 CAN/CSA-S16.1 Limit States Design of Steel Structures.
 - .2 CSA W59 Welded Steel Construction (Metal Arc Welding).
- .3 Product standards:
 - .1 ASTM A36 Standard Specification for Carbon Structural Steel
 - .2 ASTM A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - .3 ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - .4 ASTM A 307 Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .5 CAN/CSA G40.20/G40.21 General Requirements for Rolled or Welded Structural Quality Steel.

11.3 Supplementary Supports and Support Brackets

- .1 Provide supplement supports and brackets for the support of equipment, piping and ductwork.
- .2 Fabricate supports from structural grade steel with anchor bolts and fastenings, so that horizontal supporting beam deflections do not exceed 1/360 for the span, and not exceed an absolute deflection of 5 mm (0.20 in), with a safety factor of 1:4 to the ultimate strength of the material
- .3 Design the supports in consultation with the building structural Consultant, to transfer live loads and dead loads to the building structural elements,
- .4 Construct the supports as frames bracketed from walls, and/or supported from building structure above, and/or floor below.

11.4 Installation - General

- .1 Locate supporting steel to permit removal of parts for service or repair, and to allow clear access to valves, fittings, and equipment,
- .2 Set equipment on supporting frames and brackets and install hangers, anchor bolts, vibration mountings and snubbers.
- .3 Set equipment base plates on housekeeping pads on minimum 13 mm (½ in) epoxy grout and fill hollow portion of base with concrete.

- .4 Install anchor bolts, vibration mountings and snubbers between equipment and housekeeping pad, or inertia pad and housekeeping pad.
- .5 Provide anchorage, dowels, anchor clips, bar anchors, expansion bolts and shields, and toggles.
- .6 Make field connections with bolts to CAN/CSA-S16.1, or by welding.
- .7 Supply items for casting into concrete or building into masonry to appropriate trades together with setting templates.
- .8 Touch-up field welds, bolts and burnt or scratched surfaces after completion of erection with primer.
- .9 Where trench covers are cut in field or damaged, touch up with zinc rich paint.

12 HOUSEKEEPING PADS AND CURBS

12.1 Materials

- .1 Concrete: 20 MPa (3000 psi),

12.2 Concrete Housekeeping Pads

- .1 Construct housekeeping pads using plywood form-work and site-poured concrete, and run pads continuously beneath the equipment.
- .2 Structurally-connect the housekeeping pads to the concrete floor slab with dowels, consisting of not less than 13 mm (½ in) diameter steel rods. For existing concrete floors, floors are to be drilled and dowels secured in the holes with chemically-hardening adhesive.
- .3 Provide anchorage, dowels, anchor clips, bar anchors, expansion bolts and shields, and toggles.
- .4 Refer to Specification section 20 05 49 *Seismic Restraint for Mechanical Systems* for additional requirements for housekeeping pads where equipment is to be seismically restrained.
- .5 Finish exposed surfaces to make them flat, level, and smooth.
- .6 Chamfer corners 25 mm (1 in).
- .7 Housekeeping pad plan dimensions:
 - .1 extending 75 mm (3 in) larger all around than the base of apparatus for non-seismic applications,
 - .2 minimum 200 mm (8 in) larger all around than equipment-base anchor attachment points for seismically restrained equipment.
- .8 Except for air handling units with condensate drains, provide housekeeping pads of the following height based on equipment type, location and vibration isolation condition:

Equipment Type	Floor Type	Vibration Isolation	Thickness of Housekeeping Pad mm (in)
Stationary, not motorized	All	All	100 (4)
Fans	All	Yes	150 (6)
Motorized, up to 7.5kW (10 HP)	All	Yes or No	150 (6)
Motorized, 11 to 19kW (15 to 25 HP)	Slab on Grade	No	250 (10)
	Slab on Grade	Yes	150 (6)
	Suspended Slab	Yes	150 (6)

Equipment Type	Floor Type	Vibration Isolation	Thickness of Housekeeping Pad mm (in)
Motorized, 22kW (30 HP) and over	Slab on Grade	No	300 (12)
	Slab on Grade	Yes	150 (6)
	Suspended Slab	Yes	150 (6)

- .9 For air handling equipment equipped with condensate drains, provide housekeeping pads with a minimum height of 150 mm (6 in.) unless higher dimensions are shown.

12.3 Concrete Housekeeping Curbs

- .1 Concrete housekeeping curbs constructed to the same requirements as for housekeeping pads except as follows.
- .2 Dimensions for containment curbs: 150 mm wide x 150 mm high (6 in. x 6 in.), unless otherwise shown.
- .3 Concrete curbs used in lieu of housekeeping pads when shown on drawings;
- .1 curb height for AHUs: minimum 150 mm (6 in.) unless higher dimensions are shown.
 - .2 curb width for AHUs requiring seismic restraint:
 - (a) extending a minimum of 200 mm (8 in.) from the outside edge of the AHU base frame channel, and
 - (b) extending 100 mm (4 in.) from the inside face of the AHU base frame channel.
 - .3 curb width where no seismic restraint is required for AHUs:
 - (a) extending a minimum of 75 mm (3 in) greater than, and on each side of, the AHU base frame channel flange width.
 - .4 Void space between underside of AHU and structural floor filled with 64 kg/m³ (4 lb/ft³) mineral-wool rigid board insulation.

END OF SECTION

MECHANICAL WORK IN HOSPITAL CONSTRUCTION 20 05 02

1 GENERAL

1.1 Scope

- .1 Contractor is responsible to review all documents for all divisions to coordinate phasing and services required at end of each phase.
- .2 Work in existing areas where new construction connects to existing will be heavily phased. Rework of services will impact on the existing hospital. Notify the Owner and the Architect, in writing, at least one week in advance of the work where work requires shut-down or isolation of existing services.
 - .1 Note a portion of the renovation requires re-routing of existing piping. ***All new piping is to be in place prior to removal/disconnection of existing to minimize downtime.***
- .3 Except as identified, shut downs of existing services will be restricted from 11PM to 5AM and on weekends.
- .4 All work outside area of renovation and/or outside of IPAC hoarding to be done after hours and/or on weekends. Work to be done in accordance with Hospital's IPAC procedures.

1.2 Access Doors

- .1 Provide in contract, supply and installation of: 6 @ 24 x 24 keyed access doors and 4 @ 24 x 24 fire rated access doors. These spare access doors are for unexpected situations and in addition to access doors required in contract to provide access to installed devices in hard ceilings and shafts. Access doors may be provided at sizes equal to or smaller than those listed.

1.3 Chilled Water Connections

- .1 Provide connections to existing chilled water system by live tapping as the system is always active, or
- .2 Coordinate with Owner freezing of lines to make required connections. Cost of freezing to be Contractor's cost and does not include the additional freezing carried in 1.8 below.

1.4 Medical Gas Connections

- .1 Make connections to the existing medical gas systems, on a gas by gas basis, within on night time shut-down. Provide additional valves where new connections are to be made to limit shutdown to one night.
- .2 Complete, inspect and certify the medical gas installation, by hospital's designated inspection agency prior to connection to the existing hospital.
- .3 Arrange for the inspection to the connections to the existing hospital to be made immediately at the completion of the work.

1.5 Sleeving, Core Drilling and Scanning

- .1 All services penetrating concrete walls and floors to be sleeved prior to pouring. Submit sleeving drawings indicating service size and sleeve size, superimposed over structural drawings and submit for approval. Relocate sleeves as directed by Engineer.

- .2 Include in contract for additional cores and scanning for the following for missed sleeves and/or changes.
 - .1 4@4"cores

1.6 Spare Components

- .1 Provide the following components in addition to those required in contract. Components may be provided at sizes equal to or smaller than those listed.
- .2 Provide spare valves including installation on existing or new piping, modifications to insulation as required:
 - .1 Domestic Water service – 4 @ 3".
 - .1 Heating and Cooling service – 4 @ 1", 2 @3".
 - .2 Medical Gas service – 4 @ 1".
- .3 Provide 2 – 4" above grade floor drains complete with 30 feet of insulated 4" line and 30 feet of vent piping.
- .4 Provide the following spare fire dampers c/w duct access door and installation in new or existing ductwork
 - .1 2 @ 24" x 36"
- .5 Provide **20** type spare **A1** and **C1 diffusers and grilles** complete with installation, 30 feet of 12"x12" duct and insulation on supply duct.
- .6 Provide **5 spare BAS control points** complete with device, wiring and conduit (assume 200 ft per point), programming, etc in contract to be used by discretion of Engineer.
- .7 Provide 10 additional concealed pendant sprinkler heads complete with installation, 10 feet of 2" sprinkler piping, and all associated fittings.

1.7 Freezing of Live Water Services

- .1 Include in contract an allowance for the following connections where existing valves do not hold or do not exist:
 - .1 Freezing of two (2) three inch sprinkler lines
 - .2 Freezing of one (1) four inch sprinkler line
 - .3 Freezing of two (2) one inch water lines
 - .4 Freezing of four (4) four inch water lines
- .2 Freezing allowance may be used on pipe sizes equal to or smaller than those listed above.

1.8 Phasing

- .1 Carefully examine the phasing plan from the Architectural drawings and develop a mechanical construction plan in conjunction with the General Contractor to ensure that areas can be constructed mechanically for each phase/stage with all active services. All services will be complete and available for occupancy of the phased spaces, unless noted otherwise.
- .2 The drawings show service configuration for final construction layout and do not include scope required for each individual phase of construction. Prior to construction, the mechanical contractor

shall review each phase, review existing services and formulate a plan on how to construct the area with all services without interruption to other occupied areas.

- .3 The mechanical work necessary to maintain services will not be restricted to the architectural phased areas of work. This division will have to work in the existing occupied building during off hours; obtaining and modifying services for new phased areas.
- .4 The contractor shall maintain existing systems until the new services are ready for use. New equipment, ductwork, piping is to be installed prior to demolition of existing services, where possible to minimize shut down period.
- .5 Provide balance and reports at each phase of construction.

1.9 Air and Water Balancing

- .1 Air and water balancing is to be carried by the mechanical contractor (see spec section 20 08 05).
- .2 Provide air/water balancing at the end of **each** phase.

1.10 Work in Occupied Areas

- .1 Work in Owner occupied areas to be schedule with the Hospital.
- .2 Access to these areas will be at the discretion of the Hospital and strictly after hours unless otherwise noted on the drawings.

1.11 Phased Occupancy, Equipment Maintenance, Equipment Operation and Warrantee.

- .1 This is one project and substantial performance will be granted at the end of the project. There will be no phased substantial performance or phased release of holdback.
- .2 The Mechanical Contractor to ensure all mechanical equipment is complete and functioning before testing and commissioning is done.
- .3 The mechanical contractor will be responsible to maintain and operate new equipment (and systems) supplied under this project until the project is formally handed over to the Owner. Maintenance shall include all manufacturer recommended maintenance, filter changes, bearing lubrication, fan belt adjustment, chemical treatment, cleaning of coils. Maintenance and system downtime to be minimized and scheduled to suit the Hospital.
- .4 The mechanical contractor shall operate the systems to the Owners benefit to ensure that the occupied phases are fully serviced to the Owners schedule. The mechanical contractor to provide a list of emergency contacts so they can respond 24/7 to issues with their system. Repairs to be made quickly to minimize disruption to the Hospital.
- .5 Training of Owners maintenance personnel to be done at end of project prior to formal turnover to Hospital. Training will not be required at the end of each phase as the contractor will be maintaining and operating the equipment/systems installed under this project.
- .6 Equipment and system warrantees to start after substantial performance even though equipment may be installed and operating early in the construction. Notify equipment supplier of this situation during bidding and include any additional costs related to operating the equipment during the construction period or include extended equipment warrantee to cover contract duration plus the standard warrantee period starting after substantial performance.

END OF SECTION

COMMON ELECTRICAL REQUIREMENTS FOR MECHANICAL SERVICES 20 05 12

1 GENERAL

1.1 Scope

- .1 Provide wiring, conduit, fittings, supports, disconnect switches, service lights, and related devices and equipment for mechanical trades work, at voltages of 600V and less and to the extent specified herein.
- .2 Pre-installation survey of SCCR values for equipment supplied under Divisions 20 to 25 which requires power wiring supply, to verify nameplate SCCR is equal to or greater than the minimum specified SCCR values.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 29 Common Hanger and Support Requirements for Piping
 - .2 20 05 49 Seismic Restraint for Mechanical Services
 - .3 25 55 13 Building Automation Smoke Damper Control Panels

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section and referenced sections:
 - .1 **Control panels** – an electrical device that controls or monitors mechanical equipment, or that interfaces with instrumentation devices.
 - .2 **Control wiring** - wiring for the purpose of communication or control of equipment and instrumentation.
 - .3 **Electrical safety code** - the edition with amendments of CSA C22.1 as adopted by applicable legislation at the location of the Work.
 - .4 **Mechanical breaker panel (MBP)** means a 120/208 V mechanical power panel with overcurrent protection circuit breakers provided as part of an MCC.
 - .5 **Mechanical service panel (MSP)** - panelboard with branch circuit overcurrent protection devices provided by Division 26, and dedicated to supply power for equipment provided by mechanical trades work.
 - .6 **Mechanical trades work** - equipment and systems provided under Divisions 20 to 25.
 - .7 **Motor controllers** - constant speed motor controllers of the manual, magnetic or solid-state type in accordance with specification section 20 05 14.13.
 - .8 **Motor Control Center** – has the meaning as specified in section 20 05 14.13.
 - .9 **Packaged equipment** - equipment containing some or all of: motor(s), controls and/or other electrically powered equipment, such as but not limited to: electric heating equipment, water treatment equipment, packaged HVAC equipment, electric boiler, electric domestic water heaters, etc.)
 - .10 **Power Panel (PP)**: 208 up to 600 V, 3 phase, panelboard with branch circuit overcurrent protection devices provided by Division 26, which serves general building loads and may also serve equipment provided by mechanical trades work.
 - .11 **Power wiring** means wiring that provides electrical power to equipment including to control panels, including BAS panels, that are not integral to the controlled equipment.

- .12 **Receptacle panel (RP)** - a 120/208 V panelboard with branch circuit breakers, provided by Division 26.
 - .13 **SCCR**: the RMS symmetrical short-circuit current rating of the equipment or motor controller, measured at the input to the motor or controlled equipment (short-circuit withstand rating has the same meaning).
 - .14 **VFD**: variable frequency drives in accordance with specification section 20 05 14.16.
 - .15 **Wiring** means conductors, cable, conduit, fittings, supports and accessories.
- .2 With respect to these definitions, for equipment provided by Division 26 the actual terminology used in the Division 26 drawings and specification may differ but the intent remains the same.
- .3 For clarity, any reference herein to Division 20 means Divisions 20 to 25 inclusive.

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 Electrical safety legislation in the jurisdiction of the Work.
 - .2 For clarity, on Federal Government projects, comply with the provincial or territorial legislation at the place of the Work which adopts the applicable edition of CSA 22.1 with any amendments
- .2 Installation standards and codes:
 - .1 CSA C22.1 Canadian Electrical Code Part 1, as amended and adopted by the AHJ for electrical safety in the province or territory at the place of the Work.
- .3 Product standards:
 - .1 CSA C22.2 No. 4 Enclosed and Dead-Front Switches
 - .2 CSA C22.2 No. 38 Thermoset-Insulated Wires and Cables
 - .3 CSA C22.2 No. 39 Fuseholder Assemblies
 - .4 CSA C22.2 No.94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .5 CSA C22.2 No. 106 HRC – Miscellaneous Fuses
 - .6 CSA C22.2 No. 124 Mineral Insulated Cable
 - .7 CSA C22.2 No. 131 Type TECK 90 Cable
 - .8 CSA C22.2 No. 208 Fire Alarm and Signal Cable
 - .9 CSA C22.2 No. 230 Tray Cable
 - .10 CSA C22.2 No. 239 Control and Instrumentation Cables

1.5 Quality Control

- .1 Electrical wiring for mechanical trades work to be performed by a specialist electrical contractor firm with an established reputation in the field of wiring of mechanical equipment and controls.

1.6 Short Circuit Current Ratings (SCCR) and Markings

- .1 Except where another Specification section requires a SCCR of a different value, equipment provided under Division 20 to 25 which is supplied electrical power in accordance with CSA C22.1 shall have a short circuit capacity rating (SCCR) of not less than 10 kAIC RMS symmetrical.

- .2 The SCCR value is to be marked on all equipment provide with power wiring in accordance with CSA C22.1. Where the SCCR nameplate rating references an instruction manual, provide a separate label that states the SCCR value.

1.7 Permits, Fees and Inspections

- .1 Arrange and pay for electrical permits and any required inspections for electrical work for mechanical equipment and systems.
- .2 Submit to the electrical safety authority the required number of drawings and specifications for examination and approval prior to commencement of work.
- .3 Notify Consultant of changes required by the electrical safety authority prior to making changes.
- .4 On completion of the Work, furnish certificates of acceptance (or similar report) from the electrical safety authority to the Consultant.

1.8 Standard Details

- .1 Device legend with list of abbreviations and schematic wiring diagrams are included at the end of this section that delineate the scope of work between Division 20 and Division 26 and as further specified herein.
- .2 This material is to be used in the interpretation of specification requirements for power wiring and control wiring of Division 20 to 25 equipment.

1.9 Submittals

- .1 Submit manufacturer catalogue cut-sheets for the following materials;
 - .1 VFD Inverter Duty cable,
 - .2 service lights.

1.10 Storage of Materials

- .1 Store wire and cable in a clean, dry, well-ventilated area.
- .2 Protect white insulated wire from exposure to NOx gas (e.g.: exhaust from propane fueled equipment) by wrapping with shrink wrap, by locating away from sources of NOx and by maintaining adequate ventilation to minimize NOx levels.
- .3 Where white insulated wire has discoloured:
 - .1 do not install,
 - .2 dispose of the wire,
 - .3 remove and replace wire that has been installed.

2 PRODUCTS

2.1 Motor Feeder and Control Wiring (“Building Wires”)

- .1 Application:
 - .1 motor and equipment power feeders controlled by constant speed motor controllers;
 - (a) do not use for motors controlled by variable frequency drives,
 - .2 control wiring including control valves and damper actuators, panel control wiring, motor controller interlock wiring, BAS control wiring, and switch-type instrumentation,
 - .3 convenience power outlets and service lights.

-
- .2 Conductors:
 - .1 solid copper for No. 12 and 14 AWG,
 - .2 stranded conductors for 10 AWG and larger.
 - .3 Minimum wire size:
 - .1 No. 12 AWG for equipment power,
 - .2 No. 14 AWG, for control wiring at 120 VAC or lower.
 - .4 Insulation:
 - .1 chemically cross-linked thermosetting polyethylene (XLPE) material, RW90 or RWU90,
 - .2 1000 V insulation for 600 V systems,
 - .3 600 V insulation for 100 VAC to 480 VAC systems.
 - .4 300 V insulation for systems less than 100 VAC, and for systems 24 VDC and less.
 - .5 Colour coded conductors:
 - .1 colour impregnated into insulation at time of manufacture,
 - .2 phase conductors No. 8 AWG and larger with black insulation, may be colour coded with adhesive colour coding tape.
 - .6 Listed to CSA C22.2 No. 38.
 - Standard of Acceptance*
 - Aetna Insulated Wire
 - General Cable
 - Nexans Canada Inc.
 - Prysmian Cables & Systems Ltd.
 - Southwire

2.2 Extra-Low Voltage Power Wiring – 24 VAC, 24 VDC

- .1 Application: power wiring to 24 VAC or 24 VDC electrically commutated motors.
- .2 Type: ACIC,
- .3 Cable:
 - .1 insulated solid or stranded copper conductors,
 - .2 insulation: XLPE, colour coded or numbered wires,
 - .3 minimum wire size: 16 AWG,
 - .4 voltage rating: 600 V.
- .4 Armour:
 - .1 aluminium interlocked armour.
- .5 Jacket:
 - .1 FT4 flame retardant,
 - .2 FT6 when installed in raised floors, or in ceiling spaces that are used as return air plenums.
- .6 Listed to CSA C22.2 N0. 239,

Standard of Acceptance

- General Cable (Carol)
- Belden
- Nexans Canada Inc.

2.3 Instrumentation Cabling

- .1 Application: instrumentation and control wire suitable for analogue 4-20 mA and 0-10 VDC signaling.
- .2 Cable:
 - .1 insulated solid-copper twisted-multipair conductors, shielded cables with individually shielded pairs, 100% coverage overall shield, drain wires and overall rated jacket,
 - .2 insulation: XLPE, colour coded or numbered wires,
 - .3 minimum wire size: as specified by equipment manufacturer or controls vendor, but not less than 18 AWG,
- .3 Armour:
 - .1 corrugated steel, or
 - .2 none required if installed in conduit or approved wireway.
- .4 Jacket:
 - .1 FT4 flame retardant,
 - .2 FT6 when installed in open style cable trays in ceiling spaces that are used as return air plenums.
- .5 Listed to CSA C22.2 No. 239,

Standard of Acceptance

- General Cable (Carol)
- Belden
- Nexans Canada Inc.

2.4 Conduits and Fittings

- .1 Conduits:
 - .1 rigid hot dipped galvanized steel threaded conduit,
 - .2 electrical metallic tubing (EMT), hot dipped galvanized with couplings,
 - .3 PVC coated hot dipped galvanized rigid steel conduit: with 40 mil PVC exterior coating, 2 mil urethane interior and thread coating,
 - .4 flexible metal conduit and liquid-tight flexible metal conduit.
- .2 Conduit fastenings:
 - .1 single hole steel straps to secure surface conduits 50 mm (2") and smaller,
 - .2 two hole steel straps for conduits larger than 50 mm (2"),
 - .3 beam clamps to secure conduits to exposed steel work,
 - .4 channel type supports for two or more conduits,
 - .5 Ø6 mm threaded rods to support suspended channels.
- .3 Conduit fittings:
 - .1 manufactured for use with conduit specified including coatings,

- .2 factory "ells" where 90° bends are required for 25 mm (1in.) and larger conduits,
- .3 insulated throat steel set screw or raintight insulated throat steel compression connectors and couplings for EMT,
- .4 threaded or compression type raintight/concrete tight insulated throat zinc plated steel connectors and couplings for rigid steel conduit,
- .5 raintight insulated throat steel connectors at all surface equipment enclosures and other electrical equipment in sprinklered areas for all conduit terminations.

2.5 Outlet Boxes

- .1 Construction:
 - .1 hot dipped galvanized steel single and multi-gang flush device boxes for flush installation,
- .2 Size:
 - .1 76 mm x 50 mm x 38 mm (3" x 2" x 1½") or as indicated,
 - .2 102 mm (4") square outlet boxes when more than one conduit enters one side with extension and plaster rings as required.

2.6 Disconnect Switches

- .1 Construction:
 - .1 listed to CSA C22.2 No. 4,
 - .2 enclosure type:
 - (a) painted metal with hinged door,
 - (b) indoors: type 1, 3R, 4 or 12, unless otherwise specifically shown,
 - (c) outdoors: type 3R.
 - .3 fuseholder assemblies listed to CSA C22.2 No. 39,
 - .4 include fuses unless shown as unfused,
 - .5 fuseholders suitable for Class J fuses, sized to suit the fuse sizes without the use of adaptors,
 - .6 horsepower rated,
 - .7 one, two or three pole as required for single phase or polyphase circuits,
 - .8 two pole with solid neutral or three pole with solid neutral for three wire and four wire circuits with neutral,
 - .9 six pole for two speed motor applications,
 - .10 provision for padlocking in the Off switch position,
 - .11 mechanically interlocked door to prevent opening when handle is in the ON position,
 - .12 heavy duty, quick-make, quick-break action,
 - .13 ON-OFF switch position indication on switch enclosure cover.
- .2 Fuses:
 - .1 HRCI-J time delay up to 600A,
 - .2 HRCI-L for ratings above 600A,

- .3 minimum interrupting capacity: 200 kAIC
- .4 product of one manufacturer,
- .5 ampere rating as indicated, where not indicated, the maximum rating permitted by the electrical code.
- .3 Special requirements for disconnect switch located upstream of harmonic filters:
 - .1 double break contacts per pole, to isolate fuses on both the line and load side,
 - .2 14 AWG power taps on both line and load sides for control power transformers.
- .4 Special requirements for disconnect switch located between a VFD and the controlled equipment:
 - .1 auxiliary switch position status switch;
 - (a) rating: 10 A at 120 VAC,
 - (b) switch contacts open when disconnect switch is Not-Closed.
- .5 Ratings:
 - .1 IEC 90 rotary switch for motors up to 18.6 kW (25 HP),
 - .2 NEMA flange mount switch-handle for all ratings.

Standard of Acceptance

- Square "D"/Schneider Electric Company (Canada) Ltd.
- Eaton
- Siemens Canada Ltd.
- Klockner Moeller/Eaton

2.7 Receptacles

- .1 Class A GFCI type, 15 A at 120 VAC indoors, and 20 A T-slot for outdoors.
- .2 Receptacle outlet hood:
 - .1 in-use weatherproof, for both indoor and outdoor locations,
 - .2 die cast aluminum base and cover with gasket,
 - .3 vertical mount.
 - .4 self-closing lift cover.
 - .5 CSA 3R rated.

Standard of Acceptance

- Bryant Electric – WPB26EH

2.8 Conduit and Equipment Supports

- .1 General:
 - .1 supports for conduit may conform to Specification section 20 05 29 except/and as specified herein.
 - .2 Materials: carbon steel supports, hot dipped galvanized after fabrication.
 - .3 manufacturer standard products suitable for support load rating of conduit and conductors:

Standard of Acceptance

- Burndy Canada Ltd.
- Canstrut

- Electrovert Ltd.
- E. Myatt & Co. Ltd
- Steel City Electric Ltd.
- Pilgrim Technical Products Ltd.

.2 Upper attachment – concrete inserts

- .1 galvanized wedge inserts to MSS SP-58 type 18.
- .2 maximum tension load rating: 4.4 kN (1000 lbs),

Standard of Acceptance

- Anvil - fig. 281
- Unistrut - fig. P-3245

.3 Upper attachment – existing concrete:

- .1 conform to Specification section 20 05 29.

.4 Upper attachment – steel beams:

- .1 carbon steel beam clamp (top flange), hook rod with locking jaw, fasteners and lockwashers, to MSS SP-58, type 25,

Standard of Acceptance

- Anvil - fig. 227
- Myatt - fig. 504, 505

.5 Upper attachment - steel joists:

- .1 for installation of support rod in the interstice space of double-ell steel joists and open-web steel joints for support on the lower chord,
- .2 carbon steel washer plate with double locking nuts on top-side of washer,
- .3 second steel washer plate on underside of joist with nut where supported equipment is subject to vibration.

Standard of Acceptance

- Anvil - fig. 60
- Myatt - fig. 545

.6 Hanger rods:

- .1 continuous threaded rod, carbon steel, USS national course thread,
- .2 minimum rod size: Ø6 mm (1/4 in. dia.),
- .3 tension load ratings to MSS SP-58,

Standard of Acceptance

- Anvil - fig. 146
- Myatt - fig. 434

.7 Horizontal Pipe Support – Swivel Ring Hanger

- .1 swivel ring hangers, carbon steel ring strap, zinc plated, adjustable knurled swivel nut, to MSS SP-58 Type 10,
- .2 nominal conduit size: 12mmC to 100 mmC.

Standard of Acceptance

- Anvil - fig. 69, CT-69
- Myatt - fig. 41, 42, 43
- Unistrut

- .8 Support channels:
 - .1 U shape, minimum size 41 mm x 41 mm x 2.5 mm (1-1/2" x 1-1.2" x 1/10") thick, surface mounted, suspended or set in poured concrete walls and ceilings.
 - .2 channel size selected for total supported loads,
 - .3 conduit attachments: one-piece or two piece conduit clamps suitable for suspended loads and bottom supported conduit loads.
- .9 J Hooks:
 - .1 galvanized steel open-style J hooks with rolled edges for fastening direct to building structure or hanger rods.
- .10 Rooftop conduit supports:
 - .1 conform to specification section 20 05 29.

2.9 Wire Markers

- .1 Printed, self-laminating vinyl wire and cable labels and sleeve-labels.

Standard of Acceptance

- Brady BMP21 Plus series

3 EXECUTION

3.1 Pre-Installation Survey for Short Circuit Current Ratings

- .1 Prior to installation of power wiring to mechanical equipment provided under Division 20 to 25, conduct a survey of such mechanical equipment's' SCCR values. Verify that the equipment nameplate SCCR rating is equal to or greater than:
 - .1 the general value specified in this section, or
 - .2 the specific value specified in the relevant Specification section for the equipment.
- .2 Where the nameplate SCCR is less than the specified minimum SCCR required value, provide a fused disconnect switch as specified herein ahead of the equipment, even if the equipment already has an integral disconnect switch. The cost for the provision of such disconnect switches shall be borne by the trade contractor supplying the mechanical equipment, at no cost to the Owner.
- .3 For clarity, this survey also applies to existing mechanical equipment where the Work includes replacement of the power wiring supplying the equipment.

3.2 General Installation Requirements

- .1 Install electrical wiring work under this specification section in accordance with the applicable electrical safety code and regulations applicable at the location of the Work.

- .2 In other than service rooms, run conduit and cable concealed within walls or above ceilings.
 - .1 for open-cell concrete block walls, install conduit during wall construction with openings for outlet boxes,
 - .2 for solid concrete walls, rough-in conduit and outlet boxes supported from structural reinforcing bars prior to pouring of concrete,
 - .3 where walls or ceiling structures are exposed, such as steel or finished concrete, arrange conduit neatly on the supporting surface, avoid the use of elbows to the greatest extent possible, and locate conduit as close as possible to the building structure.
- .3 In service rooms, run conduit and cables exposed.

3.3 Conduit Support and Hanger Installation

- .1 As an alternative to the materials specified herein, specification section 20 05 29 may also be used for support of conduits.
- .2 Support conduit from building structure in accordance with specification section 20 05 29.
- .3 Support conduit directly from or on structural building elements. Do not support conduit directly from other services.
- .4 Provide all miscellaneous materials including nuts, washers, and backing plates to make a complete support installation.
- .5 Where wall brackets are used, select brackets and size mounting bolts and backing plates to suit the supported load, allowing for a safety factor by not loading the bracket more than 80% of its published load rating.
- .6 In steel framed construction, support conduit from structural members. Where structural members are not suitably located for upper hanger attachment locations, and where inserts of adequate capacity cannot be installed in concrete slabs, provide supplementary steel framing members;
 - .1 fabricate supplementary steel from standard HSS sections, single EL section, double C "strongback" sections, or pipe rolls,
 - .2 size supporting steel to limit span deflection to 1/250 (0.4%) between support points,
- .7 Support horizontal conduit at intervals not exceeding 3 m (6 ft).
- .8 Support vertical conduit at intervals not exceeding 3 m (6 ft).
- .9 Where trapeze hangers are used, secure conduit to trapeze with U-bolts or conduit clamps.
- .10 Mechanically fasten supplementary steel to structural steel.

3.4 Installation of Power and Control Wiring – General Requirements

- .1 Wiring methods and standards to conform with those specified in Electrical Division 26 for the area of building in which installation is to be made, except as otherwise specified in this section.
- .2 Except where fire rated cables or VFD Inverter duty cables are required, use building wire for:
 - .1 power wiring for motors and packaged equipment,
 - .2 power wiring to control panels, heat tracing and other non-motorized packaged equipment, and
 - .3 non-analog control wiring at 120 VAC or less, and 24 VDC or less.
- .3 Provided polyphase motor and equipment power conductors with the following colour coding:
 - .1 Phase A – Red,

- .2 Phase B – Black,
 - .3 Phase C – Blue ,
 - .4 Neutral - White,
 - .5 Ground - Green,
 - .6 Control - Orange.
 - .7 Where colour coded tape is utilized, apply at least 50 mm (2") at terminations, junction boxes and pull boxes. Do not paint conductors.
- .4 Provide single-phase motor and control wiring conductors with the following colour coding:
- .1 Line – Red,
 - .2 Neutral – White,
 - .3 Ground – Green.
- .5 Install all wiring in conduit or approved raceway.
- .6 Use conduit type as follows:
- .1 EMT: use thin wall conduit up to and including 32 mm (1 ¼ in) size for wiring in ceilings, furred spaces, in hollow walls and partitions and where not exposed to mechanical injury, and as otherwise shown.
 - .2 Rigid : use rigid galvanized steel conduit for wiring in poured concrete, where exposed, and for conduit 40 mm (1½ in) size and larger.
 - .3 Liquid-tight flexible: use only for the last 1000 mm (3 ft) of motor feeder at connection to motor, and for instrumentation wiring to equipment subject to vibration.
 - .4 select conduit size to be of sufficient size to allow easy removal of conductors at any time. Conduit sizes, where shown, are minimum and shall not be reduced.
- .7 Provide separate conduit for power wiring for each motor or starter. Except for motor temperature transducer wiring, do not install control wiring in the same conduit as power wiring.
- .1 exception: motor temperature transducer wiring between motor and associated motor controller may be run in the same conduit as the associated motor feeder provided the conduit is sized for the additional wire pair.

3.5 Installation of Instrumentation, Communications and Control Cabling

- .1 Install wiring in conduit.
- .2 Neatly train circuit wiring in cabinets, panels, pullboxes and junction boxes and hold with nylon cable ties.
- .3 Run instrumentation, communication and control cabling point to point and terminate on terminal strips. Do not splice communication or control cabling. Where long runs make a continuous point to point installation impractical, make splices on labelled terminal blocks in an accessible labelled terminal cabinet, installed at 1200 mm (48") above floor, and indicate cabinet location, terminal and wire numbers on the As-built drawings.
- .4 Terminate control cables in equipment with suitable connectors.
- .5 Clearly identify cables/conductors at both ends, with permanent wire markers, indicating device/panel identification and terminal numbers on the device/panel (refer to standard detail 20 15 12-021 at the end of this specification section):
 - .1 Use applicable reference name or ID tag for the device or control panel.

- .2 Print the labels such that the applicable panel/device identification is closest to the end of the cable.
- .3 Where individual wires are run in conduit, collect wires associated to the same control panel/device and apply a label to the group of wires inside each control panel/device. Where there is insufficient space inside a device (such as a transmitter), the label may be applied to the conduit at the point of connection to the device.
- .4 Where there are multiple conductors, individually identify each wire by its termination reference on the panel or device to which it connects.
- .5 Where there are only two wires and it is readily understood where each wire is to be terminated (i.e. white neutral, green ground), individually marking of the wires is not required.

3.6 Grounding

- .1 Ground electrical equipment and wiring in accordance with the applicable electrical safety code and regulations applicable at the location of the Work except where greater requirements are specified herein.
- .2 Provide insulated green bonding conductor in each power and control conduit sized per Table 16 of the Electrical Safety Code. Minimum bonding conductor size #12AWG copper.
- .3 Install grounding conductors, outside electrical rooms and electrical closets, in conduit.
- .4 Make connections to neutral and equipment with brass, copper or bronze bolts, star-washers, and connectors.
- .5 Except for VFD Inverter Duty cables, ground all motors with separate green insulated copper ground conductor installed in power feeder conduit, wired from ground terminal in the motor controller to a ground lug bolted directly to the motor frame, located inside the motor terminal box. Size the ground conductor per Table 16 of the electrical safety code except that the smallest conductor size to be #12 AWG.
- .6 Ground VFD inverter duty cables using all three integral ground conductors, from the ground terminal in the VFD enclosure to the ground lug bolted directly to motor frame inside the motor terminal box.
- .7 For VFDs, bond both ends of the VFD inverter duty cable as previously specified herein.

3.7 Disconnect Switches

- .1 Provide a disconnect switch for each piece of mechanical equipment provided under Division 20 to 25 which requires a power supply. This requirement is to be met by the following methods as applicable to each piece of equipment:
 - .1 as an integral factory-installed component of the equipment, or
 - .2 as a field-installed switch where;
 - (a) the equipment does not have an integral disconnect switch, or
 - (b) the equipment includes a factory installed disconnect switch but the equipment as a whole does not have a SCCR rating which meets or exceeds the required minimum SCCR rating specified herein or as specified in the applicable equipment Specification section.
- .2 For clarity, provide a disconnect switch upstream of harmonic filters provided for VFDs.
- .3 Locate the disconnect switches as follows;
 - .1 within 9 m (29 ft) and in the line-of-site of motors serving non-refrigeration motorized equipment, and within 9 m (29 ft) of the motor controller controlling the equipment,

- .2 within 1 m (3 ft) of non-motorized equipment.
- .4 Disconnect switch types for motorized equipment:
 - .1 fused type for motor controllers,
 - .2 fused type for motorized packaged equipment,
 - .3 unfused for non-motorized equipment,
 - .4 unfused type at the controlled equipment for:
 - (a) cooling towers and other outdoor equipment where the motor controller is located indoors, or
 - (b) where the motor controller is in excess of the distance specified above or is not in line of site of the controlled equipment.
- .5 Disconnect switches for non-motorized equipment:
 - .1 provide unfused disconnect switch for non-motorized mechanical equipment.
- .6 Where the nameplate SCCR value of a mechanical equipment is less than the specified minimum SCCR value required, provide a fused disconnect switch to isolate the mechanical equipment, even if the equipment has an integral disconnect switch.
- .7 Where fuse protection is specified, install fuses of the correct overcurrent rating as specified by the mechanical equipment installation instructions.
- .8 Where fuse protection is specified, provide a set of six spare fuses of each size used in the disconnect switches. Turn spare fuses over to the Owner and submit a copy of the receipt signed by the Owner.
- .9 Provide power wiring between the field-installed disconnect switch and the associated equipment, with the conductors of the same wire gauge as the branch circuit conductors.

3.8 Outlet Boxes

- .1 Size boxes in accordance with CSA C22.1. Use 102 mm (4") square or larger outlet boxes as required for special devices.
- .2 Gang boxes where wiring devices are grouped. Use combination boxes with barriers where outlets for more than one system are grouped.
- .3 Provide blank cover plates for boxes without wiring devices.

3.9 Seismic Restraint

- .1 Provide seismic restraints for electrical conduit in accordance with specification section 20 05 49.

3.10 Coordination and Division of Responsibility – Division 20 and Division 26

- .1 Schedule A at the end of this Specification section specifies the division of responsibility between Division 20 and Division 26 for provision of electrical work for mechanical equipment, including termination of conductors.
- .2 For clarity;
 - .1 the Division 20 electrical Work may be performed by the Division 26 contractor, but the work is managed and paid for by the Division 20 contractor.
 - .2 related work performed under Division 26 is listed in Schedule A for reference.
- .3 Coordinate power requirements for mechanical trades equipment with the contractor under Division 26 of the work, including;

- .1 provide a list of all planned and ordered mechanical trades equipment with motor horsepower ratings and electrical power requirements, prior to the Division 26 contractor procuring their power distribution equipment,
- .2 periodically update this power requirements list as mechanical trades equipment is ordered, and review with the Division 26 contractor to allow them to revise breaker ratings in a timely manner,
- .4 Where the branch circuit breaker rating requirements change as a result of the actual ordered mechanical trades equipment, coordinate and pay for any breaker and feeder changes required whether the affected work is in Division 20 or Division 26 scope of work.

3.11 Wiring Diagrams

- .1 The following wiring diagrams are included at the end of this section:
 - .1 20 05 12 - 001 Mechanical – Electrical Coordination (Sheet 1 of 3)
 - .2 20 05 12 - 002 Mechanical – Electrical Coordination (Sheet 2 of 3)
 - .3 20 05 12 - 003 Mechanical – Electrical Coordination (Sheet 3 of 3)
 - .4 20 05 12 - 005 Rooftop Custom A.H.U. – Maintenance Receptacles
 - .5 20 05 12 - 006 Rooftop HVAC Equipment – Maintenance Receptacles

Schedule A – Coordination of Division 20 and 26 Scope of Work			
Reference	Work Element	Div. 20	Div. 26
All	Motor Control Centers, motor controller racks, motor controllers, VFDs, Mechanical Breaker Panels (MBP), and disconnect switches	●	
General Mechanical Equipment fed from Dedicated Power Panels for Mechanical Equipment (Note 1)	Mechanical Service Panels (MSP), including branch overcurrent protection devices.		●
	Power wiring from MSPs and/or MCCs to: <ul style="list-style-type: none"> - motors, including between motors and motor controllers, VFDs and/or disconnect switches as applicable, - packaged equipment, including disconnect switches as applicable, - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.) 	●	
	Power wiring from RP and/or MBP to: <ul style="list-style-type: none"> - motors, including between motors and motor controllers, - packaged equipment, including disconnect switches as applicable, - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.) 	●	
General Mechanical Equipment fed from Non-dedicated Power Panels (Note 2)	Non-dedicated Power Panels (PP) and receptacle panels (RP), including branch overcurrent protection devices.		●
	Distribution splitters		●
	Power wiring from PPs and/or distribution splitters to: <ul style="list-style-type: none"> - motor controller, - disconnect switch ahead of VFD, - disconnect switch for package equipment, - packaged equipment (with integral disconnect switch) - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.) 		●
	Power wiring from RP to: <ul style="list-style-type: none"> - motor controller or disconnect switch, - disconnect switch for package equipment, - packaged equipment (with integral disconnect switch), - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.) 		●
	Power wiring from: <ul style="list-style-type: none"> - disconnect switch to a VFD, - motor controller or VFD to the motor, - disconnect switch to packaged equipment 	●	
Terminal Units BAS Controllers	Power wiring for controllers at 120 V, single phase terminating in a junction box for each group of terminal boxes.		●
	Power wiring for controllers at 120 or 24 VAC, from junction box provided by Division 26 to each terminal unit controller.	●	

Schedule A – Coordination of Division 20 and 26 Scope of Work			
Reference	Work Element	Div. 20	Div. 26
	Power wiring for controllers at 24 VAC/DC, from building automation system control panels to terminal unit box controller.	●	
	3 phase, 208 V and higher voltage wiring direct to terminal unit box.		●
BAS Controls and OEM Controls	In service rooms: provision of 120/208 VAC mechanical service panels (MSP) complete with 15 A breakers in service rooms for use by Division 20 to 25.		●
	Power wiring for controls in service rooms: wiring from MSP or BP to the BAS and OEM control equipment.	●	
	Other than service rooms: Dedicated 120V 15A normal and emergency branch circuit breakers as indicated on the receptacle panel schedules.		●
	Power wiring for controls other than in service rooms: wiring from dedicated circuits in receptacle panels to control equipment.	●	
	120 V, single phase power supply with a junction box at specific control devices as shown.		●
	Breaker tamper-protection locks.	●	
	Instrumentation and actuator power and control wiring, for both BAS controls and OEM controls.	●	
	Control wiring to interlock motor controllers and to connect safety and operating controls.	●	
Plumbing Fixtures	120 V, single phase power supply with a junction box with sufficient wiring to terminate at plumbing fixtures requiring control power		●
	Conduit from adjacent junction box or pull box to plumbing fixtures requiring control power, pulling of wiring to the plumbing fixture and termination of wiring to the fixture or primary side of control transformer.	●	
	Control transformers and extra-low voltage wiring	●	
Medical Gas Equipment	Dedicated emergency power circuits 120 VAC, single phase for central and distributed medical gas alarm panels, terminated in the control panels.		●
	Control wiring between field installed instrumentation and medical gas alarm panels.	●	
Fire and Smoke Dampers	Power wiring to damper interlock control panels for smoke dampers, motorized fire dampers, and combination smoke/fire dampers.		●
	Wiring between damper interlock control panels (for smoke dampers, motorized fire dampers, and combination smoke/fire dampers), to their associated dampers.	●	

Schedule A – Coordination of Division 20 and 26 Scope of Work			
Reference	Work Element	Div. 20	Div. 26
Life Safety Interface	Fire Alarm System (“FAS”) control and monitoring modules located at BAS control interface panel.		●
	FAS control and monitoring modules located at/near sprinkler and standpipe supervised valves and flow switches including wiring between each module and the respective valve/flow switch.		●
	Wiring between FAS control and monitoring modules, and smoke control and smoke venting fans and dampers.		●
	Termination of FAS control and monitoring wiring in BAS panels	●	

Notes:

[1] MPP and MBP will be located in mechanical services rooms.

[2] PP and RP are not dedicated for mechanical equipment and may be located in any type of service room or space.

LEGEND

	CONSTANT SPEED MOTOR CONTROLLER		SCOPE OF WORK: DIVISION "A" / DIVISION "B" BOUNDARY
	VARIABLE FREQUENCY DRIVE		WIRING AND/OR EQUIPMENT BY DIVISIONS 20-25
	UNFUSED SERVICE DISCONNECT SWITCH		WIRING AND/OR EQUIPMENT BY DIVISION 26
	FUSED SERVICE DISCONNECT SWITCH		
	TRANSFORMER		
	120 VAC/ XX VDC POWER SUPPLY, CLASS AS SHOWN		
	120/208 VAC MECHANICAL BREAKER PANEL		
	MECHANICAL SERVICE PANEL (DIV 26)		
	POWER PANEL (DIV 26)		
	JUNCTION BOX		
	MOTOR		
	ELECTRIC HEAT TRACING		
	PACKAGED EQUIPEMENT WITH MOTORS AND INTEGRAL MOTOR CONTROLLERS		
	CONTROL PANELS, TERMINAL UNIT CONTROLLERS, AND OTHER NON-MOTORIZED EQUIPMENT		
	FUSE		
	LIGHT SWITCH (FOR SERVICE LIGHTS) - FLOOR PLAN		
	POWER SWITCH (SINGLE-LINE)		
	SERVICE LIGHT		
	ALARM BEACON		

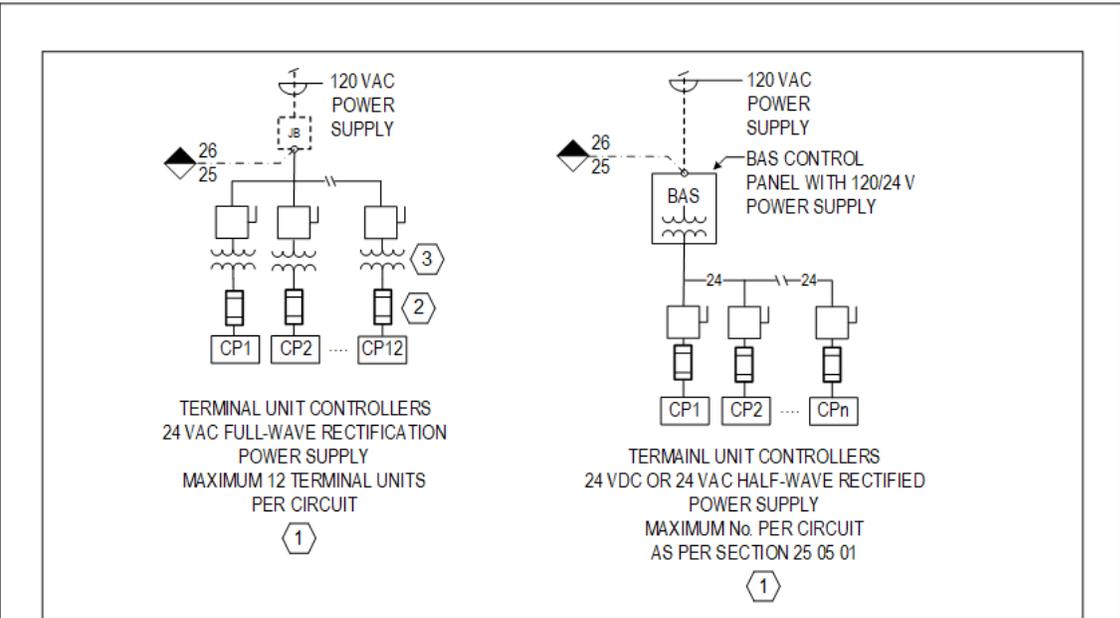
General Notes
 1. This drawing indicates general coordination of mechanical and electrical work. Refer to plan and riser drawings and specifications for project specific requirements, which take precedence over this drawing.

Issued For

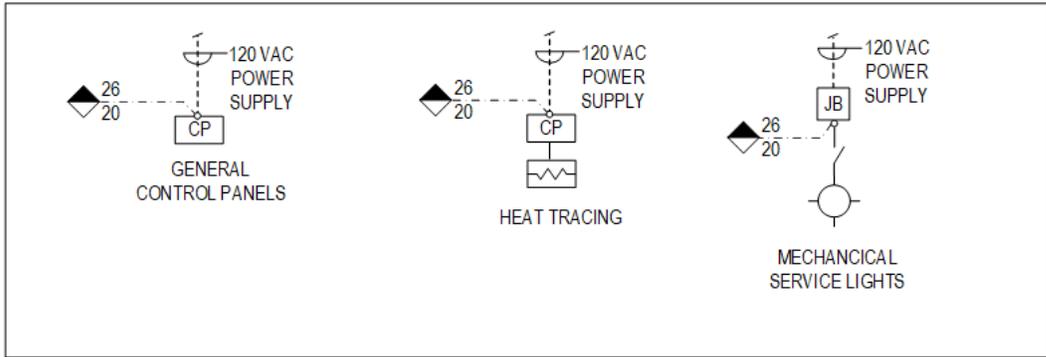


Sheet Title
**MECHANICAL – ELECTRICAL
 COORDINATION BLOCK DIAGRAM
 (SHEET 1 OF 3)**

Date: 21 JUNE 2023	Rev. No.: 03	Checked: PS
Standard Detail No. 20 05 12 - 001		



TERMINAL UNITS



MISCELLANEOUS EQUIPMENT

DRAWING NOTES
 (NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY)

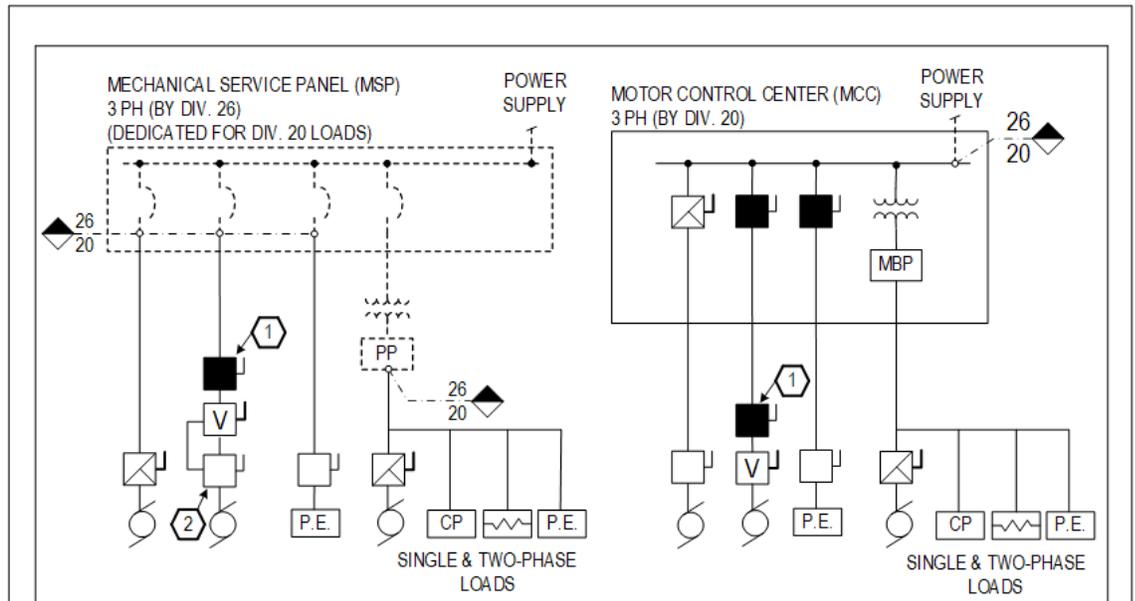
1. REFET TO SPECIFICATION SECTION 25 05 01 FOR APPLICABLE WIRING METHODS.
2. PROVIDE FUSE PROTECTION IF TRANSFORMER DOES NOT HAVE INTEGRAL CIRCUIT BREAKER.
3. PROVIDE DEDCIGATED TRANSFORMER FOR FULL-WAVE RECTIFIED 24 VAC CONTROL DEVICES.



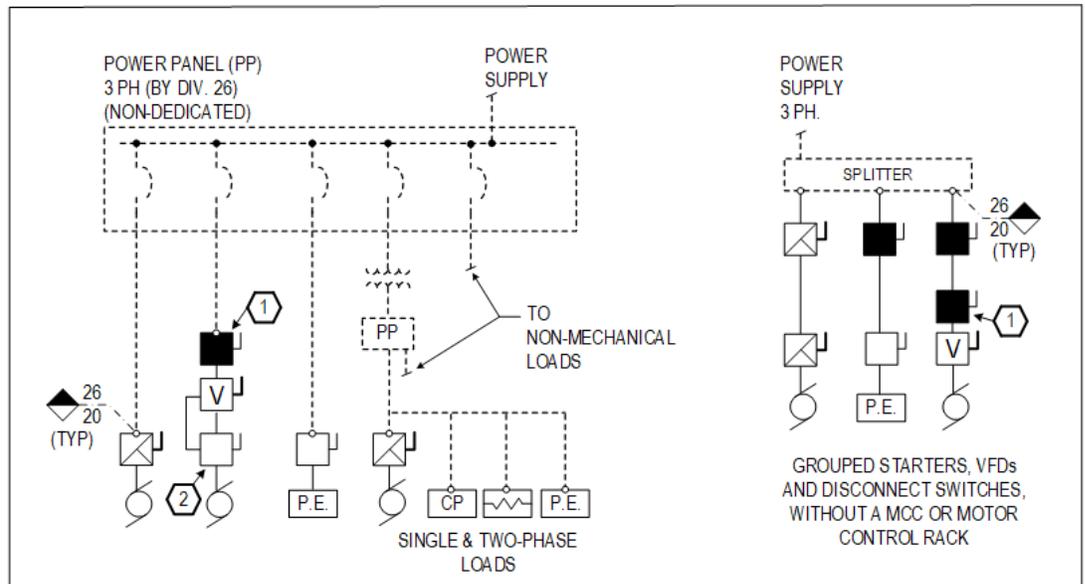
Sheet Title:
**MECHANICAL – ELECTRICAL
 COORDINATION BLOCK DIAGRAM
 (SHEET 2 OF 3)**

Date: 21 JUNE 2023	Rev. No.: 03	Checked: PS
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Standard Detail No.
20 05 12-002



DEDICATED POWER DISTRIBUTION EQUIPMENT



NON-DEDICATED POWER DISTRIBUTED EQUIPMENT

DRAWING NOTES
 (NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY)

1. SEPARATE FUSED DISCONNECT WHEN REQUIRED TO MEET SPECIFIED SCCRV VALUES. (TYP).
2. SEPARATE UNFUSED DISCONNECT WHERE V.F.D. IS REMOTE FROM THE MOTOR. PROVIDE DISCONNECT SWITCH POSITION INDICATOR WITH INTERLOCK WIRING TO THE V.F.D. (TYP).

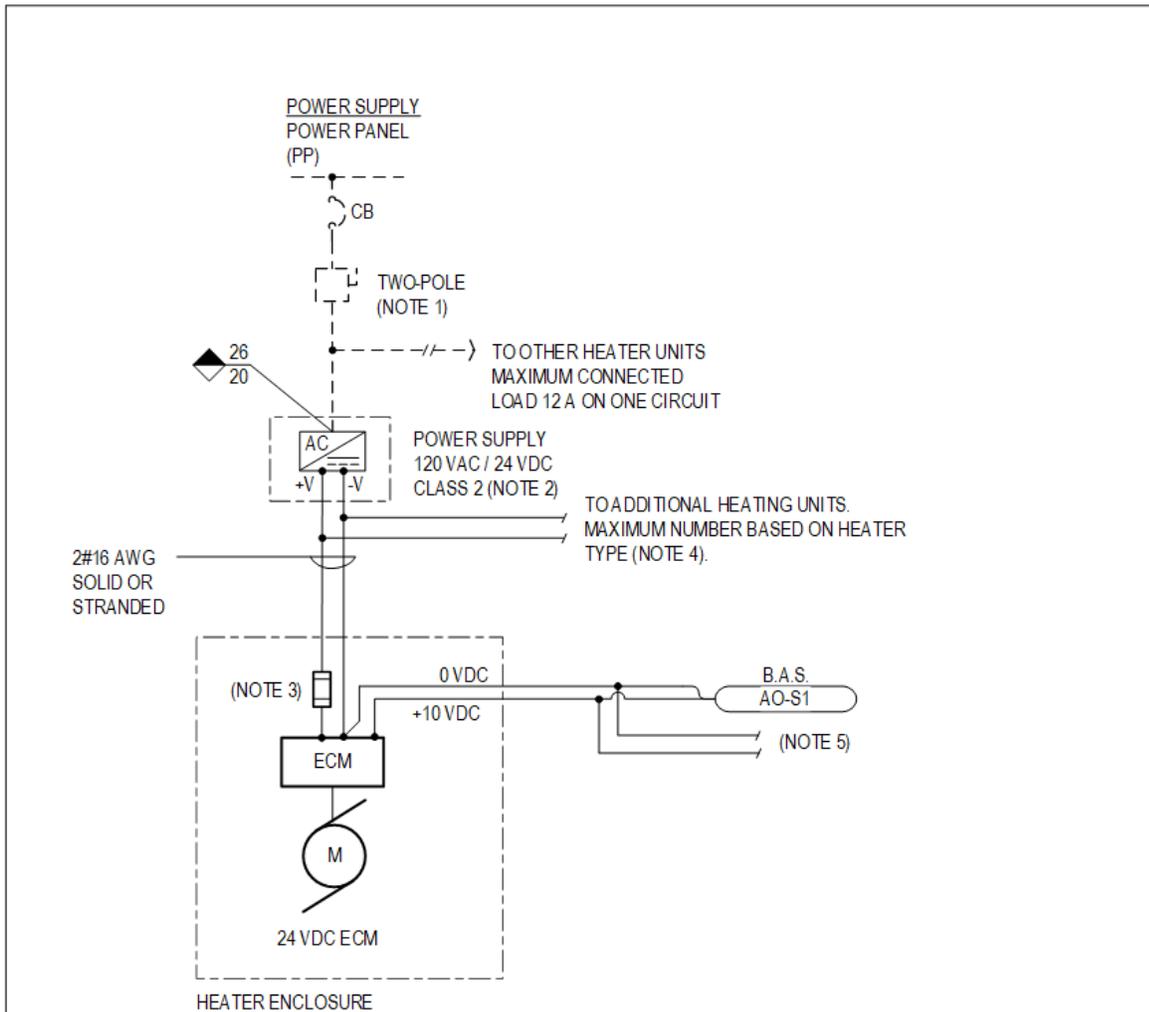
General Notes

1. This drawing indicates general coordination of mechanical and electrical work. Refer to plan and riser drawings and specifications for project specific requirements, which take precedence over this drawing.
2. Dedicated power distribution equipment is only located in mechanical service rooms.



Sheet Title
**MECHANICAL – ELECTRICAL
 COORDINATION BLOCK DIAGRAM
 (SHEET 3 OF 3)**

Date 21 JUNE 2023	Rev. No. 04	Checked PS
Standard Detail No. 20 05 12 – 003		



REFERENCE NOTES

1. DISCONNECT BOTH LINE AND NEUTRAL
2. POWER SUPPLY MOUNTED IN TYPE 1 ELECTRICAL ENCLOSURE AND MOUNTED WITHIN 10 M (30 FT) OF FIRST HEATER SERVED AS SHOWN..
3. PROVIDE FUSE OF AMPERE RATING AS SPECIFIED BY HEATING EQUIPMENT MANUFACTURER
4. REFER TO PLAN DRAWINGS FOR NUMBER OF INDIVIDUAL HEATER UNITS SERVED BY THE SAME 24 VDC POWER SUPPLY.
5. THE SAME B.A.S. OUTPUT MAY CONTROL MULTIPLE HEATER UNITS IN THE SAME ZONE.

GENERAL NOTES

1. THIS DRAWING INDICATES GENERAL WIRING REQUIREMENTS FOR 24 VDC FAN-COIL HEATING UNITS. REFER TO EQUIPMENT MANUFACTURER INSTALLATION INSTRUCTIONS FOR SPECIFIC WIRING REQUIREMENTS.
2. REFER TO DETAIL DRAWINGS 20 05 12-001 AND 20 05 12-002 FOR GENERAL COORDINATION OF WORK UNDER DIVISIONS 20 AND 26.

Issued For



Sheet Title
**FORCED-AIR CONVECTORS
 24 VDC & CONTROL WIRING**

Date: 08 DEC 2022	Rev. No.: 00	Checked: PS
Standard Detail No. 20 05 12 - 007		

END OF SECTION

INDICATING GAUGES 20 05 19

1 GENERAL

1.1 Scope

- .1 Provide temperature and pressure measuring devices and flow indicators as shown.

1.2 Submittals

- .1 Submit manufacturer's catalogue literature for;
 - .1 flow indicators,
 - .2 thermometers,
 - .3 pressure gauges.
- .2 Product data sheets to include:
 - .1 measurement range,
 - .2 maximum operating pressure,
 - .3 installation accessories
- .3 Where there are multiple piping system design pressures based on building elevation, submit separate shop drawings for measuring and indication devices based on applicable piping system design pressure.

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B51 Boiler and Pressure Vessel Code
- .2 Product standards:
 - .1 ASME B40.100 Pressure Gauges and Gauge Attachments
 - .2 ASME B40.200 Thermometers, Direct Reading and Remote Reading
 - .3 ASME PTC 19.3 TW Thermowells

1.4 Quality Control

- .1 All products that are connected to or installed in a piping system are to have Canadian Registration Numbers in accordance with CSA B51.

2 PRODUCTS

2.1 Thermometers and Pressure Gauges - Selection Criteria

- .1 General:
 - .1 normal operating reading to be between one-half and two-thirds of full scale range,
 - .2 expected maximum and minimum readings to be within scale range.
 - .3 thermometers to have both Celsius and Fahrenheit scales,
 - .4 pressure gauges to have both kPa and psi scales.
 - .5 select pressure gauges and thermometers from manufacturer's standard product line.

Standard of Acceptance

- Terice
- Ashcroft
- Dwyer
- Weksler
- Winter
- Weiss
- WIKA

2.2 Direct Reading Thermometers – Liquid and Gases

- .1 For liquid and compressed gas service only.
- .2 Industrial, adjustable angle type;
 - .1 indicator: 225 mm (9 in.) long, coloured organic spirit fill, magnifying lens type,
 - .2 measurement units: dual scale °C/ °F,
 - .3 case: cast aluminum with epoxy finish,
 - .4 window: UV stabilized acrylic for temperature range up to 150°C (300°F), and glass for higher temperatures,
 - .5 process connection: NPT threaded mount, and constructed of:
 - (a) for carbon steel pipe: brass,
 - (b) for stainless steel pipe or tube: 316L stainless steel tube and socket,
 - (c) for copper tube: brass
 - .6 accuracy: ± 1 unit minor scale division,
 - .7 conforms to ASME B40.200,
 - .8 with matching thermowell.

Standard of Acceptance

- Terice – fig. BX9

2.3 Remote Reading Thermometers

- .1 Surface-mounted remote reading thermometer:
 - .1 115 mm (4½ in) liquid filled or gas activated type,
 - .2 capillary sensing tube: armoured stainless steel capillary tube with union fitting connection, of length required to suit installation requirements,
 - .3 measurement units: dual scale °C/ °F,
 - .4 case: cast aluminum with epoxy finish, with mounting ring,
 - .5 window: clear glass with retaining ring or hinged bezel,
 - .6 process connection: NPT threaded mount, and constructed of:
 - (a) for carbon steel pipe: brass,
 - (b) for stainless steel pipe or tube: 316L stainless steel tube and socket,
 - (c) for copper tube: brass
 - .7 accuracy: ± 1 unit minor scale division,
 - .8 conforms to ASME B40.200,

- .9 with matching thermowell.

Standard of Acceptance

- Terice - fig. V/L80341 (gas/liquid activated)
- Weksler - fig. 413B (gas activated)
- Ashcroft - fig. 600A Series (gas activated)

2.4 Thermometer Wells (Thermowells)

- .1 Manufactured from bar stock or forged brass,
 - .1 compatible with temperature sensors used,
 - .2 external NPT mounting threads,
 - .3 pressure rating: 2000 kPa (300 psig) at 121°C (250°F)
 - .4 C.R.N. registered.
- .2 Body material:
 - .1 for carbon steel piping: brass,
 - .2 for copper and brass tubing: brass.
 - .3 for stainless steel piping: 304 stainless steel.
- .3 C.R.N. to CSA B51.

Standard of Acceptance

- Terice - fig. 4350

2.5 Temperature Well Conversion Kits

- .1 Retrofit kit to convert straight liquid filled thermometer wells to accept bi-metal dial thermometers.

2.6 Pressure Gauges – Liquid

- .1 For measurement of pressure piping for liquid systems.
- .2 Direct pressure measurement:
 - .1 display: Ø115 mm (4½ in. dia.) dial type, dry type, adjustable stainless steel pointer movement
 - .2 measurement units: dual scale kPa/ psi,
 - .3 case: fiberglass reinforced polypropylene, solid-front and blow-out back,
 - .4 window: acrylic,
 - .5 wetted parts:
 - (a) for carbon steel pipe: brass,
 - (b) for stainless steel pipe or tube: 316L stainless steel tube and socket,
 - (c) for copper tube: brass
 - .6 accuracy: 0.5% full scale reading,
 - .7 maximum service temperature: 121°C (250°F)
 - .8 conforms to ASME B40.100 Grade 2A.
 - .9 C.R.N. to CSA B51.

Standard of Acceptance

- Terice – 450B, 450SS

2.7 Pressure Gauges – Ventilation

- .1 For measurement in HVAC ventilation systems.
- .2 Direct or differential pressure measurement:
 - .1 process service: ventilation air,
 - .2 display: Ø115 mm (4½ in. dia.) dial type, adjustable stainless steel pointer movement, pressure relief plug, and NPT 1/8 low- and high-pressure inlet ports, and tubing adaptors,
 - .3 measurement units: dual scale Pa / in. w.c.
 - .4 case: cast aluminium with bezel with epoxy finish coat,
 - .5 window: acrylic,
 - .6 accuracy: ±2% full scale reading,
 - .7 service pressure range: -500 mm Hg to 103 kPa (- 20 in.Hg. to 15 psig)
 - .8 maximum service temperature: -6.5°C to 60°C (20 to 140°F),
 - .9 accessories:
 - (a) attached surface mounting plate,
 - (b) adjustable signal flag for measurement across air filter banks.

Standard of Acceptance

- Dwyer - fig. 2000, 2000-ASF series

2.8 Pressure Gauge Accessories

- .1 Pressure snubbers:
 - .1 brass or T303 stainless steel construction,
 - .2 C.R.N. to CSA B51.

Standard of Acceptance

- Terice - 872

- .2 Gauge isolation ball valves:
 - .1 for water, compressed gases, and fuel oil services,
 - .2 NPS 1/4, brass body, quarter-turn ball valves with Teflon seats,
 - .3 minimum pressure rating: 2000 kPa (300 psig) at 121°C (250°F),
 - .4 C.R.N. to CSA B51.

Standard of Acceptance

- Terice - fig. 866

- .5 alternate product: NPS 1/4 or 1/2 size as specified for associated liquid or gas piping system.

2.9 Test Port Plugs

- .1 Piping test port plugs with gauge adaptors for pressure tests or insertion of pocket thermometer probes.

- .1 Wetted parts: lead-free brass, with BUNA-diaphragm core,
- .2 size: 1/2" NPT with MNPT threaded connection, with probe guard
- .3 pressure rating: 7000 kPa (1000 psi) from -40 to 150°C (-40 to 300°F)

Standard of Acceptance

- Winters – fig. STP-LF

3 EXECUTION

3.1 Installation - General

- .1 Install thermometers and gauges not more than 3 m (10 ft) from floor or platform, or install remote reading thermometers and gauges, with dial mounted at eye level, mounted on backplate and fastened to building structure.
- .2 Provide nameplates for each gauge and thermometer as specified in Section 20 19 00 Identification.

3.2 Thermometer Installation

- .1 Install thermometers on inlet and outlet of;
 - .1 heat exchangers,
 - .2 water heating and cooling coils,
 - .3 water boilers,
 - .4 chillers,
 - .5 open-circuit cooling towers and closed-circuit water coolers,
 - .6 domestic hot water tanks, and
 - .7 as shown.
- .2 Install thermometers in thermowells.
- .3 Install thermowells with extension necks where piping and equipment is to be insulated.

3.3 Pressure Gauge Installation

- .1 Install pressure gauges on inlet and outlet of;
 - .1 heat exchangers,
 - .2 water heating and cooling coils,
 - .3 steam piping to heating coils (inlet only),
 - .4 water boilers,
 - .5 chillers,
 - .6 closed-circuit water coolers,
 - .7 domestic hot water tanks,
 - .8 steam boilers,
 - .9 condensate receivers,
 - .10 deaerators,
 - .11 air-compressors (discharge only),
 - .12 compress-air dryers,

- .13 compressed-air receivers, and
- .14 as shown.
- .2 Provide an isolation valve for each pressure gauge. For differential pressure gauges, provide an isolation valve on each high and low pressure sensing lines.
- .3 Provide pressure snubbers on pressure gauges at the following locations:
 - .1 suction and discharge sides of positive-displacement pumps including oil pumps,
 - .2 air-compressor discharge, and inlet and discharge of compressed-air dryers, and at outlet of compressed-air receivers,
- .4 Install coil syphons on steam and condensate pressure gauges.

3.4 Test Port Plugs

- .1 Install test port plugs in locations as shown. Test port plugs shall not be used in lieu of temperature or pressure gauges specifically shown.

END OF SECTION

GENERAL REQUIREMENTS FOR VALVES

20 05 23

1 GENERAL

1.1 Scope

- .1 Provide valves in piping systems for shut-off service, manual flow balancing, check-stops and valve bodies for automatic flow control.
- .2 This specification section provides general requirements for valves.

1.2 Related Sections

- .1 Refer to the following valve specification sections for requirements for general-duty valves in addition to the general requirements specified herein.
 - 22 05 23.13 General-Duty Valves for Plumbing Piping
 - 23 05 23.13 General-Duty Valves for HVAC Water Piping
 - 23 05 23.19 Stainless Steel Valves for HVAC Water Piping
- .2 Refer to the following specifications sections for requirements for specific-duty valves in addition to the general requirements specified herein.
 - 22 60 13.70 Medical Gas Piping

1.3 Submittals

- .1 Submit manufacturer product data-sheets for valves, including pressure-temperature ratings with confirmation that the valve meets the required MCPR rating specified for each valve.
- .2 Where valves are specified to be listed (certified) to a standard, include the following information for each affected product:
 - .1 applicable standard by name and reference number,
 - .2 name of accredited testing organization or their mark who certified the product, and
 - .3 the testing organization file reference number.
- .3 Where valves are required to have a CRN, include the CRN and its expiry date on each valve submittal.
- .4 Where manufacturer pre-printed data-sheets do not include this information, a schedule may be submitted which includes the manufacturers name, model number and the required listing and/or CRN information described above. Where the product is name-branded for a manufacturer, include the name of the source manufacturer.

1.4 Applicable codes and standards

- .1 Legislation:
 - .1 Valves installed in piping systems which are subject to provincial or federal pressure piping legislation shall have current Canadian Registration Numbers ("CRN") in accordance with CSA B51.
- .2 Installation standards, codes and guidelines:
 - .1 CSA B51 Boiler and Pressure Vessel Code.
 - .2 Refer to applicable piping specification sections for any other specific requirements.
- .3 Product standards:
 - .1 ANSI/ASME B1.20.1 Pipe Threads, General Purpose, Inch

.2	ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings
.3	ASME B16.5	Pipe Flanges and Flanged Fittings
.4	ASME B16.10	Face-to-Face and End-to-End Dimensions of Valves
.5	ASME B156.24	Cast Copper Alloy Pipe Flanges and Flanged Fittings
.6	ASME B16.34	Valves Flanged, Threaded and Welding Ends
.7	ASME B16.47	Large Diameter Steel Flanges: NPS 26 Through NPS 60
.8	ISO 5211	Industrial Valves – Part-turn Actuator Attachments
.9	MSS SP-25	Standard Marking System for Valves, Fittings, Flanges, and Unions
.10	MSS SP-42	Corrosion-Resistant Gate, Globe, Angle, and Check Valves with Flanged and Butt Weld Ends (Classes 150, 300, & 600)
.11	MSS SP-67	Butterfly Valves
.12	MSS SP-68	High Pressure Butterfly Valves with Offset Design
.13	MSS SP-70	Cast Iron Gate Valves, Flanged and Threaded Ends
.14	MSS SP-71	Cast Iron Swing Check Valves, Flanged and Threaded Ends
.15	MSS SP-72	Ball valves with Flanged or Butt-Welding ends for General Service
.16	MSS SP-78	Cast Iron Plug Valves
.17	MSS SP-80	Bronze Gate, Globe Angle and Check Valves
.18	MSS SP-85	Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
.19	MSS SP-110	Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
.20	MSS SP-125	Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves
.21	MSS SP-126	In-Line, Spring-Assisted, Center-Guided Check Valves (Carbon, Alloy Steel, Stainless Steel, & Nickel Alloys)
.22	MSS SP-136	Ductile Iron Swing Check Valves
.23	MSS SP-139	Copper Alloy Gate, Globe, Angle, and Check Valves for Low Pressure/Low Temperature Plumbing Applications
.24	NSF/ANSI 61	Drinking Water System Components – Health Effects
.25	NSF/ANSI 372	Drinking Water System Components – Lead Content (formerly NSF/ANSI 61- Annex G).

1.5 Quality and Equivalence

- .1 Valve selections are in general identified by model designations taken from manufacturers catalogues to indicate physical properties and quality requirements not otherwise described.

2 PRODUCTS

2.1 General

- .1 Refer to related specification sections.
- .2 Manufactures and/or trade names listed in Table 1 are acceptable for various indicated valve types, where products offered are essentially similar to those identified by manufacturer or model number under “Standard of Acceptance” designation in the related specification sections.

- .1 Refer to the General-duty valve specification sections and specific-duty valve requirements contained in the related piping system specification sections.
- .2 Additional specification requirements and/or certification requirements may be required by those sections.

Manufacturer	Gate, Globe, Angle, Check	Silent Check	DRV	Butterfly	Plug	Ball
A-Chem Valves & Controls	•			•		•
American Valve						•
APCO		•				
Apollo				•		•
Bonney Forge	•					
Beric	•					
Bray				•		•
Canadian Worchester Controls						•
Challenger				•		
Couplox				•		
Crane	•			•		•
Crane Centreline				•		
Crane Flowseal				•		
Dahl Bros	•					•
Demco				•		
DeZurik				!		
Durabla		•				
Grinnell				•		
Gruvlok				•		•
Hattersley Milliken (Crane)					•	
Jenkins	•			•		•
Keystone				•		
Kitz	•			•		•
MA Stewart (MAS)	•					•
Milwaukee Valve				•		•
Mueller		•		•	•	
Neo Valves	•					•
Nibco	•	•		•		•
Nordstrom					•	
Powell	•					
Preso			•			
S.A. Armstrong	•		•			
Shurjoint				•		•
Sure Seal				•		

Manufacturer	Gate, Globe, Angle, Check	Silent Check	DRV	Butterfly	Plug	Ball
Tour & Anderson			•			
Toyo Valve (Red & White)	•					•
Triad				•		
Trueline	•					•
Valmatic		•				
Velan	•			•		•
Victaulic				•		•
Watts	•			•		•
WKM				•		

3 EXECUTION

3.1 Valve Selection Criteria

- .1 Select valves in accordance with function criteria as shown in Table 2.

Function	Gate	Butterfly	Ball	Globe	Plug	DRV
Shut-Off	•	•	•		•	
Flow Balancing only (excluding pumps)				•		•
Pump Balancing		• [1] [3]		•		•

Notes:

[1] Gear operator with position limit memory stops.

[2] Not used.

[3] Sized one (1) NPS line size smaller than pipe line size (not pump discharge size).

3.2 Piping System Drain Valves

- .1 Provide drain valves on piping and at equipment as follows unless otherwise shown on drawings:
- .1 On pipe mains and branches NPS 3 and under, and for equipment with pipe connections NPS 4 and smaller:
 - (a) NPS ¾ ball valve in accordance with pipe system specification with integral NPSH ¾ hose end with cap and chain.
 - .2 On pipe mains NPS 4 to NPS 6, and for equipment with pipe connections NPS 6 and larger:
 - (a) NPS 1 ball valve, with a NPT threaded brass Cam and Groove female coupler fitting with dust-plug
 - .3 On pipe mains NPS 8 and larger:

- (a) NPS 2 ball valve, with a NPT threaded brass Cam and Groove female coupler fitting with dust-plug.

3.3 Valve Installation - General

- .1 Install shut off valves at:
 - .1 branch take-offs,
 - .2 to isolate piping to each piece of equipment, and
 - .3 in locations shown.
- .2 Remove internal parts of valves before soldering, welding or brazing pipe to valve body.
 - .1 Exception: where valve is provided with tube end extensions to allow soldering or brazing without removal of internal parts.
 - .2 For valves which do not permit disassembly including ball valves and inline check valves, comply with valve manufacturer instructions to protect valve internal components during soldering, brazing or welding.
- .3 Install triple duty or throttling valves where shown in pump discharge piping with ten pipe diameters of straight pipe on the inlet side and two pipe diameters on outlet side.
- .4 Install butterfly valves between weldneck or slip-on flanges.

3.4 Valve Orientation and Accessibility

- .1 Arrange valve hand-wheels and operating levers to be accessible.
- .2 In equipment rooms and service spaces provide chain operators for valves mounted more than 2m (6 ft) above floor or access platform. Provide sufficient chain length to extend to 1.5m (4 ft-6 in) above floor or platform and to be hooked on clips secured to building structure, clear of walking aisles.
- .3 In horizontal piping (see figure 1);
 - .1 For OS&R valves, install the valve with stem vertical where the valve centerline is not more than 1200 mm above the adjacent floor or access platform. For greater heights, install the valve with stem horizontal. Where space is restricted, the valve may be installed with the valve spindle at a 45° angle from the vertical where the valve centerline is not more than 1500 mm above the floor or access platform.
 - .2 For gear operated valves, install with gear-box on top of the valve and hand-wheel shaft in the horizontal position.
 - .3 For lever operated valves, install with handle on top of valves where the valve centerline is not more than 1500 mm above the floor or access platform. Where spaces is restricted, the valve may be positioned with the lever handle shaft in the horizontal position. For greater heights, install valves with handle shaft in the horizontal position.

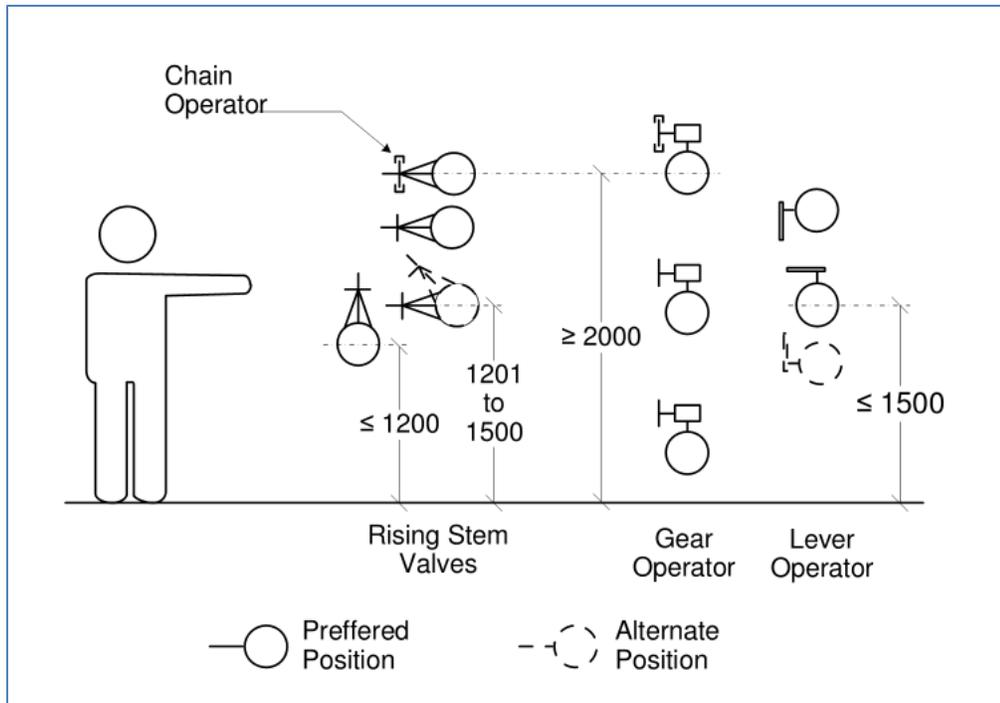


Figure 1: Valve Spindle Arrangement

- .4 In vertical piping, install with valve stem facing directly towards the means of access. Where access space in front of the valve is less than 900 mm (36 in), rotate the valve 45° from the straight forward position.

END OF SECTION

WELDING AND BRAZING

20 05 24

1 GENERAL

1.1 Scope

- .1 Weld or braze pipe and fittings for work of Division 20.

1.2 Definitions

- .1 The following definitions apply to this specification section:

AHJ (BPV): *the authority having jurisdiction which is responsible for boiler, pressure vessel and pressure piping safety in the province of the project.*

- .2 In this specification,
 - .1 the word “piping” also includes tubing as the case applies.
 - .2 the words “welding” or “welder” shall be read as to also refer to “brazing” or “brazer” unless the context otherwise dictates one or the other.

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:

- .1 ASME B31.1 Pressure Piping
- .2 ASME B31.3 Process Piping
- .3 ASME B31.9 Building Services Piping
- .4 ASME BPVC Section V Nondestructive Examination
- .5 ASME BPVC Section IX Welding and Brazing Qualifications
- .6 CSA B51. Boiler, Pressure Vessel, and Pressure Piping Code

1.4 Quality Control

- .1 Welding of piping systems which have specified design pressures greater than 100 kPa (15 psi) to be carried out using approved welding procedures by welders certified for pressure piping by the AHJ (BPV), whether or not the piping system is subject to registration as pressure piping.
- .2 Welding procedures shall be registered with the AHJ (BPV), in accordance with CSA B51 and as qualified in accordance with ASME BPVC Section IX.
- .3 Welders shall be certified for welding of pressure piping in accordance with the requirements of the AHJ (BPV). Welders shall be qualified by their employer on the employers welding procedures.
- .4 For piping systems which have specified design pressure of 100 kPa (15 psi) or less, welding procedures and welders shall be qualified by the Contractor in accordance with the requirements of ASME B31.9.

2 PRODUCTS

2.1 Not used

3 EXECUTION

3.1 Welding Method and Quality

- .1 Welding, both shop and field, to be electric arc in accordance with recommendations of Canadian Welding Bureau unless other welding methods are specified in the piping specification sections.
- .2 Welds to be solid homogeneous part of metals joined and free from pits, slag-inclusions, and scale.
- .3 Weld surfaces to be smooth and regular and weld metal deposition to achieve full penetration groove weld fused to the base metal throughout joint thickness. Fillet welds, where permitted or required by applicable piping codes, shall achieve adequate depth of fusion of the base metal as required by those codes.
- .4 Brazed joints to use brazing filler and fluxes as specified for each applicable piping system. For socket joints, the tube and joint are to overlapped not less than four times the thickness of the thinner base material, with filter material penetrating to this full depth and finished with well-developed fillet.

3.2 Welded Connections to Existing Pressure Piping Systems

- .1 At the commencement of the Work, where registration and/or inspection of the piping system is required in accordance with provincial boiler and pressure vessel regulations, review with the AHJ (BPV) inspector to determine their weld testing requirements to validate the proposed welding procedures for connecting to existing piping, including but not limited to:
 - .1 acceptable dimensional misalignment between old and new pipe;
 - .2 requirements, if any, for metallurgical analysis of exiting piping;
 - .3 sample butt weld guided-bend test; and
 - .4 sample fillet weld test.
- .2 After testing requirements are determined, provide a proposed schedule for tie-in connections and required existing service shut-down periods, for approval prior to commencing work.
- .3 Prior to shut-down of existing piping systems for tie-ins, inspect the existing pipe O.D. dimensions to confirm their suitability for pipe attachment. Specifically, where the work requires a complete transection of an existing pipe, check the existing pipe for excessive out-of-roundness which would otherwise exceed the allowable misalignment as defined in the applicable ASME piping code. Where necessary, trim the pipe ends in accordance with the referenced piping code.

3.3 Welding Examination

- .1 For piping systems which are specified to be constructed to ASME B31.1 or ASME B31.3, examination of pipe welds, including both visual and other nondestructive examination performed in accordance with those piping codes shall be arranged and paid for by the Contractor, and are to be performed by a specialist testing company whose personnel are qualified to perform such examinations in accordance with ASME BPVC Section V.
- .2 For piping systems which are specified to be constructed to ASME B31.9, examination of pipe welds in accordance with that piping code shall be performed by the Contractor using personnel who are suitably experienced for such examinations.
- .3 Acceptance criteria for weld examination shall be in accordance with the specified ASME piping code applicable to each piping system and as may be specified in other Specification sections of Division 21 to 23.

- .1 for clarity, where ASME B31.9 code applies to a piping system, the weld examinations and weld defect acceptance criteria are summarized in the following table.
 - (a) Notwithstanding the listed weld defect criteria, the overall quality of the weld shall also be able to meet the requirements for incomplete weld penetration and weld root concavity. However, examination of the interior surface of the weld is not required.

Table 1: Weld Defect Acceptance Criteria – ASME B31.9		
Type of Weld	Weld Defect	Acceptance Criteria
Girth (butt) weld, Groove weld, Fillet weld, Socket weld, Seal weld	Cracks	None
	Lack of fusion	Length of unfused areas ≤ 20% of pipe circumference or total length of weld, and not more than 25% in any 150 mm (6 in.) of weld
	Undercut	Not exceed the lessor of 1 mm (1/32 in.) or 12.5% of wall thickness.
	Weld surface	Weld reinforcement not to exceed 4.8 mm (3/16 in.)

3.4 Welding Inspection

- .1 Arrange and pay for any required inspection of welds by the AHJ (BPV).
- .2 Welders certificates and welding procedures used for the Work to be made available for inspection by the AHJ (BPV) on demand. Provide traceability of welders work by either stamping each weld with the welder's identifying number, or maintain a record log to record and identify each welders work.

3.5 Radiography

- .1 Notwithstanding that a referenced ASME piping code may not require radiographic or other non-visual non-destructive examination methods based on the service conditions of a piping system, provide radiographic examination of piping systems as specified herein.
- .2 Arrange and pay for services of an inspection company specializing in making and interpreting radiographic imaging of pipe welds.
- .3 For piping systems where ASME B31.3 is the specified piping code, the following rules apply:
 - .1 The designated lots of piping for radiographic examination ("Lots") are defined as follows:
 - (a) Lot 1: the aggregate of all piping within a boiler plant room or other mechanical service room.
 - (b) Lot 2: the aggregate of all piping located in a vertical service space (total of all such piping).
 - (c) Lot 3: the aggregate of all piping located in areas not defined in Lot 1 and Lot 2.
- .4 Submit a copy of the radiograph results and analysis for every weld so examined.
- .5 Radiography to be in accordance with ASME BPVC Section V, article 2. Weld acceptance criteria shall be in accordance with the specified ASME piping code.
- .6 Where a weld is found to be defective in a Lot, conduct two additional tests in the same Lot. If one of those additional tested welds is found defective, conduct an additional second set of two additional tests in the same Lot. If one of those welds fail, then conduct 100% radiographic examination of all butt welds in the Lot.
- .7 Repairs to defective welds shall be performed in accordance to the requirements of the specified ASME piping code.

END OF SECTION

PIPELINE LINE STOPPING

20 05 26

1 GENERAL.

1.1 Scope

- .1 Temporarily isolate portions of existing piping systems by means of pipe line-stopping.

1.2 Limitations on Use

- .1 Line-stopping is not to be used where isolation and/or draining of the pipeline is permitted by the Owner.
- .2 Line-stopping is only to be used where;
 - .1 permitted by the Owner,
 - .2 specified for particular branch connections and for temperature thermowells,
 - .3 the existing piping design pressure at the location of a welded-on hot-tap does not exceed 2100 kPa (300 psig),
 - .4 the existing piping design pressure at the location of a mechanical-bolted tapping-saddle does not exceed 1050 kPa (150 psig); and
 - .5 permitted by the AHJ responsible for boiler and pressure vessel safety.
- .3 The application of this specification is limited to the following piping systems:
 - .1 potable water systems,
 - .2 liquids no more hazardous than water, including building heating and cooling piping systems which contain industry-standard corrosion inhibitors and other related chemical treatment additives, including anti-freeze additives.

1.3 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 22 05 01 Plumbing Piping Systems – General Requirements
 - .3 22 05 23.13 General-Duty Valves for Plumbing Piping
 - .4 22 11 16.13 Domestic Water Piping – Copper
 - .5 22 11 16.16 Domestic Water Piping – Stainless Steel
 - .6 23 05 01 HVAC Piping Systems - General Requirements
 - .7 23 05 23.13 General-Duty Valves for HVAC Water Piping
 - .8 23 05 23.19 Stainless Steel Valves for HVAC Water Piping
 - .9 23 21 13.23 Hydronic Piping – Carbon Steel
 - .10 23 21 13.26 Hydronic Piping – Stainless Steel

1.4 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Line-Stopping** – the method for temporarily blocking flow in an existing pipe by use of line-plugging or line-freezing.
 - .2 **Line-Freezing** – line-stopping by freezing the mains pipe fluid by application of cryogenic fluids to the exterior of the pipe.
 - .3 **Line-plugging** – line-stopping by insertion of a plug through a branch connection, and which may require the use of hot-tapping to make suitable branch connections; not permissible in this project.

1.5 Applicable Codes and Standards

- .1 Legislation;
 - .1 TSSA SB-05-02(R2) Safety Information Bulletin: Hot Tap and Line Stopping for Pressure Equipment.
- .2 Installation codes and standards (as adopted and amended by the AHJ for pressure vessels):
 - .1 CSA B51 Boiler, pressure vessels, and pressure piping code
 - .2 ASME B31.1 Power Piping
 - .3 ASME B31.3 Process Piping
 - .4 ASME Section IX Boiler and Pressure Vessel Code: Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators – Welding, Brazing and Fusing Qualifications.
 - .5 ASME PCC-2 Repair of Pressure Equipment and Piping

1.6 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency (license) issued by the AHJ responsible for pressure piping system safety. The license shall include an endorsement for performance of hot-tapping operations, when required by the AHJ.

1.7 Registration and Inspection

- .1 Before commencing work, make arrangements and pay for registration and inspection by the AHJ responsible for boiler and pressure vessel safety as applicable to the piping system being modified. Include specific information required for hot-tapping and/or line stopping.
- .2 At the start of the Work, obtain existing pressure piping system registration numbers, if available, from the Owner and/or the AHJ.

1.8 Design Criteria

- .1 Piping design and installation code:
 - .1 Refer to the applicable specification section for the piping system.
- .2 System design criteria.
 - .1 Refer to the applicable specification section for the piping system.

2 PRODUCTS

2.1 Valves

- .1 As specified in the applicable piping specification valve sections,
 - .1 branch size NPS 2 and under: full ported ball valve,
 - .2 branch size NPS 2-1/2 and larger: gate valves.

3 EXECUTION

3.1 Site Safety

- .1 At all times manage the site safety protocols described in the line-stopping procedure(s). Exclude all personnel not necessary for the actual line-stopping operation from the work area.

3.2 Line-Freezing

- .1 Temporarily freeze the piping by use of freezing assembly jackets with cryogenic fluids (preferably liquid nitrogen). Freeze a sufficient length of pipe to achieve an ice plug which would have a nominal compression strength of at least 17 MPa (2500 psig). Allow greater ice plug length where welding on the pipe mains is required.
- .2 Once the line-stopping is achieved, in addition to the work required on the mains pipe that necessitated the line-stopping, add a drain connection consisting of:
 - .1 a branch pipe of not less than NPS 1 in size, of the same material as the mains pipe,
 - .2 a ball valve as specified for the applicable piping section, and
 - .3 a 100 mm long nipple with a hose-end fitting with cap.
- .3 After completion of the work on the main pipeline, partially open the new drain valve and leave open during melting of the plug. Provide temporary hoses to discharge fluid to a safe location until such time as both plugs are partially melted and operating fluid discharges from the drain.

3.3 Test and installation records

- .1 Submit a test record recording all pressure test results, including test method and test pressures, and in the case of a mechanical fitting include all bolt torque values and manufacturer torque requirements. Include time and date of each measurement and the name of the person conducting the test.
- .2 Submit a copy of the above test to the Owner and the Consultant.
- .3 Submit a copy of any AHJ inspection reports to the Owner and the Consultant.

End of Section

COMMON HANGER AND SUPPORT REQUIREMENTS FOR PIPING 20 05 29

1 GENERAL

1.1 Scope

- .1 Provide hangers and supports for piping, including insulation protection devices.
- .2 The requirements of this specification section apply to all piping systems, except where required otherwise by specific piping specification sections including:
 - .1 21 05 01 Common Work Results for Fire Suppression
 - .2 22 60 13.70 Medical Gas Piping
 - .3 Applicable sections of Division 22 sections for plumbing and drainage piping,
- .3 Provide engineering services associated with the design, analysis, and selection of custom piping supports, including pipe riser supports.

1.2 Related Work

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 48 Vibration Isolation
 - .2 20 05 49 Seismic Restraints for Mechanical Services
 - .3 20 07 19 Piping Insulation

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section:
 - .1 **Ambient piping:** piping with a fluid temperature greater than 16°C (61°F) and up to and including 40°C (104°F).
 - .2 **Cold piping:** piping with a fluid temperature greater than 4°C (39°C) and up to and including 16°C (61°F).
 - .3 **Dual temperature piping:** piping which operates non-simultaneously as both cold piping and hot piping depending on the season.
 - .4 **Hot piping:** piping with a fluid temperature greater than 60°C (140°F).
 - .5 **Low temperature piping:** piping with a fluid temperature greater than 40°C (104°F) and up to and including 60°C (140°F)

1.4 Applicable Codes and Standards

- .1 Product and installation codes and standards:
 - .1 ANSI/MSS SP-58 Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation
 - .2 CAN/UL 203 Standard for Pipe Hanger Equipment for Fire Protection Service
- .2 Refer to each applicable piping specification section for supplemental requirements for pipe supports.

1.5 Analysis, Design, and Inspection Services

- .1 Where custom fabricated pipe and equipment supports are proposed to be used, provide the services of a professional engineer, licensed in the province or territory of the Work and who specializes in the design of piping and equipment supports (the "Specialty Engineer"), for the design of piping and equipment support systems and to provide inspection services of the completed installation.
- .2 Provide services of a Specialty Engineer for the design and selection of constant-load and variable-load hanger supports. Where a manufacturer of such equipment provides this design service, this is deemed to meet this requirement.
- .3 Specialty Engineer design services to include;
 - .1 provide the design of the piping support system, including anchors, guides, expansion joints, and shall include seismic restraints where applicable,
 - .2 analysis of dead loads, thermal expansion loads, wind load, static seismic loads (where applicable) and capacity of materials utilized for connections to equipment and structure.
 - .3 provide design drawings showing locations of supports, restraints and details of construction and attachment of supports and restraints,
 - .4 seismic design to conform to Specification section 20 05 49 where applicable.
- .4 Specialty Engineer inspection services to include:
 - .1 at periods during installation and at completion of the installation of the piping supports and anchor devices, the Specialty Engineer shall inspect the installation, identify and report deficiencies (if any) which are observed, and re-inspect the installation after deficiencies have been corrected,
 - .2 Specialty Engineer to submit periodic inspection reports and a final inspection report after all work is completed and deficiencies have been corrected, confirming the installation conforms to the design requirements. Prepare and submit any required declarations or similar document to this effect where required by local legislation. Include in the final report site photographs of the complete installation prior to covering with insulation, with specific photos at pipe anchors, guides, and expansion joints.
- .5 Provide shop drawings of custom supports, which shall be sealed by the Specialty Engineer.
- .6 Provide signed declarations for commitment for general review and final review letters of conformity as required by applicable legislation at the place of the Work.

1.6 Design Criteria

- .1 The support spacing and hanger rod size specified herein is based on supporting a single pipe directly from the structure in accordance with MSS SP-58. If multiple pipes are supported from trapeze hangers (or similar), or from common hanger rods supporting a tier of multiple piping, then;
 - .1 the total load on the support rods or similar elements shall not exceed published tension load rating data in accordance with Table 2 of MSS SP-58.
 - .2 design of custom trapeze hangers shall meet the design criteria as specified in Part 2 of this section.
- .2 Provide complete custom engineered design services in accordance with the requirements of MSS SP-58 for support of vertical piping for the following portions of the Work:
 - .1 vertical piping located in vertical services spaces (shafts) where any of the following criteria apply;
 - (a) piping is NPS 8 and larger,
 - (b) the vertical pipe length exceeds 25 m (82 ft),
 - (c) pipe expansion joints are shown, or

- (d) vibration isolated supports, variable spring supports or constant load supports are shown.
- .2 where horizontal piping is supported on;
 - (a) trapeze hangers or supported on/suspended from horizontal structural elements, or
 - (b) pipe racks.
- .3 Where the mechanical system are required to have seismic restraints, this section is to be read in conjunction with the requirements of Specification section 20 05 49.

1.7 Submittals

- .1 Submit manufacturer product data sheets for hanger components, and include:
 - .1 load ratings,
 - .2 typical composite detail drawings for complete hanger assembly, including upper attachment, hanger rods, hanger rod swivels, pipe attachments, shields and saddles, and load ratings, for each pipe condition and size.
- .2 Submit support details for glass, fibre-reinforced plastic, and other plastic piping systems which are coordinated with the piping material manufacturer installation instructions.
- .3 Where variable spring supports or constant load supports are shown, provide completely engineered design and fabrication drawings, including any supplementary steel requirements, and loads transferred to the building structure.
- .4 Submit engineered design drawings for fabricated trapeze hangers and completely engineered support systems, including
 - .1 construction detail drawings for each loading condition,
 - .2 span deflection calculations,
 - .3 building attachment load calculations and type.
 - .4 shop drawings to be sealed by a professional engineer licensed in the project location jurisdiction.
- .5 Where custom designed supports are proposed, shop drawings are to be sealed by a professional engineer licensed in the place of the Work.

1.8 Quality Control

- .1 Where custom engineered supports are used, provide the services of a specialist professional engineer licensed in the location of the Work, to design the support systems and to conduct an inspection of the completed installation that it is in general conformance with the sealed shop drawing requirements, and submit an inspection report to the Owner and the Consultant.

2 PRODUCTS

2.1 General

- .1 Fabricate pipe hangers, supports, sway braces and associated components from stock or production parts, manufactured and fabricated in conformance with MSS SP-58, and the requirements of the piping code specified for each piping system.
- .2 Pipe hangers and supports for fire protection systems to be listed to CAN/UL 203, except where such listing requirement is excluded under applicable NFPA standards.
- .3 Select elements of pipe support systems to provide adequate factors of safety under loads applied by gravity, by temperature induced expansion and contraction, by internal pressure in mechanically jointed plain end pipe, and by fluid flow pressure thrust.

- .4 Where specified products define the applicable pipe size NPS range (notwithstanding that the product may be available for larger pipe sizes), the maximum specified pipe size is limited to not exceed the load rating of the specified product under maximum allowable pipe spans as defined in MSS SP-58 for insulated pipe filled with water.
- .5 Product finishes (unless otherwise specified for each product):
 - .1 outdoors: hot dipped galvanized,
 - .2 in mechanical service rooms, pipe tunnels and pipe trenches: hot-dipped galvanized,
 - .3 other indoor locations: plain finish, zinc plated, or painted finish.
 - (a) exception: do not use any zinc coated or electro-plated products in data center rooms.
- .6 Select pipe support products from manufacturers standard product line.

Standard of Acceptance

- Anvil
- Unistrut
- Taylor
- Acrow Richmond
- Portable Pipe Hangers
- Hilti
- nVent Caddy
- Pipe Shields
- Buckaroos

2.2 Upper Attachments – Inserts for New Concrete

- .1 General:
 - .1 upper hanger attachment for casting into new cast-in-place concrete decks, for piping or equipment supports,
 - .2 for attachment to formwork prior to concrete pour,
 - .3 designed to receive USS coarse thread hanger rods.
 - .4 in the following tables, pipe size limit is based on insulated pipe filled with water at the maximum allowable span in accordance with Schedules A1(a), A2(a), and A3 at the end of this section. Larger pipe sizes may apply where reduced spans are used in accordance with the alternate rod size and support span limits in accordance with Schedules A1(b) and A2(b) as the end of this section.
- .2 Fixed rod position:
 - .1 fixed position type,
 - .2 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8,
 - .3 materials: malleable iron, or zinc-plated carbon-steel with plastic form, with nailing feature,
 - .4 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.25 (730)	2
Ø1/2	5.0 (1130)	3

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø5/8	5.6 (1260)	4
Ø3/4	11.1 (2500)	8

Standard of Acceptance

- Anvil - fig. 152
- Hilti - fig. KCM

.3 Fixed rod position – high capacity:

- .1 fixed position type,
- .2 stainless steel insert body, with two (2) fibreglass and concrete barrier disc for attachment to concrete rebar,
- .3 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/4	14.4 (2500)	8
Ø7/8	19.9 (4480)	12
Ø1	26.2 (5900)	18
Ø1-1/4	42.2 (9500)	20
Ø1-1/2	61.4 (13,800)	30

Standard of Acceptance

- Anvil - fig. 286

.4 Single-direction adjustable rod position:

- .1 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8.
- .2 galvanized wedge inserts to MSS SP-58 type 18, with single-direction adjustment of rod position,
- .3 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.25 (730)	2
Ø1/2	5.0 (1130)	3
Ø5/8	5.6 (1200)	4
Ø3/4	11.1 (1200)	8

Standard of Acceptance

- Anvil - fig. 281
- Unistrut - fig. P-3245

- .5 Concrete inserts – channel type;
 - .1 single hanger or multiple hangers support,
 - .2 2.75 mm (12 Ga) thick channels, hot-dipped galvanized, with concrete embedment tabs, open bottom channel allowing multiple support points and lateral position adjustment,
 - .3 with back plates, end caps and closure strips to prevent concrete spillage into channel space,
 - .4 minimum point load spacing: 300 mm (12 in.)
 - .5 maximum tension load rating for single hanger support:

Channel Length mm (in.)	Tension Load kN (lbf)	Tension Load kN/m (lbf/ft)	Single Pipe Size Limit NPS
200 (8)	4.4 (1000)	---	6
300 (12)	6.6 (1500)	---	8
450 (18)	17.8 (4000)	23.8 (2000)	12

Standard of Acceptance

- Unistrut - fig. P-3249 to P-3270 series.

2.3 Upper Attachments – Anchors for Existing Concrete

- .1 General:
 - .1 upper hanger attachment for anchoring into existing concrete decks, for piping or equipment supports,
 - .2 designed to receive USS coarse thread hanger rods.
- .2 Drop-in anchors:
 - .1 zinc-plated carbon steel drop-in friction anchor design, with matched drill bit and setting tool,
 - .2 not to be used for seismic restraints or hanger rods at pipe hangers having seismic restraint,
 - .3 rated for uncracked concrete,
 - .4 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8,
 - .5 capacity rating with 4:1 safety factor to ultimate load,
 - .6 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	2.82 (635)	2
Ø1/2	4.2 (945)	3
Ø5/8	8.34 (1875)	4
Ø3/4	11.1 (2500)	8

Standard of Acceptance

- Hilti - fig. HDI, HDI+, HDI-L+

.3 Wedge anchors:

- .1 anchor-end wedging action on concrete, and not relying on friction between side of bolt and concrete hole wall,
- .2 zinc-plated carbon steel wedge anchor design with load washer and nut,
- .3 wedge anchor capacity as specified herein to be rated for cracked concrete having not less than 20 MPa (2900 psi) strength.
- .4 rated for cracked and uncracked concrete,
- .5 listed for seismic tension and shear loads in accordance with ACI 355.2 and ICC-ES AC193.
- .6 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8,
- .7 extra-long bolt length to allow attachment of hanger rod coupling with full thread engagement in the coupling, while providing required load engagement length,
- .8 standard rating: minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	4.85 (1090)	2
Ø1/2	7.52 (1690)	3
Ø5/8	12.1 (2715)	4
Ø3/4	15.5 (3495)	8

Standard of Acceptance

- Hilti - fig. Kwick Bolt series

- .9 high-capacity rating: minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)
Ø3/8	14.0 (3150)
Ø1/2	20.8 (4675)
Ø5/8	29.1 (6535)
Ø3/4	40.6 (9135)
Ø7/8	53.4 (12,000)

Standard of Acceptance

- Hilti - fig. HSL-3 series

2.4 Upper Attachment – Mounting Plates

- .1 Surface mounting plates to underside of concrete decks:
 - .1 for installation post concrete pour with either concrete inserts or drilled anchors,
 - .2 surface mount carbon steel plate, with either clevis hanger with pin (for use with hanging rod-eye) or for attachment of hanger rod and load nut,

- .3 mounting holes in four corners of plate, sized for fastening bolts to achieve rated capacity,
- .4 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.25 (730)	2
Ø1/2	6.0 (1350)	3
Ø5/8	9.6 (2160)	4
Ø3/4	14.4 (3230)	8
Ø7/8	19.9 (4480)	12
Ø1	26.2 (5900)	18
Ø1-1/4	42.3 (9500)	20
Ø1-1/2	61.4 (13,800)	30

Standard of Acceptance

- Anvil - fig. 49 clevis plate,
- Anvil - fig. 52 load nut,
- Taylor - fig. 166 clevis plate,
- Taylor - fig. 167 load nut

2.5 Upper Attachments – Steel Structure

- .1 Steel beam clamp (bottom flange), pipe size NPS 8 and smaller:
 - .1 hanger clamp attachment to beam or joist bottom flange, applying concentric loading to the beam/joist web,
 - .2 for hanger rod sizes Ø3/8 to Ø7/8 in.,
 - .3 malleable iron or carbon steel, symmetrically loading beam clamp to MSS SP-58, type 30,
 - .4 listed to CAN/UL 203 for fire protection piping,
 - .5 minimum load rating in tension: 6.1 kN (1365 lbf)
 - .6 with extension piece swivel attachment to receive hanger rod.

Standard of Acceptance

- Anvil - fig. 218 with fig. 157 extension swivel.
- Taylor - fig. 410 with fig. 411 extension swivel.

- .2 Steel beam clamp (bottom flange), pipe size NPS 2½ to 24:
 - .1 hanger clamp attachment to beam or joist bottom flange, applying concentric loading to the beam/joist web,
 - .2 for hanger rod sizes Ø5/8 to Ø1-1/2 in.,
 - .3 forged steel, symmetrically loading heavy duty beam clamp, to MSS SP-58, type 28 or 29.
 - .4 load rating based on standard hanger rod load capacities in accordance with MSS SP-58,
 - .5 with weldless eye nut.

- Anvil - fig. 228
- Taylor - fig. 450

.3 Steel beam (top flange) - for conduit, piping NPS 6 and smaller, and ductwork:

- .1 hanger clamp attachment to the top flange of beam or joist, applying an eccentric loading to the beam/joist,
- .2 carbon steel, hook rod with locking jaw, fasteners and lock washers, to MSS SP-58, type 25,
- .3 for hanger rod sizes Ø3/8 to Ø3/4 in.,
- .4 minimum load rating in tension:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.2 (730)	2
Ø1/2 to Ø3/4	4.2 (940)	6

- .5 listed to CAN/UL 203 for fire protection piping (rod size Ø3/8 and Ø1/2 in.)

Standard of Acceptance

- Anvil - fig. 227

.4 Steel joists (joist bottom chord) – for piping NPS 2 and smaller:

- .1 steel washer plates for installation of support rod within the interstice space of double-channel steel joists and open-web steel joints, installed on top and bottom surface of the joist and secured with load nut (top washer plate) and locking nut (bottom washer plate).
- .2 load rating based on standard hanger rod load capacities in accordance with MSS SP-58,
- .3 carbon steel washer plates with locking nuts,

Standard of Acceptance

- Anvil - fig. 60
- Taylor - fig. 80

2.6 Upper Attachments – Wall Brackets

.1 Medium and heavy-duty wall mounting brackets:

- .1 welded carbon steel plate or channel assembly, designed to allow at least 75 mm (3 in.) of horizontal adjustment of hanger rod position, to MSS SP-58, Types 32 and 33,
- .2 carbon steel backplates for through bolting of concrete walls where required by supported load and wall material,
- .3 for bolting into concrete wall, concrete block, or welding to building structure (where permitted by structural engineer),
- .4 minimum load rating:
 - (a) medium duty: 6.7 kN (1500 lbs).
 - (b) heavy duty: 13.4 kN (3000 lbs).

Standard of Acceptance

- Anvil - fig. 195 and 199

- Taylor - fig. 801 and 802.

.2 Light-duty wall mounting brackets:

- .1 welded carbon steel plate or channel assembly, single point rod support, to MSS SP-58, Types 31,
- .2 with carbon steel backplates for through bolting of concrete walls where required by supported load,
- .3 FM approved,
- .4 for bolting into concrete wall, concrete block, or welding to building structure,
- .5 minimum load rating: 3.35 kN (750 lbs).

Standard of Acceptance

- Anvil - fig. 194

2.7 Upper Attachment - Swivels

.1 Clevis swivel:

- .1 to allow rotation movement of suspended clevis hangers,
- .2 forged steel clevis with hanger pin, threaded rod socket, to MSS SP-58 type 14,
- .3 tension load capacity not less than the connected rod load capacity,
- .4 threaded end connected to concrete insert, with clevis end connected to weldless eye nut or welded eye rod.

Standard of Acceptance

- Anvil - fig. 299
- Taylor - fig. 63

.2 Weldless eye nut swivel:

- .1 to allow rotation movement of suspended clevis hangers,
- .2 forged steel eye nut, threaded rod socket, to MSS SP-58 type 17,
- .3 tension load capacity not less than the connected rod load capacity.
- .4 for connection to top of rod hanger, suspended from a clevis.

Standard of Acceptance

- Anvil - fig. 290
- Taylor – fig. 64

2.8 Hanger Rod

.1 Continuous threaded rod:

- .1 carbon steel, USS course thread,
- .2 tension load ratings to meet or exceed MSS SP-58.

Standard of Acceptance

- Anvil - fig. 146

- Taylor – fig. 54

.2 Welded eye rod:

- .1 carbon steel, USS course thread,
- .2 tension load ratings to MSS SP-58,
- .3 tension load ratings to meet or exceed MSS SP-58 for hanger rod.

Standard of Acceptance

- Anvil - fig. 278
- Taylor - fig. 53

.3 Rod connectors:

- .1 carbon steel, USS course thread,
- .2 with mid-point site hole,
- .3 tension load ratings to meet or exceed MSS SP-58.

Standard of Acceptance

- Anvil - fig. 135i
- Taylor - fig. 62S

2.9 Horizontal Pipe Support - Clevis

.1 Clevis support:

- .1 applicable piping materials:
 - (a) carbon steel and stainless steel pipe, schedule 10 to 80,
 - (b) cast iron DWV piping,
- .2 carbon steel, adjustable clevis, with clevis bolt reinforcing tube, to MSS SP-58 Type 1,
- .3 adjustable hanger height while under load,
- .4 listed to CAN/UL 203 for fire protection piping,
- .5 applicable pipe size:
 - (a) steel pipe: NPS ½ to NPS 16
 - (b) ductile or cast iron drainage pipe: NPS 3 to 24

Standard of Acceptance

- Anvil - fig. 260
- Anvil - fig. 590 (for ductile or cast iron drainage pipe)
- Taylor – fig. 24
- Taylor – fig. 27AC (for ductile or cast iron pipe)

.2 Clevis support with extended yoke for where yoke is located inside of pipe insulation:

- .1 applicable piping materials:
 - (a) carbon steel and stainless steel pipe, schedule 10 to 80,
 - (b) cast iron DWV piping,
- .2 carbon steel, adjustable clevis, with clevis bolt reinforcing tube, to MSS SP-58 Type 1,

- .3 adjustable hanger height while under load,
- .4 yoke sized for outside dimension of pipe only, with extended yoke to clear pipe insulation,
- .5 applicable pipe size:
 - (a) steel pipe: NPS ¾ to NPS 12

Standard of Acceptance

- Anvil - fig. 300
- Taylor – fig. 24L

.3 Clevis support with integral non-metallic insulation saddle:

- .1 alternate to using standard clevis hanger specified above with separate high density insulation inserts or pipe insulation saddles,
- .2 applicable piping materials:
 - (a) insulated carbon steel and stainless steel pipe, schedule 10 to 80,
 - (b) insulated cast iron drainage piping.
- .3 carbon steel, adjustable clevis, with clevis bolt reinforcing tube, to MSS SP-58 Type 1,
- .4 adjustable hanger height while under load,
- .5 listed to CAN/UL 203 for fire protection piping,
- .6 with glass-reinforced polypropylene saddle, sized to allow up to 50 mm (2 in.) insulation thickness,
- .7 yoke and clevis sized for outside dimension of pipe and insulation,
- .8 applicable pipe size:
 - (a) steel pipe: NPS ½ to NPS 8,
 - (b) copper tube: NPS ½ to NPS 8.
- .9 piping system design temperature limits: 4.4 to 100°C (40 to 212°F).

Standard of Acceptance

- Anvil - fig. 260 ISS

.4 Clevis support for copper pipe and tube:

- .1 for copper tube, NPS ½ to 4,
- .2 zinc-plated carbon steel yoke and clevis, adjustable clevis to MSS SP-58, type 1, copper plated or felt lined finish,
- .3 applicable tube size: NPS ½ to NPS 4,
- .4 sized for outside dimension of pipe/tube, or outside diameter of pipe and insulation as applicable.

Standard of Acceptance

- Anvil - fig. CT-65 or 260F
- Taylor – fig. 52

2.10 Horizontal Pipe Support – Clevis for Fire Protection

- .1 Pipe size range: NPS 2 to NPS 8.
- .2 Light-duty, side-opening clevis support:

- .1 for fire protection service only,
- .2 pipe size range: NPS 2 to 8,
- .3 galvanized carbon steel, adjustable clevis with fixed yoke,
- .4 listed to ULC/ORD-C203 or UL 203 for fire protection piping,
- .5 sized for outside dimension of pipe (and insulation if applicable).
- .6 sized for outside dimension of pipe (and insulation where applicable),
- .7 nominal pipe size: NPS 2 to NPS 8.

Standard of Acceptance

- Hilti - fig. MH-SLC Speed Lock

2.11 Horizontal Pipe Support – Swivel Ring Hanger

- .1 For non-insulated drain-waste-vent piping, gas piping, and chemical piping.
- .2 Pipe swivel ring hangers:
 - .1 carbon steel ring strap, zinc plated, adjustable knurled swivel nut, to MSS SP-58 Type 10,
 - .2 copper plated or epoxy-coated for use on copper tubing,
 - .3 listed to ULC/ORD-C203 or UL 203 for fire protection piping,
 - .4 nominal pipe size: NPS ½ to NPS 4.

Standard of Acceptance

- Anvil - fig. 69, CT-69
- Taylor – fig. 41, 43

2.12 Pipe Straps

- .1 General:
 - .1 for non-insulated drain-waste-vent piping, gas piping, and chemical piping.
 - .2 pipe size: NPS 4 and smaller.
- .2 Zinc plated carbon steel U-loop straps for mechanical fastening to structure.

Standard of Acceptance

- Anvil - fig. 262

- .3 Hot-dipped galvanized carbon steel U-loop with clip-in or bolt-on attachment to modular channel supports.

Standard of Acceptance

- Unistrut

2.13 Horizontal Pipe Support – Pipe Roller (Type 41, 43, 44)

- .1 Suspended support pipe roller – trapeze hanger style:
 - .1 adjustable height, pipe roller support for overhead support, to MSS SP-58 type 41,
 - .2 dual-hanger rod trapeze style,
 - .3 pipe size range: NPS ½ to NPS 16, with or without insulation.

Standard of Acceptance

- Anvil - fig. 171
- Taylor – fig. 95

.2 Suspended support pipe roller – clevis hanger style:

- .1 adjustable height, pipe roller support for overhead support, to MSS SP-58 type 43,
- .2 single rod clevis style,
- .3 pipe size range: NPS ½ to NPS 8, with or without insulation.

Standard of Acceptance

- Anvil - fig. 181
- Taylor – fig. 93

.3 Bottom support pipe roller:

- .1 adjustable height, pipe roller with bottom support rods, to MSS SP-58 type 41,
- .2 for bottom support of piping,
- .3 with mounting rods and upper/lower retention nuts at both ends,
- .4 pipe size range: NPS ½ to NPS 16, with or without insulation.

Standard of Acceptance

- Anvil - fig. 177
- Taylor – fig. 95S

.4 Bottom support pipe roller with stand:

- .1 pipe roller with cast iron support stand, to MSS SP-58 type 44,
- .2 for bottom support of piping,
- .3 fixed height and adjustable height variants,
- .4 base drilled for fastening to supporting element,
- .5 pipe size range: NPS ½ to NPS 18, with or without insulation.

Standard of Acceptance

- Anvil - fig. 271 (fixed), fig. 274 (adjustable)
- Taylor – fig. 279S (fixed), fig. 280S (adjustable)

2.14 Horizontal Pipe Support – Slides

.1 Structural slide bases – welded attachment:

- .1 Tee or H shaped pipe support for welding to pipe, to allow axial and lateral movements,
- .2 carbon steel, structural shape or fabricated, to ANSI/MSS SP-58 Type 35,
- .3 operating temperature range: -28 to 200°C (-20 to 400°F),
- .4 pipe insulation thickness clearance: up to 75 mm (3 in.),
- .5 pipe size and load rating in accordance with the following table:

Slide Base Type	Vertical Support Load Rating kN (lbf)	Lateral Restraint Load Rating kN (lbf)	Uplift Restraint Load Rating kN (lbf)	Pipe Size Range NPS	
				Water	Steam, Gas
T	35.0 (8000)	9.0 (2000)	3.6 (800)	½ to 18	½ to 30
H	53.0 (12,000)	13.0 (3000)	5.3 (1200)	6 to 8	½ to 30
	53.0 (12,000)	18.8 (4000)	7.1 (1600)	10 to 20	
	107 (24,000)	26.0 (6000)	10.7 (2400)	24 to 30	

Standard of Acceptance

- Anvil - figs. 257A, 436A, 439A
- Taylor – figs. 257A

.2 Structural slide base assemblies with PTFE pads – welded attachment:

- .1 for piping with design temperatures greater than 121°C (250°F), including steam at pressures greater than 103 kPa (15 psig),
 - (a) may also be used for lower temperatures,
- .2 as specified above for slide bases and as follows,
- .3 PTFE bonded to underside of slide,
- .4 matching lower steel plates with bonded PTFE element (for fastening to structural support beam),

Standard of Acceptance

- Anvil - figs. 257, 436, 439
- Taylor – figs. 257

.3 Restraint variants for slides:

- .1 lug restraints to limit lateral movement due to thermal expansion of between 6 mm to 25 mm (1/4 to 1 in.),
- .2 where seismic restraint is required, lug restraints designed to limit lateral and vertical uplift movement to not more than 6 mm (1/4 in.),
 - (a) exception: if lateral movement of greater than 6 mm (1/4 in.) is shown, then the seismic design load is to be two (2) times the seismic load as shown in Specification section 20 05 49.

.4 Clamp for T and H slides supporting cold piping:

- .1 galvanized steel clamp for insulated cold piping, sized for outside dimension of insulated pipe,
- .2 rolled from structural plate steel with bolting flanges,
- .3 continuous single clamp for length of slide, or two (2) individual clamps at each end of the slide,
- .4 bottom half of clamp welded to T or H slides,
- .5 top half of clamp mechanically fastened to bottom half.

Standard of Acceptance

- Anvil - fig. 212 (2 clamp) 432 (continuous clamp)

2.15 Horizontal Pipe Support – Trapeze

.1 Manufactured trapeze support:

- .1 load ratings as per manufacturers data sheets,
- .2 carbon steel, double-C channel (strong-backs), HSS shape and equal-leg angles.

Standard of Acceptance

- Anvil - fig. 45, 46, and 50
- Taylor – fig. 170

.2 Fabricated trapeze support:

- .1 custom designed trapeze hangers of either hollow structural sections, double C channels (strongbacks), single C channel or unequal lengths angle channels, to support one or more pipes, conduits or ducts,
- .2 design of custom trapeze supports to conform to the requirements of MSS SP-58,
- .3 designed and sealed by a professional engineer licensed in the jurisdiction of the work.
- .4 design criteria:
 - (a) static design load: deadweight of supported services plus 1.5 kN (250 lbf) point load at the mid-span,
 - (b) dynamic loads: include for seismic loads where system is subject to seismic restraint, and for wind and snow loads where located outdoors, superimposed on static design load,
 - (c) maximum trapeze deflection at any point: 1/250 (0.4%) of trapeze span,
 - (d) design load for carbon steel materials: not to exceed 28% of minimum tensile strength nor exceed 50% of minimum yield strength in tension/compression and bending,
 - (e) design load for stainless steel and low alloy steel materials: not to exceed 20% of minimum tensile strength and 45% of minimum yield strength in tension/compression and bending.
- .5 for concurrent tension/compression loads and bending loads, the sum of the ratio of the stresses to allowable stress shall not exceed 1.0.

$$\frac{\text{Stress in Tension or Compression}}{\text{Allowable Tension or Compression Stress}} + \frac{\text{Stress in Bending}}{\text{Allowable Bending Stress}} \leq 1.0$$

.3 Hanger rods:

- .1 minimum of two support rods per trapeze,
- .2 rod size selected not to exceed 80% of the allowable maximum rod tensile load rating in accordance with MSS SP-58,

.4 Pipe restraint:

- .1 restrain pipes from lateral movement with:
 - (a) bolt-on angle brackets or pipe U-bolts for manufactured hangers, or
 - (b) welded-on angles for fabricated hangers,
- .2 restraints to permit axial linear movement and axial-rotation, except where otherwise shown to be an anchor.

2.16 Horizontal Pipe Support – Drainage MJ

- .1 For support of horizontal cast iron drainage piping, as an alternative to clevis hangers.
- .2 Designed to support each end of the pipe on both sides of a drainage MJ joint, and at intermediate supports, elbows and tees.
- .3 Carbon steel, plain finish.
- .4 Pipe size: NPS 2 to NPS 6

Standard of Acceptance

- Anvil - fig. 250
- Taylor – fig. 25

2.17 Vertical Pipe Stanchions

- .1 Pipe support stanchion, with welded attachment:
 - .1 fixed height, or telescoping two-piece design with height adjustment, field-welded to pipe elbow or horizontal pipe,
 - .2 carbon steel, structural cylinder shape,
 - .3 designed for static loads of pipe and contents, as well as dynamic loads and anchor loads as shown,
 - .4 nominal pipe size: NPS 2 to NPS 18.

Standard of Acceptance

- Anvil - fig. 62

2.18 Vertical Pipe Riser Clamps

- .1 Steel pipe, cast iron pipe:
 - .1 carbon steel clamps for carbon steel piping and cast iron piping,
 - .2 stainless steel clamps for stainless steel piping,
 - .3 listed to ULC/ORD-C203 or UL 203 for fire protection piping,
 - .4 supplied with field-welded pipe support lugs of same material as supported steel pipe (not including cast iron pipe).
 - .5 floor supported pipe riser clamps, to ANSI/MSS SP-58, type 8,

Standard of Acceptance

- Anvil - fig. 261
- Taylor – fig. 82

- .6 suspended pipe riser clamps, 4 or 6 bolt patterns, to ANSI/MSS SP-58, type 42,

Standard of Acceptance

- Anvil - fig. 40, 40SS
- Taylor – fig. 82HCopper pipe and tube:

- .7 floor supported pipe riser clamps, carbon steel with copper plated finish, to ANSI/MSS SP-58, type 8,

Standard of Acceptance

- Anvil - fig. CT-121
- Taylor – fig. 85

2.19 Vibration Isolation Supports

- .1 Refer to specification section 20 05 48.

2.20 Cast Iron Pipe Joint Restraint

- .1 Joint restraint rodding assembly for cast iron and asbestos cement drain waste and vent pipe, for each branch, tee, wye and clean-out fittings on drainage piping NPS 5 and over.
- .2 Clamp and rod joint restraint:
 - .1 carbon steel pipe clamps with four bolt fasteners and rod washers, plain finish, to MSS SP-58, Type 8,
 - .2 carbon steel threaded rods and load nuts,
 - .3 two pipe clamps and two restraint rods required for each joint.

Standard of Acceptance

- Taylor – fig. 35

2.21 Insulation Shields

- .1 Insulation shields:
 - .1 galvanized steel protection shield, thickness and length as applicable to pipe size, to MSS SP-58 type 40
 - .2 designed to meet MSS SP-58 maximum support spans with insulation inserts having a compressive strength of 620 kPa (90 psi).
 - .3 pipe size: NPS ½ to 24,
 - .4 insulation thickness: 12 mm to 50 mm (1/2 in. to 2 in.).
 - .5 gauge: minimum 18 ga.
 - .6 sleeve width: minimum 180 degree arc of insulation exterior surface
 - .7 minimum sleeve length:
 - (a) pipe NPS ½ to 4: 300 mm (12 in.)
 - (b) pipe NPS 6: 450 mm (18 in.)
 - (c) pipe NPS 8 to 24: 600 mm (24 in.)

Standard of Acceptance

- Anvil - fig. 167 (up to NPS 24)
- Anvil - fig. 168 (up to NPS 8)
- Taylor – fig. 69H

- .8 sleeve length exemption: sleeve lengths may be reduced where shield is supplied as an integrated part of a high density insulation insert system. – refer to Specification section 20 07 19.
- .2 Heavy-duty insulation shield:
 - .1 for piping NPS 18 and larger installed on roller hangers and trapeze hangers,

- .2 insulation shield as specified above plus a heavy duty support plate as follows,
- .3 support plate fabrication: 6 mm (1/4 in.) thick ASTM A36 galvanized steel rolled plate, inside diameter to fit outer radius of insulation shield,
- .4 size:
 - (a) width: minimum 120 degrees arc of mating insulation shield,
 - (b) length: not more than 100 mm (4 in.) shorter than the primary shield.
- .5 Support plate tack welded to the insulation shield.

2.22 Insulation Pipe Saddles

- .1 Carbon steel or stainless steel (to match pipe material) saddle welded to pipe with insulation inserted between saddle and pipe, to MSS SP-58 type 39.
- .2 For pipe sizes NPS ¾ to 36.
- .3 Insulation thickness range: 25 to 140 mm (1 to 5.5 in.)

Standard of Acceptance

- Anvil - fig. 160 to 166
- Taylor – fig. 70 to 77

3 EXECUTION

3.1 General

- .1 Where the specific requirements for pipe supports are specified in other sections of Division 20 to 23, the requirements of those sections take precedence over the requirements of this specification section.

3.2 Coordination with Concrete Work

- .1 Supply, deliver and install concrete inserts in ample time to be built into the work of Division 03.
- .2 Correctly position and set concrete inserts onto concrete formwork for pipes and equipment hangers. Secure inserts firmly to formwork before concrete is poured.
- .3 Do not use explosive drive pins in any section of the Work without obtaining prior approval from the Consultant.

3.3 Support and Hanger Installation – General Requirements

- .1 Support piping directly on or from structural building elements. Do not support pipe directly from other services. Multiple piping services may be supported on a common trapeze support.
- .2 Provide all miscellaneous materials including nuts, washers, and backing plates to make a complete installation.
- .3 Where wall brackets are used, select brackets and size mounting bolts and backing plates to suit the supported load, allowing for a safety factor by not loading the bracket more than 80% of its published load rating.
- .4 Do not support piping or tubing in direct contact with hangers or supports of dissimilar metallic material. Select hangers to include an electrical insulating material between the hanger and the pipe, or provide electrical insulating material.
- .5 Coordinate location of pipe supports with pipe flexible connectors, pipe guides and pipe anchors provided under specification section 20 05 16.

- .6 In steel framed construction, support piping from structural members. Where structural members are not suitably located for upper hanger attachment locations, and where inserts of adequate capacity cannot be installed in concrete slabs, provide supplementary steel framing members;
 - .1 fabricate supplementary steel from standard HSS sections, single EL section, double C “strongback” sections, or pipe lengths,
 - .2 size supporting steel to limit horizontal span deflection to 1/250 (0.4%) between connecting points to the structure,
 - .3 mechanically fasten supplementary steel to structural steel to prevent axial and transverse displacement, and rotation.
- .7 It is permissible to offset hangers and displace the hanging rod so that in the final operating position, the hanging rods are within 4° of vertical.
- .8 Provide a pipe support within 300 mm (12 in.) of;
 - .1 an elbow or tee,
 - .2 a concentrated load, including but not limited to valves, strainers and flanges,
 - .3 a connection to equipment.
- .9 Where hanger rods are used, provide load nuts on top and load nuts on the underside of attachment to the pipe support, including clevis hangers, roll supports, roll yoke hangers, and trapeze hangers.

3.4 Horizontal Pipe Support Spacing and Hanger Rod Size

- .1 Provide horizontal pipe supports at the spacing as detailed in the Schedule “A” included at the end of this Specification section, unless specified otherwise in other sections of Division 20 to 23.
 - .1 Schedule “A” includes alternate hanger rod size and support spans for reduced rod sizes.
- .2 Use threaded rod of the size based on pipe type and horizontal pipe hanger spacing as stated in the Schedule “A” for single rod hangers. Where the pipe hanger type requires two rods, the rod size may be reduced by one trade size but shall not be less than Ø3/8 in.
- .3 For piping using flexible roll-groove joints, there shall be not less than one hanger between pairs of joints.
- .4 Support plastic and other special piping, including anchors and guides, in accordance with the pipe manufacturer's requirements.

3.5 Horizontal Pipe Hanger and Support Selection

- .1 Select horizontal pipe hanger and support type based on pipe size and fluid service temperature in accordance with Schedules “B(1)” and “B(2)” at the end of this section.
- .2 For fire protection piping;
 - .1 use clevis hangers for all pipe sizes,
 - .2 swivel ring pipe hangers may be used for fire protection piping NPS 4 and smaller.
- .3 Swivel ring pipe hangers may only be used for;
 - .1 drain waste and vent (DWV) piping and tubing, NPS 4 and smaller,
 - .2 medical gas piping and laboratory gas piping, NPS 4 and smaller,
- .4 For cast iron drainage and vent piping;
 - .1 use clevis hangers for suspended supports,

- .2 drainage MJ type hangers may be used on hub-less cast iron piping,
- .3 use roller or slide type supports for bottom supported piping. For slide supports, use a variant incorporating pipe band clamps in lieu of welded attachment.
- .5 For other piping, select pipe support types in accordance with Schedule B at the end of this section.
- .6 The use of a half-section of a suspended pipe clamp to support a horizontal pipe using two threaded rods is prohibited unless the manufacturer has written installation instructions permitting such use. The use of a pipe riser clamp for this purpose is prohibited.

3.6 Clevis Hangers

- .1 Where clevis hangers are used for cold piping, select clevis to fit the outside dimension of pipe and associated insulation.
- .2 Where clevis hangers are used for heating piping;
 - .1 select clevis to fit the pipe diameter only (clevis located inside of insulation) for small diameter piping in accordance with Schedule "C" at the end of this section,
 - .2 for larger diameter piping, select clevis to fit the outside dimensions of pipe and insulation – refer to Schedule "C" at the end of this section,
 - .3 where the distance from the building support element to the clevis pin is less than the value shown in the standard details at the end of this section, use an alternative method of support;
 - (a) exception: where the pipe is installed tight to the structure, the exposed length between the structural attachment and the top of the clevis shall not exceed 25 mm (1 in.).
- .3 Where clevis hangers are used for stainless steel pipe or tube and for copper tube;
 - .1 use copper or epoxy finished carbon steel clevis hangers for copper pipe/tube,
 - .2 use stainless steel or alloyed steel clevis hangers (for stainless steel pipe/tube), or
 - .3 use a standard clevis hanger with integral non-metallic insulation saddles, and select hanger size for outside of the pipe and insulation.
- .4 Adjust clevis hangers to provide the required drainage slope and direction for each pipe.
- .5 Where the project requires seismic bracing of piping systems, add a Schedule 40 pipe over the clevis bolt, sized to provide at least 6 mm (1/4 in.) inside diameter clearance to the clevis bolt. This applies only where a transverse or longitudinal brace is attached to the clevis hanger.

3.7 Roll Hangers and Supports

- .1 For roll hangers, provide load and lock nuts to allow final adjustment of roll hanger to allow pipe drainage.
- .2 For roll supports supported above the structure element, the length of exposed threaded pipe between the roll support and the structural element shall not exceed 10 times the outside diameter of the rod.

3.8 Trapeze Hangers

- .1 Provide U-bolts or fabricated angles to restrict lateral pipe movement, while allowing pipe thermal axial motion and rotation;
 - .1 fasten U-bolts or angles to the trapeze hanger with top and bottom nuts,
 - .2 fabricated retention angles to extend vertically at least one-quarter the outside pipe/insulation diameter, and mechanically fasten to the trapeze,
 - .3 where seismic restraint is required, only use U-bolts.

- .2 Adjust trapeze hangers to provide the required drainage slope and direction for each pipe. If the trapeze serves multiple pipes having different drainage slopes or directions, provide shims under each pipe as necessary to provide required slope. Mechanically fasten or tack-weld the shim plates to the trapeze.

3.9 Slide Supports

- .1 For hot piping, weld the T or H slide directly to the pipe.
- .2 For cold piping, weld the T or H slide to the bottom half of a carbon steel clamp assembly.
- .3 Use slides with integral lateral movement limit lugs at pipe supports required to function as a guide. Movement clearance to be between 6 mm and 25 mm (1/4 to 1 in.).
- .4 Where seismic restraint is required, use slides with integral lateral and vertical-up movement limit lugs so that the maximum allowable movement does not exceed 6 mm (1/4 in.).
- .5 For fluid service temperatures of 121°C (250°F) and less, apply grease with a service temperature of not less than 200°C (392°F) over the entire bottom of the T or H slide.
- .6 For fluid service temperatures greater than 121°C (250°F) use a PTFE slide pad bonded to the underside of the slide and a matching PTFE slide pad bonded to the top of the structural steel support.

3.10 Vertical Pipe Supports

- .1 Pipe riser clamps:
 - .1 provide pipe riser clamps for non-insulated pipes NPS 4 and smaller at every second floor level for vertical pipe risers passing through two or more floors, unless other vertical pipe support types are shown,
 - .2 for steel pipe, provide support lugs welded to steel piping so that pipe lugs bear on the top-surface of the riser clamp,
 - .3 for copper tube and pipe, arrange vertical piping so that a pipe joint bears on the top-surface of the riser clamp.
- .2 Fabricated pipe riser supports:
 - .1 support piping NPS 6 and larger, using fabricated riser support brackets complete with reinforcing gusset plates welded or clamped to piping, designed not to exceed the maximum allowable local pipe stress at a load of not less than 200% of the supported load of:
 - (a) for the lowest support point of the riser, the supported pipe plus insulation weight for the lowest support interval plus the total water weight of the entire riser.
 - (b) except at the lowest support point of the riser, the pipe plus insulation weight for each support interval (except at the bottom of the riser).
- .3 Support vertical cold piping and hot piping for riser heights that are 25 m (82 ft) or less in height as follows:
 - .1 provide spring vibration isolators in accordance with specification section 20 05 48, attached to pipe riser supports at intervals of every 2nd storey or 10 m (32 ft), whichever is less,
 - .2 provide a pipe anchor at the base of the riser or the mid-height of the riser.
- .4 Support vertical cold piping and hot piping for riser heights that are greater than 25 m (82 ft) but do not exceed 50 m (165 ft) in height as follows:
 - .1 provide a custom engineered support system utilizing variable spring isolators,
 - .2 provide pipe anchors at the mid-point of the riser, and
 - .3 provide at least one spring support per riser section above and below the anchor point.

- .5 Support vertical cold piping and hot piping for riser heights greater than 50 m (165 ft) as follows:
 - .1 provide a custom engineered support system utilizing constant load supports for each pipe section located between expansion joints,
 - .2 variable spring supports may be used at intermediate locations between main constant load supports,
 - .3 provide pipe anchor supports at the base of the riser, and at intermediate locations along riser length at locations as shown,
 - .4 provide in-line expansion joints between each pair of pipe anchors on the same riser in accordance with Specification section 20 05 16,
 - .5 design pipe anchors to withstand pressure thrust created by the expansion joints, unless pressure-balanced expansion joints are used,
- .6 Design riser anchors to support the deadweight of the riser pipe, fluid contents and insulation. Where seismic restraint is required, the anchors may also be designed to resist the seismic horizontal and vertical loads.
- .7 Where custom engineering riser supports are required, they are to be designed to meet the following criteria:
 - .1 the maximum vertical movement of a horizontal branch pipe is not to exceed 20 mm (0.75 in) from its installation temperature to its in-service temperature,
 - .2 the maximum vertical movement of the horizontal mains pipe at the base or top of the riser is not to exceed 40 mm (1.5 in.) from its installation temperature to its in-service temperature, provided that the horizontal piping adjacent to the riser are also supported on variable spring supports for the first three horizontal support points.

3.11 Pipe Saddles and Shields

- .1 Provide pipe saddles and shields for insulated piping in accordance with Schedule "C" at the end of this section.
- .2 Provide pipe shields for uninsulated glass and plastic piping NPS 1-1/2 and larger.
- .3 Where piping is insulated and requires pipe shields, install the shields between pipe insulation and pipe support. Provide high-density insulation insert between pipe and insulation shields of the designation type as shown in Schedule "C" and as specified in accordance with specification section 20 07 19.
- .4 Where piping is not insulated and requires a pipe shield, install the shields between the pipe and the pipe support.
- .5 Where clevis hangers with integral insulation saddles are used, apply insulation sealant to the polypropylene saddle in accordance with the pipe hanger manufacturer's instructions;
 - .1 for hot piping, coordinate with the pipe insulation contractor to apply sealant coating to the integral saddle at the time pipe insulation is installed,
 - .2 for cold piping, seal the saddle's pipe contact surfaces with vapour-barrier sealant before the piping is installed. Finish sealing the remainder of the saddles' exposed faces when pipe insulation is installed.

3.12 Vibration Isolation Supports

- .1 Provide vibration isolators at pipe supports for horizontal piping in accordance with specification section 23 05 48.
- .2 Provide vibration isolators at vertical pipe (riser) supports in accordance with specification section 20 05 48.

- .3 When installed with clevis hangers, install the vibration isolators below the top surface of the clevis; do not attached the vibration isolator to the structural element.

3.13 Set-up After Installation

- .1 Adjust hangers to equalize hanger loads, to support piping true to line and grade, and to minimize loads transferred through connections to equipment and outlets.

3.14 Schedules

- .1 The following appended schedules form part of this Specification section.
- | | | |
|----|----------------|--|
| .1 | Schedule A1(a) | Horizontal Pipe Support Loads and Support Spans – Schedule 20 to 80 Pipe |
| .2 | Schedule A1(b) | Alternate Hanging Rod Sizes and Support Spans for Schedule 20 to 80 Pipe |
| .3 | Schedule A2(a) | Horizontal Pipe Support Loads and Spans – Schedule 10/10S Stainless Steel Pipe |
| .4 | Schedule A2(b) | Alternate Hanging Rod Sizes and Support Spans for Schedule 10/10S Stainless-steel Pipe |
| .5 | Schedule A3 | Horizontal Pipe Support Loads and Spans – Copper and Stainless Steel Tube |
| .6 | Schedule B | Pipe Support Type Selection Requirements |
| .7 | Schedule C | Insulation Protection Requirements |

3.15 Standard Details

- .1 The following standard details are appended to the end of this Specification section.
- | | | |
|----|--------------|---|
| .1 | 20 05 29-010 | Cold Piping and Dual-Temperature Piping – Clevis Hanger Detail |
| .2 | 20 05 29-011 | Cold Piping and Dual-Temperature Piping – Roll Hanger Detail |
| .3 | 20 05 29-012 | Cold Piping and Dual-Temperature Piping – Trapeze Hanger Detail |
| .4 | 20 05 29-013 | Cold Piping and Dual-Temperature Piping – Slide Support Detail |
| .5 | 20 05 29-020 | Hot Piping – Clevis Hanger Detail |
| .6 | 20 05 29-021 | Hot Piping ≤ 100°C, Small Size Piping – Clevis Hanger Details |
| .7 | 20 05 29-022 | Hot Piping – Roll and Trapeze Hanger Detail |
| .8 | 20 05 29-023 | Hot Piping – Slide Support Detail |
| .9 | 20 05 29-030 | Slide Supports – Guides and Seismic Restraint |

Schedule A1(a)

**Horizontal Pipe Support Spacing
 for
 Carbon Steel, Galvanized Steel, Stainless-steel Piping
 Schedule 20 to 80 Inclusive**

Notes for Schedule A1(a) and A1(b):

[1] Hanging rod size for single support. Where two supports are used, the rod size may be reduced by one size but not less than Ø3/8 in..

[2] Subject to load capacity of hanger components other than the hanging rod.

[3] Where piping is hydrostatically tested with water, temporary pipe supports are required to limit pipe span to the "liquids" values.

[4] For trapeze hangers only.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Support Spacing, Liquids [Note 2] m (ft)	Maximum Support Spacing Steam, Gases [Note 2, 3] m (ft)
½	Ø 3/8	1.8 (6)	1.8 (6)
¾ to 1¼	Ø 3/8	2.1 (7)	2.1 (7)
1½	Ø 3/8	2.7 (9)	2.7 (9)
2	Ø 3/8	3.0 (10)	4.0 (13)
2½	Ø ½	3.3 (11)	4.3 (14)
3	Ø ½	3.3 (12)	4.6 (15)
4	Ø 5/8	4.2 (14)	5.2 (17)
6	Ø ¾	5.1 (17)	6.4 (21)
8	Ø ¾	5.7 (19)	7.3 (24)
10	Ø 7/8	6.7 (22)	7.9 (26)
12	Ø 7/8	7.0 (23)	9.1 (30)
14	Ø 1	7.5 (25)	9.8 (32)
16	Ø 1	8.0 (27)	10.7 (35)
18	Ø 1 [Note 4]	8.4 (28)	11.3 (37)
20	Ø 1-1/4 [Note 4]	9.0 (30)	11.9 (39.0)
24	Ø 1-1/2 [Note 4]	9.6 (32)	12.8 (42.0)
30	Ø 1-1/2 [Note 4]	10.0 (33)	13.4 (44.0)

Schedule A1(b)

**Alternate Rod Sizes and Pipe Spans
For Pipe Sizes NPS 10 to 16
Carbon Steel, Galvanized Steel, Stainless-steel Piping
Schedule 20 to 80 Inclusive**

The following table provides alternate combinations of rod hanger size and associated support spacing for select pipe sizes.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Support Spacing, Liquids [Note 2] m (ft)	Maximum Support Spacing Steam, Gases [Note 2, 3] m (ft)
10	Ø 3/4	4.0 (13)	6.7 (22)
12	Ø 3/4	3.0 (10)	5.8 (19)
14	Ø 3/4	2.7 (9)	5.2 (17)
	Ø 7/8	5.8 (19)	9.1 (30)
16	Ø 3/4	2.1 (7)	4.6 (15)
	Ø 7/8	4.9 (16)	7.9 (26)

Schedule A2(a)

**Horizontal Pipe Support Spacing
 For
 Stainless-steel Pipe
 Schedule 10/10S**

Notes for Schedule A2(a) and A2(b):

[1] Rod size for single support. Where two supports are used, the rod size may be reduced by one size but not less than Ø3/8 in..

[2] Subject to load capacity of hanger components other than the hanging rod.

[3] Where piping is hydrostatically tested with water, temporary pipe supports are required to limit pipe span to the "liquids" values.

[4] For trapeze hangers only.

Pipe Size NPS	Rod Diameter Single Support [Note 1]	Maximum Spacing, Liquids [Note 2] m (ft)	Maximum Spacing Steam, Gases [Note 2, 3] m (ft)
½	Ø 3/8	1.83 (6)	2.45 (8)
¾	Ø 3/8	2.1 (7)	2.75 (9)
1	Ø 3/8	2.45 (8)	2.75 (9)
1¼	Ø 3/8	2.75 (9)	2.75(9)
1½	Ø 3/8	2.75 (9)	3.65 (12)
2	Ø 3/8	3.10 (10)	4.0 (13)
2½	Ø 1/2	3.35 (11)	4.3 (14)
3	Ø 1/2	3.65 (12)	4.6 (15)
4	Ø 5/8	4.25 (14)	5.2 (17)
6	Ø 3/4	4.9 (16)	6.4 (21)
8	Ø 3/4	5.5 (18)	7.3 (24)
10	Ø 7/8	5.8 (19)	7.9 (26)
12	Ø 7/8	6.1 (20)	9.2 (30)
14	Ø 1	7.0 (23)	9.7 (32)
16	Ø 1	7.3 (24)	10.7 (35)
18	Ø 1 [Note 4]	7.3 (24)	11.3 (37)
20	Ø 1-1/4 [Note 4]	7.6 (25)	11.9 (39)
24	Ø 1-1/2 [Note 4]	7.3 (25)	11.9 (42)
30	Ø 1-1/2 [Note 4]	8.5 (28)	12.8 (44)

Schedule A2(b)

**Alternate Rod Sizes and Pipe Spans
 For Pips Sizes NPS 10 to 16
 Stainless-steel Pipe
 Schedule 10/10S**

The following table provides alternate combinations of rod hanger size and associated support spacing for select pipe sizes.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Spacing, Liquids [Note 2] m (ft)	Maximum Spacing Steam, Gases [Note 2, 3] m (ft)
10	Ø 3/4	4.9 (16)	4.9 (16)
12	Ø 3/4	3.7 (12)	3.7 (12)
14	Ø 3/4	2.7 (9)	2.7 (9)
	Ø 7/8	5.2 (17)	6.1 (20)
16	Ø 3/4	2.4 (8)	2.4 (8)
	Ø 7/8	4.3 (14)	5.2 (17)

Schedule A3

**Horizontal Pipe Support Spacing
 For
 Copper Tube and Stainless-steel Tube**

Notes for Schedule A3:

[1] Rod size for single support. Where two supports are used, the rod size may be reduced by one size but not less than M10 (3/8 in.).

[2] Subject to load capacity of hanger components other than the hanging rod.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Spacing, Liquids and Gases [Note 2] m (ft)
1/2	Ø 3/8	1.5 m (5 ft)
3/4 to 1 1/4	Ø 3/8	1.8 m (6 ft)
1 1/2	Ø 3/8	2.4 m (8 ft)
2	Ø 3/8	2.4 m (8 ft)
2 1/2	Ø 1/2	3.0 m (10 ft)
3	Ø 1/2	3.0 m (10 ft)
4	Ø 5/8	3.0 m (10 ft)
6	Ø 3/4	4.3 (14)
8	Ø 3/4	4.9 (16)

Schedule B

Pipe Support Type Selection Requirements

The following tables B(1) and B(2) lists hanger types which are to be used based on pipe size and service temperature. Refer to Schedule C for additional requirements concerning insulation protection.

Pipe Support Type Legend		Application Legend	
CL	Clevis hanger	A	Acceptable
CL(EY)	Clevis hanger with extended yoke for installation under pipe insulation	---	Not permitted
CL(IS)	Clevis hanger with integral insulation saddle		
CL(LD)	Clevis hanger, light duty		
SW	Swivel hanger		
RS	Roll support		
RH	Roll hanger with clevis		
RB	Roll support with integral base		
TS	T slide		
HS	H slide		
TZ	Trapeze		

**Table B(1):
 Pipe Support Type Selection Requirements
 For Fluid Service Temperatures up to 100°C (212°F) or Less**

Pipe/Tube Size NPS	CL	CL (EY)	CL (IS)	CL (LD)	SW [Note 1]	RS	RH	RB	TS	HS	TZ
1/2 - 3/4	A	A	A	A	A	---	---	---	---	---	A
1 - 4	A	A	A	A	A	A	A	A	A	---	A
6	A	A	A	---	---	A	A	A	A	A	A
8	A	A	A	---	---	---	A	A	A	A	A
10	A	A	---	---	---	---	A	A	A	A	A
12	A	A	---	---	---	---	A	A	A	A	A
14	A	---	---	---	---	---	A	A	A	A	A
16	A	---	---	---	---	---	---	A	A	A	A
18	---	---	---	---	---	---	---	A	A	A	A
20	---	---	---	---	---	---	---	---	A	A	A
24	---	---	---	---	---	---	---	---	---	A	A
30	---	---	---	---	---	---	---	---	---	A	A

Notes:

[1] For uninsulated ambient piping/tubing only.

Table B(2):

**Pipe Support Type Selection Requirements
 Fluid Service Temperatures greater than 100°C (212°F)
 Including Steam at All Pressures**

Pipe/Tube Size NPS	CL	CL (EY)	CL (IS)	CL (LD)	SW	RS	RH	RB	TS	HS	TZ
½ - ¾	A	---	---	A	---	---	---	---	---	---	A
1 - 4	A	---	---	A	---	A	A	A	A	---	A
6	A	---	---	---	---	A	A	A	A	A	A
8	A	---	---	---	---	---	A	A	A	A	A
10	---	---	---	---	---	---	A	A	A	A	A
12	---	---	---	---	---	---	A	A	A	A	A
14	---	---	---	---	---	---	A	A	A	A	A
16	---	---	---	---	---	---	---	A	A	A	A
18	---	---	---	---	---	---	---	A	A	A	A
20	---	---	---	---	---	---	---	---	A	A	A
24	---	---	---	---	---	---	---	---	---	A	A
30	---	---	---	---	---	---	---	---	---	A	A

Schedule C

**Insulation Protection Requirements
 For Pipe Hanger/Support**

Notes for Schedule C:

[1] For the column Hanger Support Position, "Insulation" means hanger or support element is outside of the pipe and insulation. "Pipe" means hanger or support element is in direct contact with the pipe and is encased in the pipe insulation.

[2] "Pipe" position only applies to clevis hangers. For all other pipe supports, use the "Insulation" hanger/support position.

[3] Include heavy-duty support plate welded to shield.

[4] Restrictions apply to minimum length of hanger rod for heating piping at this temperature range. Refer to standard details.

[5] Refer to specification section 20 07 19 Piping Insulation for type P-21, P-22 and P-23 high-density insert specifications.

[6] Where ambient piping is required to be insulated under section 20 07 19, insulation is to be protected in accordance with the requirements for Low Temperature Piping.

[7] Insulation for Dual Temperature Piping is to be protected in accordance with the requirements for Cold Piping.

Application Legend for Insulation Saddle and Shields

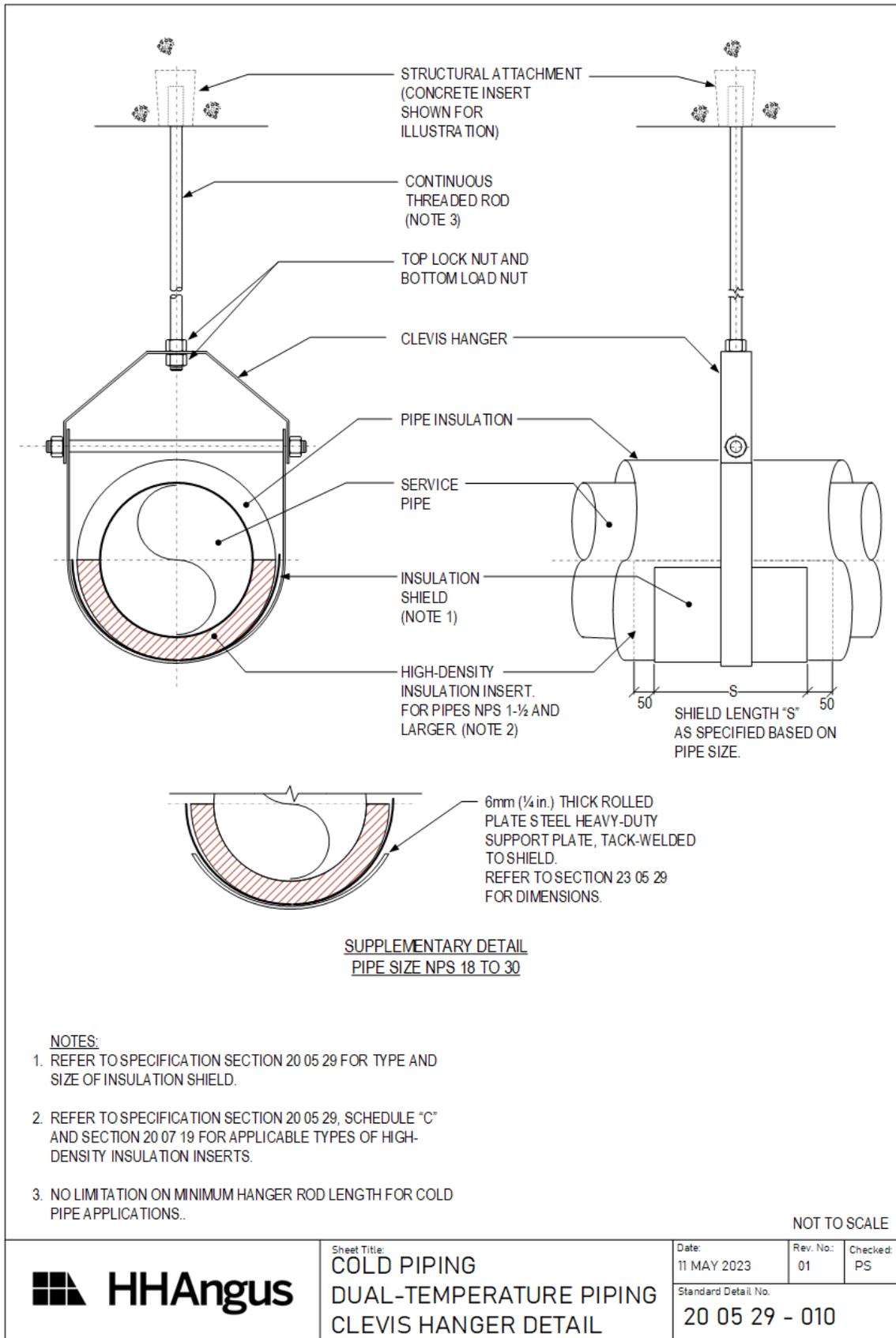
REQ	Required
ALT	Acceptable Alternate
	Not Applicable

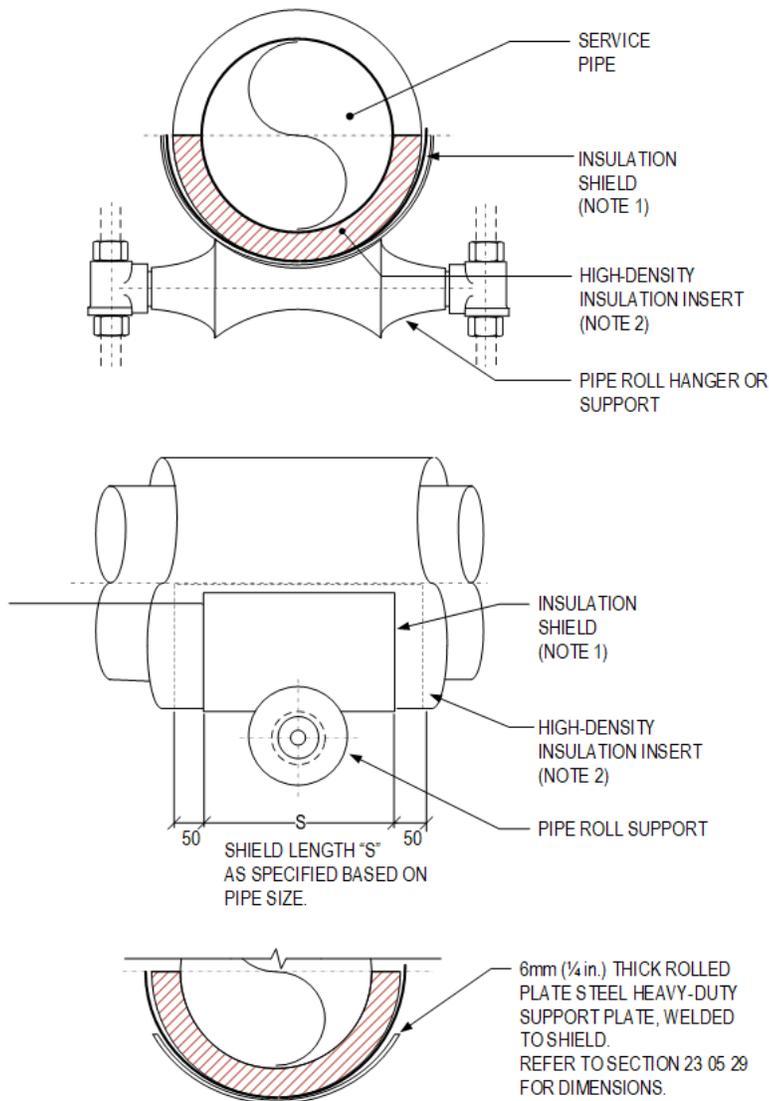
Service Temperature °C (F)	Pipe Size NPS	Hanger/ Support Position [Note 1, 2]	Pipe Saddle	Insulation Shield	
				Shield	High-Density Insert Type [Note 5]
Hot Piping > 121 to ≤ 205 (> 250 to ≤ 400) Including steam >103 kPa (15 psi)	≥ 6	Insulation	REQ		
	>1-1/4 and ≤ 4	Insulation	ALT		
				ALT	P-23
≤ 1-1/4	Insulation		REQ		
Hot Piping > 100 to ≤ 121 (> 212 to ≤ 250) Including steam ≤ 103 kPa (15 psi)	≥ 6	Insulation	REQ		
	>1-1/4 and ≤ 4	Insulation	ALT		
				ALT	P-21, P-22, or P-23

Service Temperature °C (F)	Pipe Size NPS	Hanger/ Support Position [Note 1, 2]	Pipe Saddle	Insulation Shield	
				Shield	High-Density Insert Type [Note 5]
	≤ 1-1/4	Insulation		REQ	

Schedule C (Con't)

Service Temperature °C (F)	Pipe Size NPS	Hanger/Support Position [Note 1, 2]	Pipe Saddle	Insulation Shield	High-Density Insert Type	
Hot Piping 61 to 100 (141 to 212)	≥10 and ≤ 30	Insulation	REQ			
	≥ 6 and ≤ 16	Insulation	ALT			
				REQ	P-21, P-22, or P-23	
	≥ 1-1/2 and ≤ 4	Insulation		ALT		P-21, P-22, or P-23
			Pipe [Note 4]	ALT		
	≤ 1-1/4	Insulation			ALT	
Pipe [Note 4]			ALT			
Low Temperature Water 40 to 60 (104 to 140) [Note 6]	≥18 and ≤ 30	Insulation		REQ [Note 3]	P-21, P-22, or P-23	
	≥ 6 and ≤ 16	Insulation		REQ	P-21, P-22, or P-23	
	≥ 1-1/2 and ≤ 4	Insulation			ALT	P-21, P-22, or P-23
			Pipe	ALT		
	≤ 1-1/4	Insulation			ALT	
			Pipe	ALT		
Cold Piping 4 to 16 (39 to 61) [Note 7]	≥18 and ≤ 30	Insulation		REQ [Note 3]	P-21 or P-22	
	≥ 1-1/2 and ≤ 16	Insulation		REQ	P-21 or P-22	
	≤ 1-1/4	Insulation		REQ		
Fire protection piping	≥ 1-1/2	Pipe				
	≤ 1-1/4	Pipe				
MRI Quench Piping	All	Insulation		REQ	P-22	





SUPPLEMENTARY DETAIL
PIPE SIZE NPS 18 TO 30

NOTES:

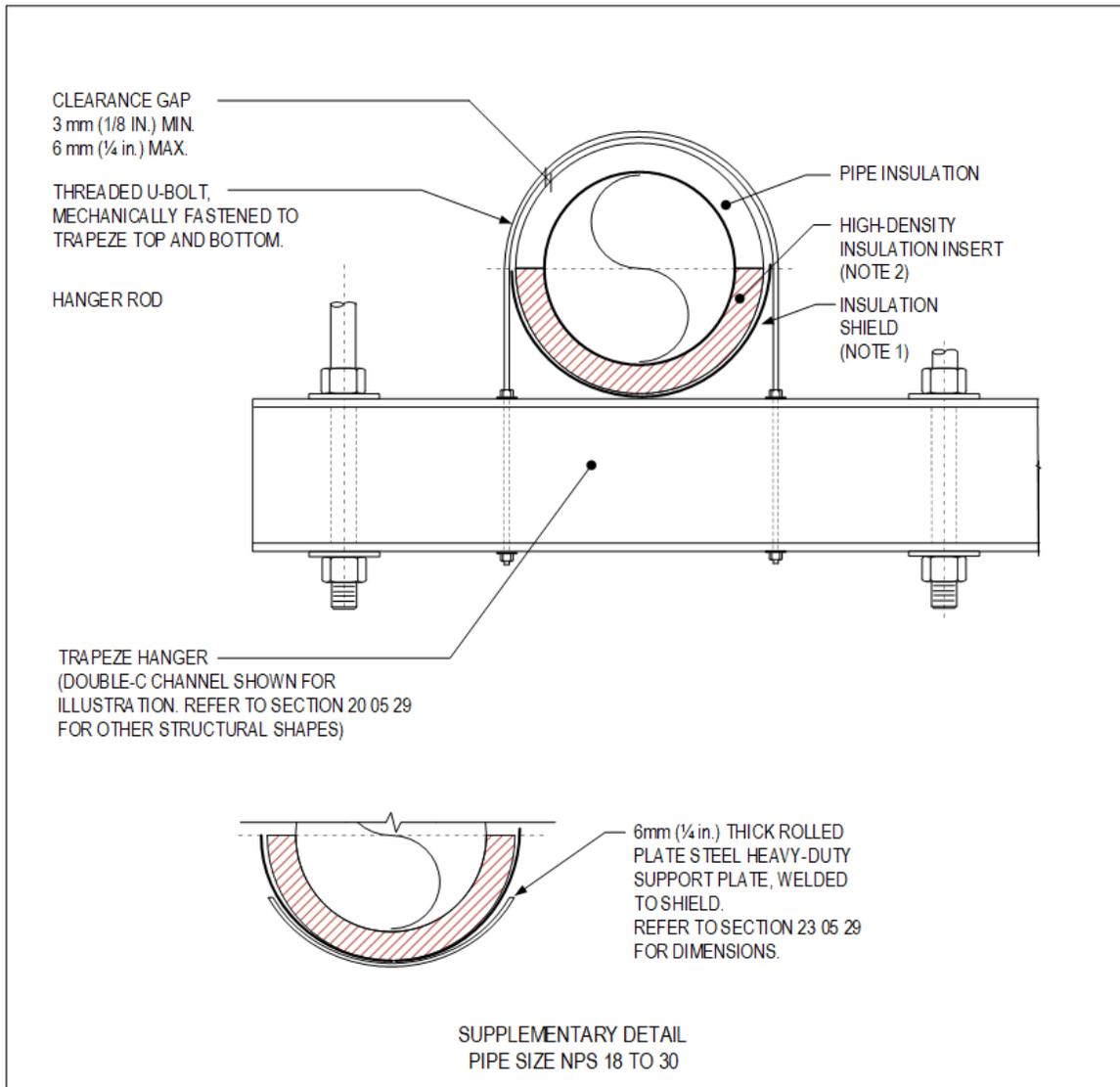
1. REFER TO SPECIFICATION SECTION 20 05 29 FOR TYPE AND SIZE OF INSULATION SHIELD.
2. REFER TO SPECIFICATION SECTION 20 05 29, SCHEDULE "C" AND SECTION 20 07 19 FOR APPLICABLE TYPES OF HIGH-DENSITY INSULATION INSERTS.
3. NO LIMITATION ON MINIMUM HANGER ROD LENGTH.

NOT TO SCALE



Sheet Title:
**COLD PIPING AND
 DUAL-TEMPERATURE PIPING
 ROLL HANGER DETAIL**

Date: 11 MAY 2023	Rev. No.: 02	Checked: PS
Standard Detail No. 20 05 29 - 011		



NOTES:

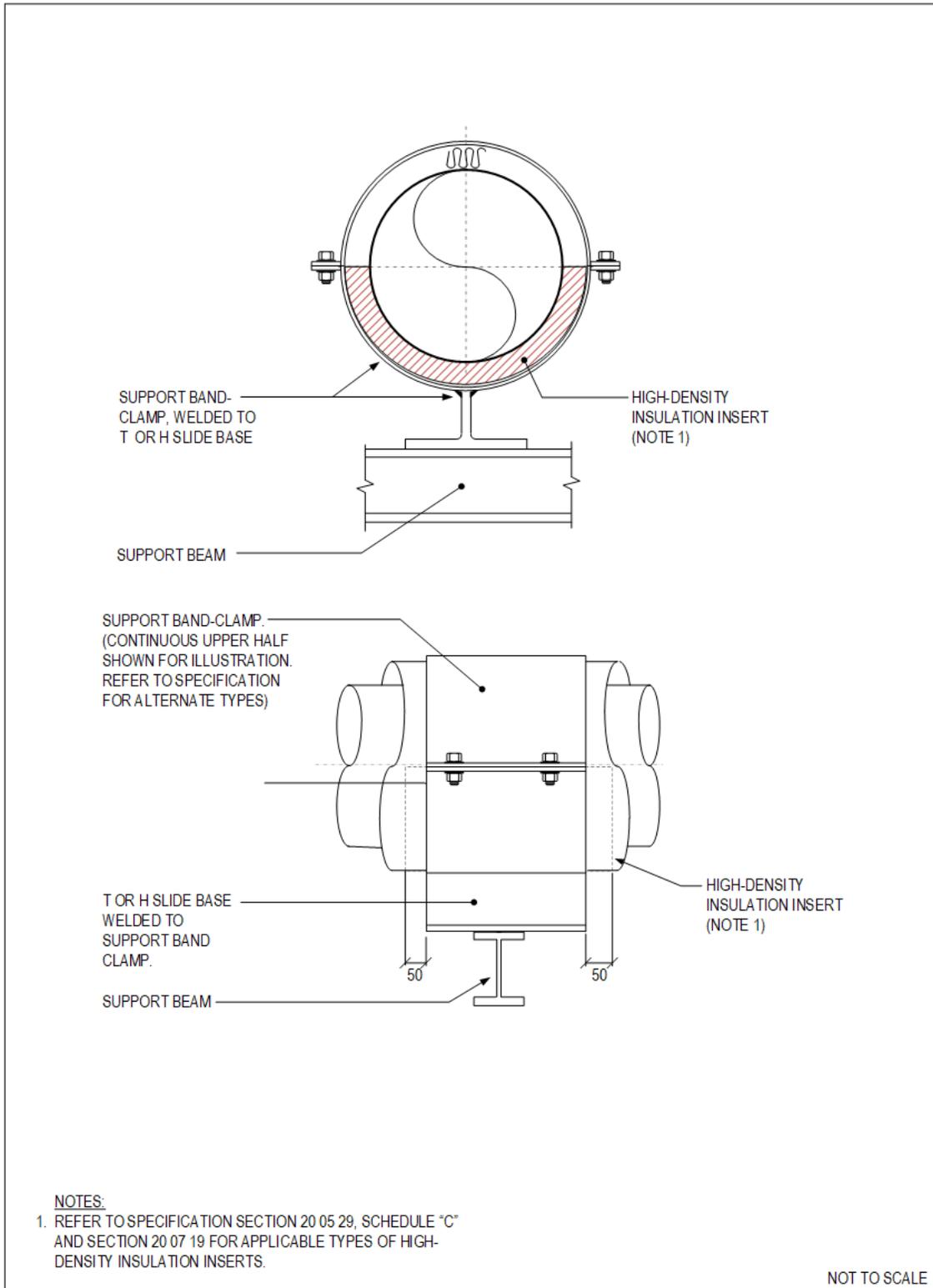
1. REFER TO SPECIFICATION SECTION 20 05 29 FOR TYPE AND SIZE OF INSULATION SHIELD.
2. REFER TO SPECIFICATION SECTION 20 05 29, SCHEDULE "C" AND SECTION 20 07 19 FOR APPLICABLE TYPES OF HIGH-DENSITY INSULATION INSERTS.

NOT TO SCALE



Sheet Title:
**COLD PIPING AND
 DUAL-TEMPERATURE PIPING
 TRAPEZE HANGER DETAIL**

Date: 11 MAY 2023	Rev. No.: 02	Checked: PS
Standard Detail No. 20 05 29 - 012		



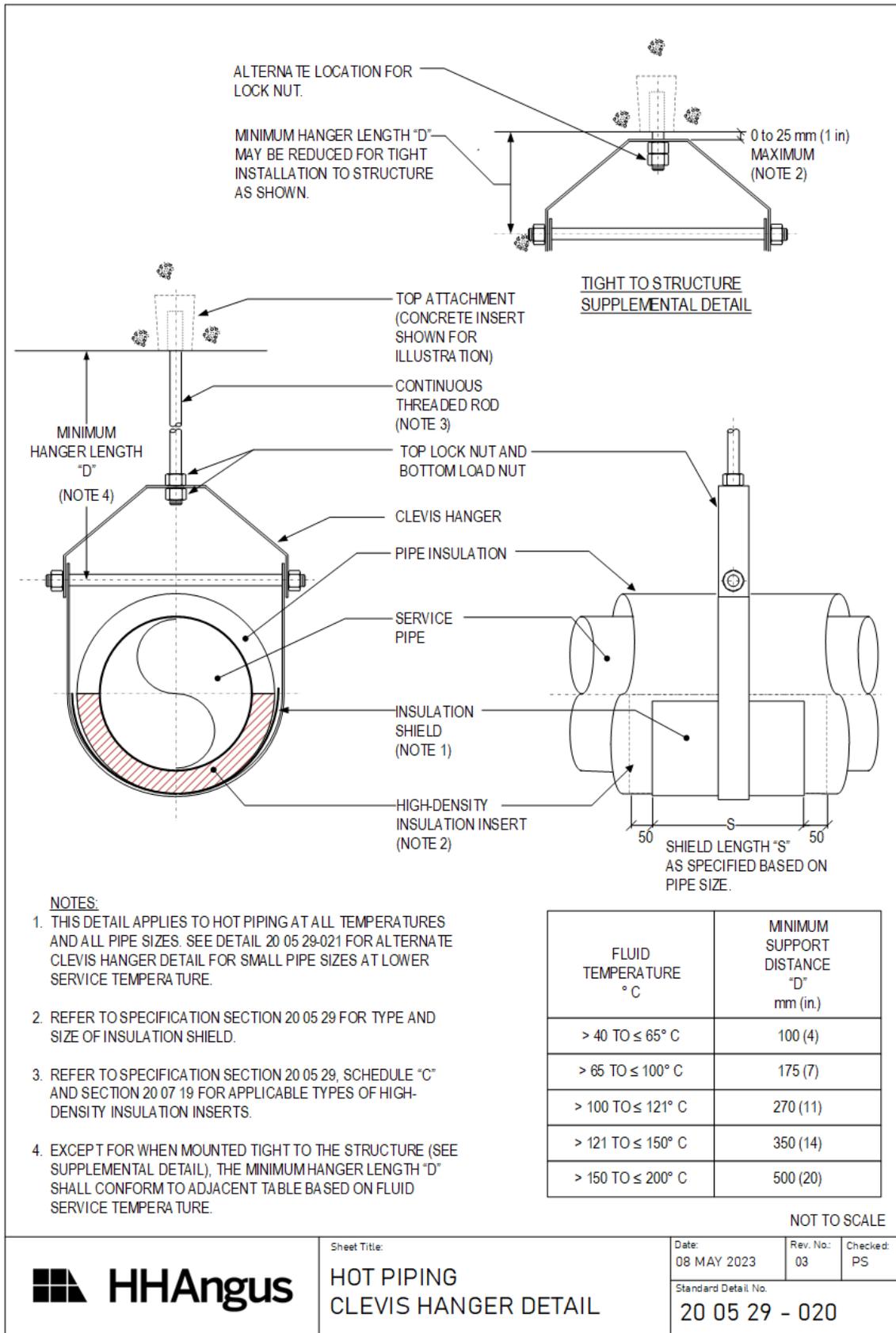
NOTES:
 1. REFER TO SPECIFICATION SECTION 20 05 29, SCHEDULE "C"
 AND SECTION 20 07 19 FOR APPLICABLE TYPES OF HIGH-
 DENSITY INSULATION INSERTS.

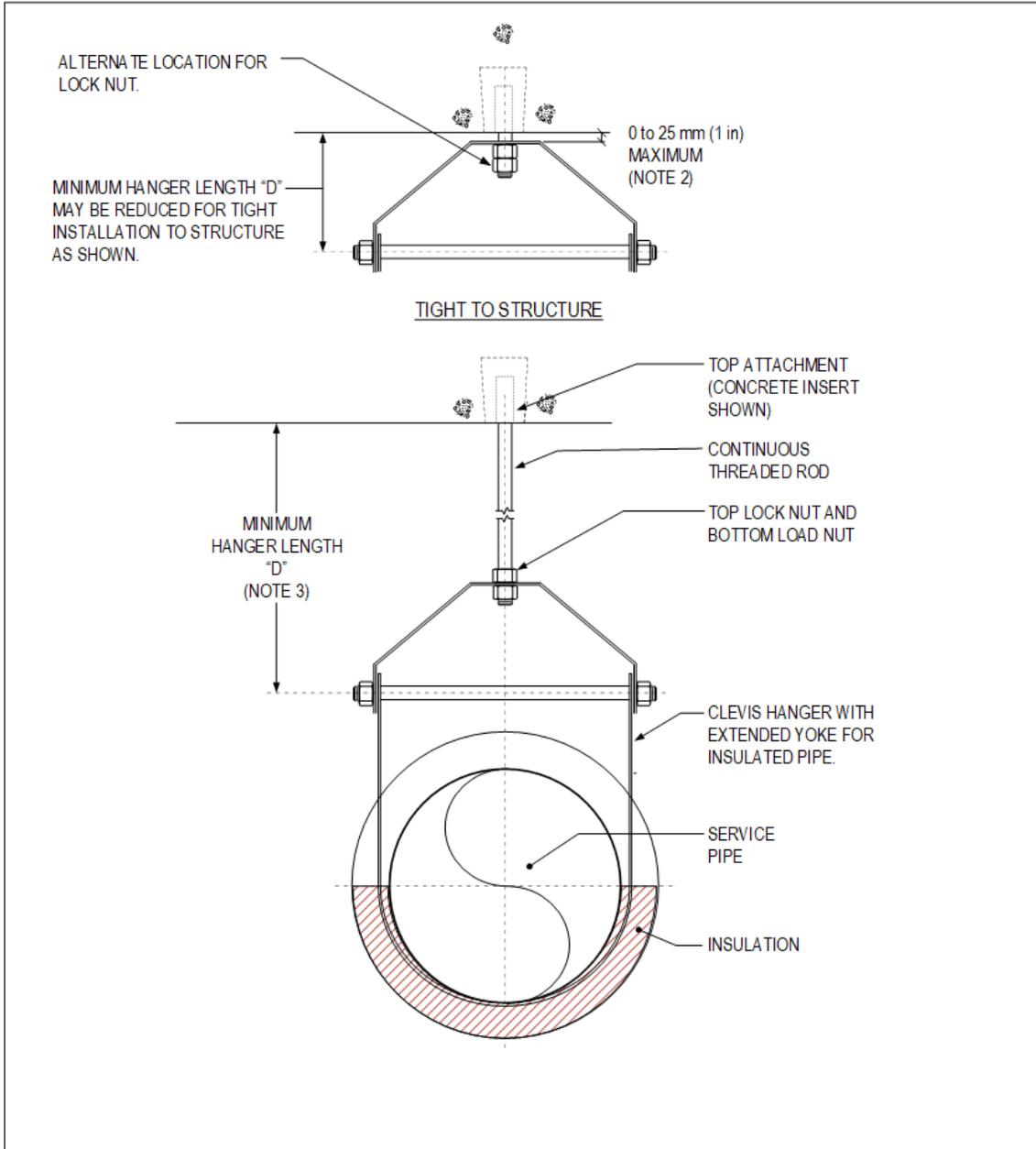
NOT TO SCALE



Sheet Title:
**COLD PIPING AND
 DUAL-TEMPERATURE PIPING
 SLIDE SUPPORT DETAIL**

Date: 11 MAY 2023	Rev. No.: 01	Checked: PS
Standard Detail No. 20 05 29-013		



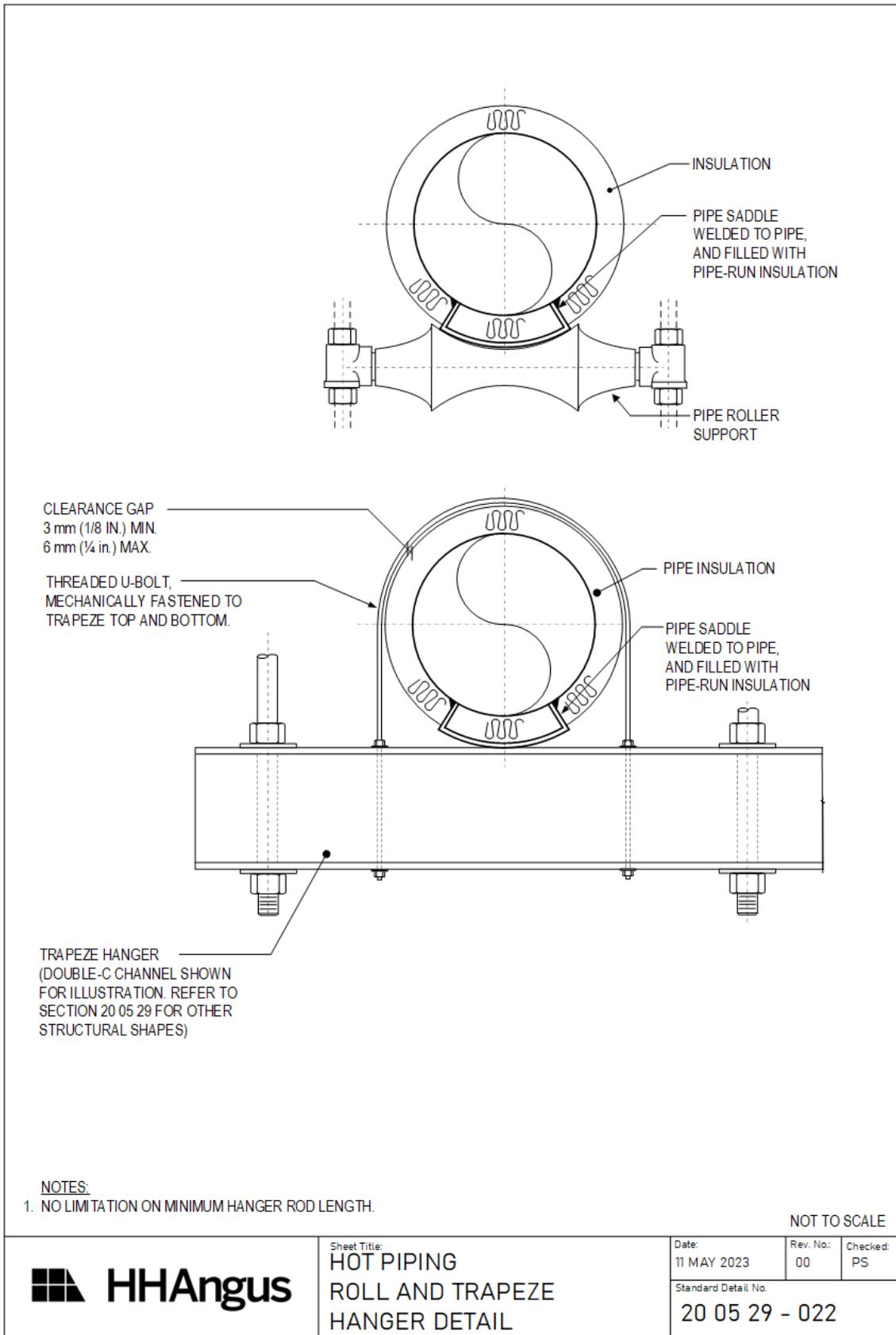


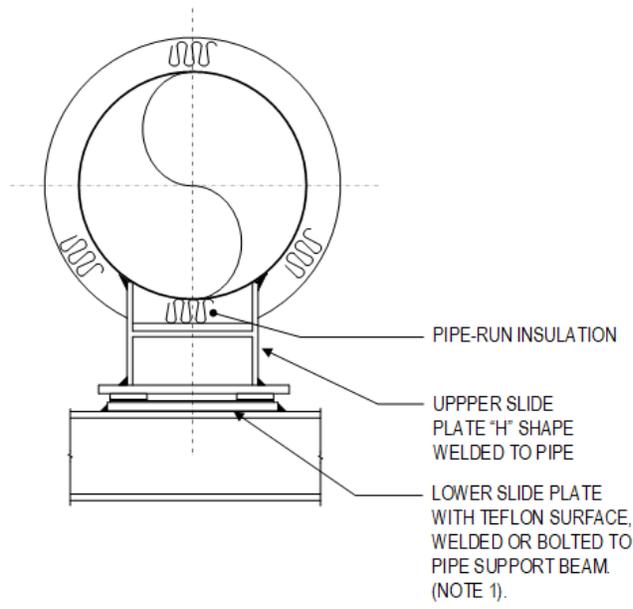
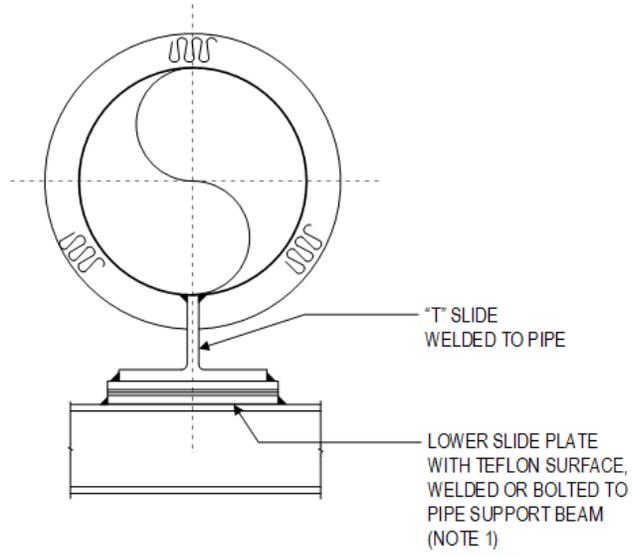
- NOTES:**
- THIS DETAIL APPLIES TO HOT PIPING \leq NPS 4 WITH FLUID TEMPERATURES \leq 100°C.
 - MAXIMUM LENGTH OF EXPOSED ROD WHEN HANGER IS INSTALLED TIGHT TO STRUCTURE.
 - WHERE DIMENSION "D" WILL BE LESS THAN AS SHOWN IN THIS TABLE, USE ROLLER, TRAPEZE, OR SLIDE SUPPORTS.

FLUID TEMPERATURE °C	MINIMUM SUPPORT DISTANCE "D" mm (in.)
> 40 TO \leq 65° C	100 (4)
> 65 TO \leq 100° C	175 (7)

NOT TO SCALE

	Sheet Title: HOT PIPING \leq 100° C SIZE \leq NPS 4 CLEVIS HANGER DETAIL	Date: 11 MAY 2023	Rev. No.: 00	Checked: PS
			Standard Detail No. 20 05 29 - 021	

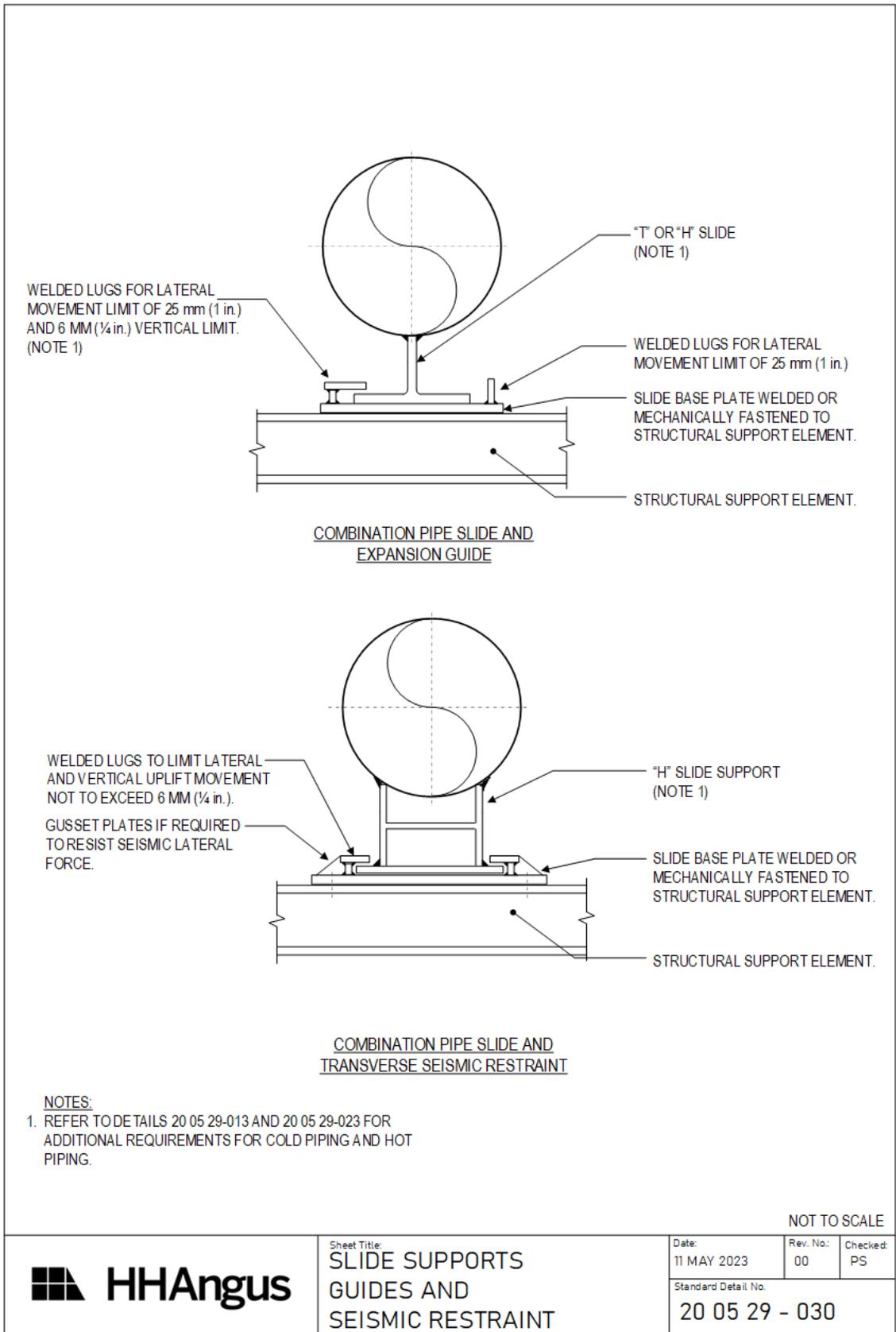




NOTES:
 1. TEFLON SLIDE PLATES ONLY REQUIRED FOR HOT PIPING WITH SERVICE TEMPERATURE > 121° C, INCLUDING STEAM AT PRESSURES > 103 kPa.

NOT TO SCALE

	Sheet Title:	Date:	Rev. No.:	Checked:
	HOT PIPING SLIDE SUPPORT DETAILS	11 MAY 2023	00	PS
		Standard Detail No. 20 05 29 - 023		



END OF SECTION

VIBRATION ISOLATION 20 05 48

1 GENERAL

1.1 Scope

- .1 Provide vibration isolation equipment for;
 - .1 vibration control for motor-driven mechanical equipment,
 - .2 vibration control for piping and ductwork connected to motor drive equipment,
 - .3 movement control for piping due to thermal movement, and
 - .4 movement control for piping due to building movement.
- .2 Provide engineering services associated with the design, analysis and selection of vibration isolation supports, including pipe riser supports.
- .3 Refer to specification section 20 05 29 for installation requirements for variable and constant load supports for pipe riser in excess of 25 m (82 ft) in height.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Wiring Requirements for Mechanical Services
 - .2 20 05 29 Common Hanger and Support Requirements for Piping
 - .3 20 05 49 Seismic Restraint
 - .4 20 05 16 Flexible Connections, Expansion Joints, Anchors & Guides
 - .5 23 33 05 Duct Accessories

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 ASTM A653-19 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - .2 ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus

1.4 Design Criteria

- .1 Isolator and base type designations are taken from the current ASHRAE Applications Handbook.
- .2 Base type, isolator type and minimum static deflection are shown in equipment schedules and/or equipment selection sheets.
- .3 Information shown in equipment schedules is to establish minimum standards and vibration isolation equipment to be selected to maintain noise levels in building below RC levels in following schedule.

AREA	NOISE CRITERIA (NC level)
Offices - private	32 to 34
-open plan	36 to 38
-business machine areas	40 to 42

AREA	NOISE CRITERIA (NC level)
-conference/boardrooms	30 to 32
Operating Rooms	25 to 27
Private Bedrooms	26 to 28
Hospital Wards	30 to 32
Public Areas	38 to 40

- .1 Provide a completely engineered design of pipe riser vibration isolated supports to minimize the pipe anchor loads under normal operating conditions, with engineering documents sealed by a professional engineer licensed in the jurisdiction of the Work.
- .2 Coordinate vibration isolation with seismic requirements under specification section 20 05 49.

1.5 Submittals

- .1 Submit shop drawings consisting of;
 - .1 product data sheets for isolation components,
 - .2 a schedule (or similar document) of vibration isolators selected for each piece of equipment, including equipment weight and isolator static deflection;
 - (a) where a common selection is used for multiple instances of the same equipment type, a single submission identifying all applicable equipment units is sufficient,
 - .3 drawing details for equipment bases, specific to each piece of equipment,
 - .4 fabrication details, location and size of anchor bolts and concrete requirements for inertia bases.
- .2 Submit shop drawings for the completely engineered pipe riser vibration isolation supports and pipe anchors;
 - .1 for each isolator, identify the estimated supported static loads, estimated supported operating loads (at temperature), spring deflections at static and operating conditions, spring deflections at static and operating condition, spring selections, and riser anchor design, including anchor loads at static and operating conditions,
 - .2 shop drawings to be sealed by a professional engineer licensed in the jurisdiction of the Work.

2 PRODUCTS

2.1 General Requirements

- .1 Provide vibration isolation equipment by one manufacturer.

Standard of Acceptance

- Vibro-Acoustics (Swegon NA)
- Kinetics
- BVA
- Korfund Mason
- Tecoustics

2.2 Resilient Isolator Pads – Type P1

- .1 Elastomer-in-shear pads:
 - .1 rubber waffle or ribbed pads:

- (a) 45 or 60 durometer neoprene depending on loading, minimum of 22 mm (7/8 in) thick,
 - (b) load rating: up to 5 mm (0.19 in) static deflection and up to nominally 4400 kg (9700 lbs.) load,
- .2 rubber-steel-rubber pads:
 - (a) two layers of rubber waffle or ribbed pad, 13 mm (½ in) thick, as specified above,
 - (b) bonded to 6 mm (¼ in) steel plate, with holes sleeved and fitted with isolation washers.
 - .3 Neoprene jacketed pre-compressed moulded fiberglass pads.

2.3 Elastomeric Mounts – Type M1

- .1 Molded neoprene mount:
 - .1 one piece, molded neoprene mount, with cast-in-top threaded steel load insert, and two hold down bolt openings on the bottom plate,
 - .2 load rating: up to 13 mm (0.5 in) static deflection and up to nominally 1800 kg (3960 lbs.) load,

2.4 Isolator Springs – Type S1

- .1 Open spring isolator:
 - .1 free-standing, open (un-enclosed) spring isolator, selected for static deflections as shown,
 - .2 upper load plate and leveling assembly, and bottom load plate with non-skid noise isolation pad and bolt holes for fastening to the floor,
 - .3 load rating: up to 50 mm (2 in) static deflection and up to nominally 8000 kg (17,600 lbs.) load,
 - .4 ratio of lateral spring stiffness to vertical spring stiffness: 1.0 or greater,
 - .5 overload capacity: 50% minimum,
 - .6 springs coated in a colour-coded corrosion protection finish and tested with a 1000 hour salt spray rating to ASTM B117.

2.5 Isolator Springs – Type S2

- .1 Enclosed spring isolator:
 - .1 free-standing, enclosed (housed) spring isolator, selected for static deflections as shown,
 - .2 suitable for equipment subject to wind loads, large changes in mass due to change in water content, torque loads, and/or seismic loads,
 - .3 load rating: up to 100 mm (4 in) static deflection and up to nominally 8000 kg (17,600 lbs.) load,
 - .4 housing: fabricated and welded steel members, hot-dipped galvanized after fabrication, with;
 - (a) top load plate with adjusting and leveling bolts,
 - (b) vertical restraints with isolation washers,
 - (c) bottom plate with non-skid noise isolation pads and bolt holes for fastening to the floor,
 - .5 ratio of lateral spring stiffness to vertical spring stiffness:
 - (a) 1.2 or greater for equipment installed outdoors,
 - (b) 1.0 or greater for equipment installed indoors,
 - .6 overload capacity: 50% minimum,
 - .7 springs coated in a colour-coded corrosion protection finish and tested with a 1000 hour salt spray rating to ASTM B117.

2.6 Isolation Springs - Type S3

- .1 Restrained open spring isolator:
 - .1 free-standing, open (un-enclosed) spring isolator, with vertical limit stops, selected for static deflections as shown,
 - .2 suitable for equipment subject to changes in mass due to change in water content,
 - .3 load rating: up to 50 mm (2 in) static deflection and nominally 1500 kg (3300 lbs.) load,
 - .4 spring assembly:
 - (a) top load plate with adjusting and leveling nut and bolt,
 - (b) integral vertical restraint limit with elastomeric washer,
 - (c) bottom fastening plate with noise isolation pad and mounting holes.
 - .5 ratio of lateral spring stiffness to vertical spring stiffness: 0.8 or greater.
 - .6 overload capacity: 50% minimum,
 - .7 springs coated in a colour-coded corrosion protection finish and tested with a 1000 hour salt spray rating to ASTM B117.

2.7 Isolator Springs – Type S4

- .1 Open spring thrust restraint isolators:
 - .1 horizontal arrangement, with equipment and structure mounting plates,
 - .2 open spring, with load plate and isolator bushing,
 - .3 static deflection to match equipment isolator.

2.8 Isolation Hangers – Type H1

- .1 Spring isolation hanger:
 - .1 open (un-enclosed) spring isolator for connection to upper and lower hanger rods, selected for static deflections as shown,
 - .2 a stamped or welded hanger bracket mount with elastomeric washer isolating the spring,
 - .3 bracket and spring: polyester powder coat finish,
 - .4 swivel arrangement to permit hanger box or rod to move through 30° of arc without metal to metal contact,
 - .5 load rating: 10 mm (0.4 in) to 50 mm (2 in) static deflection and up to nominally 1450 kg (3190 lbs.) load,
 - .6 ratio of lateral spring stiffness to vertical spring stiffness: 1.0 or greater,
 - .7 overload capacity: 50% minimum.,

2.9 Isolation Hangers – Type H2

- .1 Spring isolation hanger with elastomer-in-shear insert:
 - .1 Same as type H1 except as follows.
 - .2 includes a neoprene elastomer-in-shear insert on the upper load connection, in series to the spring,
 - .3 load rating: up to 100 mm (4 in) static deflection and up to nominally 1700 kg (3740 lbs.) load,

2.10 Isolation Hangers – Type H3

- .1 Neoprene isolation hanger:
 - .1 neoprene isolator for connection to upper and lower hanger rods,
 - .2 a stamped hanger bracket mount with isolator and load washer, with galvanized steel finish
 - .3 bracket and spring: polyester powder coat finish,
 - .4 swivel arrangement to permit hanger box or rod to move through 30° of arc without metal to metal contact,
 - .5 load rating: up to 15 mm (0.57 in) static deflection and up to nominally 900 kg (1980 lbs.) load,
 - .6 ratio of lateral spring stiffness to vertical spring stiffness: 1.0 or greater,
 - .7 overload capacity: 50% minimum.

2.11 Equipment Base – Type A

- .1 Vibration isolators attached directly to equipment,
- .2 No supplementary base required.

2.12 Equipment Base – Type B

- .1 Fabricated steel frame or rails (except cooling towers, evaporative fluid coolers, and evaporative condensers):
 - .1 prefabricated steel base for fans and other equipment requiring motor support,
 - .2 welded assemblies from structural sections,
 - .3 reinforced for motor and drive with;
 - (a) isolation elements attached to base brackets and
 - (b) adjustable motor slide rails.
 - .4 use height-saver isolator mounting brackets wherever possible,
 - .5 minimum vertical section of base selected on basis of motor size from following;

Motor Size Horsepower	Motor Size kW	Vertical Side mm (in)
up to 3	up to 2.2	75 (3)
7.5	5.5	100 (4)
20	15	150 (6)
50	37	200 (8)
over 50	37	250 (10)

2.13 Equipment Base – Type B-CT

- .1 Fabricated steel frame or rails – for cooling towers, evaporative fluid coolers, and evaporative condensers:
 - .1 prefabricated supplementary steel base for cooling towers, evaporative fluid coolers and evaporative condensers,
 - .2 fabricated from structural steel shapes, specifically designed for each equipment operating weight and support point locations,

- .3 maximum beam deflection: not greater than 1/360 of span and not to exceed 12.5 mm (1/2 in),
- .4 welded and/or bolted structural connections,
- .5 hot-dipped galvanized grade Z700 (G235) to ASTM A653 after fabrication,

2.14 Equipment Base – Type C

- .1 Concrete filled inertia base:
 - .1 Type B base and as follows,
 - .2 full depth perimeter structural section or formed plate channel frame with;
 - (a) welded in place reinforcing rods running in both directions and
 - (b) 1 mm (20 ga) metal pans,
 - (c) base section filled with concrete, vibrated into place.
 - .3 spring mount units carried by height-saver gusseted brackets welded to frame and
 - .4 'T' shaped bases to support horizontal pump elbows.

2.15 Acoustic Barriers for Anchors and Guides

- .1 Manufactured from 25 mm (1 in) thick neoprene isolation with ductile reinforcing material.

3 EXECUTION

3.1 General

- .1 Install vibration isolation equipment in accordance with manufacturer's instructions and locate isolation for equipment to provide stable support under saddles, frames and projections of equipment.
- .2 Select thrust restraints for equipment mounted on vibration isolation to limit movement during start-up and normal operation.

3.2 Equipment Bases

- .1 Provide equipment bases for equipment as shown on equipment schedule drawings.
- .2 Block and shim bases level at correct operating height. Set the bottom of bases to clear housekeeping pads under full static load conditions by:
 - .1 25 mm (1 in) minimum for type C bases, and
 - .2 50 mm (2 in) minimum for type A and B bases.

3.3 Equipment Vibration Isolation

- .1 Provide vibration isolators with required static deflection for motorized equipment as shown on equipment schedule drawings, except as otherwise specified herein.
- .2 Provide Type H1 isolators for in-line duct fans and fan-powered terminal boxes.
- .3 Provide Type H3 isolators for suspended unit heaters.
- .4 Provide Type S4 horizontal thrust restraints for horizontal discharge fans developing over 1.5 kPa (6 in wg) total static pressure, arranged symmetrically on either side of unit and attached at the center-line of thrust.
- .5 Provide vibration isolation rubber washers where isolator is bolted to floors, housekeeping pads or overhead structure.

3.4 Vibration Isolation for Service Connections to Vibration Isolated Equipment

- .1 Make ductwork connections to vibration isolated air handling equipment with flexible connections in accordance with specification section 23 33 05.
- .2 Make electrical connections to vibration isolated equipment with flexible liquid tight conduit in accordance with specification section 20 05 12.
- .3 Make pipe connections to vibration isolated equipment in accordance with specification section 20 05 16.

3.5 Vibration Isolation Piping Supports – General Requirements

- .1 Provide vibration isolators on pipe supports where piping is connected to motorized equipment that is supported on vibration isolators of any type, in accordance with the following table.

Location	Pipe Size NPS	Isolator Type	Static Deflection mm (in)
The first two pipe supports adjacent to the vibration isolated equipment	≥ 10	Variable support hanger to section 20 05 29	Equal to the equipment isolator static deflection, but not less than 20 (0.75)
	< 10	S1 or H2 [Note 1]	
The third pipe support adjacent to the vibration isolated equipment	All	S1 or H2	Equal to the equipment isolator static deflection, but not less than 20 (0.75)
The 4 th and 5 th support point from the vibration isolated equipment	≥ 6	S1 or H2	20 (0.75)
The 6 th support point from the vibration isolated equipment	≥ 10	S1 or H2	20 (0.75)
Within 15 m (50 ft) pipe-run distance of outdoor equipment	All	S1 or H2	20 (0.75)

Notes:

[1] Order springs pre-compress to suit the installed weight of the pipe filled with the operating fluid.

- .2 Provide acoustic barrier materials at pipe anchors and guides, located within pipe shafts, duct shafts, equipment and fan rooms, and up to the first anchor outside of these rooms or areas.

3.6 Thermal Expansion Supports for Pipe Risers

- .1 Unless otherwise shown for pipe riser supports to use variable or constant load pipe hangers in accordance with section 20 05 29, provide spring isolators for pipe supports to accommodate pipe thermal movement for vertical pipe (risers) as follows.
- .2 Support vertical cold- and hot-piping for riser heights that are 25 m(82 ft) or less in height on spring isolators attached to the pipe riser supports;
 - .1 select springs so that the initial spring deflection is at least four (4) times the expected thermal movement at each support point,

- .2 provide the design and fabrication of brackets at the riser spring mount as well as at the pipe attachment where standard riser clamps are not sufficient, and
- .3 in accordance with specification section 20 05 29.
- .3 For support of vertical cold- and hot-piping for riser heights greater than 25 m (82 ft), refer to specification section 20 05 29.
- .4 Provide spring isolators on horizontal branch piping or the horizontal pipe mains connecting to the riser as follows:
 - .1 type S2 or H2 isolators on the first three supports on horizontal piping connecting to the pipe risers,
 - .2 spring isolators on the horizontal piping is not required where the horizontal pipe connection is within 4 m (13 ft) of a pipe riser anchor or fixed riser base support.
 - .3 select spring isolators with a static deflection of that is four (4) times the expected thermal movement of the riser pipe at the location of the horizontal pipe connection.

3.7 Pipe Movement Isolation Supports at Building Expansion Joints

- .1 Where piping crosses building expansion joint, provide spring hangers at first two support locations of piping at either side of the construction joint line.

3.8 Start-up and Set-up

- .1 After installation of connections to resiliently mounted equipment;
 - .1 remove shims and blocking and adjust mountings to level equipment,
 - .2 adjust connections, hangers, snubbers, and restraints,
 - .3 ensure that there is no physical contact between isolated equipment and building structure.
- .2 On completion of installation and start-up of equipment;
 - .1 make arrangements for manufacturer/supplier of vibration isolation equipment to visit site, check the performance of the vibration isolation systems, inspect their installation, and submit written report,
 - .2 make corrections to installation in accordance with manufacturer/suppliers recommendations,
 - .3 provide notice 24 hours in advance of this site visit.

END OF SECTION

SEISMIC RESTRAINT FOR MECHANICAL SERVICES 20 05 49

1 GENERAL

1.1 Scope

- .1 Provide restraint devices to limit movement of piping, ducts, conduits, and equipment under seismic force and movement conditions and, where applicable, wind loads.
- .2 Provide engineering services for the design, selection of materials, installation instructions, and inspection of seismic restraint devices.
- .3 The requirements under this Specification section are in addition to the requirements for equipment, piping and duct supports and vibration isolation specified in other sections of Division 20.
- .4 Where specifications of materials of this section differ from those in other sections of Division 20, this section governs.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 29 Common Hanger and Support Requirements
 - .2 20 05 48 Vibration Isolation
 - .3 26 05 49 Seismic Restraints for Electrical Services

1.3 Definitions

- .1 The following definitions apply for the purpose of this section.

Transverse restraint - restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

Longitudinal restraint - restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

Restraint: a device which limits movement of object due to imposed seismic forces acting on the object.

Brace: a restraint directly connected to an object that reacts against both tension and compression seismic loads.

Cable restraint: a restraint consisting of cables that reacts against only tension seismic forces, and that may have a small amount of slack to prevent vibration isolation short-circuiting during normal operation.

Snubber (restraint): a restraint that does not come into contact with the object under normal operating conditions.

- .2 The following abbreviations apply to this section:

"C_p" the horizontal seismic force coefficient as defined in NFPA 13.

"K_s" horizontal seismic force coefficient (equal to $0.3 F_a S_a(0.2) I_E S_p$, as defined in the National Building Code of Canada.

“ K_v ” vertical seismic force coefficient.

“ W_p ” the weight of the component subject to a seismic force.

.3 Interpretation:

- .1 In this specification, the parameter “ S_s ” (spectral response acceleration at 5 Hz) in NFPA 13, ASHRAE, SMACNA and MSS SP-127 used for estimating the horizontal seismic force, has the same meaning as the parameter “ $S_a(0.2)$ ” for the spectral response acceleration value at 0.2 seconds as defined in the National Building Code of Canada.

1.4 Applicable Codes and Standards

.1 Installation standards and codes:

- | | | |
|----|----------------|--|
| .1 | ASHRAE D-90316 | Practical Guide to Seismic Restraint |
| .2 | ANSI/SMACNA | Seismic Restraint Manual Guidelines for Mechanical Systems, 3 rd edition. |
| .3 | MSS SP-127 | Bracing for Piping Systems: Seismic - Wind - Dynamic Design, Selection, |
| .4 | NFPA 13 | Installation of Sprinkler Systems |

.2 Product standards:

- | | | |
|-----|---------------|--|
| .1 | ACI 355.2 | Qualification of Post-Installed Mechanical Anchors in Concrete |
| .2 | ASHRAE 171 | Method of Testing Seismic Restraint Devices for HVAC&R Equipment |
| .3 | ASTM A492 | Standard Specification for Stainless Steel Rope Wire |
| .4 | ASTM A1023 | Standard Specification for Stranded Carbon Steel Wire Ropes for General Purpose |
| .5 | ICC-ES AC01 | Expansion Anchors in Masonry Elements |
| .6 | ICC-ES AC106 | Predrilled Fasteners (Screws) in Masonry |
| .7 | ICC- ES AC156 | Acceptance Criteria for Seismic Certification by Shake-Table Testing of Non-structural Components |
| .8 | ICC-ES AC193 | Mechanical Anchors in Concrete Elements |
| .9 | ICC-ES AC308 | Post-Installed Adhesive Anchors in Concrete Elements |
| .10 | MSS SP-58 | Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation |

.3 Other documents:

- | | | |
|----|--------|--|
| .1 | ASCE 7 | American Society of Civil Engineers, Minimum Design Loads and Associated Criteria for Buildings and Other Structures |
|----|--------|--|

1.5 Seismic Analysis, Design and Inspection Services

- .1 Provide the services of a professional engineer, licensed in the province or territory of the Work and who specializes in seismic restraint of building services and equipment (the “Seismic Engineer”), for the design of seismic restraints and to provide inspection services of the completed installation.
- .2 Seismic Engineer design services;
- .1 Provide the design of seismic restraint systems, including seismic restraint calculations for all connections of equipment to the structure.

- .2 Provide design drawings showing locations of restraints and details of construction and attachment of restrains. Mark-ups of Consultant drawing or Contractor installation drawings may be used for this purpose.
- .3 Analysis of dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis to detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the seismic forces acting on the equipment or components and their support and restraint attachments to the building structure.
- .3 Seismic Engineer inspection services;
 - .1 At periods during installation and at completion of the installation of the seismic restraint devices, the Seismic Engineer shall inspect the installation, identify and report deficiencies (if any) which are observed, and re-inspect the installation after deficiencies have been corrected.
 - .2 Seismic Engineer to submit periodic inspection reports and a final inspection report after all work is completed and deficiencies have been corrected, confirming the installation conforms to the seismic design requirements. Prepare and submit any required declarations or similar document to this effect where required by local legislation.
- .4 Shop drawings of custom restraints, required calculations, and reports shall be sealed by the specialist seismic professional engineer.
- .5 Prepare and submit reports of inspections of the installation and a final general review report of the completed seismic installation.

1.6 Manufacturer's Services – Seismic Restraints

- .1 Manufacturer of seismic control equipment are responsible for:
 - .1 determining seismic restraint sizes and locations,
 - .2 provide calculations and supply materials for restraint of vibration isolated and non-isolated equipment,
 - .3 provide installation instructions, drawings and trained field supervision to ensure proper installation and performance including welding details,
 - .4 field inspection of manufactured support systems including roof curbs and other rooftop equipment supports at time of installation.
- .2 Seismic restraint products shall either be:
 - .1 approved by a government agency and indicate maximum restraint ratings, or
 - .2 provided with test results verified by an independent testing laboratory which state the maximum restrain ratings.

1.7 Manufacturer Services – Pipe Risers

- .1 Notwithstanding the requirements of section 20 05 29, engineered design services for pipe riser supports are required for all pipe risers.
- .2 Manufacturer of pipe riser supports are responsible for:
 - .1 complete engineering design of pipe riser support system including design and selection of pipe riser anchors, riser guides and riser isolators,
 - .2 provide calculations and supply materials for support of pipe risers to accommodate dead loads, dynamic loads and static seismic loads.
 - .3 Provide installation instructions, drawings and trained field supervision to ensure proper installation and performance including welding details.

1.8 Design Criteria

- .1 Design seismic restraint systems to conform to the provincial or territorial building code as applicable for the place of the Work. Seismic calculation and restraint methods as described in ASHRAE D-90316, SMACNA seismic guideline and MSS SP-127 are acceptable as the baseline requirement.
- .2 Design of seismic restraints to be based on actual equipment data (dimensions, weight, center of gravity, etc.) obtained from submittals or the manufacturers of the equipment.
- .3 Testing and calculations of seismic restraints shall include both shear and tensile loads as well as one test or analysis at 45° to the weakest mode.
- .4 Site design parameters shall be obtained for the existing building.
- .5 Building seismic force coefficient data;
 - .1 seismic horizontal force coefficients “ K_s ” and seismic vertical uplift force coefficient “ K_v ” for building service are listed in Schedule A attached to the end of this Section. These coefficients are the maximum values independent of the type of equipment or service being restrained. It is permitted to calculate a lower K_s coefficient where the C_p , A_r and R_p values, as defined in the building code specific to the actual equipment or service being restrained, are used.
 - .2 seismic force coefficient “ C_p ” for fire protection piping is listed in Schedule A attached to the end of this Section.
- .6 Seismic force calculation (except fire protection piping);
 - .1 the horizontal seismic force “ V_p ” applied to a component is:
$$V_p = K_s \times W_p,$$
 - .2 the vertical seismic force “ V_{pv} ” applied to a component is:
$$V_{pv} = K_v \times W_p$$
- .7 Seismic force calculation for fire protection piping, including automatic sprinklers constructed in accordance with NFPA 13 and fire standpipes constructed in accordance with NFPA 14;
 - .1 the horizontal seismic force applied to a component is
$$F_p = C_p \times W_p \times 1.15,$$
 - .2 the vertical seismic force applied to a component is:
$$F_v = 0.15 \times C_p \times W_p \times 1.15.$$
- .8 For suspended equipment, the building elevation height is measured to the level of the floor above the suspended equipment.
- .9 For vibration isolated equipment, where the clearance distance (air gap) between the equipment support frame and the restraint (e.g. snubber or integral limit stop) exceeds 6 mm (1/4 in.), the seismic horizontal force V_p is to be increased by 100%.
- .10 Where adhesive anchors for concrete are used, the seismic force for the restrained equipment is to be increased by multiplying the horizontal seismic force coefficient specified in Schedule A of this Specification section by the “ R_p ” equipment category as defined in article 4.1.8.18 of the National Building Code of Canada specific to the equipment being restrained.

$$K_{s,adhesives} = K_s \times R_{p,applicable\ equipment}$$

- .11 Where concrete inserts are used, the seismic force for the restrained equipment is to be increased by multiplying the horizontal seismic force coefficient specified in Schedule A of this Specification section

by the “R_p” equipment category as defined in article 4.1.8.18 of the National Building Code of Canada specific to the equipment being restrained and divided by the value of 1.5.

$$K_{s,inserts} = K_s \times \frac{R_{p,applicable\ equipment}}{1.5}$$

1.9 Seismic Qualification of Equipment

- .1 Applies where other specifications of Division 20 to 25 require equipment to be seismically qualified.
- .2 Design unitary or package equipment to withstand the seismic force criteria as specified herein.
- .3 Design the equipment base frame to allow anchoring of the packaged equipment to the supporting structure by use of through-bolt anchors.
- .4 Seismically qualify and certify complete unitary or packaged equipment by the shaker table method in accordance with ICC ES-AC156 and ASCE 7 for validating continued operation after the test seismic movement.
- .5 For clarity, calculation of seismic forces for use with ASCE 7 are subject to the following for installations in Canada:
 - .1 calculate seismic forces in accordance with the building code at the place of the Work, or in its absence the National Building Code of Canada,
 - .2 under ASCE 7, the “S_{DS}” parameter is equivalent to NBCC value equal to “2/3 · F_a(0.2) · S_a(0.2)”
 - .3 under ASCE 7, the Component importance factor is to be read as the Building Importance Factor in accordance with the National Building Code of Canada,
 - .4 unless otherwise specified in the product technical Specification section, the building height factor under ASCE 7 of “z/h” is the same as NBCC “h_x/h_n” and is to have a value of 1.0.
 - .5 other factors in conformance with this Specification section.

1.10 Submittals

- .1 Submit shop drawings in accordance with Division 1 and as follows.
- .2 Seismic restraints:
 - .1 Provide test certificates for each seismic restraint device, identifying maximum tested load capacities.
 - .2 Provide calculations for each piece of restrained equipment, lengths of braced piping, ductwork and conduit, including seismic forces, restraint selection, and selection data.
 - .3 Provide a calculation analysis summary (spreadsheet is acceptable) for each piece of equipment, including the following information:
 - (a) Equipment ID,
 - (b) Floor level,
 - (c) Horizontal seismic force factor,
 - (d) Equipment weight,
 - (e) Horizontal seismic force,-
 - (f) Vertical uplift seismic force (where applicable),
 - (g) Design condition (worst case) overturning moment,
 - (h) Number of restraint fastenings,
 - (i) Pull-out tension for worst case restraint,
 - (j) Compression for worst case restraint (vibration isolated equipment),

- (k) Horizontal shear per fastener,
 - (l) Worst case simultaneous tension and shear loads at each restraint and snubber,
 - (m) Pull-out tension load rating per fastener,
 - (n) Horizontal shear rating per fastener.
- .4 Provide drawings for each type of restraint assembly, including details for connections to building structure, and associated bill of materials, and (where applicable) full welding details of field welds to structural elements.
 - .5 For building connections in concrete, provide concrete anchor sizes and nominal and effective embedment depth.
 - .6 Provide floorplan layout drawings indicating location of each restraint, identifying each restraint type in a manner to identify the restraint detail.
 - .7 Provide layout and construction details for reinforced housekeeping pads based on actual equipment to be restrained and selected concrete anchors. Shop drawings to include:
 - (a) minimum housekeeping pad plan dimensions and height, including reinforcement,
 - (b) details for securing the housekeeping pad to the structural floor slab,
 - (c) dimensioned position of restraint devices or combination isolator/restraint devices,
 - (d) minimum distance from concrete anchors to edge of housekeeping pad.
 - .8 Calculations and designs shall be sealed by a Professional Engineer licensed in the province or territory of the location of the project.
- .3 Pipe riser support system:
 - .1 Provide engineered layout drawings of pipe supports including anchors, guides and isolators, with supporting load calculation including dead loads, dynamic loads and static seismic loads, and reaction loads at building connection.
 - .2 Include:
 - (a) riser drawing indicating location of each support element for each for each piping system,
 - (b) installation instructions for presetting of pipe guides and isolators,
 - (c) riser clamp products or fabrication details of pipe brackets,
 - (d) riser clamping details as applicable for each riser pipe material.

1.11 Quality Assurance

- .1 Without limiting Contractors responsibility for quality assurance of the Work, the following minimum quality control processes are required.
- .2 Pre-Construction meeting;
 - .1 Request and arrange a meeting with the Seismic Engineer and Consultant to review seismic restraint approach, prior to any restraint installation. Obtain approval from the Consultant before commencing work.
- .3 Initial installation and review;
 - .1 Install the first three transverse and three longitudinal braces for each fire protection systems, one (1) building service piping system, and one (1) ductwork system.
 - .2 Request and arrange for a review of the installation by the Seismic Engineer and Consultant. Obtain approval of the installation before commencing remainder of the work.

- .4 Provide services of the manufacturer's technical representative to conduct site inspections of the Work in progress, and to conduct a final inspection of the Work. Provide a copy of the final inspection report to the Consultant for review. For clarity, these inspections are separate from those performed by the Seismic Engineer.
- .5 Provide services by the Seismic Engineer to conduct periodic reviews of the work in progress, and final review of the completed seismic restraint installation, before any ceilings are installed or work is otherwise concealed.
- .6 All deficiencies identified by the Seismic Engineer, manufacturer, or Consultant are to be rectified before equipment or services are concealed.

2 PRODUCTS

2.1 General

- .1 Seismic restraint materials to be provided by manufacturers specializing in the field of seismic restraint.

Standard of Acceptance

- Vibro-Acoustics (Swegon North America)
 - Kinetics Noise Control Inc.
 - B.V.A. Systems
 - Korfund (VMC)
 - Tecoustics
 - Hilti
 - nVent
- .2 Manufactured seismic restraints, anchors and related materials to be tested in accordance with ICC ES AC156 for loads meeting or exceeding the applied seismic forces of the Work.
 - .3 Seismic restraints for equipment supported by vibration isolators to be either:
 - .1 vibration isolators as specified in section 20 05 48 and provided with separate seismic snubbers, or
 - .2 combination vibration isolators with integral seismic snubbers.
 - .4 The following product articles describe the more common type of restraint devices. Other restraint devices are permissible provided they are qualified by 3rd party testing laboratories for seismic force restraint.

2.2 Seismic Snubbers

- .1 Type "SS1" – Single-Axis/Single Direction Snubbers:
 - .1 ASHRAE Type "I", designed to restrict movement in one axis,
 - .2 carbon steel construction with epoxy or electrostatic paint finish, attached to floor or housekeeping pad with minimum of two bolts, faced with minimum 6.4 mm (1/4 in.) thick neoprene pad of compounded to bridge bearing quality,
- .2 Type "SS2 / SS3" – Multi-Axis/Multi-Direction Snubber Assemblies:
 - .1 ASHRAE Type "G" and "F", designed to restrict movement in two (2) lateral ("SS2") or three (3) axis ("SS3"),
 - .2 interlocking steel construction, attached to equipment structure and equipment, maximum of 6 mm (1/4 in) seismic movement,
 - .3 minimum 6 mm (1/4 in) thick resilient neoprene pads compounded to bridge bearing specifications, to prevent metal-to-metal impact,

- .4 minimum two bolt attachments to the floor,

2.3 Seismic Restraint Brackets

- .1 Type "SRB" – Rigid Equipment Restraint Brackets:
 - .1 suitable for connection to equipment bases and tank bases,
 - .2 carbon steel "L" sections with epoxy or electrostatic paint finish, for fastening to both the floor structure/housekeeping pad and the equipment base,
 - .3 structure bolt opening equipped with neoprene bushing, compounded to bridge bearing quality,
 - .4 minimum two bolt fastening to equipment base using screws,
 - .5 suitable for equipment direct contact to floor with or without isolation pads,

2.4 Seismic Vibration Isolators

- .1 Type "2-S" – All Direction Neoprene Isolator:
 - .1 ASHRAE Type "E", designed to restrict movement in all directions with no metal-to-metal contact.
 - .2 molded, oil resistant neoprene compounded to bridge bearing quality, with encapsulated cast-in-place top steel load plate, and steel base plate with anchor holes,
- .2 Type "3-S" – Restrained Spring Isolator – Constant Load:
 - .1 ASHRAE Type "B", designed to restrict movement in all directions,
 - .2 colour coded seismic-controlled spring isolator, single or multiple spring coils, with minimum 6 mm (¼ in.) neoprene pad,
 - .3 removable coil spring element without having to disturb supported equipment,
 - .4 lateral stiffness greater than 1.2 times rated vertical stiffness,
 - .5 minimum 50% overload capacity,
 - .6 non-welded spring elements: epoxy coated, with a minimum 1000-hour rating when tested in accordance with ASTM B-117,
 - .7 steel housing design to limit lateral and vertical movement of the supported equipment,
 - .8 neoprene snubber, to limit maximum equipment movement in any direction to 6 mm (¼ in.),
 - .9 location of snubbers designed to minimize prying action on floor bolts,
 - .10 adaptor base suitable sized for larger anchors, when required to suit anchorage capacity.
- .3 Type "4-S" – Restrained Spring Isolator – Variable Load:
 - .1 colour coded seismic-controlled spring isolator, single or multiple spring coils, with minimum 6 mm (¼ in) neoprene pad mounted under spring(s),
 - .2 removable coil spring element without having to disturb supported equipment,
 - .3 lateral stiffness greater than 1.2 times rated vertical stiffness,
 - .4 minimum 50% overload capacity,
 - .5 non-welded spring elements: epoxy coated, with a minimum 1000-hour rating when tested in accordance with ASTM B-117,
 - .6 steel housing design to limit lateral and vertical movement of the supported equipment,
 - .7 top load plate with adjustable and leveling bolts,

- .8 adjustable vertical restraints to allow unloading of water-bearing equipment,
- .9 isolation washers,
- .10 bottom load plate with anchor holes,
- .11 hot dipped galvanized for outdoor installations,
- .12 neoprene snubber compounded to bridge veering quality, to limit maximum equipment movement in any direction to 6 mm ($\frac{1}{4}$ in),
- .13 adaptor base suitable sized for larger anchors, when required to suit anchorage capacity.

2.5 Restraints and Braces for Distribution Services

- .1 Type "SCR" – Cable Restraints:
 - .1 manufactured system consisting of cable, building attachment, and vertical hanger rod reinforcement assembly,
 - .2 field-built assemblies are not acceptable,
 - .3 steel wire strand cables:
 - (a) galvanized steel aircraft cable to ASTM A1023, or stainless steel to ASTM A492
 - (b) sized for seismic load with a safety factor of 2,
 - (c) arranged for restraint in both longitudinal and transverse directions under tension loads only,
 - (d) connector strength rating equal to 90% of cable breaking strength rating.
 - .4 building and equipment attachment brackets:
 - (a) carbon steel assemblies, designed to permit rotation to the final installation angle, or 45° bent steel plates with holes to allow attachment of cable loops,
 - (b) protective loop thimbles at contact with connectors,
 - (c) rope connections: overlap wire "U" clips with at least two (2) bolt fasteners, or, tool-less wedge insert lock connectors,
 - (d) selected to exceed the cable working design load by 50%,
 - (e) single sided "C" beam clamps are not acceptable.
 - (f) fasteners to building structure designed to withstand simultaneous shear and tension loads, including prying action due to the bracket.
- .2 Type "SSB" – Solid Braces:
 - .1 factory-built or field assembled solid braces, consisting of structural-shapes, building attachment, and vertical hanger rod reinforcement assembly.
 - .2 sized for seismic load with a safety factor of 2,
 - .3 arranged for restraint in both longitudinal and transverse directions.
 - .4 building and equipment attachment brackets:
 - (a) carbon steel assemblies, designed to permit rotation to the final installation angle, or 45° bent steel plates with holes to allow attachment of cable loops,
 - (b) selected to exceed the working design load by 50%,
 - (c) single sided "C" beam clamps are not acceptable.
 - (d) fasteners to building structure designed to withstand simultaneous shear and tension loads, including prying action due to the bracket.
- .3 Vibration isolators for suspended pipes and ducts:

- .1 applies where vibration isolators are specified for pipes or ducts in Specification section 20 05 48.
- .2 type "H2" spring hanger in accordance with Specification section 20 05 48 and with two (2) travel-limit stops of neoprene washers with integral steel inserts which are located:
 - (a) on the top of the isolator housing, with an air gap of 6 mm (1/4 in.) between the neoprene washer and the structure connection point,
 - (b) on the underside of the isolator housing, supported by a nut on the hanger rod, and provided with an air gap of 6 mm (1/4 in.) between the underside of the isolator housing and the top of the neoprene washer.
- .4 Bracing of vertical hanger rods for SCR restraints and SRB braces:
 - .1 hanger rods braced to avoid potential for buckling;
 - (a) structural steel angle or formed channel brace selected to prevent support rod buckling,
 - (b) brace attached to support rod with a series of adjustable clips, without the use of hand-tools.
 - .2 hanger rods are not required where two SRB braces are provided at each seismic restraint location, and are installed at 180° opposition to each other.

2.6 Seismic Pipe Riser Support System for Piping Subject to Thermal Expansion

- .1 Application: for piping subject to thermal expansion including HVAC water systems, steam, domestic hot and cold water.
 - .1 not applicable to: drainage and vent piping systems, compressed gas and vacuum systems.
- .2 Complete engineered riser support system by support manufacturer.
- .3 Pipe riser anchors:
 - .1 outboard-mounted all-direction pipe anchors, designed for load bearing of pipe by means of pipe riser clamps or pipe support brackets,
 - .2 carbon-steel interlocking plates with bridge bearing quality neoprene pads, and painted finish,
 - .3 top-side loading plate with threaded UNC tapped mounting hole, for attachment by bolting to pipe riser clamp or welded to pipe bracket,
 - .4 variants for mechanical anchoring to concrete floor or field-welding to structural steel framing,
 - .5 one pair of guides per guide location.

Standard of Acceptance

- Vibro-Acoustics - fig. PRA, PRA-S

- .4 Pipe riser guides:
 - .1 outboard-mounted pipe guides, designed for load bearing of pipe by means of pipe riser clamps or pipe support brackets,
 - .2 carbon-steel sliding guides with EPDM lateral bushings and bridge bearing quality neoprene end pads, and painted finish,
 - .3 top-side loading plate with threaded UNC tapped mounting hole, for attachment by bolting to pipe riser clamp or welded to pipe bracket,
 - .4 one pair of guides per guide location.

Standard of Acceptance

- Vibro-Acoustics - fig. PRG, PRG-S

.5 Pipe riser isolators:

- .1 open spring assembly, with neoprene base and equipment loading plate, and mounting bolt hole for attachment by bolting to pipe riser clamp or welded to pipe bracket.
- .2 springs selected for four times the riser expansion or contraction at the supported location, to not exceed a maximum 25% load change between installed and operating condition.

Standard of Acceptance

- Vibro-Acoustics - fig. FST series

.6 Pipe riser clamps:

.1 Carbon steel pipe:

- (a) NPS 1-1/2 and under – carbon steel riser clamps, ANSI/MSS SP-58 type 8.

Standard of Acceptance

- Anvil - fig. 261

- (b) NPS 2 to 24 – 4 or 6 bolt carbon steel riser clamps, ANSI/MSS SP-58 type 42.

Standard of Acceptance

- Anvil - fig. 40

.2 Stainless steel pipe:

- (a) NPS ½ to NPS 12 – T304 stainless steel, ANSI/MSS SP-58 type 8.

- (b) special pattern with extended ears and 4 bolts to allow bearing on pipe riser anchors, guides and isolators.

Standard of Acceptance

- Anvil - fig. 261SS special.

.3 Copper tube:

- (a) NPS ½ to NPS 4 – carbon steel with copper plated finish, ANSI/MSS SP-58 type 8.

- (b) special pattern with extended ears and 4 bolts to allow bearing on pipe riser anchors, guides and isolators.

Standard of Acceptance

- Anvil - fig. CT-121 special.

.7 Pipe brackets:

- .1 purpose engineered, carbon steel structural shapes with reinforcing gussets, for full welding attachment to pipe and to load plates on pipe anchors, guides or isolators.

- .2 painted finish.

2.7 Seismic Pipe Riser Supports – Piping not Subject to Thermal Expansion

- .1 Use pipe riser clamps and guides in accordance with Specification section 20 05 29, except select components to have a load capacity equal to at least two times the combined dead weight, dynamic load and seismic load.

2.8 Mechanical Anchors

.1 General:

- .1 Post-installed mechanical anchors in concrete to be seismically qualified for installation in cracked concrete in accordance with ACI 355.2 by testing for seismic tension and shear loads in cracked concrete in accordance with ICC-EC AC193, and qualified by an ICC-ES seismic evaluation report.
- .2 Anchors installed in concrete masonry units to be seismically qualified in accordance with TMS 402/602 by testing for seismic tension and shear loads in accordance with ICC-ES AC01 or AC106, and be qualified by an ICC-ES seismic evaluation report.
- .3 Anchors to be selected for concurrent shear and tension loads with a safety factor not less than 2.0 times estimated load.

.2 Undercut anchors for post-concrete installation:

- .1 zinc-plated carbon steel bolt, nut, washer and cone-shape bearing-bell, with tungsten-tipped cutting radial edges, to create bearing force by keying into concrete,
 - (a) for outdoor use, all materials are to be stainless steel.
- .2 special undercut stop-drill bit and installation setting tool,
- .3 marking system to indicate when the anchor is completely installed,
- .4 designed for pre-setting of anchors and/or fastening of anchors through the equipment attachment opening,

Standard of Acceptance

- Hilti - fig. HDA (indoor), HDA-R (outdoor)

.3 Expansion wedge anchors for post-concrete or masonry unit installation:

- .1 zinc-plated carbon steel bolt, nut, washer, expanding segments and wedge mandrel, to create restraint force by friction and keying against/into adjacent concrete,
 - (a) for outdoor use, all materials are to be stainless steel.
- .2 torque- loading to determine complete installation,

Standard of Acceptance

- Hilti - fig. KB-TZ2 (concrete and masonry)
- Hilti - fig. HSL-3 (concrete only)

.4 Screw anchors for masonry units:

- .1 Zinc-plated carbon steel masonry screw with hex washer head, to create restraint force by keying into concrete masonry units.
 - (a) for outdoor use, all materials to be stainless steel.

Standard of Acceptance

- Hilti - fig. KH-EZ series.

.5 Housekeeping pad anchors:

- .1 for installation prior to pouring of the housekeeping pad and post-installation of the structural floor,
- .2 tapered ductile iron body, with openings sized for two runs of Ø10mm (#3) reinforcing bar, and body NC threaded receiver for connection to undercut or expanding wedge anchors,

- .3 two pieces of Ø10mm (#3) reinforcing bar, of sufficient length to tie into housekeeping pad reinforcement,
- .4 undercut or expanding wedge anchor for connection to the structural floor slab.

Standard of Acceptance

- Mason Industries - fig. HPA

2.9 Adhesive Anchors

- .1 Adhesive anchors for post-concrete installation:
 - .1 seismically qualified for installation in cracked concrete in accordance with ACI 355.2 by testing for seismic tension and shear loads in cracked concrete in accordance with ICC-EC AC308.
 - .2 to have an ICC-ES seismic evaluation report, and be suitable for installation in cracked and uncracked normal- and light-weight concrete.
 - .3 anchors to be selected for concurrent shear and tension loads with a safety factor not less than 2.0 times estimated load.
 - .4 injectable, two-component hybrid adhesive, matching threaded rod and accessories.

Standard of Acceptance

- Hilti - fig. HIT-HY 200

3 EXECUTION

3.1 General Requirements

- .1 Design and construct seismic restraints to;
 - .1 keep equipment and distribution services in place during and following seismic events,
 - .2 resist vertical loading simultaneously with transverse or longitudinal seismic loading.
- .2 Give special consideration to design for adjacent connections, insulation treatment, thermal movement, vibration isolation, and relation to building seismic joints.
- .3 Select restraint fastening systems so that full restraint will be provided assuming one failed fastener.
- .4 Install seismic restraint devices in accordance with manufacturer's instructions and Seismic Engineer's installation shop drawings.
- .5 Secure each transverse or longitudinal brace to the building structure, and not any other building service.
- .6 Restraint installation:
 - .1 install cable restraints with slack not exceeding a deflection of 12 mm (1/2 in.) measured at its midpoint, where equipment being restrained is supported on/by vibration isolators or for piping which is subject to thermal expansion,
 - .2 install cable restraints snug in all other applications,
 - .3 use solid braces only in rigidly supported situations,
 - .4 brace hanger rods forming a part of a seismic restraint to accept resulting compressive loads,
 - .5 install transverse and longitudinal braces at angles between 45 and 60° measured from the horizontal, unless the seismic bracing details by the Seismic Engineer states otherwise.
- .7 Concrete or masonry walls may be used as transverse duct restraints (but not pipe restraints), provide the wall is not a fire separation requiring the duct to be installed with a fire damper, and the annual

space on any side of the duct does not exceed 12 mm (1/2 in.). Where the annual space exceeds this value, provide separate braces or use angle channels to secure the duct to the wall.

- .1 drywall partitions, including demountable partitions, are not to be used for restraint.
- .8 Trapeze support and racks piping systems may have the rack braced (transverse and longitudinally) provided each pipe supported by the rack is restrained to the rack, while allowing thermal expansion as necessary.

3.2 Use of Pre-Engineered Bracing Details for Distribution Services

- .1 Use of pre-engineered restraint and bracing details in accordance with SMACNA (for ducts, piping and conduit) or MSS-SP-127 (for piping) is permitted. Where the installation of these services exceeds the limits of these documents, provide specific engineering restraint devices and systems.
 - .1 for SMACNA details, refer to the seismic hazard level ("SHL") by floor level in Schedule A of this Specification Section.
- .2 Fire protection automatic sprinkler systems and fire standpipe systems are to be braced in accordance with NFPA 13.
- .3 Provide cable restraints or bracing for transverse and longitudinal seismic restraints at spacing and locations as specified in the above referenced standards.
- .4 Exemptions for seismic restraints for distribution services (pipes, ducts, conduit) described in ASHRAE, SMACNA or MSS SP-127 are limited to the explicit exemptions described herein.

3.3 Exemptions for Duct Seismic Restraints

- .1 Except as described in paragraph .2 below, the following ductwork is not required to have seismic restraints where all the following conditions are met;
 - .1 ducts and duct supports are constructed to SMACNA duct construction standards,
 - .2 the extent of the free movement of the duct under seismic forces will not cause the duct to come into contact with other building services or building elements,
 - .3 HVAC ducts having a cross-sectional area of 0.56 m² (6 ft²) or less or have a linear weight for ducts and any insulation of 248 N/m (17 lb/ft) or less are exempt,
 - .4 HVAC or process ducts supported on trapeze assemblies with rod hangers, where the duct and any insulation have a linear weight of 146 N/m (10 lb/ft) or less are exempt,
 - .5 for other ducts not described in items.3 or .4 above are exempt where:
 - (a) an individual duct is supported by hangers where the support height measured from the structural support to the top of the duct is 305 mm (12 in.) or less, and the hanger is attached to the duct within 50 mm (2 in.) of the top of the duct with a #10 sheetmetal screws, and
 - (b) rod hanger at the connection to the support structure are provided with a swivel in accordance with Specification section 20 05 29 to prevent bending of the hanger rod. Where such a device only provides rotation of the hanger rod in one plane, it shall be installed to allow transverse movement of the hanger rod.
- .2 Ducts conveying toxic or flammable gases, chemical or biological exhaust, or ducts used for smoke control or smoke venting are to be seismically restrained – no exemptions apply.

3.4 Exemptions for Pipe Seismic Restraints

- .1 Except as described in paragraph .2 below, the following piping is not required to have seismic restraints where all the following conditions are met;

- .1 the pipe is supported by hangers where the support height measured from the structural support to the top of the pipe is 305 mm (12 in.) or less,
 - .2 piping is supported on a trapeze where the support height measured from the structural support to the top surface of the trapeze is 305 mm (12 in.) or less,
 - .3 the rod hanger at the connection to the support structure is provided with a swivel in accordance with Specification section 20 05 29 to prevent bending of the hanger rod. Where such a device only provides rotation of the hanger rod in one plane, it shall be installed to allow transverse movement of the hanger rod, and
 - .4 the extent of the free movement of the piping under seismic forces will not cause the pipe to come into contact with other building services or building elements.
- .2 Piping conveying fuel oil, natural gas, propane gas and liquid, medical gases and compressed gases are to be seismically restrained – no exemptions apply.

3.5 Building Structural Connections

- .1 Select building connection devices based on seismic loads for actual equipment purchased.
- .2 For connection to concrete structures:
 - .1 Select building structure anchors as follows:
 - (a) post-installed undercut anchors or wedge-expansion anchors,
 - (b) concrete inserts may be used in new construction but only where complete seismic design is completed and seismic forces are adjusted to suit,
 - .2 Spacing between anchors: not less than 3 x the effective embedment of the greatest embedment length.
- .3 Where adhesive anchors or concrete inserts are used, the anchors are sized for an increased seismic force as described in article "Design Criteria".
- .4 For connection to steel structures:
 - .1 use double sided beam clamp, loaded to the centerline of the beam web, or
 - .2 were permitted by the building structural engineer, specifically designed welded or bolted connection may be used.
 - .3 the use of single sided "C" type beam clamps is not permitted for the connection to the building steel structure for hanger rods and seismic restraints.

3.6 Duct Restraints General Requirements

- .1 Use cable restraints or braces. Do not mix cable restraints and rigid bar restraints on the same duct system.
- .2 Use cable restraints for ductwork suspended on vibration isolators. Provide a small amount of slack in the cable to prevent vibration short-circuiting, with the slack not exceeding a lateral displacement of 12 mm (1/2 in.) at the center point of the cable.
- .3 Provide reinforcement of hanging rods to prevent buckling of the rod.

3.7 Piping Restraints General Requirements

- .1 Use cable restraints for piping subject to thermal expansion, including but not limited to chilled water, heating water, steam and glycol heating/cooling water.
- .2 Use cable restraints for piping supported on vibration isolation hangers or supports.
- .3 Use cable restraints or braces for all other piping.

- .4 Thermal expansion pipe anchors and guides on piping systems may be used as both a transverse and longitudinal seismic restraint where they are designed for concurrent thermal and seismic loadings.
- .5 Provide reinforcement of hanging rods to prevent buckling of the rod.
- .6 Where clevis hangers are used, provide a brace for the clevis cross bolt consisting of Schedule 40 pipe of the smallest size to fit over the clevis cross bolt, of a length to provide a 6 mm (1/4 in.) total gap between the reinforcement and the clevis frame.
- .7 For trapeze hangers, provide U-bolts over piping to limit lateral and vertical movement, but allow approximately 6 mm (1/4 in.) total clearance to allow pipe thermal expansion movement.
- .8 Attach restraints to pipe hangers and trapezes. For existing piping, restraints may be attached to the pipe using pipe clamp assemblies manufactured for this purpose.
- .9 Where pre-engineering restraints in accordance with SMACNA or MSS SP-127 are used, the spacing for transverse and longitudinal restraints are to be reduced to 50% of the stated spans in these documents for the following piping systems:
 - .1 steel piping with threaded joints,
 - .2 plastic piping including but not limited to PVC, CPVC, PP, and PVDF,
 - .3 fiberglass-reinforced pipe,
 - .4 cast iron drainage piping with no-hub connectors,
 - .5 glass drainage piping.
- .1 The following table for equipment connectors takes precedence over the requirements of Specification section 20 05 16.

Equipment Type	Limits	Connector Type
Refrigeration Condensing Units and Condenser Units	All	Flexible Metal Hose
Steam, heating and cooling coils, and humidifiers	All	Flexible Metal Hose, Corrugated Connector
Hot water reheat coils, Fan Coil units	All	Flexible Metal Hose, Flexible Non-Metallic Hose
Duct mounted humidifiers	All	Flexible Metal Hose, Flexible Non-Metallic Hose
Other equipment not specifically listed	NPS 2 and smaller	Flexible Metal Hose
	NPS 2-1/2 and larger	Corrugated Connector

- .10 Provide seismic restraints at ends of piping where connected to equipment, to limit pipe movement so that it does not cause the flexible connector devices at the equipment to exceed their lateral movement rating;
 - .1 For pipe drops to equipment, provide a pipe guide on the pipe immediately above the flexible connector device, with clearance of not more than the lateral deflection rating of the flexible connector. Line the pipe guide with 6 mm (1/4 in.) neoprene pads of bridge bearing equality. Support the guide from the floor level.
 - .2 this requirement applies to piping that is otherwise exempt from seismic restraints.

3.8 Piping Risers Restraints

- .1 Use pipe anchors and guides for seismic restraints of vertical pipe risers. Do not use separate cable restraints or braces.
- .2 For horizontal seismic forces acting on vertical pipe risers, use the seismic force coefficient "Ks" value at the floor location of the pipe anchor or guide (as applicable), and the restrained weight is to include 50% of the pipe and fluid content weight between the anchor or guide and the next anchor or guide, in both vertical directions.
- .3 For piping subject to thermal expansion:
 - .1 provide fully engineered pipe riser support system,
 - .2 for steel pipe;
 - (a) provide an anchor at the location shown,
 - (b) construct the anchor assembly using heavy-duty pipe riser clamps or pipe brackets with full-welded connections to the pipe, and full-welded or bolted connections to the anchor. Use mechanical anchors to bolt the pipe anchor to concrete floor, and weld pipe anchors to steel framing.
 - (c) unless otherwise shown, use a heavy-duty pipe riser clamp with a load capacity not less than two times the combined dead weight of pipe and water, dynamic load and seismic loads.
 - .3 for copper tube,
 - (a) attach a copper sleeve that matches the OD of the tube and fully braze the sleeve to the tube.
 - (b) alternatively, use a slip-on flange over the tube and fully-braze the flange to the tube,
 - (c) position the sleeve or flange immediately above and bearing on a pipe riser clamp, which is bolted to the riser anchor.
 - .4 based on engineered support design, provide intermediate isolator supports.
- .4 For piping not subject to thermal expansion;
 - .1 provide pipe guides and riser clamps for piping not subject to thermal expansion in accordance with Specification section 20 05 29,
- .5 For all piping;
 - .1 for cast iron DWV pipe, plastic DWV pipe, and glass DWV pipe, provide a guide at each floor level.
 - .2 for all other piping, provide guide or riser clamp at every other floor but not to exceed 7.6 m (25 ft) spacing, unless engineering design determines other spacing dimensions,

3.9 Conduit Restraints

- .1 Conduits for mechanical wiring are to be restrained in accordance with the requirements of section 26 05 49.

3.10 Floor Mounted Equipment Restraints

- .1 Anchor floor mounted equipment with anchor bolts, minimum four bolts for rectangular equipment bases, and three bolts for circular equipment bases.
 - .1 friction due to gravity loads shall not be considered to provide resistance to seismic forces.
- .2 For non-isolated equipment, secure equipment directly using equipment base supports or use SRB brackets. Alternatively, use type SS1 or SS2 snubbers where equipment is not subject to overturning moments. Use type SS3 snubbers where equipment is subject to overturning moments;
 - .1 for type SS1 snubbers, provide a minimum of eight (8) snubbers for each piece of equipment, with two units placed on each corner of the equipment base frame.

- .2 for type SS2 and SS3 snubbers, provide a minimum of four (4) snubbers for each piece of equipment, with one unit placed on each face of the equipment base frame.
- .3 For round equipment bases, such as expansion tanks with floor-support ring without mounting flanges, use type SS3 snubbers or purpose-constructed clamps to positively attach to the equipment base and anchored to the floor. Welding to the equipment base is permitted only where the equipment manufacturer information permits this method of attachment.
- .4 Provide resilient neoprene bushings and washers between equipment and anchor bolts where equipment is secured rigidly to floor or housekeeping pad.
- .5 Install snubber devices only after equipment is installed and operating, to ensure no metal-to-metal contact. Adjust snubbers so that any clearance gaps do not exceed 6 mm (1/4 in.).
- .6 For floor mounted equipment with vibration isolators;
 - .1 select basic vibration isolator in accordance with Section 20 05 48.
 - .2 select seismic restraint for each piece of equipment of either:
 - (a) integrated seismic vibration restraint type 2-S, 3-S or 4-S, or
 - (b) vibration isolator in accordance with Section 20 05 48 combined with seismic snubbers SS1, SS2 or SS3 as applicable to suit overturning moment.
 - .3 Do not mix type of restraint on the same piece of equipment.
 - .4 Where the equipment is not provided with a structural base to transfer seismic forces, provide a structural-shape or formed steel channel base or a Type C inertia base as a complete steel frames suitably cross braced in both horizontal directions to withstand seismic induced shear force and bending moments.

3.11 Suspended Equipment Restraints

- .1 For isolated equipment, select basic vibration isolator in accordance with Section 20 05 48.
- .2 Provide restraints for equipment independent of restraints provided on connecting ductwork or piping.
- .3 Provide reinforcement of hanger rods to prevent buckling.
- .4 Provide SCR type longitudinal and transverse restraints at each corner of the equipment (total of eight (8) cables). Alternatively, a single SCR cable can be installed at each corner of the equipment, positioned at 45° to both transverse and longitudinal direction and sized for concurrent transverse and longitudinal loads.

3.12 Equipment Restraints - Surface Wall-Mounted Equipment and Panels

- .1 Application: for non-rotating mechanical equipment, electrical panels, control panels, motor controllers, and other electrical distribution equipment.
- .2 Attach equipment to horizontal galvanized steel channels and fasten with bolts equipped with neoprene isolation grommet washers. Channels to extend past the side of the equipment to allow anchoring to wall. Select bolts for concurrent shear dead-weight without deduction for uplift load, and tension restraint load.
- .3 Attach channels to concrete or masonry walls with not less than four (4) anchors with each anchor having a not less than a 1.5 safety factor.

3.13 Equipment Restraints - Recessed Wall-Mounted Equipment

- .1 Application: for non-rotating mechanical equipment, electrical panels, control panels, motor controllers, and other electrical distribution equipment.

- .2 Mount recessed equipment through the top, bottom and sides of the equipment housing to adjacent block wall or wall studs.

3.14 Inspection, Testing, Adjustment and Reporting

- .1 For equipment supported on vibration isolators, field measure air gaps on each restraint and if necessary adjust the restraint so that the clearance air gap does not exceed 6 mm (1/4 in.). Provide a written report identifying the results of each test and adjustment, to the Seismic Engineer and Consultant for review.
- .2 Arrange for the seismic restraint manufacturer to inspect and report on the installation at completion of the work. Make corrections of deficiencies identified by the manufacturer. This work is to be performed prior to the final field review by the Seismic Engineer.
- .3 Arrange for Seismic Engineer to conduct a final inspection prior to substantial performance of the Work. Make corrections of deficiencies identified by Seismic Engineer. This work is to be performed prior to the final field review by Consultant.
- .4 Make corrections of deficiencies identified by Consultant.
- .5 Submit the following reports prior to application for substantial performance of the Work, or where applicable, ready-for-takeover of the Work:
 - .1 Seismic Engineer periodic and final inspection reports,
 - .2 seismic restraint manufacturer inspection reports,
 - .3 Seismic Engineer declaration of general review.

END OF SECTION

IDENTIFICATION FOR MECHANICAL SERVICES 20 05 53

1 GENERAL

1.1 Scope

- .1 Provide identification nameplates, labeling for piping, ductwork, equipment, and valves, and specialty signage.

1.2 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ANSI Z535.1 Standards for Safety Signs and Labels
 - .2 ASME A13.1 Scheme for the Identification of Piping Systems
 - .3 CSA Z7396.1 Medical Gas Pipeline Systems – Part 1: Pipelines for Medical Gases, Medical Vacuum, Medical Support Gases, and Anaesthetic Gas Scavenging Systems

1.3 Submittals

- .1 Shop drawings:
 - .1 Submit product data sheets for materials specified herein.

2 PRODUCTS

2.1 General

- .1 Manufactured identification systems:
 - .1 resistant to general chemical, and ultraviolet stabilized for outdoor use,
 - .2 minimum operating temperature: -25°C (-12°F),
 - .3 maximum operating temperature: 121°C (250°F).
 - .4 language: English

Standard of Acceptance

- Brady - identification tapes, bands, and markers.
- Seton - Setmark Pipe Markers.
- Smillie McAdams Summerlin.
- Craftmark Identification Systems.
- Primark

2.2 Engraved Equipment Identification Nameplates

- .1 Laminated nameplates:
 - .1 laminated two-layer coloured plastic plates, with engraved lettering,
 - .2 minimum size: 90 mm x 40 mm x 2.5 mm (3 in x 1½ in x ¼ in),
 - .3 letter height:
 - (a) ID and name: 20 mm (¾ in.) minimum
 - (b) power source: 10 mm (⅜ in) minimum,

- .4 provided with Class 125 barcode and tag file,
- .5 nameplate colours:
 - (a) nameplate and letter colours are dependent on type of electrical power supply to equipment.

Power Source	Background Colour	Letter Colour
Normal or None	White	Black
Life-Safety/ Emergency	Red	White
Stand-by (non-life safety)	Orange	White
UPS	Blue	White

2.3 Piping Identification - Medical Gas Systems

- .1 Self-adhesive plastic marking tape:
 - .1 text with integral flow direction arrow markers,
 - (a) reversing text may be used,
 - .2 text and field colour: to CSA Z7396.1,
 - .3 tape width: sized to suit pipe O.D. and to overlap itself a minimum 19 mm (3/4 in),
 - .4 text height and marker length:

Pipe/Tube NPS	Marker Length mm (in)	Text Height mm (in)
≤ 1-1/4	200 (8)	13 (0.5)
1.5 to 2	200 (8)	19 (0.75)
2.5 to 6	300 (12)	32 (1.25)

- .2 Coil-wrap pipe markers are not permitted.

2.4 Piping Identification – Piping Systems other than Medical Gas Systems

- .1 General:
 - .1 conform to ASME A13.1 and as shown in Schedule A at the end of this Section for marking colours and global harmonization system (GHS) hazard identification symbols.
 - .2 text height:

Pipe/Tube NPS	Marker Length mm (in)	Text Height mm (in)
≤ 1-1/4	200 (8)	13 (0.5)
1.5 to 2	200 (8)	19 (0.75)
2.5 to 6	300 (12)	32 (1.25)
8 to 10	600 (24)	65 (2.5)
>10	800 (32)	90 (3.5)

- .2 Flexible coil-wrap manufactured markers:
 - .1 PVC plastic coated markers with integral printing, or plastic cover with field applied self-adhesive markers,
 - .2 reversing text with integral arrow markers,
 - .3 application method:
 - (a) NPS ½ to NPS 6: full wrap of pipe
 - (b) NPS 8 and over: partial pipe wrap with perforations for securing with nylon tie-wraps, tie-wraps included.
- .3 Self-adhesive polyester pipe name marking tape:
 - .1 reversing text with integral flow direction arrow markers,
 - .2 tape height: 65 mm (2.5 in) minimum.
- .4 Self-adhesive vinyl flow direction marking bands:
 - .1 colour band tape with flow direction arrows,
 - .2 colours: as specified for pipe name markers.
 - .3 tape width: 50 mm (2 in)
 - .4 tape length: wrapped around pipe or covering with ends overlapping one pipe diameter but not less than 25mm (1 in).
 - .5 flow arrow: 20 mm (¾ in) minimum high

2.5 Ductwork Identification

- .1 Punched stencils in PVC or card material, suitable for application of field painting.
- .2 Letter height: 50 mm (2 in).
- .3 Letter paint colour: black.

2.6 Valve and Steam Trap Identification

- .1 Engraved plastic laminate tags:
 - .1 text for valves:
 - (a) piping system fluid service, area location description, following by a series number
 - (b) where a valve is shown on drawings to be normally closed, include “Normally Closed”
 - .2 text for steam traps: abbreviation for steam pressure (e.g. “S70”) as shown, followed by a series number,
 - .3 tag background colour and test colour: same as for pipe markers in accordance with Schedule A at the end of this section.
 - .4 brass or stainless steel chain.

2.7 Medical Pipeline Valve Lockout Tags

- .1 Printed vinyl lock-out valve tags with brass grommets:
 - .1 text:
 - (a) 1st line: “Medical Gas Valve”
 - (b) 2nd line: “Normally Closed” or “Normally Open”) as applicable.

2.8 Miscellaneous Identification

- .1 Self-adhesive polyester marking labels with global harmonized system (GHS) hazard pictograms.
 - .1 red border on white field,
 - .2 symbol height: 100 mm (4 in) minimum.

2.9 Signage

- .1 Rigid plastic signs, UV stabilized and suitable for indoor and outdoor installation, for surface mounting.
- .2 Graphic symbols:
 - .1 graphic image in accordance with WHIMS and ISO 7010,
 - .2 sign dimensions:
 - (a) indoors: 300 x 300 mm (12 in. x 12 in.)
 - (b) outdoors: 450 x 450 mm (18 in. x 18 in.)
- .3 Colours:
 - .1 Field and text colours in accordance with ANSI Z535.1

Information Type	Background Colour	Letter Colour	Primary Notification Text
General information	Blue	White	NOTICE
General Safety, Exiting	Green	White	---
Caution	Yellow	Black	CAUTION
Warning	Orange	Black	WARNING
Danger	Red	White	DANGER
Biological	Fluorescent Orange	Black	BIOHAZARD

3 EXECUTION

3.1 Equipment Identification

- .1 Where required:
 - .1 provided for equipment identified with number designations shown in equipment schedules, drawings, specifications, and/or equipment selection sheets.
 - .2 marked with equipment ID, service name, and power source using wording and numbering used in contract documents.
 - .3 for clarity, equipment identification nameplates are in addition to manufacturers plates.
- .2 Locate nameplates to be easily read, and fasten securely with mechanical fasteners. For pressure vessels, secure nameplates to equipment with high-tensile epoxy adhesive.
- .3 Do not paint over equipment manufacturer or field installed nameplates.
- .4 Provide metal standoffs on insulated equipment.

.5 Examples:

- .1 at equipment (fan, pump, etc.), illustrated for Normal Power:



- .2 at motor starter, adjustable frequency drive, and separate local disconnect, illustrated for Emergency Power:



3.2 Piping Identification - Except Non-Medical Gas Systems

- .1 Provide manufactured pipe markers of the following types based on area of the building:
- .1 self-adhesive type:
 - (a) indoor uninsulated piping,
 - (b) indoor insulated piping with PVC or smooth metal jackets,
 - .2 flexible coil-wrap:
 - (a) outdoor piping,
 - (b) indoor insulated piping with any type of jacket.
 - .3 Install self-adhesive markers on cleaned and prepared surfaces free of dirt and oil.
- .2 Install pipe markers in the following locations:
- .1 maximum every 15 m (50 ft) along length of pipe, except for natural gas and fuel oil,
 - .2 maximum every 6 m (20 ft) along length of pipe for natural gas and fuel oil,
 - .3 within 1 m (3 ft) of each side of barriers, floors and walls,
 - .4 within 1 m (3 ft) of and behind access doors ,
 - .5 within 1 m (3 ft) of piping termination point.
- .3 Marker colours and hazard identification:
- .1 Use the existing piping marker colour coding system for building additions and alterations.

3.3 Piping Identification - Medical Gas Systems

- .1 Provided identification markings on medical gas systems:
- .1 maximum every 6 m (20 ft) along length of pipe,
 - .2 before and after barriers, floors and walls,
 - .3 at each valve,

- .4 behind access doors,
- .5 inlet and outlet points including vents.

3.4 Valve Lockout Tags – Medical Gas Systems

- .1 Provide valve lockout tags at each valve which is not located in a zone control panel. Tags to be provided as Normally Open or Normally Closed as shown on drawings.

3.5 Piping Identification - Buried Piping

- .1 Provide tracer tape along entire length of pipe at a depth of:
 - .1 600 mm (2 ft) mm below top of grade for water piping,
 - .2 150 mm (6 in) above top of natural gas, propane, or fuel oil piping, and medical gas piping.
- .2 This tape is in addition to any required electrical tracing wire that may be required under other Specification sections or by legislation.

3.6 Ductwork identification

- .1 Paint stenciled letters showing;
 - .1 duct service,
 - .2 fan number, and
 - .3 arrows showing direction of flow,
- .2 Paint stencil markings at the following locations:
 - .1 exposed ducts at 15 m (50 ft) intervals in service rooms,
 - .2 exposed ducts at wall and floor penetrations in other than service rooms,
 - .3 concealed ducts above drywall-ceilings next to access doors, and
 - .4 concealed ducts above removable tile ceilings at wall and floor penetrations, and at 15 m (50 ft) intervals.
- .3 Stencil indication on prepared surfaces, and locate on both sides of any penetration.

3.7 Valve Identification

- .1 Provide valves with a numbered tag showing valve type and size, attached to valve stem or wheel handle with chain.
 - .1 Valve identification is not required at the following valves:
 - (a) inside fire hose cabinets,
 - (b) radiation heating units, unit heaters, or fixture stops,
 - (c) plumbing fixture service stops,
 - (d) within 4 m (12 ft) and in sight of equipment, fixtures, or apparatus that the valve controls provided there is no branch piping between the valve and equipment served,
 - (e) existing valves that are not provided under this project.
- .2 Identification information – manual valves:
 - .1 each valve tag to indicate fluid service, sequential valve number (unique for each service) including supply or return, location identifier, and normal operating position
 - .2 examples (colour coding shown for illustration):

Domestic Cold Water
Riser C/1
No. 12

Natural Gas
Boiler Plant
No. 2
Normally Closed

- .3 Identification information – automatic control valves:
- .1 provide valve tags for all automatic control valves except as follows:
 - (a) within sight of equipment that the valve controls.
 - .2 each valve tag to indicate fluid service, control function, control valve identification number,
 - .3 examples (colour coding shown for illustration):

Chilled Water
Constant Pressure
Differential Valve
CV-3

- .4 Provide a tag schedule for each system, designating valve numbers, fluid service, function, valve size, and location of each tagged item and normal operating position of each valve. Submit copies in original file format (Excel, Word) on two (2) removable mass storage devices.

3.8 Schedules

- .1 The following Schedules form part of this specification section.
 - .1 Schedule A: Piping Marker Colours and Hazard Labels

Schedule A – Piping Marker Colours and Hazard Labels

Fluid Service Category	Piping Services	Background Colour	Lettering Colour	GHS Hazard Symbol
Water	Potable (city) water, Non-potable water, Treated City Water, Sanitary, Storm Drainage, Chilled water, Condenser water, Cooling water, Heating water, Glycol heating or cooling water, Brine water, Boiler feedwater, Steam condensate	Green	White	None
Vapour from Water	Steam, Steam Vents	White	Black	None
Fire Protection Fluids	Sprinklers, Standpipe, Foam, Gaseous	Red	White	None
Combustible Liquids	Heating oil, Diesel, Lubrication oil, Hydraulic oil	Brown	White	None
Flammable Fluids	Natural Gas, Propane	Yellow	Black	None
	Gasoline	Yellow	Black	  
Compressed Air	Compressed Air, Instrument Air, Laboratory Air	Blue	White	None
Compressed Gases	Nitrogen, Helium, Carbon Dioxide	Grey	White	
Other Gases	Vacuum, Laboratory Vacuum, Plumbing Vents	Grey	White	None

Fluid Service Category	Piping Services	Background Colour	Lettering Colour	GHS Hazard Symbol
Oxidizing Fluids	Chlorine	Yellow	Black	
Toxic and Corrosive Fluids	HVAC chemical treatment, Acid Drain, Acid Vent Isotope Drain, Isotope Vent, Decontamination Drain and Tank	Orange	Black	

END OF SECTION

COMMON REQUIREMENTS FOR MECHANICAL INSULATION 20 07 11

1 GENERAL

1.1 Scope

- .1 Common requirements for insulation of mechanical services provided under Division 20 to 25 of the Work. The requirements of this specification section apply to separate specification sections for insulation of ductwork, equipment and piping.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 29 Common Hanger and Support Requirements for Piping
 - .2 20 07 13 Duct Insulation
 - .3 20 07 16 Equipment Insulation
 - .4 20 07 19 Piping Insulation
 - .5 20 05 29 Common Hanger and Support Requirements for Piping

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Ambient**: as applied to temperatures means the interior or outdoor air temperature at time of installation.
 - .2 **Coating**: light-consistency compound for indoor applications used in conjunction with reinforcing membrane, to provide either a breathable or vapour barrier finish to insulation.
 - .3 **Cold services**: means cold ductwork, equipment and/or equipment.
 - (a) **Cold ductwork**: mechanical ductwork with a service temperature greater than 1°C and up to and including 16°C (34°F to 61°F).
 - (b) **Cold equipment**: mechanical equipment with a service temperature of 16°C (61°F) or less,
 - (c) **Cold piping**: mechanical piping with a service temperature of 16°C (61°F) or less,
 - .4 **Concealed (services)**: mechanical services that are located: in the space above opaque suspended ceilings; within trenches not located in service rooms; within pipe and/or duct shafts; or in non-accessible chases and wall cavities.
 - .5 **Conditioned air**: air supplied from air handling units that heats, cools, dehumidifies, or humidifies the air.
 - .6 **Conditioned space**: an enclosed space or room that is heating, cooled, dehumidified and/or humidified.
 - .7 **Dual temperature services**: means dual temperature ductwork, piping and/or equipment that operates, at different times, at both hot and cold temperatures.
 - (a) **Dual temperature ductwork**: mechanical ductwork that operates at temperatures greater than 1°C and up to and including 38°C (34°F to 100°F), at different times or at different locations in the duct system and includes cooling systems with terminal reheat.

- (b) **Dual temperature equipment:** means mechanical equipment that operate, at different times, at cold equipment temperatures and at hot equipment temperatures.
 - (c) **Dual temperature piping:** mechanical piping that operate, at different times, at cold piping temperatures and at hot piping temperatures.
- .8 **Ductwork:** includes ducts, fans, air handling equipment casings, and plenums.
- .9 **Exposed (services):** mechanical services that are located in areas that are not "concealed" as defined above for concealed services. For greater certainty, the following locations are exposed services:
- (a) services in tunnels,
 - (b) services in space beneath raised floors.
 - (c) trenches located in service rooms.
- .10 **Finish covering:** a field-applied protective layer for insulation that provides an aesthetic finish but that may also provide mechanical-impact protection, weather-protective, moisture and/or vapour barrier protection.
- .11 **Hot services:** means hot ductwork, equipment and/or equipment.
- (a) **Hot ductwork:** mechanical ductwork with a service temperature greater than 28°C and up to and including 65°C (80 to 150°F) and does not have any mechanical cooling.
 - (b) **Hot equipment:** mechanical equipment with a service temperature 38°C (100°F) and greater.
 - (c) **Hot piping:** mechanical piping at service temperatures as shown in Table 1 of specification section 20 07 19.
- .12 **Jacket:** a factory-applied material used to contain insulation and may function as a vapour barrier. Jacketed insulation may also be further protected by covering with a finish covering.
- .13 **Mastic:** heavy-consistency waterproof compound for outdoor applications, used in conjunction with reinforcing membrane that remains adhesive and generally pliable with age, to provide either a breathable or vapour barrier finish for outdoor insulation.
- .14 **Mechanical services:** equipment, piping, ductwork and related accessories provided under Division 20 to 25 of the Work.
- .15 **Outdoor (services):** mechanical services located outside of the building envelope including services located beneath overhangs, located in unconditioned soffits, or exposed to any outdoor condition including temperature, sun exposure, or precipitation.
- .16 **Pure water:** water that has been treated with filtration equipment, including but not limited to reverse osmosis, deionization, ultra-filtration, ultra-violet, distillation or any combination of such or similar equipment, to achieve water quality significantly free of impurities.
- .17 **Service temperature:** the highest (for hot mechanical services) or the lowest (for cold mechanical services) gas or vapour design operating temperature, or the liquid supply operating temperature.
- .18 **Surface temperature:** for the purpose of this specification, has the same meaning as service temperature.
- .19 **Unconditioned (space):** rooms or spaces that are not conditioned spaces, and includes ceiling spaces which are not part of a ceiling return air plenum system.
- .20 **Wet area:** spaces subject to high humidity or where mechanical services may be exposed to direct contact with water, including not limited to: pools, shower rooms, tub rooms, medical device reprocessing, dishwashers, sterilizers, cart-washing, vehicle washing, and emergency showers.

1.4 Applicable Codes and Standards

.1 Installation codes and standards:

- .1 NFPA 90-A Installation of Air-Conditioning and Ventilating Systems
- .2 ASHRAE/IES 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings
- .3 NFPA 255 Test of Surface Burning Characteristics of Building Materials

.2 Product standards:

- .1 CAN/ULC-S102 Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies
- .2 CAN/ULC-S102.2 Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies
- .3 CAN/ULC-S114 Standard Method of Test for Determination of Non-Combustibility in Building Materials
- .4 ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- .5 ASTM B240 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
- .6 ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot-Plate Apparatus
- .7 ASTM C411 Standard Test Method for Hot Surface Performance of High Temperature Thermal Insulation
- .8 ASTM C449 Standard Specification for Mineral Fibre Hydraulic-Setting Thermal Insulation and Finishing Materials
- .9 ASTM C518 Standard Test Method for Steady State Thermal Transmission Properties by Means of Heat Flow Meter Apparatus
- .10 ASTM C533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
- .11 ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- .12 ASTM C547 Standard Specification for Mineral Fiber Pipe Insulation
- .13 ASTM C552 Standard Specification for Cellular Glass Thermal Insulation
- .14 ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- .15 ASTM C591 Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
- .16 ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
- .17 ASTM C795 Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- .18 ASTM C1126 (Gr.1) Standard Specification for Faced and Unfaced Rigid Cellular Phenolic Thermal Insulation

.19 ASTM C1290	Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
.20 ASTM C1393	Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks
.21 ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
.22 CGSB 51-GP-52MA	Vapour Barrier, Jacket and Facing Material for Pipe, Duct, and Equipment Thermal Insulation.
.23 CGSB 51.53-95	Poly(Vinyl Chloride) Jacket Sheeting, for Insulated Pipes Vessels and Round Ducts.

1.5 Qualified Tradespersons

- .1 Work to be performed by a recognized specialist firm with an established reputation in this field.

Standard of Acceptance

- Custom Insulation Systems
- White & Greer Co Ltd
- Thermax Environmental Inc.
- ICON Insulation Inc.

1.6 Submittals

- .1 Submit manufacturer catalogue cut-sheets for the following materials in one bound submission;
 - .1 insulation,
 - .2 coatings, mastics, and sealants,
 - .3 reinforcing membranes,
 - .4 finish covering materials,
 - .5 PVC fitting covers.
- .2 Submit an installation detail drawing indicating how insulation, coatings and vapour barriers are applied in general, and specifically for pipe fittings and equipment insulation.

1.7 Quality

- .1 Manufacturers and products are listed in this section to establish quality and manufacturing standards. Products from other manufacturers with explicitly similar characteristics may be acceptable but must be submitted as an alternative product submission.

2 PRODUCTS

2.1 General Requirements

- .1 Adhesives, coatings, finish coverings, lagging, sealers, and tapes:
 - .1 maximum flame spread rating of 25 to CAN/ULC-S102/102.2 or ASTM 84.
 - .2 maximum smoke developed rating of 50 to CAN/ULC-S102/102.2 or ASTM 84.
 - .3 exception: vapor barrier mastics on mechanical services located outside of the building.

2.2 Adhesives, Fasteners, and Tape

.1 Contact bond cement:

- .1 for quick setting for metal surfaces.
- .2 Volatile Organic Content: maximum 80 g/L.

Standard of Acceptance

- Bakor - fig. 220-05
- Foster – fig. Drion 85-75

.2 Adhesive for flexible closed cell foam insulation:

- .1 Volatile Organic Content: maximum 80 g/L.

Standard of Acceptance

- Armacell - Armaflex 520 BLV
- Armacell - Armaflex. Low VOC Spray Contact Adhesive

.3 Lap seal adhesive:

- .1 for joints and lap sealing of vapour barriers.
- .2 Volatile Organic Content: maximum 250 g/L.

Standard of Acceptance

- Bakor - fig. 220-05
- Childers - fig. CHIL-STIX FRN CP-82

.4 Fibrous insulation adhesive:

- .1 Volatile Organic Content: maximum 250 g/L

Standard of Acceptance

- Childers - fig. CHIL-STIX FRN CP-82
- Foster - fig. 85-70

.5 Vapour barrier tape:

- .1 colour matched and foil faced
- .2 listed to UL 181A.

Standard of Acceptance

- Johns Manville - fig. Zeston Z-Tape
- MacTac Canada Ltd – fig. Vinyl Scrim or Foil Scrim Kraft
- Compac Corp.
- Fattal Canvas Inc. - fig. Insultape

.6 Weld pins, studs, clips and washers:

- .1 Galvanized steel or copper plated steel, stainless steel or aluminium to match ductwork material.
- .2 Attachment method:
 - (a) welded for outdoor ducts,
 - (b) welded for indoor ducts,
 - (c) self-adhesive base may be used for vertical surfaces of rectangular ducts.

Standard of Acceptance

- Midwest - fig. Fasteners
- Jordahl - fig. Studwelding

.7 Staples:

- .1 Monel, flare type, minimum size 12 mm (½ in).

.8 Tie wire:

- .1 1.6 mm (16 ga) stainless steel with twisted ends.

.9 Caulking for sheetmetal finish covers (outdoor use only)

- .1 fast-drying, aluminum colour finish, flexible butyl elastomer based vapour barrier sealant.

Standard of Acceptance.

- Foster - fig. 95-44

2.3 Coatings and Reinforcing Membranes

.1 Reinforcing membrane:

.1 synthetic fibre:

- (a) Leno weave,
- (b) indoor and outdoor use.

Standard of Acceptance

- Foster - fig. Mast-A-Fab

.2 glass-fibre fabric:

- (a) indoor use.

Standard of Acceptance

- Childers - fig. Chil-Glas #5/#10

.3 glass-fibre fabric for use with elastomeric closed cell foam:

- (a) indoor use.

Standard of Acceptance

- Childers - fig. Chil-Glass #10

.2 Breather coating - Indoors:

- .1 for breather coatings and lagging adhesive,
- .2 Volatile Organic Content: maximum 50 g/L
- .3 white in colour,

Standard of Acceptance

- Childers- fig. CP-50A HV2
- Foster - fig. 30-36

.3 Breather mastic - Outdoors:

- .1 for breather coatings and lagging adhesive,
- .2 abrasion resistive, flexible,
- .3 UV stabile,

.4 grey in colour.

Standard of Acceptance

- Childers - fig. Vi-Cryl CP-10/11
- Foster - fig. 35-00 / 45-00
- Bakor - fig. 120-10

.4 Vapor barrier coatings - Indoors:

.1 Volatile Organic Content: maximum 50 g/L.

.2 for vapor barrier coatings and lagging adhesive except for elastomeric closed cell foam,

- (a) permeance rating 0.02 perms maximum,
- (b) white in colour

Standard of Acceptance

- Childers - fig. Chil Perm CP-34/35
- Foster - fig. 30-80, 30-90

.5 Vapor barrier mastic - Outdoors:

.1 for vapor barrier coatings and lagging adhesive,

.2 asphalt cutback,

.3 permeance rating 0.02 perms maximum,

.4 grey in colour.

.5 for outdoor use only.

Standard of Acceptance

- Childers - fig. Chil-Pruf CP-22
- Foster - fig. 60-25/60-26

.6 Vapour barrier coatings – elastomeric foam insulation:

.1 for indoor and outdoor use,

.2 water bases sealer/finishing coat, water and UV resistant.

.3 white in colour.

Standard of Acceptance

- Armacell - fig. ArmaFlex WB Finish

2.4 Insulation Finishing Cement

.1 Mineral fibre, hydraulic-setting insulation cement, to ASTM C449

.2 Temperature rating: 650°C (1200°F)

Standard of Acceptance

- Johns Manville - fig. CalCoat-127
- Ramco Insulation - fig. Ramcote 1200 (PKI Quick Cote)

2.5 Field Applied Coverings

.1 Fabric finish covering:

.1 plain weave cotton fabric at 220 g/m² (6 oz/sq yd), treated with fire retardant lagging adhesive, or Issued For Tender

- .2 re-wettable fiberglass lagging fabric with water activated self-adhesive.
- .3 suitable for field painting.

Standard of Acceptance

- Fattal - fig. Thermocanvas
- Clairmont - fig. Diplag 60
- Newtex - fig. Zetex Rewettable

.2 PVC finish covering:

- .1 PVC sheeting, or pre-cut and rolled sheeting to suit OD of pipe and insulation, with UV inhibitor for white colour product,
 - (a) minimum thickness:
 - i) indoors: 0.5 mm (20 mil-in.),
 - ii) outdoors: 0.8 mm (30 mil-in.),
 - (b) maximum operating temperature: 66°C (150°F) at the material,
 - (c) listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .2 PVC fitting covering with integral insulation inserts:
 - (a) minimum 0.5 mm (20 mil-in) thickness,
 - (b) pre-molded fitting covers, one or two piece,
 - (c) maximum operating temperature: 66°C (150°F) at the material,
 - (d) self-sealing longitudinal joints or field applied sealer adhesive,
 - (e) listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .3 colour: white
- .4 foam-glass or glass-fibre insulation molded insert, including for elbows, tees, valves, end-caps, and mechanical pipe couplings,
- .5 multiple layers where required for thicker pipe insulation thicknesses.
- .6 pressure sensitive, colour matching vinyl tape.

Standard of Acceptance

- Johns Manville - fig. Zeston 2000
- Proto PVC - fig. LoSMOKE
- ACWIL Insulations
- Sure Fit Systems

.3 Metal finish covering:

- .1 straight pipe, duct or plenum:
 - (a) stucco embossed aluminum 3105 or 3003 to ASTM B-209, not less than 0.45 mm (0.016 in) thick sheet, with integral 3 mil polyfilm moisture barrier on the interior surface, lock-forming quality,
 - (b) stainless steel type 304 to ASTM A-240, not less than 0.25 mm (0.010 in) thick sheet, lock-forming quality;
 - i) stucco embossed,
 - ii) 0.19 mm (3/16 in) corrugated.
- .2 fittings:

- (a) custom made swaged ring or lobster back covers on bends and die shaped fitting covers over pipe fittings, round duct fittings, valves, strainers, flanges, and grooved couplings.

.3 bands:

- (a) 12 mm (½ in) wide stainless steel with mechanical fasteners.

Standard of Acceptance

- Alcan Canada Products - fig. Thermaclad Type 1
- Childers Products Inc. - fig. Fab Straps

.4 Protective finish for elastomeric cellular foam insulation

.1 indoors and outdoors:

Standard of Acceptance

- Armaflex WB Finish

2.6 Insulation

- .1 Refer to specification sections for duct, equipment, and piping insulation.

3 EXECUTION

3.1 General Requirements

- .1 Apply insulation after pressure and leakage testing is completed and accepted, and heat tracing (if any) is installed.
- .2 Surfaces to be clean and dry before application of insulation.
- .3 Store and use adhesives, mastics, and insulation cements at ambient temperatures and conditions recommended by the product manufacturers.
- .4 Do not apply insulation on chrome plated surfaces of piping, valves, fittings, and equipment.
- .5 Cut and bevel insulation around nameplates and pressure vessel certification stamps, seals or similar markings.
- .6 Neatly finish insulation at supports, protrusions, and interruptions.
- .7 Where insulation media is exposed, seal the insulation with reinforced vapor barrier or breather coating or mastic.

3.2 Installation of Insulation

- .1 Refer to specification sections for duct, equipment, and piping insulation.

3.3 Sealing of Insulation – General Requirements

- .1 The following requirements apply to all mechanical insulation unless otherwise specified in each mechanical service insulation specification section. Refer to separate specifications for specific sealing requirements for ductwork, equipment and piping insulation.
- .2 Apply sealer coatings and mastic in accordance with the following:
 - .1 use breather coating/mastics for hot services:
 - .2 use vapour barrier coating/mastic for cold and dual temperature services:
 - .3 only use mastics on outdoor installations.

- .4 apply mastics and coatings when ambient temperature is above 4°C (40°F), unless manufacturer's instructions permit colder ambient installation conditions.
- .3 Maintain integrity of vapour barrier through sleeves, around fittings and at hangers and supports.

3.4 Insulation Finish Coverings

- .1 Where required to be provided by other mechanical insulation specification sections, install protective finish coverings in accordance with the following.
- .2 Install protective finish coverings on insulation after breather and vapor barrier sealing is completed.
- .3 For hot services that are exposed in wet areas, secure and seal coverings in accordance with the requirements for cold and dual temperature services.
- .4 Cut finish covering materials to allow 50 mm to 100 mm (2 in to 4 in) overlaps onto adjacent sheets. On vertical services, arrange circumferential overlaps to be on the lower end of each cover section.
- .5 PVC finish covering:
 - .1 Adhesives and sealers to be compatible with PVC material.
 - .2 Hot services;
 - (a) secure sheeting with colour matched tape around circumference, at least two places per section of sheet, and by stapling longitudinal and circumferential edges,
 - (b) except in wet areas, do not seal major joint edges with vapour barrier tape,
 - (c) seal PVC fitting covers at throat and heel seams by stapling and secure over adjacent insulation covers by banding or taping ends to adjacent finish covering with colour matched tape.
 - (d) Install PVC covers in accordance with the requirements for cold and dual temperature services.
 - .3 Cold and dual temperature services:
 - (a) seal longitudinal edges with vapor barrier coating adhesive or colour matched vapour barrier tape for the full length and depth of the overlap,
 - (b) seal circumferential butt edges of PVC fitting covers with reinforced vapour barrier coating adhesive extending over adjacent pipe insulation section with an overlap of at least 50 mm (2 in),
 - (c) seal PVC fitting covers at throat and heel seams by solvent bonding and secured over insulation with reinforced vapor barrier coating overlapping adjacent service insulation a minimum of 50 mm (2 in),
 - (d) neatly finish exposed edges with vapour barrier sealant/mastic.
- .6 Metal finish covering:
 - .1 use stucco embossed metal finish covers on round surfaces with diameter of 2.4 m (8 ft) and smaller; refer to applicable duct, equipment and piping specification sections for metal type.
 - .2 use corrugated stainless steel metal finish covers on flat surfaces, and on round surfaces with diameters greater than 2.4 m (8 ft).
 - .3 apply metal finish coverings over mechanical services, with a 60 mm (2-1/2 in) overlap,
 - .4 use lock-on systems or secure sheeting with bands 450 mm (18 in) apart.
 - .5 make-up curved surfaces with custom made swaged ring or lobster back covers.

- .6 for indoor mechanical services;
 - (a) seal cover joints for cold and dual temperature services with clear or colour-matched calking.
- .7 on outdoor mechanical services;
 - (a) seal cover joints for cold and dual temperature services with clear or colour-matched calking to permit expansion of metal finish covers.

3.5 Mechanical Damage Protection - Indoors

- .1 Protect visible pipe insulation extending up through a floor sleeve at the floor line with 1.2 mm (18 ga) thick stainless steel protection shield approximately 100 mm (4 in) high, secured to floor slab. Conceal fastenings by use of a floor plate.
- .2 For piping systems using finishes, this protection cover is in addition to the specified pipe finish cover.

3.6 Field Quality Control

- .1 The Consultant reserves the right to have protective finish coverings removed on up to 1% of all cold service and dual temperature service surfaces, fittings, flanges, couplings, valves, and ductwork/pipeline accessories to review the installation of the insulation, at no additional cost.
- .2 If insulation sealing is found to be incorrect at any one sampled location, remove the protective finish on all fittings, flanges, couplings, valves, and pipeline accessories for review, at no additional cost.
- .3 Repair defective insulation sealing and replace protective coverings at no additional cost.

End of Section

**DUCTWORK INSULATION
 20 07 13**

1 GENERAL

1.1 Scope

- .1 Provide insulation, coatings, finish coverings and mechanical protection for ducts, casing, plenums, fans and associated equipment.
- .2 insulation is not required on factory insulated casings and/or over acoustically lined ductwork except as otherwise shown.
- .3 Conform to specification section 20 07 11 for common requirements for mechanical insulation.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 07 11 Common Requirements for Mechanical Insulation
 - .2 23 31 13 Metal Ducts

2 PRODUCTS

2.1 General Requirements

- .1 Insulation, adhesives, coatings, finish coverings, lagging, sealers, and tapes:
 - .1 maximum flame spread rating of 25 to CAN/ULC-S102/102.2 or ASTM 84,
 - .2 maximum smoke developed rating of 50 to CAN/ULC-S102/102.2 or ASTM 84,
 - .3 exception: vapor barrier mastics on mechanical services located outside of the building.

2.2 Ductwork Insulation

- .1 Type D-1 (glass-fibre roll blanket):
 - .1 flexible glass-fibre blanket, formaldehyde-free to ASTM C1290,
 - .2 density: 12 kg/m³ (0.75 pcf),
 - .3 service temperature with jacketed: up to 65°C (150°F),
 - .4 foil skim kraft ("FSK") jacket of aluminium foil reinforced with glass fibre yarn, and laminated to kraft paper,
 - .5 vapour transmission: maximum 0.02 perms to ASTM E96 Procedure A,
 - .6 listed to CAN/ULC-S102/S102.2 or ASTM E84,
 - .7 minimum RSI values at a mean temperature of 24°C (75°F) at the pre-installed nominal insulation thickness:

Nominal Thickness mm (in)	RSI m ² .°C/W	Nominal Thickness mm (in)	RSI m ² .°C/W
25 (1)	0.53	55 (2.2)	1.06

40 (1.5)	0.74	110 (4.4)	2.11
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Standard of Acceptance

- Johns Manville - Microlite FSK Duct Wrap
- Owens Corning - SOFTR Duct Wrap
- Knauf Fibreglass - Atmosphere Duct Wrap

.8 Same as above except provided with a PSK (polypropylene-scrim-draft) vapour barrier jacket.

Standard of Acceptance

- Johns Manville - Microlite Black PSK

.2 Type D-2 (rigid glass fibre board):

- .1 rigid glass-fibre insulation board to ASTM C612,
- .2 density:
 - (a) indoors: 48 kg/m³ (3.0 lb./ft³),
- .3 service temperature:
 - (a) unfaced board: up to 232°C (450°F),
 - (b) faced board: up to 65°C (150°F),
- .4 foil skim kraft ("FSK") jacket of aluminium foil reinforced with glass fibre yarn, and laminated to kraft paper,
- .5 vapor transmission: maximum 0.02 perms,
- .6 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .7 minimum RSI values at a mean temperature of 24°C (75°F) at the specified insulation thickness:

Nominal Thickness mm (in)	RSI m ² ·°C/W	Nominal Thickness mm (in)	RSI m ² ·°C/W
25 (1)	0.76	50 (2)	1.51
40 (1-1/2)	1.14	75 (3)	2.27

Standard of Acceptance

- Johns Manville - Manville 814 Spin-Glas
- Owens Corning - 703 Board
- Knauf Fiberglass - Insulating Board

.3 Type D-3 (mineral fibre board, high temperature)

- .1 rigid-board, mineral fibre to ASTM C411,
- .2 density: 145 kg/m³ (9.1 lb./ft³),
- .3 service temperature: up to 700°C (1292°F),
- .4 listed to CAN/ULC-S102/S102.2 or ASTM E84,

.5 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
100	0.044	700	0.158

Standard of Acceptance

- Roxul - ProRox SL 980

3 EXECUTION

3.1 Applicable Systems to be Insulated

- .1 Insulate ductwork, plenums, casings and equipment in accordance with the following, and of the insulation type and thickness in accordance with Table 1 at the end of this specification section.
- .2 Externally insulate casings and equipment:
 - .1 air handling units producing conditioned supply air,
 - .2 air handling units conveying exhaust air downstream of heat recovery devices,
 - .3 free-standing supply air fans (not enclosed in a casing or plenum).
- .3 Externally insulate ductwork and plenums:
 - .1 cold and dual temperature ductwork conveying conditioned supply air including downstream of reheat coils,
 - .2 hot ductwork conveying conditioned supply air up to the space served but not within the space itself,
 - .3 unconditioned supply air ducts and plenums located in unheated spaces,
 - .4 return air and exhaust air ducts and plenums in unheated spaces,
 - .5 outside air intake ducts and plenums,
 - .6 exhaust air plenums at point of discharge to outside of building,
 - .7 exhaust air ducts and plenums downstream of heat recovery devices,
 - .8 exhaust air ducts between exhaust air damper and point of discharge to outside of building,
 - .9 mixed air plenums and ducts;
 - (a) for recirculating type ventilation systems without cooling coils, terminate outside air intake insulation 300 mm (12 in) downstream of mixing plenum,
 - .10 150 mm (6 in) entering and leaving length overlap of acoustically lined ductwork,
 - .11 sheet metal blank-off plates behind unused sections of air intake louvres.
- .4 External insulation is not required on:
 - .1 casings, ducts or plenums which have been lined with acoustic insulation, except as described above,
 - .2 ducts, plenums, casings and freestanding supply fans conveying unconditioned air,

- .3 portions of intake ducts or plenums, unit casings and conditioned air plenums which are of double wall insulated construction,
- .4 factory insulated flexible connectors (ducts),
- .5 factory insulated air handling units,
- .6 for non-recirculating make-up air type ventilation systems with a supply air temperature less than 27°C (80°F),
 - (a) terminate casing insulation 300 mm (12 in) downstream of heating coil or heating unit, and
 - (b) insulation is not required on the supply ductwork.

3.2 Installation of Rigid Insulation - Indoors

- .1 Attach insulation fastener pins, studs and clips to all surfaces of ducts, casings, plenums and fans, at approximately 300 mm (12 in) centers, each direction, but not less than two (2) rows per duct. Attachment method:
 - .1 welded type for indoor ducts,
 - .2 self-adhesive base type may be used for vertical surfaces of rectangular ducts.
- .2 Install rigid board insulation with joints staggered and tightly butted and no visible gaps. Install horizontal boards to overlapping over vertical boards.
- .3 Secure rigid insulation by impaling on insulation fastener pins, apply speed washers and cut off excess pin length flush with speed washer. Cover washers with vapour barrier tape extending at least 50 mm (2 in) beyond the washer.
- .4 Where space restrictions do not permit the use of mechanical fasteners, secure the insulation with 100% coverage of contact adhesive along with stainless steel banding on 300 mm (12 in) centers, with a band within 50 mm (2 in) of each duct corner.
- .5 Neatly finish insulation at supports, protrusions, and interruptions.
- .6 Apply colour matched vapour barrier tape neatly and firmly to all joints, including outside and inside corner joints, and at any exposed ends of insulation and cuts or damage to the insulation jacket. Alternatively, apply two heavy coats of applicable sealer coat and with reinforcing membrane. Extend tape or coating at least 50 mm (2 in) on each side of joint, exposed ends of insulation or repairs to insulation jacket.

3.3 Installation of Flexible Insulation – Indoors

- .1 On rectangular ducts 600 mm (24 in) and wider, and round ducts 450 mm (18 in) and wider, attach mechanical fastener pins, studs and clips to the bottom exterior surface of the duct at approximately 300 mm (12 in) centers, each direction, but not less than two (2) rows per duct. For round ductwork, the bottom of the duct is measured as being half the circumference of the duct.
- .2 Except for flexible connectors, cut flexible insulation to required circumferential length and pull-out to final installed thickness in accordance with manufacturer instructions, and to overlap insulation 50 mm (2 in) on each lap joint, and tightly butt end edges together.
- .3 For flexible connectors, apply insulation to bare (uninsulated) supply flexible connectors as follows:
 - .1 remove insulation to create a minimum 50 mm (2 in.) wide lap for both the longitudinal joint and the circumferential joint,
 - .2 cut insulation to width to provide a slightly compressed longitudinal butt joint; do not pull out insulation,

- .3 secure longitudinal and circumferential joints with staples through the laps, and then apply vapour barrier tape over joints to create a vapour barrier seal,
 - .4 secure the ends of the insulation with vapour barrier tape to the rigid duct insulation,
 - .5 secure the ends of the insulation at the diffuser or grill with a Nylon tie-wrap over the diffuser/grille spigot and recover with vapour barrier tape to fully seal end of insulation to the diffuser/grille.
- .4 Secure flexible insulation by:
- .1 impaling on mechanical fastener pins and secure with speed washers, and either;
 - (a) secure insulation with stainless steel wire or stainless steel banding on 300 mm (12 in) centers, or by stapling laps, or
 - (b) secure insulation with 100% insulation adhesive coverage.
 - .5 Cut off excess pin length flush with speed washer. Cover washers with vapour barrier tape extending at least 50 mm (2 in) beyond the washer.
 - .6 Neatly finish insulation at supports, protrusions, and interruptions.
 - .7 Apply colour matched vapour barrier tape neatly and firmly to all joints, including outside and inside corner joints, and at any exposed ends of insulation and cuts or damage to the insulation jacket. Alternatively, apply two heavy coats of applicable sealer coat and with reinforcing membrane. Extend tape or coating at least 50 mm (2 in) on each side of joint, exposed ends of insulation or repairs to insulation jacket.

3.4 Insulation of Fittings, Flanges and Accessories

- .1 Cut and miter rigid insulation at elbows and fittings and attach to ductwork with mechanical fasteners as specified for ducts, and in addition secure insulation with 50% coverage of adhesive.
- .2 At junctions between external insulation and acoustically lined ducts, overlap external insulation 300 mm (12 in) over acoustically lined ducts.
- .3 Insulate flanges, support angles and standing seams with 100 mm (4 in) wide overlapping strips of insulation matching adjacent ductwork and of same thickness, and seal with two coats of breather mastic with reinforcing membrane.

3.5 Sealing Insulation - Hot Ductwork

- .1 Seal hot ductwork insulation in accordance with specification section 20 07 11 and/except as specified herein.
- .2 Indoor installation (except wet areas):
 - .1 apply vapour barrier tape to butt joints, overlapping by at least 50 mm (2 in) each side,
 - .2 do not tape longitudinal lap seams except as required to secure the insulation.
- .3 Indoor installations – wet areas:
 - .1 apply vapour barrier tape to:
 - (a) all longitudinal lap seams and butt edges,
 - (b) 100% coverage of insulation at pipe joints, fittings, couplings, etc.
 - (c) over insulation fasteners including pins/washers and staples.

3.6 Sealing Insulation - Cold and Dual Temperature Ductwork

- .1 Seal cold and dual temperature ductwork insulation in accordance with specification section 20 07 11 and/except as specified herein.
- .2 Indoor installation (except wet areas):
 - .1 tightly seal insulation lap seams and butt joints, using factory lap seams or field-fabricated lap seams and butt strips,
 - .2 apply [vapour barrier tape][vapor barrier coating with reinforcing membrane] to all corners, lap edges and butt edges, overlapping joint by minimum 50 mm (2 in) each side,
 - .3 cover insulation pin/washer fastener penetrations including staples with [vapour barrier tape] [vapour barrier coating with reinforcing membrane], overlapping the fasteners by a minimum of 50 mm (2 in) in all directions.

3.7 Insulation Finish Covering

- .1 Provide insulation protective finish coverings selected in accordance with Table 2 at the end of this specification section and installed in accordance with specification section 20 07 11 and/except as specified herein.
- .2 Not applicable.

3.8 Mechanical Damage Protection - Indoors

- .1 Protect exposed insulated ductwork from floor level up to a height of 1200 mm (4 ft) above the floor with 0.9 mm (20 ga.) galvanized steel jacket, with riveted longitudinal seams and mechanically fastened to the floor with countersunk stainless steel screws.
- .2 Where waterproof floor sleeves are required, the floor sleeve may be combined with this requirement.

3.9 Insulating and Finishes Tables

- .1 The insulating and finishing tables follow:
 - .1 Table 1 - Ductwork, Insulation Type and Thickness
 - .2 Table 3 - Ductwork Insulation Protective Finishes.

**Table 1:
 Ductwork Insulation Type and Thickness**

Duct Nominal Air Temperature	Location	Equipment Description	Insulation Type	Insulation Thickness mm (in) [Note 1]
5°C to 65°C (40 to 150°F)	Indoors	Air handling unit casings and plenums, Free standing supply fans	D-2	50 (2)
		Rectangular ducts and plenums – exposed or concealed	D-2	25 (1)
		Rectangular ducts - concealed	D-1	25 (1)
	Round and Oval ducts - exposed			
	Unconditioned Space	Rectangular ducts and plenums	D2	40 (1-1/2)
			D1	55 (2.2)
		Round and Oval ducts	D1	55 (2.2)

.... continued on next page

**Table 1: (continued)
Ductwork Insulation Type and Thickness**

Duct Nominal Air Temperature	Location	Equipment Description	Insulation Type	Insulation Thickness mm (in) [Note 1]
-40 to +40°C (-40 to 104°F)	Indoors	Plenums and Casings – Air Intakes	D2	Two layers 50 (2)
-10 to +40°C (14 to 104°F)	Indoors	Plenums and Casings – Exhaust	D2	50 (2)
5 to 16°C	Indoors	Drain Pans	D2	1 (25)

Notes:

[1] Type D-1 flexible duct insulation thickness is “out of box” before installation.

[2] Insulation thickness may be provided by two layers, so that the total insulation thickness “out of the box” is equal to or greater than the specified thickness.

[3] Flexible duct may be used only on the rounded sides of flat oval ducts.

**Table 2:
Ductwork Insulation Protective Finish Coverings**

Location	Exposed/ Concealed	System/ Space	Protective Finish Covering
Indoors	Concealed	All	None
	Exposed	Service Rooms	Metal
		Public Spaces	Metal
Outdoors	Any	All	Metal

End of Section

PIPING INSULATION 20 07 19

1 GENERAL

1.1 Scope

- .1 Provide insulation, coatings, finishing coverings and mechanical protection of piping, valves, fittings, and pipeline accessories.
- .2 Conform to Specification section 20 07 11 for common requirements for mechanical insulation.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other Specification sections, the work under this section directly integrates with or refers to the following Specification sections:
 - .1 20 05 29 Common Hanger and Support Requirements for Piping
 - .2 20 07 11 Common Requirements for Mechanical Insulation

2 PRODUCTS

2.1 General Requirements

- .1 Insulation, adhesives, coatings, finish coverings, lagging, sealers, and tapes:
 - .1 maximum flame spread rating of 25 to CAN/ULC-S102/102.2 or ASTM 84.
 - .2 maximum smoke developed rating of 50 to CAN/ULC-S102/102.2 or ASTM 84.
 - .3 exception: vapor barrier mastics on mechanical services located outside of the building

2.2 Pipe Insulation

- .1 Type P-1 (molded glass-fibre):
 - .1 factory molded rigid glass-fibre to ASTM C547,
 - .2 nominal pipe size: NPS 24 and smaller,
 - .3 service temperature, jacketed: -18°C (0°F) to 65°C (150°F),
 - .4 jacket: all-service-jacket (ASJ) of white kraft paper bonded to aluminum foil, reinforced with glass fibre yarn, and laminated to an interior kraft paper face,
 - .5 vapor transmission: maximum 0.02 perms to ASTM E96,
 - .6 listed to CAN/ULC-S102/S102.2 or ASTM E84,
 - .7 reduced environmental impact feature of either: bio-based binders, 25% minimum recycled glass content, and/or paper-free ASJ jacket material,
 - .8 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
24	0.034	93	0.040

Standard of Acceptance

- Johns Manville - fig. Micro-Lok HP (25% recycled content)
- Owens Corning - fig. Fiberglas Evolution (paper-free ASJ)
- Knauf Fiberglass - fig. Earthwool 1000 Ecosse (bio-based binders)

.2 Type P-2 (semi-rigid glass-fibre roll):

- .1 glass fibre semi-rigid roll insulation for tanks and pipes, to ASTM C1393 or ASTM C177,
- .2 glass-fibre oriented to maintain uniform thickness when installed on round surfaces,
- .3 density: 40 kg/m³ (2.5 lb/ft³),
- .4 nominal pipe size: NPS 14 and larger,
- .5 service temperature with jacket: up to 65°C (150°F),
- .6 jacket: all-service-jacket (“ASJ”) of white kraft paper bonded to aluminum foil, reinforced with glass fibre yarn, and laminated to an interior kraft paper face,
- .7 vapor transmission: maximum 0.02 perms to ASTM E96,
- .8 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .9 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
24	0.035	93	0.046

Standard of Acceptance

- Johns Manville - fig. Micro-Flex Pipe and Tank Wrap
- Owens Corning - fig. Fiberglas Pipe and Tank
- Knauf Fibreglass - fig. KwikFlex Pipe and Tank

.3 Type P-3 (molded mineral fibre):

- .1 factory molded mineral fibre to ASTM C547,
- .2 density: 128 kg/m³ (8.0 lb/ft³),
- .3 nominal pipe size: NPS 30 and smaller,
- .4 service temperature: up to 650°C (1200°F),
- .5 jacket: integral foil skim-kraft (FSK) jacket of aluminium foil reinforced with glass fibre yarn, and laminated to kraft paper,
- .6 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .7 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
38	0.036	149	0.049

Standard of Acceptance

- Rockwool - fig. ProRox PS 960

- Johns Manville - fig. MinWool-1200
- Industrial Fiber-Tek - fig. IFT 1200 Pipe

.4 Type P-4 (molded mineral fibre, high temperature):

- .1 factory molded mineral fibre, high temperature, to ASTM C547,
- .2 density: 145 kg/m³ (9.1 lb/ft³),
- .3 nominal pipe size: NPS 6 and larger,
- .4 service temperature: up to 760°C (1400°F),
- .5 jacket: none,
- .6 compressive strength: 53 kPa (8 psi) at 10% compression,
- .7 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .8 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
38	0.039	149	0.049

Standard of Acceptance

- Rockwool - fig. ProRox PS 980

.5 Type P-5 (cellular glass):

- .1 fabricated pipe and fitting shapes, cellular glass to ASTM C552,
- .2 density: 120 kg/m³ (7.5 lb/cu ft),
- .3 minimum compressive strength perpendicular to pipe surface: 620 kPa (90 psi),
- .4 nominal pipe size: NPS 16 and smaller,
- .5 service temperature: -268°C (-450°F) to 480°C (900°F),
- .6 minimum compressive strength perpendicular to pipe surface: 620 kPa (90 psi),
- .7 jacket: none,
- .8 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .9 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
10	0.040	24	0.042

Standard of Acceptance

- Owens Corning - fig. Foamglas

.6 Type P-6 (elastomeric foam plastic):

- .1 flexible elastomeric closed cell foam, tubular with self-sealing seams, to ASTM C534,

- .2 nominal pipe size: NPS 2 and smaller,
- .3 service temperature: -183°C (-297°F) to 82°C (183°F),
- .4 jacket: none,
- .5 manufacturer specific sealer/adhesive,
- .6 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .7 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
24	0.035	32	0.037

Standard of Acceptance

- Armacell - fig. AP Armaflex SS Pipe Insulation
- KFlex USA - fig. Insul-Tube

.7 Type P-7 (calcium silicate):

- .1 fabricated pipe and fitting shapes, calcium silicate, asbestos-free, to ASTM C533 Type I,
- .2 density: 232 kg/m³ (14.5 lb/cu ft),
- .3 minimum compressive strength perpendicular to pipe surface: 620 kPa (90 psi),
- .4 integral corrosion inhibitor to reduce under insulation corrosion,
- .5 nominal pipe size: NPS 4 to NPS 24,
- .6 service temperature: 20 to 649°C (70 to 1200°F).
- .7 jacket: none,
- .8 listed to CAN/ULC-S102/S102.2 or ASTM E84,
- .9 non-combustible to CAN/ULC-S114 or does not flame, glow, smolder or smoke when tested to ASTM C411.
- .10 not to exceed a maximum thermal conductivity at the following meant insulation temperatures:

Mean Temperature °C	Conductivity W/(m·°C)	Mean Temperature °C	Conductivity W/(m·°C)
38	0.050	93	0.056

Standard of Acceptance

- Johns Manville - fig. Thermo-12 Gold

.8 Type P-8 (removable high-temperature insulated jackets):

- .1 custom fabricated, removable/reusable high temperature insulated jackets for hot surfaces,
- .2 suitable for indoor and outdoor use,
- .3 process surface temperature: as shown in Schedule A,
- .4 maximum outer jacket touch-safe temperature protection: 95°C (203°F),

- .5 jacket: silicone impregnated glass-fibre, for temperatures up to 260°C (500°F),
- .6 insulation: mineral or fibreglass insulation suitable for system operating temperature,
- .7 internal liner: silicone impregnated fibreglass fabric, or stainless steel knitted wire mesh,
- .8 fasteners:
 - (a) stainless steel laced wire, for pipe sections,
 - (b) stainless steel mesh straps with buckle rings, for valves, strainers, meters and similar pipeline accessories,
- .9 metal identification tag, referenced equipment served.

Standard of Acceptance

- Firwin Corporation
- Thermohelp Canada Inc.

2.3 Pipe Support Insulation Inserts

- .1 General:
 - .1 molded or fabricated high-density molded insulation inserts for pipe supports.
- .2 Type P-21 – factory insulated shields:
 - .1 factory assembled high-density insulation insert with insulation shield,
 - .2 nominal pipe size: NPS 1/2 to NPS 30,
 - .3 service temperature: -40 to +125°C (-40 to +275°F),
 - .4 insulation:
 - (a) rigid phenolic foam insulation, to ASTM C1126, Gr.2, Type III,
 - (b) thickness: to match thickness of adjacent pipe insulation,
 - (c) nominal density:
 - i) NPS 10 and under: 60 kg/m³ (3.75 lb/ft³),
 - ii) NPS 12 to 30: 80 kg/m³ (5.0 lb/ft³),
 - (d) minimum compressive strength perpendicular to pipe surface: 620 kPa (90 psi),
 - (e) pipe circumference coverage: 360°,
 - (f) insulation length: to extend at least 38 mm (1-1/2 in.) past each end of the integrated shield.
 - (g) vapour barrier jacket: three-ply composite polyester film and aluminium foil with self-securing lap-seal, with zero perm rating,
 - (h) listed to CAN/ULC-S102/S102.2 or ASTM E84.
 - .5 insulation shield:
 - (a) Z275 (G90) coating-weight galvanized steel to ASTM A653, with formed ribs to centre clevis hanger or strut,
 - (b) edges flared or hemmed to prevent damage to insulation,
 - (c) adhered to bottom of insulation insert,
 - (d) width: covering 180° arc of insulation,
 - (e) length and thickness: as required to not exceed the compression strength of the insulation insert when supporting piping filled with water based on the maximum pipe support spans as defined in MSS SP-58.
 - .6 heavy-duty insulation shield (designation P-21HD):

- (a) as specified above for insulation shield except/and as follows,
- (b) shield thickness: 2.75 mm (12 ga),
- (c) with structural steel plate welded to bottom of shield.

.7 sliding protection shield (designation P-21SL)

- (a) as specified above for insulation shield except/and as follows,
- (b) secondary shield located below the primary protection shield, with PTFE layer bonded to the upper surface of the secondary shield,
- (c) designed to allow relative movement between the primary shield and secondary shield.

Standard of Acceptance

- Buckaroos Inc. - fig. CoolDry Insulated Saddles
- Buckaroos Inc. - fig. CoolDry Heavy Duty Insulated Saddles
- Buckaroos Inc. - fig. CoolDry Sliding Insulated Saddles

.3 Type P-22 - cellular glass:

- .1 cellular glass to ASTM C552,
- .2 nominal pipe size: NPS 1-1/2 to NPS 24,
- .3 density: nominal 120 kg/m³ (7.5 lb/ft³),
- .4 minimum compressive strength perpendicular to pipe surface: 620 kPa (90 psi),
- .5 service temperature: -73°C to +121°C (-100°F to 250°F),
- .6 listed to CAN/ULC-S102/S102.2 or ASTM E84.

Standard of Acceptance

- Owens Corning - fig. Foamglas

.4 Type P-23 - calcium silicate:

- .1 calcium silicate to ASTM C533 Type I, with integral corrosion inhibitor to reduce under insulation corrosion, asbestos-free,
- .2 nominal pipe size: NPS 1-1/2 to NPS 24,
- .3 density: nominal 232 kg/m³ (14.5 lb/cu ft),
- .4 minimum compressive strength perpendicular to pipe surface: 620 kPa (90 psi),
- .5 service temperature: 20 to 649°C (70 to 1200°F),
- .6 thermal performance: 0.058 W/m/C @ 149°C (0.40 btu/hr/in/sq ft/F @ 300°F).

Standard of Acceptance

- Johns Manville - fig. Thermo-12 Gold

3 EXECUTION

3.1 General

- .1 Where repairs are made to existing insulated piping due to connections of new piping work, the insulation thickness for the existing piping is permitted to match the existing insulation nominal thickness, provided the extent of new insulation does not exceed a length of 1000 mm (39 in).

3.2 Applicable Systems – Hot piping

- .1 Insulate Hot piping systems including pipe, valves, fittings, and pipeline accessories in accordance with the Schedule A at the end of this Specification section.
 - .1 Table 1A for all piping except engine combustion gas exhaust piping,
 - .2 Table 1B for engine combustion gas exhaust piping.
- .2 Insulate condensate piping in accordance with the same criteria as its associated steam system.
- .3 Insulate piping for safety valves or safety relief valves that is located;
 - .1 less than 2.4 m (8 ft) above a floor or work surface, or
 - .2 within 1 m (39 in) horizontally of, and less than 2.4 m (8 ft) above, an elevated work surface.

3.3 Applicable Systems - Cold and Dual Temperature Piping

- .1 Insulate Cold and Dual temperature piping systems including pipe, valves, fittings, and pipeline accessories in accordance with Schedule B at the end of this Specification section.
- .2 Insulate the following drainage services or equipment:
 - .1 storm water drainage systems in the following locations:
 - (a) roof drain bodies,
 - (b) rainwater leaders (storm water piping) from roof drain bodies to the floor level below the drain body,
 - (c) rainwater leaders in or above data and telecommunication rooms,
 - (d) rainwater leaders in or immediately above wet areas.
 - .2 sanitary piping in the following locations:
 - (a) horizontal sanitary drainage piping NPS 3 and larger in ceiling spaces,
 - (b) sanitary drainage piping in or above wet areas,
 - (c) sanitary drainage piping in or above data and telecommunication rooms,
 - (d) exposed sanitary drainage piping in service tunnels,
 - (e) exposed sanitary drainage piping serving spaces located in a parking garage,
 - (f) and where shown on drawings.

3.4 Insulating Hot Piping

- .1 Insulate straight pipe sections by staggering adjacent longitudinal seams 1/4 turn for each butt joint.
- .2 Secure insulation for domestic hot water piping, domestic hot water recirculation piping, non-potable hot water piping and non-potable hot water recirculation piping in accordance with the requirements for insulating Cold and Dual Temperature piping.
- .3 Secure insulation with integral ASJ or FSK jackets by stapling the lap flap on 75 mm (3 in) centers or by use of self-sealing lap adhesive strip.
- .4 Secure insulation that does not have an integral ASJ or FSK jacket by use of stainless steel wire at not less than 300 mm (12 in) centers, or by a continuous wire helix on the same center spacing.
- .5 For type P-2 and P-4 insulation, or where the required pipe insulation thickness is greater than 50 mm (2 in);
 - .1 provide two layers of approximately equal thickness such that the total thickness is as specified,
 - .2 install straight pipe sections by staggering adjacent section longitudinal seams 1/4 turn for each section, and stagger butt joints between the first layer and second layer by at least 1/4 of the insulation section length, and

- .3 secure the first layer of insulation with stainless steel wire on 300 mm (12 in.) centers, and secure the second layer with band straps on 300 mm (12 in) centers.
- .6 Secure butt joints with vapour barrier tape or insulation butt strips.
- .7 For piping service temperatures greater than 121°C (250°F);
 - .1 apply insulation finishing cement at all exposed edges of insulation where the insulation is interrupted by valves, connections to other equipment, and piping supports and anchors.

3.5 Insulating Cold and Dual Temperature Piping

- .1 Insulate straight pipe sections by staggering adjacent longitudinal seams 1/4 turn for each butt joint.
- .2 Secure insulation with integral ASJ and FSK jackets by;
 - .1 sealing all lap flaps and butt strips with vapour barrier adhesive, or
 - .2 securing insulation with staples on 75 mm (3 in) centers and covering longitudinal seams with vapour barrier tape, or
 - .3 use of integral self-sealing vapour barrier jacket with lap flaps and butt strips.
- .3 Except for type P-6 insulation, secure insulation that does not have an integral ASJ or FSK jacket by:
 - .1 use of 12 mm (1/2 in.) wide reinforced filament tape on approximately 150 mm (6 in.) centers for piping NPS 4 and smaller, and use stainless steel banding on 225 mm (9 in.) centers for piping NPS 6 and larger, and
 - (a) apply an all-service-jacket with 100% coverage of adhesive suitable for the insulation material, with longitudinal and butt seams having a 50 mm (2 in) overlap, and seal the laps with vapour barrier adhesive/ coating, or
 - (b) apply a heavy brush coat of vapour barrier coating at the rate of 1.2 L/m² (2.5 Imp.gallon per 100 ft²), embed a layer of reinforcing membrane, and then applying a second heavy brush coat of vapour barrier coating at the rate of 1.0 L/m² (2.1 Imp.gallon per 100 ft²).
- .4 For type P-2 insulation, or where the required pipe insulation thickness is greater than 50 mm (2 in);
 - .1 provide two layers of approximately equal thickness such that the total thickness is as specified,
 - .2 install straight pipe sections by staggering adjacent section longitudinal seams 1/4 turn for each section, and stagger butt joints between the first layer and second layer by at least 1/4 of the insulation section length, and
 - .3 secure the first layer of insulation with stainless steel wire on 300 mm (12 in.) centers, and secure the second layer with stainless steel banding on 225 mm (9 in) centers.
- .5 Secure type P-6 insulation with field-applied adhesive or self-adhesive longitudinal edge seams, and apply vapour barrier adhesive/sealant to butt joints.
- .6 Secure butt joints with vapour barrier tape, unless otherwise sealed using vapour barrier adhesives and coatings.
- .7 For straight pipe runs greater than 15 m (50 ft) and at every 15 m (50 ft) length thereafter, provide an insulation expansion joint consisting of 50 mm (2 in) wide flexible glass-fibre insulation for full depth of pipe insulation. Seal adjacent pipe insulation ends with vapour barrier coating.
- .8 Where pipe anchors are attached to chilled water piping;
 - .1 cover exposed ends of cut insulation with reinforced vapour barrier coating, with the fabric and coating overlapping by at least 50 mm (2 in.) onto the pipe anchor,
 - .2 insulate the pipe anchor with type P- 6 insulation (in round or equivalent sheet form) to a distance equal to 10 times the largest outside dimension of the anchor structure element, but not less than 150 mm (6 in) beyond pipe insulation outer surface,

3.6 Insulation of Fittings, Flanges, and Couplings – Hot, Cold and Dual Temperature Piping

- .1 Insulate fittings including elbows and tees, other than flanges and grooved-couplings:
 - .1 NPS 1½ and smaller:
 - (a) miter cut insulation to create tight fit,
 - (b) where PVC covers are used, trim backside of insulation on elbows to suit cover but do not reduce total thickness less than that of adjacent pipe insulation.
 - .2 NPS 2 and larger:
 - (a) use matching preformed insulation inserts, or fabricate tightly-fitting mitered insulation segments made from the same material as pipe insulation,
 - (b) number of mitered segments to be sufficient to maintain thickness of insulation around throat of elbow or tee,
- .2 Insulate flanges and grooved-joint couplings:
 - .1 insulate with preformed inserts or build-up insulation with same material as on adjacent pipe:
 - (a) butt pipe insulation to each side of flange or grooved-joint coupling,
 - (b) build up rigid insulation blocking on each side of flange or grooved-joint coupling, with a width dimension same as pipe insulation thickness,
 - (c) apply insulation layer over the top of the flange or coupling to a thickness equal to pipe insulation thickness.
- .3 Where type P-5 or P-7 insulation is used;
 - .1 insulate as described above except use factory made insulation inserts, or fabricate inserts to suit the pipe fitting, flange or coupling.
- .4 Where type P-6 insulation is used;
 - .1 insulation as described above except adhere insulation to fitting, flange, or coupling with 100% coverage of adhesive,
 - .2 do not adhere insulation across bolted connections - insulate on each side of connection and add additional insulation layer across connection and fix in place with bands and seal joints.
- .5 Secure insulation with stainless steel wire (Hot piping), or vapour barrier tape (all piping), prior to application of coatings and finishes.

3.7 Insulation of Pipeline Accessories – Hot, Cold and Dual Temperature Piping

- .1 Insulate pipeline accessories depending on service temperature:
 - .1 valves,
 - .2 strainers,
 - .3 pressure reducing valves,
 - .4 control valves,
 - .5 meters,
 - .6 steam separators.
- .2 Insulate pipeline accessories for Hot piping systems with service temperatures greater than 93°C (200°F) as follows:
 - .1 insulated with type P-8 removable/reusable fitted insulation covers, designed to allow free movement of valve actuator,
 - .2 insulation is not required at this service temperature range for drain valves, blowoff/blowdown valves, and drip caps or plugs.

- .3 Insulate pipeline accessories for Hot piping systems with service temperature greater than 60°C (140°F) and up to 93°C (200°F) or less, as follows:
 - .1 insulated with:
 - (a) type P-8 removable/reusable fitted insulation covers designed to allow free movement of valve actuator, or
 - (b) insulated with fitted pipe insulation segments, or oversized sections of insulation arranged to permit its removal and reinstallation, or
 - (c) tightly placed flexible insulation and covered with PVC fitting covers.]
 - .2 insulation is not required at this service temperature range for drain valves, drain caps/plugs, and for pipeline accessories NPS 1 and smaller.
- .4 Insulation of pipeline accessories is not required for Hot piping with service temperatures less than 60°C (104°F).
- .5 Insulate pipeline accessories for chilled water, liquid refrigerant, and dual temperature heating/cooling systems as follows:
 - .1 detachable insulated box type with embossed aluminum or stainless steel jacket, with vapor barrier tape applied to seams when installed, and lined with one layer of 25 mm (1 in) P6 elastomeric blanket with no voids at corners or joints,
 - .2 alternatively, for accessories NPS 8 and larger, install one layer of 25 mm (1 in) type P-6 elastomeric blanket insulation adhered to pipeline accessories with 100% adhesive coverage, and all joints sealed with manufacturers sealant, including the joint between P-6 insulation and adjacent piping insulation,
 - (a) at locations requiring access, extend insulation to create a collar around bolted connection, and install a compression fit piece of insulation to cover equipment.
 - .3 alternatively, for accessories NPS 4 and smaller, insulate with fitted pipe insulation or mitered blocks with all joints sealed with two coats of vapour barrier coating complete with reinforcing membrane.
- .6 Insulate accessories for all other Cold and Dual Temperature Piping systems as follows:
 - .1 insulate with flexible blanket insulation, fitted pipe insulation or mitered block of same material and thickness of adjacent piping and seal all joints with two coats of vapour barrier coating complete with reinforcing membrane or vapour barrier tape.
- .7 At locations requiring access including valve handles, valve actuators, drain valves, etc. cut-back insulation and seal exposed edges.

3.8 Additional Requirements for Insulation of Engine Combustion Gas Exhaust Piping

- .1 In addition to the general requirements for Hot piping insulation installation specified herein, insulate field-fabricated engine combustion gas exhaust piping systems as follows:
 - .1 where the 1st insulation layer is ceramic fibre, install the 1st layer of insulation with at least 50 mm (2 in) longitudinal overlap;
 - (a) do not stretch-out the insulation.
 - (b) secure with stainless steel wire in a double helix at approximately 225 mm (9 in.) on centers and at an incline of approximately 45°,
 - .2 where the 2nd insulation layer is mineral wool, install the 2nd layer of insulation by compressing slightly the 1st layer and secure the 2nd layer insulation with stainless steel bands at not more than 225 mm (9 in) spacing,

- .3 where calcium silicate insulation is used, do not use adhesive to attach the insulation to the equipment,
- .4 provide type P-23 (calcium silicate) high-density insulation inserts at hanger support locations where clevis hanger or trapeze hangers are used.
- .5 for straight piping runs greater than 15 m and at every 15 m length thereafter;
 - (a) provide an insulation expansion joint consisting of 50 mm (2 in) wide type P-10 insulation for full depth of both insulation layers,
 - (b) where insulation expansion joint is concealed, secure with a stainless steel cover jacket that extends at least 50 mm (2 in) on each side of the insulation expansion joint.

3.9 Additional Requirements for Insulation of Drainage Systems

- .1 In addition to the general requirements for Cold and Dual Temperature piping insulation specified herein, insulate the underside of roof drain hoppers with flexible blanket insulation of same type as pipe insulation, and seal all joints with two coats of vapour barrier coating complete with reinforcing membrane or vapour barrier tape.

3.10 Additional Requirements for Insulation of MRI Quench Vent Piping

- .1 In addition to the general requirements for Cold and Dual Temperature piping insulation specified herein, insulate MRI quench vent piping in accordance with the following supplemental requirements:
 - .1 insulate piping located inside the building,
 - .2 insulate piping located outdoors as follows:
 - (a) insulate vertical vent piping to a height of 2.8 m (8 ft) above the roof or ground level,
 - (b) horizontal vent piping and discharge are not required to be insulated.
 - .3 provide two layers of insulation of applicable thickness as specified in the article Schedules at the end of this Section,
 - .4 stagger insulation joints between the layers so that no joint in one layer aligns with a joint on the other layer,
 - .5 provide vapour barrier sealing on the first (inner) layer using reinforced vapour barrier coating,
 - .6 cover the second insulation layer with jacket material as specified in the article Schedules at the end of this section.
 - .7 install insulation over expansion joints to allow removal to permit inspection of the expansion joint,

3.11 Insulation Protection at Pipe Supports

- .1 Installation of pipe insulation saddle protection for Hot piping:
 - .1 pipe saddles provided under Specification section 20 05 29,
 - .2 insulate the interior void spaces of pipe saddles, using the same material as adjacent pipe insulation,
 - .3 butt insulation up to sides and end of pipe saddle, and leave bottom surface of saddle exposed for direct contact with pipe support.
- .2 Installation of pipe insulation shield protection for hot and cold piping:
 - .1 pipe insulation shields are provided under Specification section 20 05 29 except where specified herein as a factory assembled insulation insert and shield.
 - .2 provide high-density insulation inserts at pipe hanger locations as specified herein and in accordance with Specification 20 05 29 subject to fluid service temperature and pipe size,

- (a) insert length: at least 50 mm (2 in) longer than the shield length to allow application of vapour barrier sealant or tape, but not less than the following:

Pipe Size NPS	Insulation Insert Length mm (in)
1 ½ to 4	400 (16)
6	550 (22)
8 - 24	700 (28)

- (b) arc width: one-half of the pipe diameter for type P-22 and P-23 inserts,
- .3 fabricate the high-density inserts so their thickness is the same as the adjacent installed pipe-run insulation, with finished surface thickness within +3 mm/-0 mm (+1/8 in / -0 in) of adjacent pipe insulation thickness,
 - .4 for cold water piping, apply insulation cover and vapour barrier sealant to fully cover and seal the high-density insert, and to overlap the adjacent pipe-run insulation by at least 50 mm (2 in) on all edges,
 - .5 install the insulation shield between the finished insulation and the support pipe; the pipe support is sized for the outside dimension of pipe and insulation.

3.12 Insulation at Floor and Wall Openings

- .1 Extend pipe insulation at full required thickness through floor and wall openings for Hot, Cold and Dual Temperature piping. Vapour barrier jackets for Cold and Dual Temperature piping are to extend unbroken through the wall or floor penetration. Finish coverings for Hot piping with service temperatures not exceeding 93°C (200°F) may terminate on each side of the opening.
- .2 Reduction in insulation thickness through floor or wall openings is not permitted except by prior approval of Consultant on specific exceptional case basis;
 - .1 exception: Hot piping with service temperature not exceeding 93°C (200°F) may be reduced by one-half the required thickness stated in Schedule A1 through wall and floor penetrations, but such thickness reduction shall not extend more than 25 mm (1 in.) on each side of the opening.
- .3 For penetrations through fire rated separations, provide finishes in accordance with fire stopping manufacturer's listing requirements.
- .4 For outdoor piping passing through exterior walls or roof, terminate mastic lagging at outside face of sleeve and provide storm flashing to protect insulation, caulked to lagging and to building structure.

3.13 Sealing of Insulation – Hot Piping

- .1 Seal hot piping insulation in accordance with Specification section 20 07 11 and/except as specified herein.
- .2 Indoor installation (except wet areas):
 - .1 except where a separate protective finishing jacket is used, apply vapour barrier tape to butt joints, overlapping by at least 50 mm (2 in) each side,
 - .2 do not tape lap joints except as required to secure the insulation,
 - .3 where a separate protective finishing jacket is provided, no additional sealing of the insulation is required.
- .3 Indoor installations – wet areas:

- .1 regardless of how insulation is secured, apply vapour barrier tape to:
 - (a) all longitudinal lap seams and butt edges,
 - (b) 100% coverage of insulation at pipe joints, fittings, couplings, etc.
- .4 Outdoor installation:
 - .1 apply two coats of breather mastic complete with reinforcing membrane to all lap edges and butt edges, overlapping joint by minimum 50 mm (2 in) each side, and to all insulation that does not have a factory installed jacket.

3.14 Sealing of Insulation – Cold and Dual Temperature Piping

- .1 Seal Cold and Dual Temperature piping insulation in accordance with Specification section 20 07 11 and/except as specified herein.
- .2 Indoor installation (except wet locations):
 - .1 except for chilled water and Dual Temperature piping, tightly seal insulation ASJ jacket longitudinal seams and butt joints;
 - (a) using factory or field fabricated lap seams and butt joint strips with adhesive, or
 - (b) by applying colour matched vapour barrier tape to all edges, overlapping joint by minimum 50 mm (2 in) each side,
 - (c) where factory lap seams are damaged, apply colour matched vapor barrier tape along the damaged edges,
 - .2 for chilled water and dual temperature piping insulation with ASJ jackets, tightly seal longitudinal seams and butt joints;
 - (a) with two coats of vapor barrier coating complete with reinforcing membrane,
 - (b) for pipe size NPS 6 and smaller, colour matched vapour barrier tape is permitted to be used depending on location of piping in accordance with the following table.

Insulation Joint Sealing – Pipes NPS 6 and Smaller		
Piping Location	Vapour Barrier Tape	Vapour Barrier Coating with Membrane
Mechanical Service Rooms	No	Required
Vertical Service Spaces (shafts)	No	Required
Tunnels and trenches	No	Required
Unconditioned spaces	No	Required
Conditioned Spaces	Permitted [Note 1]	Permitted
Ceiling spaces over Conditioned Spaces	Permitted [Note 1]	Permitted
IT rooms	No	Required

Notes:

[1] Pipe size NPS 6 and smaller only.

- (a) overlap insulation edges and butt joint by minimum 50 mm (2 in) each side,
- (b) seal the butt end of the insulation with vapour barrier coating, overlapping onto the piping, at every fourth length of piping, but not to exceed 4 m (13 ft) in pipe run length.
- .3 cover mechanical fastener penetrations including staples with colour matched vapour barrier tape, overlapping the fasteners by a minimum of 50 mm (2 in) in all directions.
- .4 seal insulation on pipe elbows, tees, flanges, joints, couplings, and other fittings;

- (a) with two coats of vapor barrier coating complete with reinforcing membrane,
- (b) for pipe sizes NPS 6 and smaller, colour matched vapour barrier tape may be used in locations as described in the above table for piping.

.3 Indoor installations – wet areas:

- .1 in wet areas, tightly seal piping in accordance with the requirements for outdoor installation except use vapour barrier coatings.

.4 Outdoor installation:

- .1 tightly seal insulation with two coats of vapour barrier mastic complete with reinforcing membrane;
 - (a) at all lap edges and butt joints,
 - (b) 100% coverage of insulation of pipe elbows, tees, flanges, joints, couplings, and other fittings,
 - (c) to cover mechanical fastener penetrations including staples,
 - (d) in all cases overlapping the joint, fitting or fastener by a minimum 50 mm (2 in) each side.

.5 In all locations;

- .1 seal insulation that does not have a factory applied ASJ jacket with 100% coverage of two coats of vapor barrier coating/mastic complete with reinforcing membrane,
- .2 seal high-density inserts for pipe supports with two coats of vapour barrier coating/mastic complete with reinforcing membrane, overlapping adjacent insulation a minimum of 50 mm (2 in).

3.15 Insulation Finish Covering

- .1 Provide insulation finish coverings selected in accordance with Schedule C at the end of this Specification section and installed in accordance with Specification section 20 07 11 and/except as specified herein.
- .2 Self-adhesive weather barrier (SAWB) coverings;
 - .1 apply SAWB in accordance with manufacturer's instructions,
 - .2 do not place an overlap within one-eighth pipe diameter on each side of a horizontal pipe top centerline,
 - .3 for vertical piping, overlap higher layers over lower layers with an overlap not less than 100 mm (4 in).

3.16 Mechanical Damage Protection - Indoors

- .1 Protect exposed pipe insulation extending up through a floor sleeve at the floor line with 1.2 mm (18 ga) stainless steel jacket approximately 200 mm (8 in) high, secured with rivets and mechanically fastened to the floor with countersunk stainless steel screws.
- .2 Where waterproof floor sleeves are required, the floor sleeve may be combined with this requirement.
- .3 For clarity, where piping systems use finish covering in accordance with Schedule C of this Specification section, this mechanical damage protection cover is in addition to the specified pipe finish cover.

3.17 Standard Details

- .1 Refer to Specification section 20 05 29 for illustration of coordination of insulation with pipe supports, unless otherwise shown on drawings.

3.18 Schedules

- .1 The following appended schedules form part of this Specification section.
 - .1 Schedule A1 Hot piping Systems, Insulation Type and Thickness

- (excluding engine combustion gas exhaust piping)
- .2 Schedule A2 Hot Equipment Insulation Type, Thickness, and Coverings For Engine Combustion Gas Exhaust Piping
 - .3 Schedule B Cold and Dual Temperature Piping Systems, Insulation Type and Thickness
 - .4 Schedule C Piping Insulation Protective Finishes.

Schedule A1
Hot Piping Insulation Type and Thickness
(excluding engine combustion gas exhaust piping)

System	Fluid Nominal Temp. °C (F)	Insulation Type	Nominal Pipe Size (NPS)				
			< 1	1 to 1¼	1½ to 3	4 to <8	≥ 8
			Insulation Thickness, mm (in)				
Steam and Condensate > 860 kPa (125 psi)	177 to 315°C (351 to 600°F)	P-3	115 (4.5) [Note 3]	125 (5) [Note 3]	125 (5)	125 (5)	125 (5)
		P-4	---	---	---	---	125 (5) [Note 1, 2]
		P-7	200 (8) [Note 3]	200 (8) [Note 3]	200 (8)	175 (7)	175 (7)
Steam and Condensate > 100 kPa (15 psi) and ≤ 860 kPa (125 psi) Boiler Feed Water	122 to 176 (251 to 350)	P-1 P-3	80 (3) [Note 3]	100 (4) [Note 3]	115 (4.5)	115 (4.5)	115 (4.5)
		P-2 P-4	---	---	---	---	150 (6) [Note 1, 2]
		P-7	125 (5) [Note 3]	175 (7) [Note 3]	175 (7)	175 (7)	150 (6)
Safety Relief Piping	122 to 176 (251 to 350)	P-1 P-3	40 (1½)	40 (1½)	40 (1½)	40 (1½)	40 (1½)
Steam and Condensate ≤ 100 kPa (15 psi) High temperature hot water heating	94 to 121 (201 to 250)	P-1 P-3	65 (2.5) [Note 3]	65 (2.5) [Note 3]	80 (3)	80 (3)	90 (3½)
		P-2 P-4	---	---	---	---	100 (4) [Note 1, 2]
		P-7	125 (5) [Note 3]	100 (4) [Note 3]	125 (5)	125 (5)	125 (5)
Hot Water Heating Glycol Heating Pumped Condensate	61 to 93 (141 to 200)	P-1 P-3	40 (1½) [Note 3]	40 (1½) [Note 3]	50 (2)	50 (2)	50 (2)
		P-2 P-4	---	---	---	---	65 (2½) [Note 1, 2]
		P-7	65 (2½) [Note 3]	65 (2½) [Note 3]	65 (2½)	65 (2½)	65 (2½)
Hot Water Heating (Buried)	61 to 93 (141 to 200)	P-5	50 (2) [Note 3]	50 (2) [Note 3]	65 (2.5)	65 (2.5)	65 (2.5)

...continued on next page

Schedule A1 (Continued)
Hot Piping Insulation Type and Thickness
(excluding engine combustion gas exhaust piping)

System	Fluid Nominal Temp. °C (F)	Insulation Type	Nominal Pipe Size (NPS)				
			< 1	1 to 1¼	1½ to 3	4 to <8	≥ 8
			Insulation Thickness, mm (in)				
Pure Water (with heat sanitization)	25 to 93 (77 to 200)	P-1 P-3	25 (1)	25 (1)	25 (1)	25 (1)	25 (1)
Low Temperature Hot Water Heating Low Temperature Glycol Heating	41 to 60 (105 to 140)	P-1 P-3	25 (1)	25 (1)	40 (1½)	40 (1½)	40 (1½)
Domestic Hot Water Domestic Hot Water Recirculation Not-Potable Hot Water Non-Portable Hot Water Recirculation	41 to 60 (105 to 140)	P-1 P-3	25 (1)	25 (1)	40 (1½)	40 (1½)	40 (1½)
Condenser Water (outdoors)	16.5 to 40 (61 to 104)	P-3 P-4 P-5	40 (1½)	40 (1½)	40 (1½)	40 (1½)	40 (1½)
Fire protection Sprinkler piping and valves, Fire protection Standpipe piping and valves [Note 4]	4 to 40 (50 to 104)	P-1 P-3	25 (1)	25 (1)	40 (1½)	40 (1½)	40 (1½)

Notes:

[1] For NPS 14 and larger.

[2] Install in two layers of insulation to make up total thickness.

[3] For piping NPS 1-1/4 and smaller located in partitions within conditioned spaces, insulation thickness may be reduced by up to 25 mm, but final thickness shall not be less than 25 mm.

[4] For heat-traced fire protection piping only, including drum drip assemblies on dry systems.

Schedule A2
Hot Equipment Insulation Type, Thickness, and Coverings
For Engine Combustion Gas Exhaust Piping

Equipment Description	Exhaust Gas Service Temperature °C (°F)	1 st Layer Type x Thickness mm (in)	2 nd Layer Type x Thickness mm (in)	Protective Finishing Covering, Exposed Piping [Note 1]
Natural Gas Engine combustion gas exhaust piping	≤ 700 (≤ 1292)	P-10 50 (2)	P-3 90 (3.5)	Fabric
		P-10 50 (2)	P-3 150 (6) [Note 2]	Stainless Steel
Diesel Engine combustion gas exhaust piping	≤ 540 (≤ 1000)	P-10 25 (1)	P-3 50 (2)	Fabric
		P-10 50 (2)	P-3 90 (3.5)	Stainless Steel
		P-7 40 (1.5)	P-7 50 (2)	Fabric
		P-7 75 (3)	P-7 90 (3.5)	Stainless Steel

Notes:

[1] For exposed piping located indoors. See Schedule C for other locations.

[2] Made up of two equal thickness layers with a total thickness of the indicated value.

Schedule B
Cold and Dual Temperature Piping Insulation Type and Thickness

System	Fluid Nominal Temp. °C (°F)	Insulation Type	Nominal Pipe Size (NPS)				
			< 1	1 to 1¼	1½ to 3	4 to <8	≥ 8
			Insulation Thickness, mm (in)				
Dual Temperature Heating/Cooling	4 to 93 (39 to 200)	P-1 P-3	40 (1½)	40 (1½)	50 (2)	50 (2)	50 (2)
		P-2	---	---	---	---	65 (2½) [Note 1, 2]
Domestic Cold Water Non-potable Water	4 to 16 (39 to 61)	P-1 P-3	25 (1)	25 (1)	40 (1½)	40 (1½)	40 (1½)
Storm and Sanitary Drainage	4 to 16 (39 to 61)	P-1	25 (1)	25 (1)	25 (1)	25 (1)	25 (1)
		P-6	15 (1/2)	20 (3/4)	25 (1) [Note 3]	---	---
Equipment Drains	4 to 16 (39 to 61)	P-6	15 (1/2)	20 (3/4)	25 (1) [Note 3]	---	---
Chilled Water, Glycol Heat Recovery	4 to 16 (39 to 61)	P-1 P-3 P-5	25 (1)	25 (1)	40 (1½)	40 (1½)	50 (2)
Chilled Water (Outdoors)	4 to 16 (39 to 61)	P-3	50 (2)	50 (2)	50 (2)	75 (3)	75 (3)
Chilled Water (Buried)	4 to 16 (39 to 61)	P-5	25 (1)	25 (1)	40 (1½)	40 (1½)	40 (1½)
Refrigerant Suction	< 4 (< 39)	P-6	25 (1)	25 (1)	25 (1) [Note 3]	---	---
MRI Quench Vent	-268 (-450)	P-3 (inner layer)	---	---	---	25 (1)	25 (1)
		P-6 (outer layer)	---	---	---	25 (1)	25 (1)

Notes:

[1] For NPS 14 and larger.

[2] Install in two layers of insulation to make up total thickness.

[3] Do not use on pipe size NPS 2-1/2 to 3.

**Schedule C
 Piping Insulation Finish Coverings**

Location	Exposed/ Concealed	Piping System	Finish Covering
Indoors	Concealed	Piping with insulation types P-4, P-5, P-7, P-10	PVC
		All other piping	None (factory jacket only)
	Exposed	Fire Protection Piping	PVC (red in colour)
		All other piping	Metal

END OF SECTION

START-UP AND PERFORMANCE TESTING REPORTING

20 08 01

1 GENERAL

1.1 Scope

- .1 Provide integrated reporting of start-up and performance testing of mechanical equipment and systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 08 05 Testing, Adjusting and Balancing
 - .2 20 08 11 Testing of Integrated Mechanical Life Safety and Fire Protection Systems

1.3 Coordination

- .1 Coordinate the work of testing companies;
 - .1 schedule sufficient time so that testing and balancing can be completed before occupancy begins and coordinate with trades involved,
 - .2 keep testing and balancing firm informed of any major changes made during construction and furnish same with a set of project drawings and reviewed Shop Drawings,
 - .3 furnish balancing devices, test connections access openings, balancing probe inlets and plugs,
 - .4 clean and pre-run all equipment, filters, etc. and place all heating, ventilating and air conditioning systems into full operation and continue same during each working day of testing and balancing,
 - .5 provide labour from pertinent mechanical trades and tools, equipment and materials to make equipment and system alterations and adjustments, as required including control adjustments,
 - .6 Building Automation System technical representative to operate the BAS during air and water balancing testing,
 - .7 where required in applicable Specification sections, refrigeration machine manufacturer service representative conducts performance testing of the refrigeration equipment, and Testing and Balancing contractor to witnesses and records all test results.
 - .8 where required in applicable Specification sections, fuel-fired heating equipment manufacturer service representative, or other qualified service company technical representative, conducts performance testing of heating equipment and Testing and Balancing contractor to witnesses and records all test results.
- .2 Be responsible for systems constructed, installed and adjusted to provide optimum performance as required by design intent. Perform any re-adjusting required as the result of spot checks by the Consultant at no increase in Contract Price.

1.4 Submittals

- .1 Submit a report format template a minimum 14 days prior to start of air and water balancing on-site.
 - .1 submit proposed format of initial report,
 - .2 include a complete list of instruments and tests for which they are to be used as they relate to this project, including date of last calibration

2 PRODUCTS

2.1 Not applicable.

3 REPORT FORMAT

3.1 General

- .1 Include the following information for each test report:
 - .1 Owner Name,
 - .2 Project Name,
 - .3 Contractor Name,
 - .4 Consultant Name,
 - .5 Name of Test Report,
 - .6 Name and signature of the person submitting the report,
 - .7 Date of report.
- .2 Submit two (2) copies of test reports in hardcopy form in 3-“D” ring binders, indexed for each type of report, separately bound from the Operations and Maintenance manuals. Provide two (3) copies of the same reports in Adobe Acrobat version 7 PDF forma.

4 START-UP AND PERFORMANCE REPORTS

4.1 Required reports

- .1 Provide the following Start-Up and Performance Testing reports:
 - .1 Equipment start-up report,
 - .2 Authorities inspection reports,
 - .3 Air and water balancing report,
 - .4 Controls / BMS operation report,
 - .5 Alternate Season test report.

4.2 Equipment Start-up Report

- .1 Provide a test report in spreadsheet format which summarizes the following data for each piece of equipment which is powered or has automatic controls:
 - .1 equipment ID and name,
 - .2 motor insulation megger test - result and initialed by contractor,
 - .3 motor rotation (bump test) - result and initialed by contractor,
 - .4 equipment start-up report - status and initialed by contractor,
 - .5 manufacturer Start-Up report – status and initialed by contractor,
 - .6 test completion date.
- .2 Provide a test report in spreadsheet format which summarizes the following data for testing of piping systems, organized by each piping system:
 - .1 system name,

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- .2 system limits (if system is not tested in its entirety),
 - .3 type of test (pneumatic, hydrostatic),
 - .4 pressure at start of test,
 - .5 pressure at end of test,
 - .6 duration of test,
 - .7 contractor dated and initialed,
 - .8 expansion tank initial pressure,
 - .9 expansion tank final pressure,
 - .10 backflow preventers have been tested - status and initialed by contractor,
 - .11 pressure relief valves installed – record setpoint and initialed by contractor.
- 3 Provide a test report in spreadsheet format which summarizes the following data for testing of ductwork systems, organized by each ductwork system:
 - .1 system name,
 - .2 system limits (if system is not tested in its entirety),
 - .3 test pressure,
 - .4 duration of test,
 - .5 seal Class,
 - .6 tested duct surface area,
 - .7 allowable airflow leakage rate,
 - .8 estimated leakage rate,
 - .9 contractor dated and initialed.
 - 4 Equipment/System Start-Up Test Report:
 - .1 Provide a separate start-up report for each piece of the following equipment. The SMACNA “Systems Ready to Balance Check List”, where applicable, may be used for this report.
 - (a) HVAC units,
 - (b) duct Systems,
 - (c) pumps,
 - (d) boilers, and boiler auxiliaries,
 - (e) heat exchangers,
 - (f) cooling towers,
 - (g) air compressors,
 - (h) refrigeration equipment,
 - (i) hydronic piping systems,
 - (j) steam piping systems,
 - (k) sprinkler systems (to NFPA 13),
 - (l) standpipe systems (to NFPA 14).
 - .5 Manufacturer’s Start-Up Test:

- .1 Provide a separate start-up report for each piece of the following equipment, utilizing the manufacturer's start-up check list. This report may be prepared by the manufacturer's service representative:
 - (a) chemical water treatment - pipe cleaning,
 - (b) chemical water treatment - passivating and inhibition,
 - (c) refrigeration equipment,
 - (d) packaged AC equipment,
 - (e) heating boilers,
 - (f) steam boilers,
 - (g) deaerators,
 - (h) packaged humidity steam generators,
 - (i) domestic hot water heaters,
 - (j) air compressors,
 - (k) cooling towers,
 - (l) adjustable frequency drives,
 - (m) Building Automation Systems.

4.3 Authorities Inspection Reports

- .1 Submit copies of authorities-having-jurisdiction inspection and test reports, including:
 - .1 plumbing and drainage municipal inspector reports,
 - .2 AHJ for boiler, pressure vessels and pressure piping reports,
 - .3 AHJ for electrical safety inspection reports and, if applicable, field certification reports.
- .2 Where an AHJ inspects the work but does not issue an inspection report, provide a signed and dated written declaration of the name of the AHJ inspector, the date of their inspection, what they inspected, and any comments they provided orally or in writing (other than an inspection report).

4.4 Air and Water Balancing Reports

- .1 Provide air and water balancing reports in accordance with Specification section 20 08 05.

4.5 Alternate Season Testing Report

- .1 Provide alternate season test report in accordance with Specification section 20 08 05.

5 SPECIFIC EQUIPMENT PERFORMANCE TESTS

5.1 Performance data

- .1 In addition to tests specified in other Specification sections of Division 20 to 25, perform the following equipment performance tests. If contractor's standard forms provide for additional data, also submit such additional data.
 - .1 Some equipment tests may need to be performed during the alternate season testing.
 - .2 Include nameplate data and as-tested results.

6 REPORT SUBMISSIONS

6.1 Deficiencies

- .1 Immediately report to Consultant, any deficiencies in the systems or equipment performance resulting in design requirements being unobtainable.

6.2 Draft Report

- .1 On completion of the start-up, testing, adjusting and balancing of all systems, submit to the Consultant, two (2) typewritten copies of a full report on all tests, adjustments, and balancing performed.
- .2 Attachments including systems schematics with numbered terminals for referring to data above.

6.3 Spot Checks

- .1 After review of the draft report by the Consultant, Consultant has the right to require a retest of up to 25% of all air and water balancing measurements in locations as directed by the Consultant, at no cost extra to the contract.
- .2 If results indicate unusual testing inaccuracy, omissions, or incomplete balancing/adjustment, in the opinion of the Consultant, re-balance entire affected system(s) at no increase in Contract Price.

6.4 Interim Report

- .1 After completion of any retesting described above, submit three (1) typewritten copies of the interim report bound in a 3-hole "D" style binder, and two (2) removable drives (thumb drive) of the report in PDF format.
- .2 This report is required to obtain Substantial Performance of the Contract.

6.5 Final Report

- .1 Submit to Consultant the final report following completion of alternate season testing and balancing. Submit two (2) typewritten copies bound in a 3-hole "D" style binder, and two (2) removable drives (thumb drive) of the report in PDF format.

6.6 Acceptance

- .1 The Substantial Performance of the Mechanical Work will be considered reached when the interim Start-Up and Performance Testing report is reviewed by the Consultant and in the opinion of the Consultant all systems have been satisfactorily installed, operated tested, balanced, and adjusted to meet the specified and intended performance, except for deferred seasonal-dependent work or other deferred work agreed by the Owner.
- .2 The substantial performance is not dependent upon alternate season testing.
- .3 The total performance of the Mechanical Subcontract (Contract) will not be considered reached until the alternate season testing and balancing and any other deferred Work is completed and the final report submitted and reviewed by the Consultant.

END OF SECTION

TESTING OF INTEGRATED MECHANICAL FIRE PROTECTION AND LIFE SAFETY SYSTEMS 20 08 11

1 GENERAL

1.1 Scope

- .1 Provide testing of integrated fire protection and life safety systems and related equipment provided under Division 20 to 25 with those provided under other Divisions of the Work, in accordance with Division 01.
- .2 This specification is limited to testing of the interconnections between fire protection and/or life safety systems. Refer to separate technical specification sections for the individual testing and commissioning requirements for those systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 Section 01 75 11 Testing of Integrated Fire Protection and Life Safety Systems

1.3 Definitions and Abbreviations

- .1 Refer to section 01 75 11.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CAN/ULC-S1001 Integrated Systems Testing of Fire Protection and Life Safety Systems

1.5 Qualified Tradesperson

- .1 Refer to section 01 75 11.

2 PRODUCTS

- .1 Not used.

3 EXECUTION

3.1 General Requirements

- .1 Conduct complete and thorough testing and documentation of the systems interface and integration between various FPLS systems provided under Divisions 20 to 25 and those provided under other Divisions of the Work.
- .2 Include all labor and material as required to participate in and implement the integrated FPLS testing process for equipment and systems provided under Division 20 to 25.

3.2 Integrated Test Plan and Procedures - Development

- .1 Participate in the development of the integrated FPLS test plan and procedures in accordance with the requirements of specification section 01 75 11.
- .2 Supply manufacturer's operating and testing instructions to the ITC prior to the development of the integration FPLS test plan.

3.3 Integration Test Plan – Implementation

- .1 Complete related FPLS system testing in accordance with the applicable technical specification sections of Divisions 20 to 25, prior to implementation of integrated FPLS testing. Where testing of such systems inherently test the FPLS system interconnection(s), such testing is not required to be duplicated for the integrated FPLS testing provided the results of the integration test are recorded in accordance with the requirements of the integrated FPLS test plan.
- .2 Prior to implementing any integrated FPLS test,
 - .1 provide written confirmation from each trade contractor under Divisions 20 to 25 of the Work, that their respective FPLS related equipment or systems, or parts thereof, have been installed in accordance with the design and are ready for integrated FPLS testing,
 - .2 provide test verification reports from the organization that verified the installation of any FPLS system as required by referenced codes or standards, such as NFPA or ULC.
 - .3 provide a copy of inspection reports from an authority having jurisdiction governing a FPLS system.
- .3 Coordinate with the ITC and provide all necessary resources to implement the integrated FPLS test plan.

3.4 Final Test Results Report

- .1 The final test report will be prepared by the ITC.

END OF SECTION

MECHANICAL COMMISSIONING 20 08 15

1 GENERAL

1.1 Scope

- .1 Provide commissioning of mechanical systems provided under Division 20.
- .2 Mechanical system installation, start-up, testing, balancing, preparation of Operating and Maintenance manuals and operator training are the responsibility of the Division 20 Contractors, with the coordination of the commissioning process the responsibility of the Contractor.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 08 01 Start-up and Performance Testing
 - .2 20 08 05 Testing, Adjusting and Balancing
 - .3 20 08 11 Testing of Integrated Mechanical Fire Protection and Life Safety Systems

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Contractor** – means the general contractor or construction manager who is responsible for the management and overall execution of the Work as applicable to the type of project delivery method used.
 - .2 **Major deficiency** – an item which if not corrected renders the equipment or system unsuitable or un-safe for use by the Owner. Major deficiencies must be corrected as a condition for achieving Substantial Performance.
 - .3 **Minor deficiency** – an item which does not impact on the operation of the equipment or system and will allow the Owner to use the system safely. Minor deficiencies may be corrected before or after Substantial Performance, but will not prevent certification of Substantial Performance of the Work.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ASHRAE Guide 0 The Commissioning Process
 - .2 ASHRAE Guide 1.2 Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies
 - .3 ASHRAE Guide 1.3 Building Operations and Maintenance Training for the HVAC&R Commissioning Process
 - .4 ASHRAE Guide 1.5 The Commissioning Process for Smoke Control Systems

1.5 Commissioning Process

- .1 The Commissioning process develops, coordinates, and documents the following:
 - .1 equipment start-up,
 - .2 control system calibration,
 - .3 testing and balancing,

- .4 verification and Performance Testing,
 - .5 operation documentation,
 - .6 operator training.
- .2 The Commissioning Program is divided into the following parts:
- .1 Part 1: Pre-Start and Start-Up testing
 - .2 Part 2: Installation Verification testing
 - .3 Part 3: Performance Validation testing
 - .4 Part 4: Systems Operating Manuals
 - .5 Part 5: Operator Training

1.6 Work Included

- .1 Commissioning work of Division 20 includes, but is not limited to:
- .1 testing and start-up of equipment,
 - .2 testing, adjusting and balancing of hydronic and air systems,
 - .3 cooperation with the Commissioning Authority in developing and implementation of the commissioning plan,
 - .4 providing qualified personnel for participation in implementing commissioning test procedures, including seasonal testing required after the initial testing,
 - .5 providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process,
 - .6 providing operation and maintenance manuals, and as-built drawings to the Commissioning Authority for verification,
 - .7 providing training and demonstrations for the systems specified in this Division.
- .2 Conduct complete and thorough evaluation and documentation of the operation and performance of all components, systems, and sub-systems, including the following equipment and systems:
- .1 air handling systems,
 - .2 cooling generation systems,
 - .3 heating generation systems,
 - .4 hydronic distribution systems,
 - .5 air distribution and exhaust systems,
 - .6 domestic hot water systems,
 - .7 domestic cold water systems,
 - .8 fire protection systems / suppression systems,
 - .9 constant speed motor controllers and variable frequency drives,
 - .10 building automation systems,
 - .11 medical gas systems,
- .3 Commission equipment which has been pre-tendered, pre-purchased, or pre-ordered by the Owner or their Agent, and the value of which has been assigned to the Mechanical Contractor or their sub-trades and is included in the value of the Work.

- .4 Commission services to equipment, but not the equipment itself, where the supply of the equipment does not form part of the mechanical Work.
- .5 Provide the following commissioning documentation:
 - .1 recording completed Pre-start and Start-up procedures test results,
 - .2 recording completed Installation Verification and Performance Validation test results,
 - .3 as-built records.
 - .4 operation and maintenance manuals
- .6 The final commissioning report will be prepared by the Commissioning Authority.

1.7 Excluded Work

- .1 Unless otherwise specified, equipment which is not supplied by the mechanical contractor or their sub-trades, where the value for the supply of equipment is not included as part of the Work, such as:
 - .1 Supplied by Owner (SBO) equipment,
 - .2 Equipment marked Not in Contract (NIC) or Not in Mechanical Contract (NIMC).

1.8 Submittals - Commissioning Schedule

- .1 Provide a detailed commissioning schedule for consolidation into the main construction schedule.
- .2 Include:
 - .1 equipment and systems start-up predecessors
 - .2 time periods for pre-start and start up testing, verification and validation testing for each equipment and system.

1.9 Submittals - Documentation

- .1 Identify documents including test documents, binder covers, etc. using equipment ID numbers provided on equipment schedules.
- .2 Scan original signed test reports, including verification and performance test reports, manufacturers service reports, etc. in Adobe Acrobat *.pdf version 8 format. For original document chapters, provide Adobe chapter referencing.
- .3 Submit three (3) copies of each completed and accepted Verification and Functional Performance Test reports, both preliminary and final issues.
- .4 Collate final, accepted and signed test results in separate binders as follows:
 - .1 Fire Protection
 - .2 Plumbing and Drainage
 - .3 HVAC Systems
 - .4 Building Management Systems
- .5 Provide three (3) CD-R or DVD-R copies of commissioning documentation.

1.10 Substantial Performance

- .1 Application for Substantial Performance of the Work is precedent on the Work being ready for Owner's use which includes completion of the following commissioning elements:
 - .1 start-up and testing, including TAB reports,
 - .2 commissioning Verification testing including submission of completed records,

- .3 commissioning Performance Validation testing including submission of completed records, except for alternate season tests,
- .4 commissioning Controls Validation testing,
- .5 training of Owner's operations personnel,
- .6 as-built documentation issued for Consultant's review,
- .7 Operations and Maintenance manuals which have been reviewed by the Consultant and accepted by the Owner.

2 PRODUCTS

2.1 Test Equipment

- .1 Furnish tools and equipment required during the commissioning process.
- .2 Utilities (water, gas, fuel oil, electrical power) are provided by the Owner
- .3 Provide any proprietary test equipment and software required by equipment manufacturer for programming and / or start-up, whether specified or not.
- .4 Manufacturer provides test equipment, demonstrate its use, and assists in the commissioning process as needed.
- .5 Turn-over proprietary test equipment to the Owner upon completion of the commissioning process, where such requirement is specified in the relevant equipment specification sections.

3 EXECUTION

3.1 General

- .1 Perform commissioning in accordance with ASHRAE Guide 0, Guide 1.2 except/and as specified herein.
- .2 Complete all phases of work so that the systems can be started, tested, balanced, and owner's acceptance procedures be undertaken in a timely manner such that only one acceptance test is conducted at any one time.
- .3 Participate and assist in the development of the Commissioning Plan and schedule by the Contractor, by providing necessary information pertaining to the equipment and installation. Provide commissioning schedule information to be incorporated into the overall Construction Plan schedule.
- .4 Acceptance procedures may begin prior to completion of a system and/or sub-system. Start of acceptance procedures before system completion does not relieve the Contractor from completing those systems in accordance with the commissioning and construction schedule.

3.2 Participants

- .1 Commissioning Team consists of multiple parties with separate responsibilities.
- .2 Owner:
 - .1 establishes acceptance criteria,
 - .2 provides operations staff to receive training, and to witness any or all tests at their discretion,
 - .3 final acceptance of commissioning results.
- .3 Design Consultant:
 - .1 responsible for the construction review activities in accordance with local building code requirements,

- .2 may participate in development and / or review of commissioning procedures,
- .3 reviews commissioning test results,
- .4 Commissioning Authority:
 - .1 develops commissioning plan and procedures,
 - .2 coordinates Owner's commissioning team members who witnesses tests,
 - .3 selectively witnesses commissioning tests on an audit basis to confirm compliance by the Contractor to the Commissioning Plan,
 - .4 reviews commissioning test results and makes recommendations to the Owner for acceptance.
- .5 Contractor:
 - .1 coordinates and manages commissioning activities,
 - .2 develops and integrates commissioning activities into the construction schedule,
 - .3 ensures commissioning procedures are completed and documented, and commissioning records including any required attachments are submitted.
- .6 Mechanical trades subcontractors:
 - .1 Provide the services of qualified technician(s) who are familiar with the construction and operation of the system, to start-up and debug equipment and systems within the Division 20 scope of Work. Include for labour, materials, and subsistence costs for these same technicians to assist the Commissioning Authority in completing the commissioning program.
 - .2 Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.
 - .3 Ensure the qualified technician(s) are available and present during commissioning testing to complete the tests, make adjustments and to assist in problem resolutions.
 - .4 Should any equipment or system experience performance problems and/or reconstruction or replacement of components is required, include for additional technician time for subsequent retesting of systems until required system performance is achieved.
 - .5 The Commissioning Authority reserves the right to approve proposed technicians with regard to the technical skill level required for each type of equipment and/or system, and a willingness by the individual(s) to work within the Commissioning Group.
- .7 Controls subcontractor, in addition to the requirements described above:
 - .1 Provide test reports using own documentation formats, for wiring tests, loop testing, loop tuning, and sequence functional tests.
 - .2 Provide details of the control system, schematics, and a narrative description of control sequences of operation.
- .8 Electrical subcontractor:
 - .1 provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces and interlocks.
- .9 Equipment suppliers:
 - .1 provide the services of manufacturers' service personnel to provide assistance with pre-start and initial start-up of the equipment, as required.

3.3 Commissioning Meetings

- .1 Participate in periodic commissioning team meetings, and trade commissioning meetings.

- .2 Pre-construction:
 - .1 participate in a pre-construction meeting of commissioning team members, to familiarize parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
- .3 Construction and Post-Construction:
 - .1 participate in commissioning meetings as scheduled by the Contractor.
 - .2 participate in trade commissioning meetings as required, in addition to the regular commissioning team meetings,
 - .3 identify to the commissioning group problems relating to the commissioning schedule, identification of start-up issues, etc., and participate in the resolution of these problems.

3.4 Commissioning Procedures

- .1 The Owner's designated Commissioning Authority provides the commissioning procedures (checklists, etc.) for use by the Contractor and trade subcontractors.
- .2 Each commissioning procedure tests the equipment and systems, and consists of the following elements:
 - .1 Document sign-off
 - .2 Pre-start and Initial test
 - .3 Installation Verification - Equipment
 - .4 Installation Verification - Systems
 - .5 Performance Validation
 - .6 Controls Validation
 - .7 Appendices.
- .3 Document Sign-Off:
 - .1 each completed procedure is signed off by the following parties:
 - (a) Contractor, for testing,
 - (b) Commissioning Consultant, for review and witnessing,
 - (c) Owner, for test acceptance.
- .4 Pre-Start and Initial Test:
 - .1 Checklists included: confirmation of authorities inspections, pre-start safety checks (where applicable), system cleaning and pressure testing, and confirmation of availability of supporting systems.
- .5 Installation Verification - Equipment
 - .1 Checklists to verify the installation of equipment, including: design specification requirements, drawing requirements, manufacturer installation requirements, and other experience-related items.
 - .2 Use of pre-printed manufacturer installation and start-up checklists are permitted and encouraged; however, the commissioning procedure checklists may contain supplemental items.
- .6 Installation Verification - System:
 - .1 Checklists to verify the installation of the system associated with the equipment.
- .7 Performance Validation:

- .1 Specific test procedures and record documentation requirements for performance measurements of the various systems.
- .8 Controls Validation:
 - .1 Step-by-step testing methodologies to prove the functional operation of control systems, for normal and abnormal operating conditions, and alarm conditions.
- .9 Appendices:
 - .1 Collate test reports from authorities having jurisdiction, manufacturer start-up and test reports, balancing reports, etc.

3.5 Commissioning Test Methodology

- .1 Step 1: complete the pre-start, start-up and testing, and adjusting and balancing tests. On completion of this phase, complete the related documentation and submit to the Commissioning Authority and Consultant.
- .2 Steps 2 and 3: on completion of Step 1, conduct the Verification and Validation testing of the operating systems. Identify deficiencies and correct. After the deficiencies have been corrected, notify the Commissioning Authority and agree on dates to demonstrate the commissioned systems.
- .3 Step 4: where the Commissioning Authority identifies systems which require witness demonstration, repeat Steps 2 and 3. These demonstrations may be coordinated with training demonstrations of Owner's operations staff.
- .4 On completion of systems which do not require witness demonstration, finalize the report and submit to the Commissioning Authority and the Consultant for review.
- .5 On completion of systems which have been witness demonstrated, the Commissioning Authority is to sign-off the completed document, before they are issued for review.

3.6 Commissioning Implementation

- .1 Conduct operating tests and checks to verify that all components, equipment, systems, and interfaces between systems, operate in accordance with contract documents.
- .2 Demonstrate and verify operating modes, interlocks, specified control sequences, specific responses to abnormal or emergency conditions, and verification of the proper response of the Building Automation System.
- .3 Validate the results of the TAB report.
- .4 Roles and Responsibilities:

Organized by:	Contractor
Test sheets provided by:	Commissioning Authority
Testing conducted by:	Div. 20 trade subcontractors
Testing recorded by:	Div. 20 trade subcontractors
Tests witnessed by:	Commissioning Authority (selected tests) Design Consultant (selected tests)
Reports reviewed by:	Contractor Commissioning Authority Design Consultant Owner
Reports Accepted by:	Owner

3.7 Operating Checks

- .1 The Commissioning Authority witnesses selected equipment and system tests on an audit basis.
- .2 Set the system equipment into operating mode to be tested including but not limited to:
 - .1 Normal shut-down
 - .2 Normal auto position
 - .3 Normal manual position
 - .4 Unoccupied cycle
 - .5 Emergency power operation, including transition states.
 - .6 Alarm conditions
- .3 Inspect and verify the position of each device and interlock identified on the checklist.
- .4 Repeat the above tests for each operating cycle that applies to the system being tested.
- .5 Check the operating condition of the following elements during all modes of operation of the system:
 - .1 Safety interlocks
 - .2 Alarms
 - .3 Smoke control and smoke venting interlocks
 - .4 Life safety systems
- .6 For failed test items, provide appropriate comments to the checklist data sheet and classify whether it is a “Major” or “Minor” deficiency.
 - .1 The Consultant retains the right to make the final decision regarding classifications of deficiencies.
- .7 Verify the operational control of the systems through the Building Management System as follows:
 - .1 TAB airflow rates and calibrate terminal boxes in all modes of operation
 - .2 Equipment operation in both heating and cooling modes.
 - .3 Minimum outdoor air intake positions, air-side economizer cycles, and multi-set outdoor air damper positions as required for each operating sequence and mode.
 - .4 Building pressurization and other specialty programs
- .8 Verify the proper responses of instrumentation and control devices (actuators) as follows:
 - .1 For each controller or sensor, record the indicated monitoring and control system reading, and the test instrument reading.
 - .2 If the initial test indicates that the test reading is outside of the control range of the installed device, check the calibration of the installed device and adjust as required. Re-test the deficient device and record the results on the checklist data sheets.
- .9 The Commissioning Authority witnesses the field verification of the final TAB report as follows:
 - .1 Select, at random, 10% of the report data for verification.
 - .2 The TAB contractor will be provided advance notice of the date of retesting, but not the equipment to be tested.
 - .3 The TAB contractor uses the same equipment and instruments used for collecting the original data.
- .10 Test failure is defined as:

- .1 For all readings other than sound, a deviation of more than 10 percent from the TAB report results.
 - .2 For sound pressure readings, a deviation of 2 dB at any bandwidth, not including differences in background noise readings.
 - .3 A failure rate greater than 10% of the selected items (1% of all TAB test results) will result in rejection of the final TAB report.
- .11 Acceptance
- .1 The final reports will be reviewed by the Commissioning Authority and the Consultant, to determine if verification is complete and the operating systems are functioning in accordance with the contract documents.
 - .2 The Commissioning Authority, in conjunction with the Consultant, reviews and makes final classification of all noted deficiencies. Correct deficiencies classified as “Major” before acceptance of the Verification stage.
 - .3 The Owner will make the final acceptance of test results.

3.8 Performance Validation Testing

- .1 Conduct performance tests and checks to validate that equipment and system components are providing the required heating and cooling performance (capacity), including but not limited to:
 - .1 Capability of the Chilled water system to deliver the required flow rate, and water temperature at design conditions.
 - .2 Capability of the hydronic and domestic water heating systems to deliver the required flow rate, and temperature.
 - .3 Capacity of electric heating systems at design temperatures.
 - .4 Confirm the ability of the HVAC systems to deliver the required cooling/heating services, at the design supply air temperature, required static pressure, and proper outside air ventilation rate.
- .2 Special testing requirements:
 - .1 Test water chillers in accordance with ARI 590 and 591, at design conditions for full load ratings, and IPLV ratings.

3.9 Problem Resolution

- .1 In the event that additional work is required to either correct systems, misapplied equipment, and/or deficient performance under varying load conditions, assist the Owner and Commissioning Authority in developing an acceptable resolution to the problem, including the resources of equipment suppliers.
- .2 The Owner has final approval over any additional work required to achieve the required level of performance.
- .3 Complete corrective work in a timely fashion to permit the completion of the commissioning process.

3.10 Acceptance

- .1 Any identified deficiencies will be reviewed by the Consultant in conjunction with the Contractor to determine if correction of the deficiency is as a result of a defect in the equipment or installation.
- .2 If it is determined the performance deficiency is as a result of a defect in the equipment or its installation, rectify the deficiency and repeat the performance test until the required performance levels are achieved.
- .3 If it is determined the equipment or system has been constructed in accordance with the contract documents, the Owner will decide whether to accept the performance as is, or, direct the installation

contractor to make changes to the system as required to obtain performance levels which meet the design intent, and retest the system.

3.11 Seasonal Commissioning

- .1 Commence initial performance validation testing commissioning at the completion of the installation and verification testing phase. Conduct performance testing, which is weather dependent, as applicable to current seasonal conditions. Complete performance testing on non-weather dependent systems in accordance with the agreed commissioning plan schedule.
- .2 For out-of-season system performance testing, conduct initial performance tests to demonstrate off-peak load performance. Schedule peak load performance testing over the succeeding nine (9) months to ensure all equipment is tested at peak load prior to the expiry of the warranty period.
- .3 Test heating equipment/systems during winter design extremes.
- .4 Test cooling systems during summer design extremes with a fully occupied building.
- .5 Alternatively, provide temporary equipment (load banks, etc.) to simulate full load conditions. Submit proposed methodology for review by the Commissioning Authority and Consultant.

3.12 Additional Commissioning

- .1 Additional commissioning activities may be required after completion of system performance testing. Include in the tender cost a reasonable reserve to complete this work, including assistance from manufacturers' service technicians.

3.13 Systems Operating Manuals

- .1 Provide Operating and Maintenance Manuals in accordance with the requirements of section 20 01 01.
- .2 The Systems Operating Manuals (SOM) are in addition to the Operating and Maintenance Manuals (OMM) required under Section 20 01 01.
 - .1 Provided by Commissioning Authority and/or Consultant.

3.14 Training

- .1 Perform training in accordance with ASHRAE Guideline 1.3 except/and as specified herein.
- .2 Equipment Training:
 - .1 Provide equipment training in accordance with Section 20 01 01. The manufacturer's representative training will emphasize operating instructions and preventative maintenance.
- .3 Systems Training:
 - .1 In addition to the equipment training described above, provide additional training to describe the operational requirements and design intent of each system.
 - .2 Include classroom instruction, delivered by competent instructors. Place emphasis on overall systems diagrams and descriptions, and design criteria and conditions.
 - .3 If required, obtain and pay for the services of the Design Consultant to provide the instructor services and to provide lecture material for inclusion in the training manual.
 - .4 Training topics to include:
 - (a) Types of installed systems
 - (b) Design intent and design criteria
 - (c) Design constraints
 - (d) Different operating modes – occupied, unoccupied, emergency conditions, etc.

- (e) Seasonal operating modes
 - (f) IAQ
 - (g) Energy efficiency
 - (h) System operation
 - (i) Automatic controls
 - (j) Service, maintenance, diagnostics and repairs
 - (k) Use of reports and logs
 - (l) Troubleshooting
- .5 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, with the services of the manufacturers' representative as required. Demonstrate the start-up and shut-down of each system.
- .6 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each topic, separated by approximately one week each, to allow for shift coverage.
- .7 Structure each training session based on type of maintenance personnel attending the training session, i.e. Plumbers, fitters, general maintenance, controls technicians, etc. Develop the proposed training plan and obtain approval from the Owner before commencing the training.
- .8 Complete the training as close to Substantial Performance as possible, so that the Owner's operations staff are prepared to operate the system after Substantial Performance is certified.
- .4 Training Manuals
- .1 Provide training material hand-outs for each session.
 - .2 Collect training material and bind into separate binders.

END OF SECTION

CLOSEOUT REQUIREMENTS FOR MECHANICAL WORK 20 77 19.20

1 GENERAL

1.1 Scope

- .1 Provide documentation deliverables at completion of the Work for the following milestone events:
 - .1 Occupancy permit (where applicable) (Form OP1M),
 - .2 Substantial Performance of the Work (Form SP1M),
 - .3 Ready for take-over by Owner (Form RFT1M),
 - .4 Total Performance of the Work (Form TP1M).

1.2 Definitions

- .1 The following definitions apply to this section.
 - .1 **Occupancy permit** – means either: (i) a permit issued by a regulatory authority to allow the Owner to occupy the building subject to the building permit, or (ii) a building permit close-out procedure where documentation must be submitted to the building authority for that purpose.

1.3 General

- .1 The prerequisites and submittal of supporting documentation for the aforementioned milestone events may be combined as a single submission at one point in time for the following combination of events:
 - .1 Occupancy Permit, and Substantial Performance.
- .2 Where a prerequisite is listed in more than one milestone event, it shall be included in the earliest-occurring milestone event unless expressly specified otherwise.

1.4 Occupancy Permit

- .1 Submit the reviewed final record of the Testing of Integrated Life Safety and Fire Protection Commissioning report two weeks prior to application for occupancy permit, where such a report is required.
- .2 Complete the Occupancy Permit Checklist and submit with required documentation to support the Owner's application for occupancy.

1.5 Substantial Performance

- .1 Complete the Substantial Performance Checklist and submit with required documentation when applying for Substantial Performance of the Work.
- .2 Where the work is sub-divided into separate scopes of Work, each requiring a separate Substantial Performance application, provide a separate checklist for each application.
- .3 Within five working days of the Consultant's review report which indicates that Substantial Performance of the Work has been achieved, provide a detailed schedule for completion and/or correction of the Work of all items described in the Contractors' and the Consultants' deficiency list.

1.6 Ready-for-Takeover by Owner

- .1 The basic prerequisites to attaining Ready-for-Takeover of the Work are described in the General Conditions and Supplementary General Conditions of the Contract.

- .2 Complete the Ready-for-Takeover Checklist and submit with required documentation when applying for Ready-For Takeover of the Work.

1.7 Total Performance

- .1 Complete the Total Performance Checklist and submit with required documentation when applying for Total Performance of the Work.

Form OP1M: OCCUPANCY PERMIT CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- Building department inspection reports.
- AHJ pressure piping inspection reports (if applicable).
- AHJ fuel system inspection reports (if applicable).
- AHJ electrical systems inspection reports.
- Sprinkler installation certification report to NFPA 13.
- Standpipe installation certification report to NFPA 14.
- Fire pump installation and test certificate to NFPA 20.
- Integrated Fire Protection and Life Safety test report to ULC-S1001.
- Medical gas inspection report and certificate.
- Air and Water Balancing reports (Interim) for ventilation and heating.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

Form SP1M: SUBSTANTIAL PERFORMANCE APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- Occupancy permit has been issued by the AHJ (where applicable).
- Systems have been started-up, tested, and demonstrated to Owner or Consultant.
- First submission TAB reports have been submitted to Consultant.
- Acoustic survey report submitted to Consultant (if specified).
- Vibration survey report submitted to Consultant (if specified).
- Controls / BMS operation report submitted to Consultant (if specified).
- Equipment, pipeline, and valve identification completed
- Spare parts and replacement parts turned over to Owner, transmittal attached.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

Form RFT1M: READY-FOR-TAKEOVER APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- Substantial Performance has been certified or verified.
- Occupancy permit has been issued by the AHJ (where applicable).
- Final cleaning and waste removal completed.
- Delivery to Owner of Operating and Maintenance documents for systems being taken-over by Owner.
- Submit copies of up-to-date as-built drawings.
- Final start-up, testing and balancing reports completed and submitted to Owner, including any items requiring corrections identified by Consultant.
- The portions of the building being turned over to the Owner can be secured by Owner.
- Demonstration and training are completed, or Contractor and Owner has agreed to a schedule to provide such training to be completed within one month after the date of Ready-for-Takeover.
- All commissioning activities except for those activities that are identified or otherwise agreed by the Owner to be deferred commission activities which may be completed after Ready-for-Takeover of the Work.
- Integrated systems testing of fire protection and life safety systems.
- All warranties have been submitted to the Owner.
- A comprehensive list of items to be completed or corrected is provided to Owner and Consultant and included in the application for Ready-for-Takeover, and includes a schedule of when such work will be completed.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

Form TP1M: TOTAL PERFORMANCE APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- All final Operating and Maintenance documents have been delivered to Owner.
- All final up-to-date as-built drawings have been delivered to Owner.
- Any follow-up testing and balancing reports, including alternate season testing reports, have been submitted to Owner.
- All demonstration and training are completed.
- All commissioning activities are completed, including deferred alternate season commissioning activities.
- All known deficiencies have been corrected, including latent deficiencies reported by the Owner.
- All inspections and tests required to be performed by Contractor or manufacturer's prior to expiry of the warranty period have been completed, and documentation for those inspections and tests are included in this application.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

End of Section

COMMON WORK RESULTS FOR FIRE SUPPRESSION 21 05 01

1.1 GENERAL

1.2 Scope

- .1 Fire suppression work includes;
 - .1 Wet Pipe Sprinkler System,
- .2 Piping materials specified herein are limited to design pressures not exceeding 2000 kPa (300 psi).

1.3 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 20 05 29 Common Hanger and Support Requirements for Piping

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 Fire suppression work to conform to standards of the National Fire Prevention Association (NFPA) and relevant sections of the provincial Building Code applicable to the location of the Work.
 - .2 CSA B64.10 Selection and Installation of Backflow Preventers / Maintenance and Field Testing of Backflow Preventers
- .2 Product standards:
 - .1 ANSI B1.20.1 Pipe Threads, General Purpose (inch)
 - .2 ASME B16.1 Cast Iron Pipe Flanges And Flanged Fittings
 - .3 ASME B16.3 Malleable Iron Threaded Fittings.
 - .4 ASME B16.4 Cast Iron Threaded Fittings, Class 125 and 250
 - .5 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .6 ASME B16.9 Factory Made Wrought Steel Buttwelding Fittings
 - .7 ASME B16.11 Forged Steel Fittings, Socket-Welding and Threaded
 - .8 ASME B16.15 Cast Bronze Threaded Fittings, Classes 125 and 250
 - .9 ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
 - .10 ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges.
 - .11 ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - .12 ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings; Class 150, 300, 400, 600, 900, 1500, & 2500.
 - .13 ASME B16.39 Malleable Iron Threaded Pipe Unions: Classes 150, 250 and 300.
 - .14 ASME B18.2.1 Square and Hex Bolts and Screws,
 - .15 ASME B18.2.2 Square and Hex Nuts

.16	ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
.17	ASTM A135	Standard Specification for Electric-Resistance-Welded Steel Pipe
.18	ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High-Pressure or High-Temperature Service, or Both.
.19	ASTM A795	Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire suppression Use
.20	CSA B64.4	Backflow Preventers, Reduced Pressure Principle Type (RP)
.21	ULC-B65.5	Backflow Preventers, Double Check Valve Type (DCVA)
.22	CSA B242	Groove and Shoulder Type Mechanical Pipe Couplings
.23	UL 203	Pipe Hanger Equipment for Fire suppression Service
.24	UL 393	Indicating Pressure Gauges for Fire Protection Service
.25	UL 1468	Standard for Direct Acting Pressure Reducing and Pressure Restricting Valves
.26	UL 1739	Standard for Pilot-Operated Pressure-Control Valves for Fire-Protection Service
.27	ULC/ORD-C203	Pipe Hanger Equipment for Fire suppression Service
.28	ULC/ORD-C213	Rubber Gasketed Fittings for Fire suppression Service
.29	ULC/ORD-C213B	Welded Outlet Fittings
.30	ULC-S548	Alarm Initiating and Supervisory Devices for Water Type Extinguishing Systems

1.5 Qualified Tradesmen

- .1 Work to be performed by qualified and recognized firm with an established reputation in this field, using tradesmen holding certificates of competency.

1.6 Water Supply Test Results

- .1 Provide water flow test on municipal water service in proximity to building connection, in accordance with NFPA 14 and NFPA 291. Flow test must be conducted within one (1) year prior to system design. Submit record of test including static pressure, and residual pressure and flow.
 - .1 Obtain municipal approval and pay fees associated with testing.

1.7 Design Criteria

- .1 Pressure piping design conditions and applicable codes are specified herein. Where different operating and design pressures are shown on drawings, the drawings govern.
- .2 System design criteria are described in the relevant Division 21 system specifications.
- .3 Where a "Class" is indicated on drawings, this refers to Class as defined in the applicable ASME B16 series of product standards. Notwithstanding the maximum allowable pressure-temperature ratings defined for each ASME Class designation, the applicable Class designation by floor level shown on the drawings may identify lower maximum allowable design pressures applicable to any Class rating.

2 PRODUCTS

2.1 Carbon Steel Pipe

- .1 Piping materials:
 - .1 to ASTM A53 Grade B, seamless or electric-resistant-welded (ERW),
 - .2 to ASTM A135 Grade B, ERW,
 - .3 to ASTM A795. Grade B, ERW.
- .2 Pipe wall thickness: as specified in each applicable fire suppression specification section.
- .3 Piping to be hot-dipped galvanized where required in each system specification section in Division 21.

2.2 Steel Pipe Joints and Fittings

- .1 Threaded fittings:
 - .1 end connections: NPT thread to ANSI B1.20.1.
 - .2 fittings:
 - (a) Class 125 cast iron to ASME B16.4,
 - (b) Class 150 and Class 300, malleable iron to ASME B16.3.
 - .3 unions: Class 150 and Class 300, malleable iron body with ground joint and bronze face to ASME B16.39.
 - .4 threaded joint compound: pulverized lead paste or Teflon pipe tape sealant.
- .2 Welding fittings:
 - .1 butt weld fittings:
 - (a) forged to ASME B16.9,
 - (b) wall thickness to match pipe,
 - (c) long radius elbows.
 - .2 welding outlet fittings:
 - (a) forged to ASTM A105,
 - (b) dimensions and pressure ratings to MSS SP-97, Standard Class for buttwelding branch connection and Class 3000 for threaded or socket welded branch connection,
 - (c) NPT ends to ASME B1.20.1.
 - .3 special welding outlet fittings for fire protection:
 - (a) weld-on branch outlet fittings for groove-end and threaded-end connections for fire protection services,
 - (b) listed to ULC/ORD-C213B for fire protection service,
 - (c) forged from materials meeting ASTM A53 Gr. B.,
 - (d) pressure rating: 2067 kPa (300 psi) for fire protection water,
 - .4 socket welded fittings:

Standard of Acceptance

- Masters Pro-Dope
- Masters Orange or White Tape.

- (a) forged to ASTM A105,
 - (b) dimensions and pressure ratings to ASME B16.11, Class 3000.
- .5 half couplings:
- (a) forged carbon steel to ASTM A105,
 - (b) dimensions and pressure rating to ASME B16.11, Class 3000 socket weld or threaded ends,
 - (c) NPT ends to ASME B1.20.1.
- .3 Flanges:
- .1 flat-faced cast iron to ANSI B16.1, Class 125.
 - .2 raised-face forged carbon steel to ASME B16.5, Class 150 and Class 300, weld neck with wall thickness to match pipe, or slip on type.
 - .3 studs, bolts and nuts to ANSI B18.2.1, ANSI 18.2.2 and ASTM A194, "high strength" type.
 - .4 gaskets:
 - (a) styrene butadiene rubber sheet to ANSI B16.21.
 - (b) 1.6 mm (1/16 in) thick.
- Standard of Acceptance*
- Chesterton - fig. 100
 - Beldam
- .4 Grooved fittings and couplings:
- .1 couplings listed to CSA B242,
 - .2 listed for combination of fittings, couplings and gaskets to ULC/ORD-C213,
 - .3 rolled or cut grooved (depending on pipe wall thickness), standard or rigid style,
 - .4 fittings and couplings NPS 2 to 12: malleable iron to ASTM A47 or ductile iron to ASTM A536,
 - .5 gaskets: dry lubricated EPDM,
 - .6 design temperature rating: -34°C (-30°F) to 110°C (230°F),
 - (a) design pressure rating: 2400 kPa (350 psig),
- Standard of Acceptance*
- Victaulic
 - Gruvlok

2.3 Pipe Supports

- .1 Pipe supports and hangers to conform to specification section 20 05 29 except/and as specified herein.
- .2 Pipe hangers and supports to be listed ULC/ORD-C203 or UL 203 for fire suppression service, except where such listing requirement is excluded under applicable NFPA standards.

3 EXECUTION

3.1 Piping Installation General Requirements

- .1 General layout of mains, risers, run-outs and connection details of piping systems are shown.
- .2 Install concealed pipes close to building structure to keep furring spaces to minimum and minimize obstruction to other services in ceiling spaces.

- .3 Run exposed piping parallel to walls and conserve headroom and space, except where specific installation details are shown.
- .4 Support piping in accordance with the requirements of the NFPA standard applicable to the system type, subject to and in accordance with the requirements of specification section 20 05 29.
- .5 Ream pipe after cutting to length and clean off scale and dirt inside and outside of pipe before threading, grooving or welding.
- .6 Provide bends, expansion loops, hoses or joints to compensate for pipe seismic movement.
- .7 Anchor, guide and laterally support vertical and horizontal piping to support filled weight and absorb thrust under operating conditions.
- .8 Erect piping so that gravity forces and thrust from changes in direction do not stress connections to apparatus.
- .9 Provide di-electric couplings or flanges where steel pipe connects to copper tube.
- .10 Install drain valves at low points in water piping systems and in valved run-outs from risers so that system or isolated parts of system can be drained.
- .11 Do not use galvanized materials in contact with glycols.
- .12 Personnel involved in installation of grooved joint piping and fittings to be trained by product manufacturer and be conversant with;
 - .1 pipe end preparation and special tools,
 - (a) pipe ends to be clean and free from indentations, projections and roll marks in area from pipe end to groove.
 - (b) dimensions to be according to standard cut groove or roll groove in accordance with CSA
 - .2 coupling and fitting selection.
 - .3 joint assembly to accommodate expansion, contraction, and flexibility,
 - .4 specifications and/or recommendations with respect to support, anchorage and guiding of pipe systems.

3.2 Pipe Joints

- .1 Refer to applicable fire suppression system specification sections for permissible type of pipe joints to be used and any restrictions therein.
- .2 Use flat-faced steel flanges when attaching to cast iron flanges.

3.3 Welding Procedures

- .1 Welding of fire suppression piping to be in accordance with specification section 20 05 24 except as otherwise required by the NFPA standard applicable to the type of fire suppression system.
- .2 Welding acceptance criteria to be in accordance with the NFPA standard applicable to the type of fire suppression system.

3.4 Pressure and Leak Testing

- .1 In accordance with the applicable specification sections of Division 21.

END OF SECTION

WET PIPE SPRINKLER SYSTEM

21 13 13

1 GENERAL

1.1 Scope

- .1 Provide wet pipe automatic sprinkler systems.
- .2 Provide installation drawings and hydraulic calculations, designed and sealed by a professional engineer licensed in the province or territory of the Work.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 08 11 Testing of Integrated Mechanical Life Safety and Fire Protection Systems
 - .2 21 05 01 Common Work Results for Fire Suppression

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Pressure reducing valve** – a valve that reduces the inlet water pressure to a regulated constant outlet pressure under static (no flow) and dynamic (water flowing) conditions (“pressure reducing” and “pressure controlling” valves have the same meaning).

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Building Code
- .2 Installation codes and standards:
 - .1 ASTM C636 Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustic Tile and Lay-In Panels
 - .2 NFPA 13 Standard for the Installation of Sprinkler Systems
- .3 Insurance company standards:
 - .1 FM Global Engineering Data Sheets
- .4 Product standards:
 - .1 ASTM C635 Standard Specification for Manufacture, Performance and Testing of Metal Suspension systems for Acoustic Tile and Lay-in Panel Ceilings
 - .2 UL 199 Standard for Automatic Sprinklers for Fire Protection Services
 - .3 UL 1478A Standard for Pressure Relief Valves for Sprinkler Systems
 - .4 UL 2443 Flexible Sprinkler Hose with Fittings for Fire Protection Service
 - .5 ULC/ORD-C312 Check Valves for Fire Protection Service

1.5 Qualified Subcontractors

- .1 Sprinkler work to be undertaken by specialist fire protection installation firm with an established reputation in this field, and licences or otherwise qualified to perform such work where required by regulation.

1.6 Design Criteria

- .1 Piping design temperature: 38°C (100°F)
- .2 Piping design pressure: 2060 kPa (300 psi)
- .3 Sprinkler system type: stand-alone
- .4 Consultant's indicative system layout is designed to NFPA 13 and FM requirements using hydraulic method for hazard classification shown with design densities and design areas for each zone as detailed.
- .5 Changes to pipe sizes, pipe layout and head layouts accompanied with modified hydraulic calculations and sealed by a professional engineer licensed in the jurisdiction of the Work may be submitted for approval at the time of shop drawing submission, but prior to installation, purchasing or fabrication of associated materials and equipment.

1.7 Design Services

- .1 Provide engineering design services for the automatic sprinkler systems, including piping system detailed fabrication and installation drawings, supported by contractor's own hydraulic calculations and water supply test flow data.
- .2 Design of wet-pipe sprinkler systems is to conform with the requirements of NFPA 13 of the edition adopted by the AHJ, except/and as otherwise specified herein.
- .3 Coordinate sprinkler system layout with the work of other Trades. Prepare fabrication/installation drawings taking into account this coordination.
- .4 Conduct a site water flow test and prepare hydraulic calculations based on those test results.

1.8 Submittals

- .1 Submit manufacturer data sheets for products specified herein.
- .2 Prepare and submit shop drawings for sprinkler system fabrication and installation drawings including hydraulic calculations;
 - .1 forward three copies to Owners Insurers for review and acceptance,
 - .2 after shop drawings are accepted by reviewing authority, submit copies of these stamped shop drawings and product data sheets to Consultant for review.
- .3 Samples:
 - .1 Submit samples of;
 - (a) sprinkler heads,
 - (b) signs.

1.9 Maintenance Materials

- .1 Provide cabinet, containing special sprinkler wrench, and spare stock of sprinklers. Include at least one head of each type and temperature rating installed in system.

2 PRODUCTS**2.1 Pipe, Fittings and Valves**

- .1 Pipe and fittings: in conformance with specification section 21 05 01 except/and as specified herein.
- .2 Valves: in conformance with specification section 21 05 23.
- .3 Pipe minimum wall thickness: in accordance with Table 1 except as follows:

- .1 use schedule 40 of either ASTM A53 or A135 in the following locations:
 - (a) exposed vertical piping in parking garages, truck docks and other areas subject to vehicular traffic, between floor level and to a height of 3.0 m (10 ft) above floor level,
 - (b) exposed vertical piping in factories and manufacturing plants, between floor level and to a height of 5.0 m (15 ft) above floor level or the bottom of the roof structural steel, whichever is lower,
 - (c) do not use ASTM 795 in the above listed locations.

Table 1: Pipe Selection and Minimum Pipe Wall Thickness			
Pipe Size	Joining Method	ASTM A53, ASTM A135	ASTM A795
≤ 2-1/2	Threaded, Cut Groove	Schedule 40	Standard Weight
2-1/2 to 6	Welded, Roll Groove	Schedule 10	Light-Weight
	Cut Groove	Schedule 40	Standard- Weight
8 to 10	Welded Roll Groove	Schedule 40	Standard-Weight
	Cut Groove	Schedule 40	Standard-Weight
≥ 12	Welded, Roll Groove	9.5 mm (0.375 in)	Not applicable

- .4 Mechanical Tees for grooved pipe fittings:
 - .1 restricted use; refer to Part 3,
 - .2 gasket-sealed mechanical Tee's, for installation of branch piping to mains pipe,
 - .3 ductile iron body to ASTM A-395, with EPDM gasket,
 - .4 gull-wrap coupling around pipe mains; half-coupling with U-bolt arrangement not permitted.

Standard of Acceptance

- Victaulic - fig. 920/920N

2.2 Pipe Supports, Hangers and gaskets

- .1 To section 21 05 01.

2.3 Sprinkler Heads

- .1 Ratings:
 - .1 listed to UL 199 for Canada and FM approved for fire service,
 - .2 standard temperature rating 57°C to 74°C (135°F to 165°F) with intermediate or high temperature rating to suit local conditions.
 - .3 thermal sensitivity:
 - (a) Quick Response type for Light and Ordinary hazard applications
 - (b) Standard response type for Extra hazard applications.

Standard of Acceptance

- Viking
- Tyco
- Reliable
- Victaulic

.2 General purpose sprinkler head types in accordance with Table 1.

Table 1: Sprinkler Head Types						
Type	Orientation	Feature	Body Finish	Escutcheon Finish	Release	Remarks
U-1	Upright	---	Bronze body	---	Glass Bulb	12 mm (½ in) diameter orifice or 13 mm (17/32 in) diameter orifice as shown
P-2	Pendent	Concealed	Bronze	White	Glass Bulb	Fusible cover plate

2.4 Signage

.1 Construction:

.1 1.2 mm (18 ga.) thick aluminium, with Mylar protective facing, red enamel background, white letters, inscription in accordance with NFPA standards,

.2 Size:

.1 230 x 180 mm (9 x 7 in) for automatic control valves and alarm valves,

.2 50 x 150 mm (2 x 6 in) for other valves,

.3 130 x 180 mm (5 x 7 in) for hydraulic calculation signs,

2.5 Maintenance Materials

.1 Storage cabinet: steel cabinet with lockable doors, baked enamel red finish,

.2 Included maintenance materials:

.1 special sprinkler wrench,

.2 spare stock of sprinklers, with at least one head of each type and temperature rating installed in the system.

3 EXECUTION

3.1 Piping Installation General Requirements

.1 Install sprinkler piping and supports in accordance with specification section 21 05 01 except/and as specified herein.

.2 Extend piping from existing mains and branches and connect to sprinklers.

.3 Provide NPS ¾ drain valves with hose end and caps in the following locations:

.1 at the bottom of sprinkler risers,

- .2 at trapped low points in piping system.
- .4 Provide NPS $\frac{3}{4}$ manual air vent valve with cap and chain at the top of each sprinkler riser and where shown;
 - .1 run NPS $\frac{3}{4}$ air vent piping from top of riser and down to a location where the manual vent valve is accessible,
 - .2 manual vent valve to be located at a height of not more than 2.1 m (7 ft) above local floor level, and positioned so outlet is pointed down.
- .5 Provide additional sprinkler heads with associated piping for sprinkler protection under ducts, under obstructions, and in blind spaces. Identify additional sprinkler heads on shop drawings with capital letter "A" and resubmit drawings to permit inclusion of these sprinkler heads in hydraulic calculations.

3.2 Pipe Joints (other than Mechanical Tees for Branch Piping)

- .1 Make pipe joints using jointing methods in accordance with Specification section 21 05 01.

3.3 Mechanical Tees for Branch Piping

- .1 The use of mechanical Tees for grooved joint installation is restricted by the following conditions:
 - .1 may be used in existing buildings for connection of single- sided branch piping connections to existing installations,
 - .2 may be used in new buildings, for single-sided branch piping connections in areas without ceilings, and
 - .3 where specifically authorized by Consultant on a case-by-case basis.

3.4 Sprinkler Head Selection and Layout

- .1 Use concealed pendant sprinklers where suspended ceilings occur. Locate sprinklers in symmetrical pattern to suit reflected ceiling plans and to avoid speakers, fire alarm components, lighting fixtures, ductwork and diffusers. In general, centre heads in ceiling tiles. Examine architectural reflected ceiling plan to coordinate sprinkler head layout and locations.

3.5 Identification and Signage

- .1 Provide signs at each valve, including control valves, shut-off valves, drain valves, vent valves and test valve, identifying portion of system controlled. Provide hydraulic design parameters nameplate on each alarm check valve.
- .2 Fasten signs to pipe in immediate vicinity of valve.
- .3 Coordinate with Electrical Division 26 to ensure consistency between fire alarm annunciation and associated tagging.

3.6 Maintenance Materials Cabinet

- .1 Coordinate with Owner as to their desired location for installation of the maintenance materials cabinet.
- .2 Provide signage on the front of the cabinet identifying its function.

3.7 Pressure Testing

- .1 Conduct pressure testing of sprinkler piping systems in accordance with requirements of NFPA 13 and building insurer requirements, if any, and as follows.
- .2 In existing buildings, conduct an initial pneumatic pressure test of the new and modified work before connection to the existing system, to test for significant leaks before filling the modified installation or new work with water.

- .1 isolate the new piping from the existing system,
 - .2 pressure test the new piping at 280 kPa (40 psig) using oil-free compressed air or nitrogen,
 - .3 maintain pressure test for one hour without loss of pressure,
 - .4 if any leaks are discovered, repair leaks and retest.
- .3 Conduct hydrostatic pressure tests at the test pressures and for the test durations as follows:
- .1 for new piping systems with a working pressure of 1030 kPa (150 psi) or less:
 - (a) a minimum of 1380 kPa (200 psi) for a test period of not less than two hours,
 - .2 for new piping systems or portion thereof with a working pressure of greater than 1030 kPa (150 psi):
 - (a) a minimum of the working pressure plus 345 kPa (50 psi) for a test period of not less than two hours,
 - .3 for modifications or additions to an existing systems involves more than 20 sprinkler heads:
 - (a) the test pressure and duration as specified for a new installation, except only the new piping is to be tested with the new piping isolated from the existing systems,
 - (b) the new piping section may be isolated by a service valve at the tie-in point to the existing system, or it may be isolated by installation of a temporary plug,
 - (c) for installation of a temporary test plug, a section of the new pipe at the connection to the existing system is removed; this spool piece is not to exceed a length of 300 mm (12 in.) nor contain more than two pipe joints.
 - (d) after pressure testing is completed and the spool piece is reinstalled, conduct an in-service pressure test of the spool piece and its joints.
 - .4 where the work only involves the modification to an existing system that impacts not more than 20 sprinkler heads, only an in-service pressure test is required,
 - .5 where modifications to an existing system only involves relocating sprinkler heads and associated pipe drops (but without any changes to any other system piping), only an in-service pressure test is required.
- .4 In-service pressure test:
- .1 where an in-service pressure test is required, return the sprinkler system to its normal operating condition and bleed-off trapped air as much as possible,
 - .2 visually inspect the subject joints, using joint leak detection solution.
- .5 Pressure testing of multi-storey buildings:
- .1 pressure test the sprinkler risers separate and isolated from on-floor piping, except that the feed main connecting the risers may be included in the riser pressure test,
 - .2 pressure test each on-floor sprinkler zones separately and independently of the system sprinkler risers; isolate each floor from the system riser during the test.
- .6 Pressure test acceptance criteria:
- .1 pressure loss not exceeding 10 kPa (1.5 psi) as measured by installed pressure gauge, or where visual examination of all pipe joints determines there are no visible leaks.

3.8 Operational Testing

- .1 Conduct an operational test of all flow control and alarm devices. Test sprinkler systems in accordance with requirements of NFPA 13, and building insurer requirements (if any).
- .2 Schedule testing to give at least two weeks' notice to AHJs having jurisdiction for:

- .1 building/plumbing Inspector,
 - .2 fire department representative,
 - .3 insurer's representative,
 - .4 Owner, and
 - .5 Consultant.
- .3 Prior to testing, ensure that valves, flow switches, pressure switches, supervisory switches and other devices are functioning and in-service.

3.9 Integrated Testing of Life Safety and Fire Protection Systems

- .1 Participate as required in the integrated system testing of the standpipe system in accordance with specification section 20 08 11.

3.10 Testing Reports and Certificates

- .1 Provide completed and signed Contractor's Material and Test Certificate for above ground piping.
- .2 Submit copies of completed Certificates to the Consultant, and include copies in the Operating and Maintenance manuals.

END OF SECTION

COMMON WORK RESULTS FOR PLUMBING PIPING 22 05 01

1 GENERAL

1.1 Scope

- .1 Provide piping systems for plumbing, drain and vent systems for:
 - .1 potable (domestic) water systems,
 - .2 non-potable water piping systems,
 - .3 drainage system including:
 - (a) sanitary drainage and vent systems,
 - .4 other plumbing systems including:
 - (a) specific duty piping systems otherwise specified in Division 22.

1.2 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Building Code
 - .2 Municipal bylaws regarding potable water, water services, and sewage systems.
- .2 Installation standards and codes:
 - .1 AWWA C651 Disinfecting Water Mains.
- .3 Product standards:
 - .1 CSA B272 Pre-Fabricated Self Sealing Roof Vent Flashings

1.3 Qualified Tradesmen

- .1 Work to be performed by qualified and recognized firm with an established reputation in this field, using tradesmen holding certificates of competency.

1.4 Design Criteria – Pressure Piping Systems

- .1 The following design conditions apply unless otherwise shown on drawings.
- .2 System design criteria:
 - .1 Domestic Cold Water Service (to building):
 - (a) Design pressure: 900 kPa (130 psig)
 - (b) Design temperature: 25°C (77°F)
 - .2 Potable water:
 - (a) Design pressure: 900 kPa (130 psig)
 - (b) Design temperature: 107°C (225°F)
 - .3 Non-potable water:
 - (a) Design pressure: 900 kPa (130 psig)
 - (b) Design temperature: 107°C (225°F)

2 PRODUCTS

2.1 Flashings

- .1 Through-roof penetration flashing, and other waterproofed areas:
 - .1 manufactured from composite material in accordance with CSA B272,
 - .2 minimum dimensions of 500 mm x 500 mm (20 in x 20 in),
 - .3 with sleeve extending at least 150 mm (6 in) above roof.

2.2 Dielectric Unions

- .1 Construction:
 - .1 Bronze or brass body with non-metallic fitting or coating the FNPT tailpiece.
 - .2 FNPT x Copper sweat connection.
 - .3 Pressure rating; ASME Class 3000 at 121°C (250°F)

Standard of Acceptance

- Hart Industrial Unions - fig. D-3136 or Polymer Composite Coating

2.3 Dielectric Flanges

- .1 Construction:
 - .1 ASME Class 150 or 300 carbon steel flange, Van-stone style with copper tube adapter tailpiece.
 - .2 Flange provided with a powder coated finish, and an EPDM insulator to isolate the copper tailpiece from contact with the flange.
 - .3 Minimum MCPR:
 - (a) Class 150: 1400 kPa (200 psi) at 121°C (250°F)
 - (b) Class 300: 2800 kPa (400 psi) at 121°C (250°F)

Standard of Acceptance

- CTS Flange Canada - fig. BF / WBG

3 INSTALLATION

3.1 Piping

- .1 Piping system routing is shown diagrammatically. Locate mains, risers and runouts concealed behind furrings or above ceilings except in mechanical equipment rooms and access spaces where piping is to be exposed.
- .2 Determine areas without ceilings from Architectural Drawings and Room Finish Schedules, and in these areas keep piping as high as possible.
- .3 Anchor, guide and support vertical and horizontal runs of piping to resist dead load and absorb thrust.

3.2 Domestic Cold Water System Distribution

- .1 Extend existing domestic cold water system with
 - .1 distribution pipe and fittings,

- .2 valves,
 - .3 premises backflow isolation,
 - .4 zone or equipment backflow protection.
- .2 Minimum water pressure at street level: approximately 500 kPa (70 psi).
 - .3 Provide valved connections from supply system, to fixtures and other equipment requiring cold water.

3.3 Domestic Hot Water System Distribution

- .1 Extend existing domestic hot water system with
 - .1 distribution pipe and fittings
 - .2 valves
 - .3 zone or equipment backflow protection.
- .2 Provide cold water connections to hot water tank, with shut-off and expansion tank on supply and valved drain at bottom of tank.
- .3 Provide valved connections from hot water supply system to fixtures and other equipment requiring hot water.

3.4 Domestic Hot Water Recirculation System

- .1 Extend existing domestic hot water recirculation system with
 - .1 distribution pipe and fittings
 - .2 valves
 - .3 pumps
- .2 Connect ends of hot water risers to recirculation mains and extend to recirculation pump.
- .3 Provide minimum flow balancing valves at each connection between the domestic hot water loop and the hot water recirculation loop.

3.5 Dissimilar Metals Galvanic Isolation

- .1 Provide dielectric unions or flanges to separate copper and copper alloy tube and fitting materials from contact with carbon (plain and galvanized) steel material.
 - .1 For clarity, dielectric unions or flanges are not required when connecting copper to T304 or T316 stainless steel pipe or tubing.
- .2 Refer to specification section 23 05 01 for exemptions when connecting domestic water copper piping or stainless steel piping to HVAC piping systems.

3.6 Drainage

- .1 Existing storm drainage piping system is to remain.
- .2 Provide waste and vent connections to plumbing fixtures and equipment.
- .3 Drainage fittings;
 - .1 do not use double hubs, straight crosses, double T's, or double TY's in soil or waste pipe below any fixture,
 - .2 do not use branch fittings other than full "Y" or "Y" and an eighth bend, on soil or waste pipe running in horizontal direction,
 - .3 do not use quarter bend placed on its side,

- .4 do not use inverted joints below fixtures,
- .5 do not install cleanouts above food preparation or patient treatment areas. In these areas carry rodding connection up to floor cleanout fitted with adjustable gasketed access cover and plug, with cleanout body cast in floor slab above,
- .6 drainage fittings to match connected piping for quality and wall thickness.

3.7 Flashings

- .1 Provide flashing for piping penetrations through roofs and other waterproofed areas. Leave flashing ready for Roofing or Waterproofing Trades to make watertight connections.

3.8 Vent Termination (VTR)

- .1 Fit vents passing through roof with vent stack sleeve terminating not less than 150 mm (6 in) above roof, above flood level of roof, and 900 mm (3 ft) above or 3500 mm (11.5 ft) horizontally from any air intake, door, or operable window.

3.9 Water and Waste Connections

- .1 Provide hot and cold water, waste and vent connections to building service equipment. Provide connections to Owners equipment and equipment supplied by Divisions of the Work other than Division 20 to 25, as specified herein and in accordance with specification section 20 05 73.13.
- .2 Provide vacuum breakers and backflow preventers on equipment connections, and hose bibs, and on fixture connections without adequate air gaps.
- .3 Where hot and cold water supply pipes connect to combination supply fitting with shut-off valve on discharge, or where combination supply fitting is equipped with manual or thermostatic mixing valve, equip each hot and cold water supply pipe with composition disc swing check fitting.
- .4 Provide shut-off valve on each service line close to the apparatus and brass traps complete with cleanout on waste connection unless waste discharges directly into floor drain or funnel drain.
- .5 Where specific sizes are not shown, valves, and final connections to equipment to be one pipe size larger than equipment tapping size, and trap and drain size to be one pipe size larger than waste connection on apparatus.

3.10 Pressure Testing – Water Pressure Piping Systems

- .1 Pressure test piping before insulation is applied.
- .2 Initial pneumatic leak test:
 - .1 Conduct an initial pneumatic pressure test at a maximum pressure of 70 kPa (10 psig) prior to hydrostatic pressure test, to check for large leaks or incomplete joints.
 - .2 Remove compressed air source and maintain this pressure for the time necessary to inspect for leaks, but not less than 2 hours.
 - .3 Maintain pressure and examine each joint with commercial leak detector solution.

Standard of Acceptance

- Snoop
- Leak-tec
- .4 Repair leaks where found prior to performing hydrostatic pressure tests.

- .5 During pneumatic pressure tests, comply with the site safety requirements for notification and guarding during testing with compressed gasses.
- .3 Final hydrostatic pressure test:
 - .1 Use the system design pressure for the entire installation, unless different design pressures are indicated for each floor.
 - .2 Fill the system with water and gradually increase the system pressure to 150% of the design pressure and hold for 10 minutes, then reduce pressure to the design pressure.
 - .3 Inspect each pipe joint for leaks.
 - .4 As an alternative to inspection of each joint for leaks, conduct a 24 hour standing pressure test:
 - (a) raise the water pressure to 150% of the design pressure for 10 minutes, then reduce pressure to design pressure,
 - (b) record the test pressure one (1) hour after establishing the system hydrostatic test pressure at the design pressure. Record ambient air temperature at the same time.
 - (c) at the end of the 24 hour standing test period, record the test pressure and ambient air temperature. Make adjustments to the measured end-of-test pressure to account for change in fluid density due to change in ambient air temperature,
 - (d) acceptance criteria: maximum pressure loss over 24 hours not to exceed 1% of test pressure, corrected for ambient temperature,
 - (e) where acceptance criteria is not met, inspect pipe joints for leaks.
 - .5 Where leaks are found, repair leaks and retest piping as specified above.
 - (a) for soldered or brazed joints, one attempt at repairing the joint is permitted. If joint continues to fail, cut-out and replace the fitting.

3.11 Pressure Test Report

- .1 Maintain a log of all pressure tests, including locating of where leaks have been repaired. Submit the log to the Consultant for review when requesting prior to substantial completion of the Work. Where a piping system is subject to AHJ inspection, provide evidence of such inspection by means of an AHJ inspection report or name of the AHJ inspector and the date they witnessed the pressure test.

3.12 Flushing and Disinfecting - Water Service Pipe

- .1 Complete piping pressure tests prior to flushing and disinfecting operations. Notify Consultant at least two days in advance of date when disinfecting operations are proposed, so that the Consultant may witness the tests.
- .2 Isolate the water service pipe inside the building at the point of entry, from the building water distribution system. Flush water service pipes for a minimum of 10 minutes to produce a water velocity of 1.5 m/s (5 fps) and discharge water to drain or other acceptable area.
 - .1 Minimum flushing flow rates:

Pipe size	Minimum Flow	
	L/s	USGPM
2	3.3	52
2 1/2	4.7	75
3	7.3	115

4	12.6	200
6	23.4	450
8	49	780
10	76	1200
12	110	1750

- .3 Disinfect water service pipes NPS 4 and larger:
- .1 Provide chemicals and equipment to clean, disinfect and flush domestic water service pipes in accordance with AWWA C651.
 - .2 Drain down system to remove flushing water.
 - .3 Isolate service water pipe from the building distribution system.
 - .4 Disinfect water supply pipe by introducing chlorine close to point of connection to the municipal water supply and evenly add to water as water service pipe is refilling, to provide an initial concentration of 50 mg/L.
 - .5 Close off drains and maintain chlorinated water in mains pipe for 24 hours.
 - .6 At the end of 24 hours, arrange and pay for laboratory testing of water samples taken from newly disinfected main. If the residual chlorine is < 25 mg/L, drain down water and repeat disinfection for an additional 24 hours and lab testing until a residual of minimum 25 mg/L is obtained.
 - .7 After the lab test indicates a residual of 25 mg/L, flush line to remove chlorine solution.

3.13 Flushing and Cleaning - Building Water Distribution Piping

- .1 Conduct first fill and pressure testing of building distribution piping only after completion of flushing and disinfection of water service pipe.
- .2 Complete piping pressure tests prior to flushing and cleaning operations.
- .3 Flush water distribution piping through available outlets with sufficient flow to produce velocity of 1.5 m/s, within pipe for 10 minutes, or until foreign materials have been removed and flushed water is clear.
- .4 Minimum flushing flowrates:

Pipe size	Minimum Flow	
	L/s	USGPM
NPS		
2	3.3	52
2 1/2	4.7	75
3	7.3	115
4	12.6	200

- .5 Open and close valves, hydrants and service connections to ensure thorough flushing.[]

- .6 When flushing has been completed to satisfaction of Consultant, introduce strong solution of chlorine into watermain and ensure that it is distributed throughout entire system:
 - .1 Drain down system to remove flushing water,
 - .2 Introduce Chlorine close to point of re-filling of system, and evenly add to water as system is refilling, to provide an initial concentration of 50 mg/L
 - .3 Operate valves, hydrants, and appurtenances while main contains chlorine solution.
 - .4 Flush line to remove chlorine solution after 24 hours contact time.
 - .5 Arrange and pay for laboratory testing of water samples taken from newly disinfected main.
 - .6 Where samples do not meet laboratory test standard for potable water, disinfection procedure and testing is to be repeated until satisfactory results are achieved.]

3.14 Testing and Balancing – Water Pressure Piping Systems

- .1 Balance domestic water piping systems where double regulating valves are installed, including hot water recirculation piping and as otherwise shown.

END OF SECTION

GENERAL-DUTY VALVES FOR PLUMBING PIPING

22 05 23.13

1 GENERAL

1.1 Scope

- .1 Provide valves for general duty service in plumbing piping systems, including shut-off valves, check valves, manual balancing valves, and automatic flow balancing valves.
- .2 Valves under this specification section are provided for:
 - .1 Domestic (potable) water systems using copper tubing, stainless steel pipe or tube, ductile iron water piping, and galvanized steel piping.
 - .2 Non-potable water piping systems including:
 - (a) Process water systems

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 23 General Requirements for Valves
 - .2 22 05 01 Plumbing - General

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Contaminant-free:** means the material is free of contaminants and impurities to the prescribed limits of NSF/ANSI 61 – section 8 (NSF/ANSI 61/8), but excludes evaluation for lead.
 - .2 **Lead-free:** means the weighted average lead content does not exceed 0.25% when evaluated in accordance with the test methods in NSF/ANSI 61-Annex G or NSF/ANSI 372.

1.4 Submittals

- .1 Conform to the requirements of Specification section 20 05 23 except/and as follows.
- .2 For double regulating valves, in addition to manufacturer data sheets, submit a schedule listing all double regulating valves and include the following information:
 - .1 a valve reference number,
 - .2 valve service (e.g. associated equipment, or distribution piping service by drawing, room, etc.)
 - .3 associated pipeline size, NPS
 - .4 valve body size, NPS
 - .5 specified design flow rate,
 - .6 valve minimum and maximum flow rate limits,
 - .7 valve pressure drop at specified design flow rate,
 - .8 expected valve open position (number of valve turns open, percent valve stroke, etc.).
- .3 For automatic flow balancing valves, in addition to manufacturer data sheets, submit a schedule listing all automatic flow balancing valves and include the following information:
 - .1 a valve reference number,

- .2 valve service (e.g., where the valve is located, floor, room, etc.),
- .3 associated pipeline size, NPS
- .4 valve body size, NPS
- .5 specified design flow rate,
- .6 valve fixed flow rate,
- .7 valve operating differential pressure range.

1.5 Applicable Codes and Standards

- .1 Refer to section 20 05 23 and as specified herein.
- .2 Product standards:
 - .1 CSA B125.3 Plumbing Fittings
 - .2 NSF/ANSI 61 Drinking Water System Components – Health Effects
 - .3 NSF/ANSI 372 Drinking Water System Components – Lead Content (formerly NSF/ANSI 61, Annex G).

2 PRODUCTS

2.1 General

- .1 Where products are specified as being lead-free, they shall be listed to either:
 - .1 CSA B125.3;
 - .2 NSF/ANSI 61-G; or
 - .3 NSF/ANSI 372.
- .2 Where products are specified as being contaminant-free, they shall be listed to either:
 - .1 CSA B125.3;
 - .2 NSF/ANSI 61-G; or
 - .3 NSF/ANSI 61/8

2.2 Ball Valves: Brass Body (type BV-1)

- .1 NPS 4 and under, copper alloy body:
 - .1 To MSS SP-110, 600 CWP, two-piece bronze or DZR brass body, full port, stainless steel or chrome plated bronze ball, PTFE seat rings, solder or NPT threaded ends.
 - .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
 - .3 Required MCPR: 2500 kPa (363 psig) at 93°C (200°F).
 - .4 Certified for lead-free and contaminant-free service.
 - .5 Soldered ends: NPS 2 and under.

Standard of Acceptance

- Kitz - fig. 859
- Apollo - fig. 77FLF-20x
- Nibco - fig. S-685-66-LF
- Watts - fig. LFB6081

- .6 Threaded ends: NPS 4 and under.

Standard of Acceptance

- Kitz - fig. 858
- Apollo - fig. 77FLF-10x
- Nibco - fig. T-685-66-LF
- Watts - fig. LFB6080

2.3 Ball Valves: Stainless Steel Body (type BV-2)

- .1 NPS 4 and under, threaded ends:

- .1 To MSS SP-110, 600CWP, two piece T316 stainless steel body, full port, stainless steel or chrome plated bronze ball, PTFE seat rings, NPT threaded ends.
- .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
- .3 Required MCPR: 2500 kPa (363 psig) at 93°C (200°F).
- .4 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Apollo - fig. 76F-10x series (NPS 2 and under)
- Watts - fig. S-FBV-1 series

- .2 NPS 1- ½ to NPS 12, flanged ends:

- .1 To MSS SP-72, two piece CF8M stainless steel body, full port, stainless steel ball, PTFE seat rings, flanged ends.
- .2 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
- .3 Certified for lead-free and contaminant-free service.
- .4 ASME Class 150:
 - (a) Required MCPR: 1600 kPa (232 psig) at 93°C (200°F).

Standard of Acceptance

- Apollo - fig. 87A-200 series

- .5 ASME Class 300:

- (a) Required MCPR: 4000 kPa (580 psig) at 93°C (200°F).

Standard of Acceptance

- Apollo - fig. 87A-900 series

2.4 Globe Valves (type GLV-1)

- .1 NPS 2 and under:

- .1 To MSS SP-80, Class 125 bronze body valves, brass or bronze disc, threaded bonnet, threaded or soldered ends.
- .2 Required MCPR: 1200 kPa (174 psi) at 93°C (200°F).
- .3 Certified for lead-free and contaminant-free service.
- .4 Soldered ends:

Standard of Acceptance

- Kitz - fig. 812
- Apollo - fig. 121S-LF

.5 Threaded ends:

Standard of Acceptance

- Kitz - fig. 811
- Apollo - fig. 121T-LF

2.5 Gate Valves: Bronze Body (type GTV-1)

.1 NPS 2 and under:

- .1 To: MSS SP-80, Class 125; or MSS SP-139, 300 CWP, bronze body, solid wedge brass or bronze disc, non-rising stem, screw in or union bonnet.
- .2 Required MCPR: 1200 kPa (174 psi) at 93°C (200°F).
- .3 Certified for lead-free and contaminant-free service.
- .4 Soldered ends:

Standard of Acceptance

- Kitz - fig. 828
- Apollo - fig. 102SLF
- Crane (GGC) - fig. LF1320
- Nibco - fig. S-111-LF

.5 Threaded ends:

Standard of Acceptance

- Kitz - fig. 827
- Apollo - fig. 102TLF
- Crane (GGC) - fig. LF438
- Nibco - fig. T-113-LF

2.6 Gate Valves: Cast Iron Body (type GTV-2)

.1 NPS 2 to 12:

- .1 To: MSS SP-70, Class 125, cast iron body, solid wedge bronze disc and bronze seat rings, adjustable graphite stem packing, bolted bonnet.
- .2 Finish: FDA food grade epoxy power coat,
- .3 Required MCPR: 1380 kPa (200 psi) at 38°C (100°F).
- .4 CRN to CSA B51,
- .5 Certified for lead-free and contaminant-free service.
- .6 End connections: flat-faced flanged, suitable for ASME Class 125 and Class 150 pipe flanges,
- .7 Non-rising stem:

Standard of Acceptance

- Apollo - fig. 610F-LF

- .8 Outside screw and yoke:

Standard of Acceptance

- Apollo - fig. 611F-LF

2.7 Gate Valves, Non-Potable Applications (type GTVNP)

- .1 For non-potable water systems only. Do not use on potable water systems.

- .2 NPS 2½ to NPS 12, cast iron:

- .1 To MSS SP-70, Class 125, cast iron body with flat faced flange, bronze or bronze faced solid wedge disc with bronze seat rings, OS & Y, bolted bonnet, flanged ends.

- (a) Required MCPR: 1200 kPa (174 psi) at 93°C (200°F).

Standard of Acceptance

- Kitz - fig. 72
- Crane - fig. 465 ½
- Jenkins - fig. 454J
- Nibco - fig. F-617-O

- .3 NPS 2½ to NPS 24, stainless steel:

- .1 To ASME B16.34, Class 150, ASTM A216 grade WCB cast steel body with raised faced flange, flexible Type 416 stainless steel disc and hard faced seat rings, rising stem, OS & Y, bolted bonnet, flanged ends.

- .2 ASME Class 150:

- (a) Required MCPR: 1700 kPa (246 psi) at 93°C (200°F).

Standard of Acceptance

- Kitz - fig. 150 SCLS
- Crane - fig. 47 XU-F
- Jenkins - fig. J1009B8F
- Powell - fig. 1503-FC8G

- .3 ASME Class 300:

- (a) Required MCPR: 4000 kPa (580 psi) at 93°C (200°F).

Standard of Acceptance

- Kitz - fig. 300 SCLS
- Crane - fig. 33 XU-F
- Powell - fig. 3003-FC8G

2.8 Butterfly Valves - Flanged

- .1 NPS 2 to NPS 12, ductile iron (type BFV-1):

- .1 To MSS-SP-67, ductile iron lug body style, with flange bolt holes drilled and tapped for ANSI 150 flange pattern.

- .2 Required MCPR: 1200 kPa (174 psi) at 93°C (200°F).

- .3 Stainless steel shaft, aluminum bronze or 316 stainless steel or ductile iron/nickel plated disc, and replaceable EPDM resilient seat to provide bubble tight shut-off under system pressure from either side with flange removed from un-pressurized side.

- .4 ISO 5211 mounting pad.
- .5 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
- .6 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Nibco - fig. LD-2000
- Apollo - fig. LD 141, LD 145
- Kitz - fig. 6122EL
- MA Stewart - fig. L-D-4-A-E-LH
- Watts - fig. DBF-03
- Milwaukee - fig. ML233E, ML333E
- Crane Center Line fig. 200

- .2 NPS 2 to NPS 12, stainless steel (Type BFV-2):
 - .1 To MSS-SP-68, Class 300, CF8M stainless steel lug body style, with flange bolt holes drilled and tapped for ANSI 300 flange pattern.
 - .2 Required MCPR: 4000 kPa (580 psi) at 93°C (200°F).
 - .3 T316 or 17-4 stainless steel disc and shaft, TFM-PTFE seat complete with titanium or 316 stainless steel spiral wound back-up ring to provide bubble tight shut-off under system pressure from either side, when installed with single flange.
 - .4 ISO 5211 mounting pad.
 - .5 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
 - .6 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Apollo - fig. 230
- Keystone - fig. K-Lok 37

2.9 Butterfly Valves – Groove Ends

- .1 NPS 2 to NPS 12, stainless steel (type BFV-4).
 - .1 To MSS SP-67, CF8M stainless steel body, and grooved ends to CSA B242.
 - .2 Required MCPR: 2000 kPa (290 psi) at 93°C (200°F).
 - .3 Stainless steel shaft, CF8M stainless steel disc, and fluoroelastomer seat to provide bubble tight shut-off under system pressure from either side with flange removed from un-pressurized side.
 - .4 ISO 5211 mounting pad.
 - .5 Locking handles up to NPS 3, and gear operators for NPS 4 and over.
 - .6 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Victaulic - fig. Vic 300 MasterSeal series 461

- .2 NPS 2-1/2 to NPS 6, grooved ends for copper tubing (type BFV-5).
 - .1 To MSS SP-67, brass or bronze body, grooved ends for copper tubing.

- .2 Required MCPR: 2000 kPa (290 psi) at 93°C (200°F).
- .3 Stainless steel shaft, aluminum bronze disc with fluoroelastomer seat or ductile iron with EPDM encased disc/seal combination.
- .4 ISO 5211 mounting pad.
- .5 Locking handles up to NPS 6.
- .6 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Victaulic - fig. Vic 608N
- Gruvlok - fig. AN6721

2.10 Inline Silent Check Valves

- .1 NPS 2 and under:
 - .1 To MSS SP-80, Class 125, bronze or stainless steel body, inline spring-actuated disc or ball type, and PTFE or EPDM seat.
 - .2 Required MCPR: 1200 kPa (174 psi) at 93°C (200°F).
 - .3 Certified for lead-free and contaminant-free service.
 - .4 Soldered ends:

Standard of Acceptance

- Nibco – fig. S-480-Y-LF
- Apollo – fig. CVB-LF (61LF-600)
- Kitz – fig. 826

- .5 Threaded ends:

Standard of Acceptance

- Nibco - fig. T-480-Y-LF
- Apollo - fig. CVB-LF (61LF-500)
- Kitz - fig. 836

- .2 NPS 2 to NPS 12:
 - .1 To MSS SP-125, cast iron body with flat faced flange or wafer body, inline spring-actuated silent type, replaceable PTFE or BUNA-N seats, bronze faced iron or bronze disc.
 - .2 Required MCPR: 13200 kPa (188 psi) at 65°C (150°F).
 - .3 Certified for lead-free and contaminant-free service.
 - .4 Class 125:
 - (a) Required MCPR: 1380 kPa (200 psi) at 65°C (150°F).

Standard of Acceptance

- Nibco - fig. F-910-W-LF, W-910-LF
- Valmatic - fig. VM-8802-S

- .5 Class 250:
 - (a) Required MCPR: 2700 kPa (392 psi) at 65°C (150°F).

Standard of Acceptance

- Nibco - fig. F-960-W-LF, W-910-LF
- Valmatic - fig. VM-8802-S

.3 NPS 2 and over, grooved ends:

- .1 CF8M stainless steel body with spring-assisted twin stainless steel discs, and fluoroelastomeric seat.
- .2 Required MCPR: 2000 kPa (290 psi) at 93°C (200°F).
- .3 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Victaulic - fig. 816

2.11 Swing Check Valves – Non-slam

.1 For building sump pumps service only.

.2 NPS 2 and larger, flanged:

- .1 To MSS SP-71, Class 125, swing check type with external lever weight and/or spring closure, cast iron body, renewable bronze seat rings, bronze faced iron or bronze disc, bolted cap, flanged ends.
- .2 Required MCPR: 1200 kPa (174 psi) at 93°C (200°F).

Standard of Acceptance

- Val-Matic - fig. 7800LW / 7800LS
- DeZurik - fig. APCP swing check

2.12 Double Regulating Valves (DRVLF)

.1 NPS 3 and under, threaded or soldered:

- .1 Brass body, plug type stem with flow measurement ports and tamper-proof setting.
- .2 NPT threaded or soldered ends.
- .3 Required MCPR:
 - (a) Soldered: 2000 kPa (300 psig) at 93°C (200°F).
 - (b) Threaded: 2750 kPa (400 psi) at 93°C (200°F).
- .4 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Bell and Gossett - fig. CB-*-LF, RF-*-LF
- Nexus - fig. Ultra MBNL
- Victaulic/Tour and Anderson - fig. 78BL

.2 Flow meter for DRVs:

- .1 Differential pressure gauge with calibration charts or digital flow meter type.
- .2 Hoses and fittings to suit manual double regulating valves.

Standard of Acceptance

- Bell and Gossett - Readout Kit
- Nexus - Meter Kit, MKM series

2.13 Automatic Flow Balancing Valve (AFBV)

- .1 NPS ½ to NPS ¾, threaded:
 - .1 Automatic flow balancing valve providing constant flow rate over a wide differential pressure control range.
 - .2 Stainless steel or brass body, with stainless steel cartridge and EPDM seals.
 - .3 Performance:
 - (a) +/- 5% flow rate over 95% of control range.
 - (b) Differential pressure control range: minimum of 14 to 220 kPa (2 to 32 psi) operating range.
 - .4 NPT threaded ends.
 - .5 Minimum M CPR: 2750 kPa (400 psi) at 93°C (200°F).
 - .6 Certified for lead-free and contaminant-free service.

Standard of Acceptance

- Victaulic/Tour and Andersson - fig. 76X
- Griswald Controls - fig. K Valve

2.14 Solenoid Valves for Potable Water

- .1 Construction:
 - .1 2-way bronze, brass or composite engineered plastic body valve with EPDM seals and disc,
 - .2 control function: On/Off,
 - .3 for normally closed or normally open operation as shown,
 - .4 pilot operated electric solenoid with general purpose enclosure and conduit hub,
 - .5 minimum allowable working pressure: 1035 kPa (150 psig),
 - .6 minimum operating differential pressure: 820 kPa (120 psi)
 - .7 minimum design temperature: 82°C (180°F)
 - .8 manual override operator for normally-closed valves,
 - .9 pipe ends: ASME B1.20.1 NPT threaded ends, or push/twist lock connector for copper tube,
 - .10 certified for lead-free and contaminant-free service.
 - .11 listed to CSA C22.2 No. 139,
 - .12 power supply: 24 VAC, 24 VDC or 120 VAC.
 - .13 valve size limits based on service temperature:

Valve Size	Maximum Water Temperature
NPS 1	50°C (122°F)
NPS ¾ and smaller	82°C (180°F)

Standard of Acceptance

- ASCO - fig 212

3 EXECUTION

3.1 Installation

- .1 Refer to section 20 05 23 and as required herein.
- .2 Use certified lead-free and contaminant-free valves on potable cold, hot and recirculating water systems. Valves not certified as lead-free may only be used on non-potable water systems, pumped drainage systems and other similar systems.

3.2 Valve Selection Based on Pressure Rating

- .1 Unless otherwise specified herein or shown, select valves that have a Minimum Component Pressure Rating (MCPR) which exceed the applicable piping system Design Pressure and Design Temperature specified in section 22 05 01.
- .2 Where drawings indicate either: (a) a pressure rating; or (b) a pressure rating and Class rating, by floor level then select valves as follows:
 - .1 for all valves, select a valve with a MCPR rating equal to or greater than the pressure rating indicated on the drawings for each floor level,
 - .2 for clarity, even if a valve has an ASME Class rating, do not select a valve based on its Class to match any Class rating shown on the drawings.

3.3 Manual Valve Selection Based on Service and Pipe Material

- .1 Select manual valve types based on the requirements of Table 1.

Table 1: Manual Valve Selection		
Piping System	Pipe and Tube Material	Manual Valve Type
Domestic Cold Water Domestic Hot Water Domestic Recirculating Water Domestic Tempered Water	Copper	BV-1 GLV-1 GTV-1, GTV-2 BFV-1, BFV-2, BFV-5
	Stainless Steel	BV-2 BFV-2, BFV-4
	Ductile Iron	BFV-1, BFV-2, GTV-2
Domestic Cold Water (Industrial Occupancies only)	Galvanized steel	BV-1 GTV-2 BFV-1, BFV-3
Non-potable water	Copper	BV-1 GLV-1 GTV-1 BFV-1, BFV-2, BFV-5
	Stainless Steel	BV-2 BFV-2, BFV-4

Table 1: Manual Valve Selection		
Piping System	Pipe and Tube Material	Manual Valve Type
	Galvanized Steel	BV-1, BV-2 GLV-1 GTV-1, GTV-2, GTVNP BFV-1, BFV-2, BFV-3, BFV-4

3.4 Check Valves

- .1 Select check valves based on the requirements of Table 2.

Table 2: Check Valve Type Selection	
General use	Inline silent check
Domestic water heaters	Inline silent check
Temperature mixing valves	Inline silent check

3.5 Double Regulating Valves Installation

- .1 Where double regulating valves are used, supply one flow meter for double regulating and triple duty valves and turn over to operating staff during operations and maintenance training. Obtain and provide a copy to the owner of a signed receipt showing time, date, and name of recipient.
- .2 Consult with double regulating valve manufacturer to ensure correct valve selection. Balancing valves to be sized according to design flow rate.
- .3 Size and select valves for flows as shown, based on at 6 kPa (2 ft) pressure drop across the valve in the fully open position, and in accordance with manufactures recommendation. Table 3 identifies the nominal valve size selection:

Table 3: Double Regulating Valve Nominal Sizing				
Valve Size NPS	Nominal Flow			
	Min.	Max.	Min.	Max.
	L/s	L/s	gpm	gpm
½	0.038	0.177	0.6	2.8
¾	0.126	0.379	2.0	6.0
1	0.246	0.631	3.9	10.0
1-¼	0.316	0.947	5.0	15.0
1-½	0.416	1.262	6.6	20.0
2	0.795	2.272	12.6	36.0
2-½	2.398	6.310	38.0	100.0
3	1.956	8.203	31.0	130.0
4	4.291	12.620	68.0	200.0

5	5.679	20.192	90.0	320.0
6	11.48	28.395	182.0	450.0
8	23.16	51.742	367.0	820.0
10	34.07	82.030	540.0	1300.0
12	60.58	94.650	960.0	1500.0

- .4 Install double regulating valves with five pipe diameters of straight pipe on inlet side, two pipe diameters on outlet side and 10 pipe diameters from any pump.
- .5 Install double regulating valves with ports facing horizontal or facing up. Do not install with ports facing down to prevent debris from falling and accumulating inside the ports.
- .6 Double regulating valves shall not be used as isolation valves. Where double regulating valves are installed, provide isolation valve downstream.

3.6 Automatic Flow Balancing Valves Installation

- .1 Select automatic flow balancing valves to suit the flow rates as shown at a pressure differential of 35 kPa (5 psig). Where the indicated flow rate falls between two catalogued values, select the lower flow rated valve.

End of Section

TESTING ADJUSTING AND BALANCING FOR PLUMBING 22 05 93

1 GENERAL

1.1 Scope

- .1 Test, adjust, and balance (“TAB”) plumbing systems installed, modified or extended as part of this work, including:
 - .1 domestic cold water booster pumps,
 - .2 domestic hot water systems,
 - .3 domestic hot water recirculation systems

1.2 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.

Standard of Acceptance(no alternatives)

- Air & Water and Precision Balancing – Matthew Crittenden matt@awpbgroup.com – 647-896-5353

1.3 Accuracy

- .1 Adjust systems until operating values are within the acceptance criteria stated for each system type. Where an acceptance criterion is not stated, balance the system so that measured values are within ±5% of design value.
- .2 Measurement device accuracy:

Measurement	Application	Device	Accuracy
Liquid Flow	Piping	Installed meter	As per meter rating
Liquid Flow	Equipment	Differential Pressure and equipment data	See below
Temperature	Liquids	Digital Electronic Thermometer	± 0.2°C over 0 to +40°C
Temperature	Liquid	Digital Electronic Thermometer	± 0.4°C < 0°C and >+40°C
Pressure	Liquid, Gas, Steam	Bourbon type	± 1.0% of reading
RPM	Motor, fans	Chronometer tachometer	± 1.0% of reading
Voltage	All	Portable	± 2.5% of reading
Current	All	Portable clamp-on ammeter	± 2.5% of reading

1.4 Audit Verification

- .1 After review of the draft TAB report by Consultant, the Consultant may at their sole discretion require re-measurement of TAB results on an audit sample rate of 5% of all measured equipment, at no cost extra to the Contract Price or change to project schedule.

- .2 If audited results indicate a variance of more than 10% between the original reported value and the audit measured value for a piece of equipment, re-balance the audited device. If this excessive variance condition occurs at more than 25% of the number of audited equipment sample, re-balance the entire affected system at no cost extra to the Contract Price or change to project schedule.

1.5 Preparatory Work

- .1 Review design drawings and specifications, shop drawings, interference drawings and other related documentation to become familiar with their intended performance.
- .2 Carry out site visits during later stages of construction to ensure that arrangements for TAB are incorporated. Confirm proper placement of thermometer wells, test ports, pressure gauge cocks, and balancing valves.
- .3 Commence TAB measurements when building is “closed in” and work is sufficiently advanced including;
- .1 permanent heating is in operation,
 - .2 potable water systems have been flushed and cleaned.

1.6 Measurement Parameters

- .1 Reporting units of measure:

Parameter	Unit	Abbreviation
Mass	kilogram	kg
Length	metre	m
Volume	litre	L
Volume flow rate	Litres per second	L/s
Time	seconds	s
Temperature	Celsius	°C
Pressure	kilopascal	kPa
Pump Head	metre	m
Pump Pressure	kilopascals	kPa
Mass flow rate	kg per second	kg/s
Heat flow rate	kilowatts	kW
Electrical Power	kilowatts	kW
Voltage	Volts	V
Electrical Current	amps	A
Rotation speed	Rotations per minute	RPM

2 PRODUCTS

2.1 Not used.

3 EXECUTION – DOMESTIC WATER DISTRIBUTION

3.1 Measurement Parameters

- .1 The following measurement parameters identify the minimum requirements for inclusion in the TAB process:
 - .1 volume flow rate,
 - .2 temperature,
 - .3 pressure (gauge),
 - .4 equipment related;
 - (a) rotational speed (rpm),
 - (b) electrical power, kW
 - (c) voltage, V
 - (d) current, A,
- .2 Measurement are required at and around equipment to establish fluid side performance of;
 - .1 domestic water heaters and heat exchangers.
 - .2 domestic water booster pumps,
 - .3 hot water recirculation pumps.
- .3 Measurement are required to characterize system performance;
 - .1 water flowrates at plumbing fixtures,
 - .2 hot water recirculation flow rates.

3.2 General Requirements

- .1 Use permanent water flow meters, temporary non-invasive flow meters, or metered fittings and pressure gauges to determine flow rates for system balance.
- .2 Base flow balance flow rates on (in order of preference):
 - .1 permanent flow meters,
 - .2 temporary non-invasive flow meters,
 - .3 double regulating valves,
 - .4 differential pressure measurement across heat transfer elements, with flowrate determined from manufacturer's literature, or

3.3 Hot Water Recirculation Balancing Procedure

- .1 Where circuit-balancing valves are used on hot water recirculation systems, adjust each valve to obtain the required design flow rate.
- .2 Where pressure-independent flow regulating valves are used in a hot water recirculation system, for each valve;

- .1 measure system static pressure at the closest service sink to the pressure-independent flow control valve where a pressure gauge may be added to the faucet outlet ("adjacent system inlet static pressure"), and record system static pressure at the at-test system operating condition,
- .2 measure system static pressure at the inlet to the recirculating pump,
- .3 verify model type and size of each pressure-independent flow regulating valve and record results in the TAB report. Include the following data for each valve:
 - (a) location of flow control valve (i.e. floor level, room reference),
 - (b) adjacent system inlet static pressure,
 - (c) recirculation pump inlet static pressure,
 - (d) calculated differential pressure estimate (excluding pipe friction losses),
 - (e) valve model and size, with flow rate at the calculated differential pressure.

3.4 Plumbing Fixtures Hot Water Test Procedure

- .1 At each floor level, measure the cold and hot water static pressure at the outlet of any fixture that can have a pressure gauge attached to it.
- .2 For plumbing fixtures with automatic hot water temperature or pressure control, test and set each fixture as follows:
 - .1 flow hot water from the fixture for a sufficient time to stabilize hot water temperature,
 - .2 if hot water temperature is greater or less than specified water supply temperature, adjust fixture to obtain required hot water outlet temperature,
 - .3 record adjusted temperature results for all fixtures.
- .3 For sinks and lavatories, perform the following hot water time-to-delivery test;
 - .1 randomly select 10% of all fixtures, evenly distributed by type and over each floor, with selections approved by Consultant,
 - .2 do not select a fixture where it shares a portion of a hot water dead-leg pipe with another selected test fixture,
 - .3 allow each floor to be at rest (no water flow from plumbing fixtures) for a period of 24 hours prior to conducting the time-to-delivery test,
 - .4 at each fixture, run hot water (or tempered water for fixtures with blending valves) into a receptacle that has a bottom outlet, with the outlet sized to allow water to collect in and simultaneously drain from the receptacle. Record the time required for the hot water in the receptacle to stabilize at the expected water outlet temperature,
 - .5 after completion of the preceding test, measure the flow rate from the fixture using another receptacle and a stop-watch,
 - .6 record the time-to-delivery of design hot water temperature and measured flow rate for each selected fixture. Include the fixture type and room location of the fixture.

4 EXECUTION - EQUIPMENT TESTING

4.1 Performance Data

- .1 Submit the following data as a minimum. If contractor's standard forms provide for additional data, also submit such additional data.
- .2 Include nameplate data and as-tested results.

- .3 Hot water heaters:
 - .1 manufacturer and model,
 - .2 heat output rating (kW),
 - .3 electric power input rating (kW),
 - .4 gas and fuel oil input flow rating,
 - .5 gas and fuel oil input pressure rating (minimum, maximum),
 - .6 gas pressure regulator inlet and outlet pressure,
 - .7 pressure rating (MAWP),
 - .8 pressure relief valve rating (pressure setpoint, heat rating, steam rating),
 - .9 heat performance:
 - (a) entering and leaving water temperature,
 - (b) entering and leaving water pressure,
 - (c) liquid flow rate (minimum, maximum),
 - (d) steam flow rate and pressure,
 - (e) calculated heat output rating at measured design water flow rate and measured temperatures.
- .4 Hot water heat exchangers:
 - .1 manufacturer and type,
 - .2 inlet and outlet temperatures,
 - .3 pressure drop,
 - .4 design pressure rating (MAWP),
 - .5 heat performance:
 - (a) entering and leaving water temperature,
 - (b) entering and leaving water pressure,
 - (c) liquid flow rate (minimum, maximum),
 - (d) input steam flow rate and pressure (where applicable),
 - (e) calculated heat output rating at measured design water flow rate and measured temperatures.
- .5 Pumps:
 - .1 manufacturer name,
 - .2 model or serial number,
 - .3 flow rate,
 - .4 developed pump head,
 - .5 RPM.

5 EXECUTION - MISCELLANEOUS

5.1 Balance Position Marking

- .1 Mark the balance position of valves at the completion of the final testing:

- .1 valves: self-adhesive label, placed on piping (insulated or not) adjacent to valve, neatly filled in with either % valve open, or number of valve turns to open.
- .2 Additional requirements for circuit-balancing valves with test ports:
 - .1 remove valve handle or other protective device, and set memory stop to limit valve open travel. Replace valve handle or protective cover.

6 EXECUTION - REPORT PRESENTATION AND VERIFICATION

6.1 Required Reports

- .1 Provide the following reports:
 - .1 Water balancing and equipment test report.

6.2 Record Keeping

- .1 Keep records of trial and final balance and submit preliminary report as each system is completed.
- .2 Do not submit the final TAB report until all audit verification re-measurements, and any required re-balancing, is completed to the satisfaction of Consultant.

6.3 Report Format

- .1 Reports to incorporate approved standard forms, with values expressed in the same units as shown on Contract Documents.
- .2 Include "as-built" system schematics, marked-up to show as-measured flow quantities and measurement points. Use as-built drawings and ventilating line diagrams for reference.
- .3 Submit an electronic PDF copy of the draft TAB report for review by Consultant. Where a report page length is more than 20 pages, include bookmarks in the PDF document organizes by system number and/or name.
- .4 After any revisions requested by Consultant have been made and final review accepted by Consultant, submit the final TAB report in the following formats:
 - .1 two (2) hard copies of the completed report, each with index tabs and bound in "D" ring binders,
 - .2 electronic file PDF copies by email or drop-box as coordinated with Owner and Consultant.

6.4 Completion

- .1 Continue TAB until reports are approved.
- .2 The Substantial Performance of the Mechanical Work will be considered reached when the initial Start-Up and Performance Testing report is accepted by the Consultant and in the opinion of the Consultant all systems have been satisfactorily installed, operated tested, balanced, and adjusted to meet the specified and intended performance.
- .3 The substantial performance of the Work is not dependent upon alternate season testing.
- .4 The total performance of the Work will not be considered reached until the alternate season testing and balancing is completed and the final report submitted has been reviewed by Consultant and accepted by the Owner.

END OF SECTION

DOMESTIC WATER PIPING - COPPER

22 11 16.13

1 GENERAL

1.1 Scope

- .1 Provide copper tube and fittings for potable domestic water piping systems for aboveground installations.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 22 05 01 Plumbing Piping Systems – General Requirements
 - .3 22 05 23.13 General-duty Valves for Plumbing Piping
 - .4 20 05 29 Common Hanger and Support Requirements for Piping

1.3 Definitions

- .1 The following definitions apply to this specification section:
 - .1 **Exposed areas:** include inside service rooms and above lay-in tile ceilings, but excludes: vertical and horizontal service shafts; above any other ceiling construction; and inside walls and partitions.

1.4 Applicable Codes and Standards

- .1 Installation standards:
 - .1 Copper Development Association (CDA) Copper Tube Handbook
- .2 Product standards:
 - .1 ASME B16.15 Cast Bronze Threaded Fittings, Classes 125 and 250
 - .2 ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
 - .3 ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - .4 ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings; Class 150, 300, 400, 600, 900, 1500, & 2500.
 - .5 ASME B16.50 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
 - .6 ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature
 - .7 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
 - .8 ASTM B32 Standard Specification for Solder Metal
 - .9 ASTM B88 Standard Specification for Seamless Copper Water Tube
 - .10 ASTM B813 Standards Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
 - .11 ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.

- .12 AWS A5.8 Brazing Filler Metal.
- .13 AWS A5.31 Specification for Fluxes for Brazing and Braze Welding
- .14 AWS C3.4 Specification for Torch Brazing
- .15 MSS SP-106 Cast Copper Alloy Flanges and Flanged Fittings, Class 125, 150 and 300

2 PRODUCTS

2.1 Copper Tube

- .1 Hard drawn, type L.
- .2 Listed to ASTM B88 and to have certification markings made by testing agency accredited by Standards Council of Canada.

2.2 Fittings

- .1 Brass or bronze flanges and flanged fittings: to ASME B16.24.
- .2 Brass or bronze threaded fittings: to ASME B16.15.
- .3 Solder/brazed fittings: cast bronze to ASME B16.18, or wrought copper and bronze to ASME B16.22.
- .4 Threaded fittings including unions to ASME B16.15, Class 250.

2.3 Joints

- .1 Solder: 95:5 tin-antimony solder to ASTM B-32.
- .2 Silver brazing alloy to AWS A5.8 classification BCUP-5.

Standard of Acceptance

- Handy Harman "SIL-FOS"
- All-State Welding Alloys "SILFLO 15"

.3 Flanges:

- .1 Threaded end connection: flat face, cast copper alloy to ASME B16.24, class 150 and 300, NPT threaded,
- .2 Brazed end connection: flat face, cast copper alloy to MSS SP-106, class 150 or 300.
- .3 Dielectric flanges: to specification section 22 05 01.
- .4 Studs and bolts: stainless steel to ASTM A193.
- .5 Nuts: stainless steel type 316, to ASTM A194.

.4 Flange gaskets:

- .1 Full flat-faced style to ANSI B16.21.
- .2 Suitable for use in potable water service and listed to NSF/ANSI 61.
- .3 Ethylene propylene diene monomer (EPDM);
 - (a) required working pressure: 1700 kPa (250 psi) at up to 95°C (203°F)
- .4 Compressed mineral fibers bonded with nitrile (NBR);
 - (a) required working pressure: 2750 kPa (400 psi) at up to 95°C (203°F)

Standard of Acceptance

- American-Biltrite (EPDM) – fig. AB-576
- Durlon (NBR) – fig. 7910

3 EXECUTION

3.1 Installation

- .1 Refer to section 22 05 01 for piping design criteria and general requirements for piping installation.
- .2 Install tubing close to building structure to minimize furring and conserve headroom. Group tubing and run parallel to walls and ceilings.
- .3 Cut tube square, ream tube ends and clean tubing and tube ends before joint assembly.
- .4 Before making solder or brazed joints, remove working parts of valves, clean inside of solder fittings and outside of mating pipe with emery paper and coat with applicable flux.

3.2 Pipe Supports

- .1 Support piping and tubing in accordance with specification section 20 05 29 except as specified herein.
- .2 Support horizontal copper tubing at intervals in accordance with Table 1:

Table 1: Horizontal Pipe Support Spacing for Copper Tube		
Pipe Size NPS	Rod Diameter	Maximum Spacing
½	M10 (3/8 in)	1.5 m (5 ft)
¾ to 1¼	M10 (3/8 in)	1.8 m (6 ft)
1½	M10 (3/8 in)	2.4 m (8 ft)
2	M10 (3/8 in)	2.4 m (8 ft)
2½	M12 (½ in)	3.0 m (10 ft)
3	M12 (½ in)	3.0 m (10 ft)
4	M16 (5/8 in)	3.0 m (10 ft)

- .1 Support vertical pipe and tube risers;
 - .1 at the base (bottom) of the riser by a support that is independent of any adjacent horizontal pipe supports,
 - .2 at every other floor level with pipe riser clamps, but not to exceed a vertical spacing of more than 7.5 m (24.5 ft).

3.3 Class Rated Fittings

- .1 Select ASME Class rated fittings and flanges in accordance with the following Table 2 for design pressure limits at coincident design temperature limits unless otherwise shown on drawings.

Table 2: Pressure and Temperature Limits for Class Rated Fittings		
Class	Maximum Design Pressure	Maximum Coincident Design Temperature
150	1720 (250 psi)	≤ 38°C (100°F)
150	1400 kPa (200 psi)	≤ 121°C (250°F)
300	3700 kPa (535 psi)	≤ 38°C (100°F)
300	3100 kPa (450 psi)	≤ 121°C (250°F)

3.4 Joints and Fittings

- .1 Joints in tubing:
 - .1 NPS ½ to NPS 2:
 - (a) soldered.
 - .2 NPS 2-1/2 and larger:
 - (a) brazed or flanged joints.
- .2 Make solder joints in accordance with the recommendations of the CDA handbook.
- .3 Make braze joints in accordance with specification section 20 05 24.
- .4 Use manufactured fittings. Use of fabricated pulled-tee's is subject to approval by the local municipal authority for plumbing, and only brazed butt weld joints shall be used.
- .5 For flange joints, select gasket materials in accordance with the following Table 3 so that gasket pressure and temperature both exceed the piping system design pressure and design temperature.

Table 3: Flange Gasket Selection				
Gasket Temperature Limit	Gasket Pressure Limit	Gasket Material	Gasket Thickness	Figure
95°C (203°F)	1720 kPa (250 psig)	EPDM	1.5 m (1/6 in)	A-B AB-576
	2750 kPa (400 psig)	NBR	1.5 m (1/6 in)	Durlon 7910

3.5 Equipment Connections

- .1 Make pipe connections to equipment as follows.
 - .1 NPS 2 and smaller: threaded fittings.
 - .2 NPS 2 ½ and larger:
 - (a) flanged connections

- .2 Where connection is made to equipment with a threaded fitting, provide a union between the isolation valve and the equipment connection.
- .3 For threaded flanges, provide a sweat x NPT adaptor; do not thread tubing directly.
- .4 Provide a dielectric union or dielectric flange in accordance with specification section 22 05 01 when connecting potable water piping to equipment with carbon steel connections. Dielectric fittings are not required when connecting to equipment with stainless steel connections.

3.6 Valves

- .1 Provide valves in accordance with specification section 22 05 23.13.
 - .1 Isolate equipment, fixtures and branches with gate, ball or butterfly valves.
 - .2 Use globe, DRVs, ball or butterfly valves for throttling service.

3.7 Pressure Testing, Flushing and Balancing

- .1 Pressure test, flush and balance water systems to specification section 22 05 01.

END OF SECTION

DOMESTIC WATER PIPING – STAINLESS-STEEL

22 11 16.16

1 GENERAL

1.1 Scope

- .1 Provide stainless-steel pipe and tube and fittings for potable domestic water piping systems for aboveground installations.
- .2 Use of stainless-steel pipe/tube is an alternative to copper tubing.
- .3 Size limits:
 - .1 Stainless-steel pipe: NPS 3/4 to NPS 12.
 - .2 Stainless-steel tube: OD ½ to OD 2.
- .4 Acid descaling and passivation of welded piping and tubing, depending on welding procedures used and quality of welding performed.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 22 05 01 Plumbing Piping Systems - General Requirements
 - .3 22 05 23.13 General-duty Valves for Plumbing Piping.

1.3 Definitions

- .1 The following definitions apply to this specification section:
 - .1 **Exposed areas:** include inside service rooms and above lay-in tile ceilings, but excludes: vertical and horizontal service shafts; above any other ceiling construction; and inside walls and partitions.
 - .2 **Plumbing fixtures:** has the meaning in the Ontario Building Code
- .2 In this specification section, reference to “piping” also means “tubing” unless the context indicates otherwise.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ASME B31.9 Building Services Piping Code
 - .2 ASTM A380 Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
 - .3 AWS D18.2 Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube
- .2 Product standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose (inch)
 - .2 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .3 ASME B16.9 Factory-Made Wrought Steel Buttwelding Fittings
 - .4 ASME B16.11 Forged Fittings, Socket Welding and Threaded

- .5 ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges.
- .6 ASME B18.2.1 Square and Hex Bolts and Screws,
- .7 ASME B18.2.2 Square and Hex Nuts
- .8 ASTM A182 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
- .9 ASTM A312 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- .10 ASTM A269 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- .11 ASTM A351 Standard Specification for Castings, Austenitic, for Pressure Containing Parts
- .12 ASTM A403 Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
- .13 ASTM A182 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service.
- .14 ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature
- .15 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- .16 MSS SP-114 Corrosion Resistant Pipe Fittings Threaded and Socket Welding Class 150 and 1000

2 PRODUCTS

2.1 Stainless-steel Pipe, Fittings and Joints

.1 Pipe:

- .1 To ASTM A312 Type 304/304L or 316/316L, seamless or welded, and pipe schedule in accordance with the following table.

Table 1: Pipe Schedule Based on Jointing Method			
Joint Method	Pipe Size NPS	Maximum System Design Pressure	Schedule
Threaded	NPS ¾ to NPS 2	2750 kPa (400 psig)	40/40S
Welding (butt weld, socket weld)	NPS 2-1/2 to NPS 6	2750 kPa (400 psig)	10

Table 1: Pipe Schedule Based on Jointing Method			
Joint Method	Pipe Size NPS	Maximum System Design Pressure	Schedule
	NPS 8 to 12	1720 kPa (250 psig)	10
		2750 kPa (400 psig)	40/40S

.2 Threaded fittings:

- .1 End connections: NPT thread to ANSI B1.20.1.
- .2 Fittings: Class 150 and Class 1000 to MSS SP-114, and material to ASTM A351 Gr. CF8 or CF8M stainless-steel to match pipe grade.
- .3 Unions: Class 150 and Class 1000 to MSS SP-114, and material to ASTM A182 Gr. CF8 or CF8M stainless-steel to match pipe grade, with ground joint and face.
- .4 Threaded joint compound: Teflon pipe tape.

Standard of Acceptance

- Masters Orange or White Tape.

.3 Welding fittings:

- .1 Pipe fittings of same steel alloy and grade as connected pipe.
- .2 Butt-weld fittings:
 - (a) forged stainless-steel fitting to ASTM A403,
 - (b) wall thickness to match pipe,
 - (c) elbows to be long radius type.
- .3 Welding outlet fittings:
 - (a) forged stainless-steel to ASTM A182,
 - (b) dimensions and pressure ratings to MSS SP-97, Standard Class for buttwelding branch connection and Class 3000 for threaded or socket welded branch connection,
 - (c) NPT ends to ASME B1.20.1.
- .4 Socket welded fittings:
 - (a) forged stainless-steel to ASTM A182,
 - (b) dimensions and pressure ratings to ASME B16.11, Class 3000.
- .5 Half couplings:
 - (a) forged stainless-steel to ASTM A351,
 - (b) dimensions and pressure rating to ASME B16.11, Class 3000 socket weld or threaded ends,
 - (c) NPT ends to ASME B1.20.1.

.4 Flanges:

- .1 Raised face stainless-steel to ASTM A182, Class 150 and Class 300, weld neck with wall thickness to match pipe, or slip on type.
- .2 Studs and bolts: stainless-steel type 316, to ASTM A193.
- .3 Nuts: stainless-steel type 316, to ASTM A194.
- .5 Flange gaskets:
 - .1 For raised face and flat faced flanges to ANSI B16.21 or AWWA/ANSI C111.
 - .2 Suitable for use in potable water service and listed to NSF/ANSI 61.
 - .3 Ethylene propylene diene monomer (EPDM);
 - (a) required working pressure: 1700 kPa (250 psi) at up to 95°C (203°F)
 - .4 Compressed mineral fibers bonded with nitrile (NBR);
 - (a) required working pressure: 2750 kPa (400 psi) at up to 95°C (203°F)

Standard of Acceptance

- American-Biltrite (EPDM) – fig. AB-576
- Durlon (NBR) – fig. 7910

2.2 Stainless-steel Tube, Fittings and Joints

- .1 Tube:
 - .1 size: OD 1/4 to OD 2
 - .2 fully annealed Type 316/316L stainless-steel tubing: to ASTM A269.
 - .3 minimum design pressure: 2700 kPa (400 psi) at 85°C (185°F).
 - .4 tube wall thickness:

Table 2: Stainless Steel Tube Pipe Wall Thickness						
NPS	1/2	3/4	1	1-1/4	1-1/2	2
Tube OD, mm	Ø12	Ø20	Ø25	Ø32	Ø38	Ø50
Wall Thickness, mm	1.0	1.2	1.8	2.0	2.2	3.0

- .5 Tubes to be suitable for bending and flaring.
- .6 Tube OD tolerance to meet the requirements of the selected compression fitting manufacturer requirements.
- .2 Welded fittings:
 - .1 Specifically manufactured for stainless-steel tubing.
 - .2 Elbows, reducers and tees: wall thickness not less than that of pipe to which they are connected.
 - .3 Extended tube ends suitable for automatic orbital TIG welding.

3 EXECUTION

3.1 Installation of Piping and Tubing

- .1 Install piping and tubing in accordance with ASME B31.9 except/and as specified herein.
- .2 Refer to section 22 05 01 for piping design criteria and general requirements for piping installation.
- .3 Install piping close to building structure to minimize furring and conserve headroom. Group piping and run parallel to walls and ceilings.
- .4 Cut pipe/tube square, ream pipe/tube ends, and clean pipe/tube ends before joint assembly.
- .5 Before making welded joints, remove working parts of valves, clean inside of solder fittings and outside of mating pipe with emery paper and coat with flux.
- .6 Where welding is used, provide a removable 300 mm long spool section with flanged or grooved-end connections, which includes a butt-weld joint at its midpoint. Locate the spool piece in the largest pipe service that may be subjected to a post-weld pickling process.

3.2 Pipe Supports

- .1 Support piping and tubing in accordance with specification section 20 05 29 except as specified herein.
- .2 Support horizontal stainless steel pipe and tube in accordance with Table 3A and 3B:

Table 3A: Horizontal Pipe Support Spacing for Stainless Steel Pipe			
Pipe Size NPS	Pipe Schedule	Rod Diameter DN (inches)	Maximum Spacing m (ft)
1/2	40	M10 (3/8 in)	2.1 (6.7)
3/4	40	M10 (3/8 in)	2.4 (7.7)
1	40	M10 (3/8 in)	2.8 (9.0)
1-1/4	40	M10 (3/8 in)	3.0 (9.8)
1 1/2	40	M10 (3/8 in)	3.0 (9.8)
2	40	M10 (3/8 in)	3.0 (9.8)
2 1/2	10	M10 (3/8 in)	3.0 (9.8)
3	10	M12 (1/2 in)	3.0 (9.8)
4	10	M12 (1/2 in)	3.0 (9.8)
6	10	M12 (1/2 in)	3.0 (9.8)
8	10S or 40	M12 (1/2 in)	3.0 (9.8)
10	10S or 40	M16 (5/8 in)	3.0 (9.8)
12	10S or 40	M16 (5/8 in)	3.0 (9.8)

Table 1C: Horizontal Pipe Support Spacing for Stainless Steel Tube		
Pipe Size NPS	Rod Diameter	Maximum Spacing
½	M10 (3/8 in)	1.5 m (5 ft)
¾ to 1¼	M10 (3/8 in)	1.8 m (6 ft)
1½	M10 (3/8 in)	2.4 m (8 ft)
2	M10 (3/8 in)	2.4 m (8 ft)
2½	M10 (3/8 in)	3.0 m (10 ft)
3	M12 (1/2 in)	3.0 m (10 ft)
4	M12 (1/2 in)	3.0 m (10 ft)

- .3 Support vertical pipe and tube risers;
 - .1 at the base (bottom) of the riser by a support that is independent of any adjacent horizontal pipe supports,
 - .2 at every other floor level with pipe riser clamps, but not to exceed a vertical spacing of more than 7.5 m (24.5 ft).

3.3 Class Rated Fittings and Flanges

- .1 Select ASME Class rated fittings and flanges in accordance with the following table for design pressure limits at coincident design temperature limits unless otherwise shown on drawings.

Class	Maximum Design Pressure	Maximum Coincident Design Temperature
150	1400 kPa (200 psi)	≤ 121°C (250°F)
300	3100 kPa (450 psi)	≤ 121°C (250°F)

3.4 Joints and Fittings

- .1 Use manufactured fittings except where otherwise permitted herein for branch connections.
- .2 Joints in tubing:
 - .1 NPS ½ to NPS 2:
 - (a) butt-welded
- .3 Joints in pipe:
 - .1 Pipe NPS ¾ to NPS 2:

- (a) NPT threaded joint to ANSI B1.20.1 and made with Teflon tape, or
- (b) socket welded.
- .2 Pipe NPS 2-1/2 and larger:
 - (a) flanged or butt- welded
- .4 For flange joints, select gasket materials in accordance with the following table so that gasket pressure and temperature both exceed the piping system design pressure and design temperature.

Gasket Temperature Limit	Gasket Pressure Limit	Gasket Material	Gasket Thickness	Figure
95°C (203°F)	1720 kPa (250 psig)	EPDM	1.5 mm (1/6 in)	A-B AB-576
	2750 kPa (400 psig)	NBR	1.5 mm (1/6 in)	Durlon 7910

3.5 Limitations on Use of Threaded Joints

- .1 Use of threaded joints for NPS ¾ to NPS 2 pipe is limited to the following applications:
 - .1 for run-out branch connection to process equipment (not including plumbing fixtures),
 - .2 for run-out branch connection to hot water heaters with NPT connections,
 - .3 plumbing fixtures with water passages constructed of stainless-steel and which has NPT connections.
- .2 Where schedule 10 piping is used for branch connection to equipment, provide weld x NPT cast adaptor fittings. Do not thread schedule 10 pipe.

3.6 Branch Connections

- .1 Make branch connections to mains in accordance with the following table.
 - .1 For direct welding of pipe branch to main or use of half-couplings, this table is valid for design pressures up to 2070 kPa (300 psig) without adding reinforcement material. For welded branch connections at higher design pressures, only use butt-welded or integrally reinforced outlet fittings only.
 - .2 In this table, the following abbreviations apply, as applicable to pipe or tube.

Abbreviations – for pipe materials

- TH Threaded to MSS SP-114
- SW Socket weld fittings to ASTM A182 and ASME B16.11
- HC Half coupling to ASTM A351 and ASME B16.11
- BW Buttweld fitting to ASTM A403
- OF Reinforced Outlet Fittings to ASTM A182 and MSS SP-97
- DP Direct welding of Branch Pipe to Main without added reinforcement

Abbreviations – for tube material

- BWT Buttweld fitting for tubes

Allowable Branch to Main Connections Maximum 2070 kPa (300 psig) Design Pressure											
Branch NPS	Mains Pipe, NPS										
	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10	12
3/4	TH SW BWT	TH SW BWT	TH SW BWT	TH SW BWT	BW SW	BW OF SW HC DP	BW OF SW HC DP	BW OF HC DP	BW OF HC DP	BW OF HC DP	BW OF HC DP
1	TH SW BWT	TH SW BWT	TH SW BWT	TH SW BWT	BW SW	BW OF SW DP	BW OF SW HC DP	BW OF HC DP	BW OF HC DP	BW OF HC DP	BW OF HC DP
1-1/4	---	TH SW BWT	TH SW BWT	TH SW BWT	BW SW	BW OF SW DP	BW OF SW DP	BW OF HC DP	BW OF HC DP	BW OF HC DP	BW OF HC DP
1-1/2	---	---	TH SW BWT	TH SW BWT	BW SW	BW OF SW DP	BW OF SW DP	BW OF HC DP	BW OF HC DP	BW OF HC DP	BW OF HC DP
2	---	---	---	TH SW BWT	BW SW	BW, OF SW	BW OF SW DP	BW OF DP	BW OF HC DP	BW OF HC DP	BW OF HC DP
2-1/2	---	---	---	---	BW SW	BW OF SW	BW OF SW	BW OF DP	BW OF DP	BW OF DP	BW OF DP
3	---	---	---	---	---	BW	BW OF SW	BW OF DP	BW OF DP	BW OF DP	BW OF DP
4	---	---	---	---	---	---	BW	BW OF	BW OF DP	BW OF DP	BW OF DP
6	---	---	---	---	---	---	---	BW	BW OF	BW OF DP	BW OF DP
8	---	---	---	---	---	---	---	---	BW	BW OF	BW OF DP
10	---	---	---	---	---	---	---	---	---	BW	BW
12	---	---	---	---	---	---	---	---	---	---	BW

.2 Use of Class 3000 half-couplings as a branch connector (HC), and direct welding of branch pipe to the main pipe (DP), is permitted in accordance with the following requirements:

- .1 half-coupling or branch pipe to sit-on the mains pipe, and does not insert into the main pipe,
 - .2 the opening size in the main pipe to closely follow the inside diameter of the half-coupling or branch pipe,
 - .3 half-coupling or branch pipe attachment end is shaped and beveled to closely following the surface of the main pipe, suitable for a full-penetration groove weld,
 - .4 the half-coupling or direct branch pipe is attached with a groove weld and covered with a smooth finishing fillet cover weld, and
 - .5 in accordance with the requirements of the applicable piping code.
- .3 Where integrally reinforced outlet fittings, half-couplings or direct welding of branch pipe is used, hole saw or drill and ream mains pipe to maintain full inside diameter of branch line prior to welding.
 - .4 Where multiple branch pipes are to connect to the main pipe in close proximity to each other, provide a minimum separation between the centerlines of adjacent branch pipes equal to or greater than the sum of the OD dimensions of the adjacent branch pipes.
 - .5 If threaded fittings have been installed where the specification requires welded fittings, either cut-out and replace the fitting, or fully seal-weld the exposed threads.
 - .6 Where saddle type branch welding fittings are used on mains, hole saw, flame-cut or drill and ream the main pipe to closely follow the dimensions of the saddle fitting.

3.7 Welding

- .1 Comply with section 20 05 24 and as specified herein.
- .2 Use welding procedures which reduce the formation of chromium carbide in the heat affected zone. Acceptance criteria is to achieve a No. 4 colour value in accordance with AWS D18.2, equivalent to 100 ppm oxygen content in the internal purge gas/air mix during welding.
- .3 Do not use carbon steel wire brushes for cleaning pipe or tube ends. Do not use stainless-steel wire brushes that have been previously used on carbon steel.
- .4 Weld pipe using automatic orbital tungsten inert gas (“TIG”) welding.
 - .1 Exception: use hand TIG weld for socket welds, branch connections other than butt-weld fittings, and slip-on flanges.
 - .2 Hand TIG tack welding for alignment of stainless-steel pipe is permitted, prior to automatic welding.
- .5 Use removable/inflatable gas dams to continuously purge the inside of pipes/tubes with 100% argon backing gas during welding. Use of argon mixed with carbon dioxide or other gasses is not permitted.
 - .1 Provide a purge restrictor on pipe to maintain oxygen levels in the gas exiting the weld gap from inside the pipe below a nominal 100 ppm; actual oxygen concentration is as required to obtain a heat affected zone (“HAZ”) colour as specified in accordance with AWS D18.2.
 - .2 Use portable oxygen analyzers reading ppm on pipe sizes NPS 2 ½ and larger, to check oxygen levels at purge outlet. Qualified time purging is acceptable on pipe sizes NPS 2 and smaller.
- .6 Use of backing gas is not required where the inside surface of the pipe is accessible for removal of the HAZ weld tint by grinding or manual application of pickling compound to remove the weld tint, while the weld is accessible before installation. This condition would apply to welding of flanges, or welding of branch connections using methods other than the use of butt-weld fittings.
 - .1 Use of a passivation-only solution is not acceptable for this purpose.
- .7 Use of welding methods other than TIG, or the use of TIG for the root pass and MIG for the second/cover pass, will be considered provided that the welding procedure can demonstrate the visual acceptance criteria specified herein.

3.8 Equipment Connections

- .1 Make pipe connections to equipment as follows.
 - .1 NPS 2 and smaller:
 - (a) threaded fittings
 - .2 NPS 2 ½ and larger:
 - (a) flanged connections
- .2 Where connection is made to equipment with a threaded fitting, provide a union between the isolation valve and the equipment connection.

3.9 Valves

- .1 Provide valves in accordance with specification section 22 05 23.13.
 - .1 Valve body material: copper alloy, ductile iron or stainless-steel
 - .2 Isolate equipment, fixtures and branches with gate, ball or butterfly valves.
 - .3 Use globe, DRVs, ball or butterfly valves for throttling service.

3.10 Pressure Testing, Flushing and Balancing

- .1 Pressure test, flush and balance water systems to specification section 22 05 01.

3.11 Post-Weld Pickling (descaling)

- .1 The following post-weld pickling (descaling) procedure may be omitted when approved by the Consultant where all of the following conditions are met:
 - .1 a written welding procedure and test plan is provided for review by the Consultant prior to any welding work, which demonstrates the control measures used to control the formation of chromium carbide scale in the heat affected zone of the interior surface of the pipe in accordance with the specified acceptance criteria,
 - .2 ensure proper use of backing (internal purging) gas and type of gas,
 - .3 orbital automatic TIG welding is used for butt-weld joints,
 - .4 three (3) welding samples of NPS 2 (tube), NPS 4 and NPS 6 are supplied to the Consultant prior to production welding as follows:
 - (a) a complete butt-weld using automatic orbital TIG welding, with each sample split lengthwise to expose the interior weld surface for examination,
 - (b) one (1) example for an integrally reinforced welding outlet fitting, using hand TIG welding, with interior surface exposed for examination, and
 - (c) the interior HAZ heat tint is not greater than the No. 4 sample colour in accordance with AWS D18.2,
 - .5 the Consultant may request up to three (3) production weld samples to be removed from the piping system, and the samples cut-open for visual examination,
 - .6 a completed and signed report is submitted for review by the Consultant at the completion of welding for each piping or tubing system, prior to flushing and cleaning of the piping/tubing. The report shall include compliance log of each weld to the weld specification including use of automatic welding and inert backing gas.
- .2 Pickling of piping systems only applies to welded piping or tubing systems.

- .3 After flushing and cleaning, provide the services of a specialist pipe cleaning company to chemically pickle the stainless-steel piping and tubing in accordance with ASTM A380, to remove weld heat tint (descaling) where welding of joints is used.
- .4 Provide test sample pipe welds of the type and size when requested by the specialist pipe cleaning company. The specialist company shall be evaluated and determine the appropriate pickling method. The acceptance criteria is to achieve colour No. 4 in accordance with AWS D18.2.
- .5 Chemically pickle inside of piping and tubing to remove weld heat tint;
 - .1 perform pickling operations after pressure testing is completed, and before making connections to plumbing fixtures,
 - .2 provide temporary cross connections to bypass equipment,
 - .3 temporarily remove flexible connections at pumps and install stainless-steel spool pieces. Reinstall flexible connections after completion of pickling program,
 - .4 provide temporary recirculation piping as required,
 - .5 bypass piping material: stainless-steel 304, threaded, flanged, or welded. Hoses as recommended by the chemical cleaning company may be used,
 - .6 provide temporary circulating pumps and power supplies.
- .6 Cross-connecting domestic cold water, domestic hot water and domestic recirculating water piping/tubing systems to permit circulation of the pickling solution is permitted under the following conditions:
 - .1 temporarily remove any check valves in the distribution path,
 - .2 where a temporary branch connection is required, provide an isolation valve and arrange the branch/valve as a system drain,
 - .3 distribution piping may be sub-divided into sections and cleaned separately, provided the interconnection between sections is by means of flanges,
 - .4 where stainless-steel tubing is used to connect to plumbing fixtures, provide a temporary hose to cross-connect the hot and cold-water supplies,
 - .5 mark each temporary cross-connection with a high-visibility orange marker or tag,
 - .6 maintain a record log of all temporary cross-connections, indicating location of each connection, date of removal, and signed by the person checking their removal.
- .7 Continuously circulate pickling solution and periodically check concentration levels. Temporarily remove the spool test piece to permit visual inspection of the flange and butt welds. Continue to clean pipe until the acceptance criteria is achieved.
- .8 At completion of pickling, drain down and dispose of liquid solution as contaminated waste.
- .9 Prepare and submit a report from the specialist cleaning company at completion of pickling and passivation treatments, which details the results of the test. Include photographs of interior surface finishes at accessible butt-weld joints.

3.12 Passivation

- .1 After pickling of the piping or tubing system is completed (when required), passivate the inside of piping and tubing with nitric acid to ASTM A380.
 - .1 Passivation may form part of the pickling process, or may be post-pickling.
 - .2 For clarity, passivation is only required where circulation of a pickling solution is required.
- .2 At completion of passivation, drain down and dispose of passivation chemical as contaminated waste.

3.13 Final Flush

- .1 After pickling and passivation is completed (when required) and treatment solution has been drained, refill the system with municipal water and flush to drain until water pH level at 3% of randomly selected fixtures is within 0.5 pH of the incoming water supply value.
- .2 If the domestic water piping/tubing system will not be turned over to the owner within one month after final flush, drain down the piping or tubing system and leave it empty until just prior to handover to the owner, at which time refill the system. Alternatively, set-up and document a periodic flushing regime where each plumbing fixture is flushed for 30 seconds once a week.

END OF SECTION

DOMESTIC WATER PIPING SPECIALTIES 22 11 19

1 GENERAL

1.1 Scope

- .1 Provide domestic water piping specialties and accessories.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 ANSI/ASSE 1010 Water Hammer Arrestors
 - .2 CSA-B125 Plumbing Fittings.
 - .3 CSA B.64.1.1 Atmospheric Vacuum Breakers (AVB)
 - .4 CSA B.64.1.2 Pressure Vacuum Breakers (PVB)
 - .5 CSA B64.2.1 Hose Connection Vacuum Breaker (HCVB) with Manual Drain Feature
 - .6 CSA B64.4 Backflow Preventers, Reduced Pressure Principle (RP)
 - .7 CSA B64.5 Backflow Preventers, Double Check Valve Type (DCVA)
 - .8 CSA B64.10 Manual for the Selection and Installation of Backflow Prevention Devices/Manual for the Maintenance and Field Testing of Backflow Prevention Devices
 - .9 CSA B137.6 Chlorinated Polyvinylchloride (CPVC) Pipe, Tubing, and Fittings for Hot- and Cold-Water Distribution Systems
 - .10 CSA C22.2 No. 14 Industrial Control Equipment
 - .11 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .12 NSF/ANSI 61 Drinking Water System Components – Health Effects
 - .13 NSF/ANSI 372 Drinking Water System Components – Lead Content
 - .14 PDI-WH201 (Plumbing and Drainage Institute) Standard Water Hammer Arresters

1.3 Submittals

- .1 Submit product data sheets for materials specified herein.

2 PRODUCTS

2.1 Water Hammer Arresters

- .1 Stainless steel construction with precharged air chamber of nesting bellows.
- .2 Selected in accordance with Plumbing and Drainage Institute Standard PD1-WH201.
- .3 Listed to ANSI/ASSE 1010

Standard of Acceptance

- Jay R. Smith - fig. Hydrotrol 5000 series
- Mifab - fig. WHB series
- Zurn - fig. Shocktrol Z-1700 series]

2.2 Trap Seal Primers

.1 Electrically operated manifold units – Type A:

- .1 factory assembled in 1.5 mm (16 ga) recessed metal cabinet with hinged stainless steel lockable access door,
- .2 atmospheric vacuum breaker,
- .3 24 hr controller with manual over ride switch,
- .4 120 Volt solenoid valve,
- .5 NPS ¾ or NPS ½ valved inlet water connection,
- .6 calibrated water distribution manifold,
- .7 NPS ½ outlet compression fittings,
- .8 power supply: 120 VAC.

Standard of Acceptance

- Precision Plumbing Products - fig PT-3 thru PT-30
- Mifab - fig.MI-100

.2 Electrically operated manifold units – Type B:

- .1 Same as Type A electronic trap seal primer, except distribution manifold is shipped loose for field installation external to the trap primer cabinet.

2.3 Back-flow Preventers - Reduced Pressure Principle (“RP”)

- .1 Listed to CSA B.64.4.
- .2 Type: two independent check valves with intermediate relief valve and drain port,
- .3 NPS ½ to 2:
 - .1 quarter turn full port resilient seated ball valves on inlet and discharge connections,
 - .2 bronze inlet strainer,
 - .3 four (4) ball-valve test cocks,
 - .4 air gap drain,
 - .5 lead free and listed to NSF/ANSI 61/G or 372.
 - .6 required MCPR: 1200 kPa (175 psi) at 82°C (180°F).

Standard of Acceptance

- Watts - fig. LF909QT
- Apollo - fig. RPLF4A

.4 NPS 2 to 10:

- .1 butterfly or OS&Y resilient seated gate valves on inlet and discharge connections,
- .2 four (4) ball-valve test cocks,
- .3 air gap drain body,
- .4 lead free and listed to NSF/ANSI 61/G or 372,

- .5 required MCPR: 1200 kPa (175 psi) at 60°C (140°F).

Standard of Acceptance

- Watts - fig. LF909-OSY
- Apollo - fig. RPDA40
- Cla-val Company - fig. RP-1EX

2.4 Back-flow Preventers – Double Check Valve Assemblies (“DCVA”)

- .1 Listed to CSA B64.5.
- .2 Type: double check valve backflow preventers, with two positive seating spring-loaded check valves.
- .3 NPS ½ to 2:
- .1 bronze body, replaceable seats and seat discs,
 - .2 quarter turn full port resilient seated ball valves on inlet and discharge connections,
 - .3 bronze inlet strainer,
 - .4 four (4) ball-valve test cocks,
 - .5 lead free and listed to NSF/ANSI 61/G or 372,
 - .6 required MCPR: 1200 kPa (175 psi) at 82°C (180°F).

Standard of Acceptance

- Watts - fig. LF007QT series
- Apollo - fig. DCLF4A series
-

- .4 NPS 2-1/2 to NPS 10:
- .1 T304 stainless steel body and stainless steel, bronze and EPDM trim,
 - .2 OS&Y resilient seated gate valves, or butterfly valves on inlet and discharge connections,
 - .3 four (4) ball-valve test cocks,
 - .4 lead free and listed to NSF/ANSI 61/G or 372,
 - .5 required MCPR: 1200 kPa (175 psi) at 60°C (140°F).

Standard of Acceptance

- Watts - fig. LF757, LF757N
- Apollo - fig. DCLF4A series (NPS 2-1/2 to 8 only).

2.5 Vacuum Breakers

- .1 Atmospheric type (“AVB”):
- .1 listed to CSA B.64.1.1.
 - .2 NPS ¼ to 3:
 - (a) atmospheric type (AVB), with single float and disc, and
 - (b) large atmospheric port.

Standard of Acceptance

- Watts - fig. 288A

- Cash Acme - fig. V-101

.2 Pressure type (“PVB”):

- .1 listed to CSA B.64.1.2.
- .2 NPS ½ to 2:
 - (a) pressure type (PVB) with spring loaded single float and disc,
 - (b) independent first check, shut off valves, and ball type test cocks.

Standard of Acceptance

- Watts - fig. 800

.3 Hose connection type (“HCVB”):

- .1 listed to CSA B.64.2
- .2 NPS ¾:
 - (a) atmospheric vent vacuum breaker with non-removable single check,
 - (b) hose connection,
 - (c) drainage feature to prevent freezing,

Standard of Acceptance

- Watts - fig. 8
- Cash Acme – fig. V-3

2.6 Pressure Reducing Valves

- .1 Bronze body, self-contained type, single renewable nickel alloy seat and resilient disc.
- .2 Diaphragm suitable for 90°C (200°F) service.
- .3 Close coupled bronze strainer with stainless steel screen.
- .4 Required MCPR: 2060 kPa (300 psi) at 49°C (120°F).
- .5 Flow rates and pressure reduction: as shown on drawings.
- .6 Lead free and listed to NSF/ANSI 61/G or 372.

Standard of Acceptance

- Watts
- Cash Acme Valve
- Singer Valve
- Leslie
- Victaulic Bermad

2.7 Pressure Relief Valves

- .1 Brass body to ASME Section IV.
- .2 Preset pressure settings: 515, 700, 860 and 1030 kPa (75, 100, 125 and 150 psi).
- .3 Lead free and listed to NSF/ANSI 61/G or 372.

Standard of Acceptance

- Watts - fig. LF3L

2.8 Strainers

.1 NPS ½ to NPS 3:

- .1 wye pattern, bronze body, solid retainer cap with gasket, and NPT threaded or soldered end,
- .2 type 304 stainless steel baskets: 1.2 mm (3/64 in) diameter perforations,
- .3 required MCPR: 2750 kPa (400 psi) at 93°C (200°F)
- .4 lead free and listed to NSF/ANSI 61/G or 372.

Standard of Acceptance

- Watts - fig. LF777, LFS777
- Zurn - fig. YBXL
- Cash Acme

.2 NPS 4 to NPS 10:

- .1 simplex basket strainer, cast iron body, bolted screen retainer cover, plugged drain/blowdown NPT connection, ASME Class 125 flat faced flange ends,
- .2 type 304 stainless steel baskets: 3.2 mm (1/8 in) diameter perforations,
- .3 required MCPR: 1370 kPa (200 psi) at 66°C (150°F),
- .4 lead free and listed to NSF/ANSI 61/G or 372.

Standard of Acceptance

- Watts - fig. LF98FB-CIB

2.9 Expansion Tanks

.1 Diaphragm style:

- .1 carbon steel body, butyl diaphragm, airside factory pre-charged to 80 kPa (12 psi), and stainless steel NPT pipe connections,
- .2 required MCPR: 1000 kPa (150 psig) at 93°C (200°F)
- .3 tank volume: 8, 17, 32 and 53 litres, as shown.
- .4 lead free and listed to NSF/ANSI 61/G or 372.

Standard of Acceptance

- Watts - fig. PLT series

3 EXECUTION

3.1 Water Hammer Arresters

- .1 Select, supply and install water hammer arrestors in accordance with PDI-WH 201 on branch supplies to each fixture or group of fixtures.
- .2 In addition, provide water hammer arrestors on branch supplies to each piece of owner's process equipment, of the size as shown.

3.2 Trap Seal Primers

- .1 Electronic manifolds:
 - .1 Install trap seal primer panels in the locations as shown on drawings to serve individual or groups of floor drains and/or hub drains.
 - .2 120V/1ph/60 Hz power supply will be brought to electric manifolded units under Division 26 and connected under Division 22.
 - .3 For Type B trap primer unit, pipe the outlet of the primer unit in type L hard-drawn copper down through the floor slab and connect to the trap primer distribution manifold located in ceiling space below.
- .2 Trap primer tubing:
 - .1 Use soft annealed copper tube to connect trap primer distribution manifold to floor drains and/or funnel drains.

3.3 Back-Flow Preventers and Vacuum Breakers

- .1 Provide back-flow preventers and vacuum breakers in accordance with CSA B64.10.
- .2 Install backflow preventers horizontally, in accordance with manufacturer's recommendations, but not less than 750 mm (30 in.) and not greater than 1500 mm (59 in.) above the floor level, or a fixed work platform, in front of the valve.
- .3 Install pressure vacuum breakers not more than 1500 mm (56 in.) above the floor level, or a fixed work platform, in front of the valve.
 - .1 exception: where the pipe connection to the protected fixture or equipment is higher than 1500 mm (56 in.) above the floor, locate the pressure vacuum breaker at an elevation just high enough so that the outlet pipe to the fixture/equipment does not rise above the vacuum breaker.
- .4 Pipe relief ports and air vents from backflow preventer, with an air gap, to nearest floor/hub drain or service sink using hard-drawing DWV copper tube.
- .5 Position backflow preventers and pressure vacuum breakers so that test ports are accessible.
- .6 Provide cabinets for backflow preventers as shown.

3.4 Additional Requirements for Reduced Pressure Backflow Preventers

- .1 For reduced pressure type (RP) backflow preventers, install an inline spring-loaded disc or ball type check valve with threaded ends, within 300 mm (12 in.) of the inlet connection to the RP backflow preventer. Provide a pipe union on the upstream side of this check valve.

3.5 Pressure-Reducing Valves

- .1 Install pressure-reducing valves ("PRV") with upstream and downstream shut-off valve and unions, and provide a 115 mm (4½ in) pressure gauge immediately downstream of the PRV.
- .2 For high-flow/low-flow parallel PRV arrangements, install the high-flow valve in the pipe main run and the low-flow valve in the offset run. Set the low-flow PRV setpoint to be 35 to 70 kPa (5 to 10 psi) greater than the high-flow PRV setpoint.

3.6 Pressure Relief Valves

- .1 Provide pressure relief valves as follows:
 - .1 after each pressure reducing valve,

- .2 after each backflow preventer, and
 - .3 where shown on drawings.
- .2 Select relief valve setpoint to be not more than the design pressure of the piping system.

3.7 Strainers

- .1 Install with sufficient space to remove baskets.
- .2 Provide a valved blow-down drain line on NPS 4 to NPS 10 basket strainers, and pipe blow-down line in hard type L copper tube and terminate over floor drain, hub drain or trench drain.

3.8 Expansion Tank

- .1 Provide expansion tanks as follows:
 - .1 at each set of domestic hot water tanks or heaters,
 - .2 where shown on drawings.
- .2 Select tank volume size in accordance with Schedule A at the end of this section.
- .3 Install tank on cold water line immediately before the connection to the domestic hot water tank or heater.
- .4 Provide lockshield shut-off valve and pressure gauge on water line to expansion tank. Place a nylon tie-wrap through the lockshield to secure the valve in the open position.
- .5 Check and adjust pressure charge in accordance with manufacturer's instructions.
 - .1 Set minimum pressure on tank before domestic hot water piping is warmed up.
 - .2 Where the expansion tank is located other than the top of the building, increase the factory pre-set pressure charge by 10 kPa per 1 meter (1.3 psi per 3 feet) of riser height above the tank, before filling the water piping system with water.

3.9 Equipment Schedules

- .1 The following appended equipment schedules form part of this specification section.
 - .1 Schedule A Expansion Tanks

Schedule A – Expansion Tanks			
Equipment Tag	Location Reference	Expansion Tank Volume Litres	No of Individual Tanks Required
T-			
T-			

END OF SECTION

SANITARY WASTE AND VENT PIPING – CAST IRON AND COPPER

22 13 16.13

1 GENERAL

1.1 Scope

- .1 Provide cast iron pipe and fittings and/or copper tube and fittings for sanitary soil and waste drain and vent piping, for aboveground and buried services.
- .2 Provide PVC-DWV piping for urinal fixture drains and a portion of the fixture vent piping.
 - .1 For clarity, the use of PVC DWV piping under this specification section is restricted to this purpose.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 25 Excavation and Backfilling
 - .2 20 05 29 Common Hanger and Support Requirements for Piping

1.3 Applicable Codes and Standards

- .1 Installation standards and codes:
 - .1 Cast Iron Soil Pipe Institute (CISPI) Technical Manual
- .2 Product standards:
 - .1 ASME B16.23 Cast Copper Alloy Solder Joint Drainage Fittings: DWV
 - .2 ASME B16.29 Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings-DWV
 - .3 ASTM B32 Standard Specification for Solder Metal
 - .4 ASTM B306 Standard Specification for Copper Drainage Tube (DWV)
 - .5 ASTM C564 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
 - .6 ASTM C1540 Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
 - .7 ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
 - .8 CSA B70 Cast Iron Soil Pipe, Fittings, and Means of Joining
 - .9 CSA-B125 Plumbing Fittings.
 - .10 CSA B158.1 Cast Brass Solder Joint Drainage, Waste, and Vent Fittings
 - .11 CSA B602 Mechanical Couplings for Drain, Waste, and Vent Pipe and Sewer Pipe.

2 PRODUCTS

2.1 Copper DWV Pipe and Fittings

- .1 Application: inside of buildings only. Do not use for buried drain or vent.
- .2 Pipe:
 - .1 copper DWV tube to ASTM B306

.2 certification markings made by testing agency accredited by Standards Council of Canada.

.3 Fittings:

.1 copper or copper alloy to ASME B16.23, or ASME B16.29.

.4 Solder

.1 tin-antimony 95/5 to ASTM B32 alloy Sb5.

2.2 Cast Iron DWV Pipe and Fittings

.1 Application: inside of buildings and buried drain and vent.

.2 Pipe and fittings:

.1 cast to CSA B70,

.2 with heavy bituminous coating for buried service.

.3 riser fittings with integral riser support ring for hub-less piping installed in vertical risers.

.3 Joints above ground:

.1 Plain end made up using mechanical sleeve joints to CSA B602 and ASTM C1540 with neoprene or butyl rubber compression gaskets to ASTM C564, with stainless steel sleeve and not less than four stainless steel drive clamps with stainless steel worms.

.2 Hub and spigot made up neoprene gasket to ASTM C564 and lubricating compound.

2.3 PVC DWV Pipe and Fittings

.1 Application:

.1 Restricted to fixture drain piping and partial vent pipe for urinals.

.2 Pipe and fittings:

.1 PVC pipe and fittings to CSA-B181.2,

.2 flame spread rating ("FSR") of not more than 25 when tested to ULC-S102.2,

.3 smoke developed rating ("SDR") of not more than 50 when tested to ULC-S102.2.

.4 materials marked for CSA B181.2 and ULC-S102.2.

Standard of Acceptance

- IPEX -"System XFR 15-50"

.3 Joint cement:

.1 one-step CSA listed cement for pipe sizes NPS 1½ to NPS 6.

.2 IPS primer Type P-70 and Heavy Bodied IPS Cement Type 711 for pipe sizes larger than NPS 6.

.3 Volatile Organic Content: maximum 510 g/L.

3 EXECUTION

3.1 Installation General

- .1 Install soil, waste and vent piping in accordance with the requirements of the plumbing code applicable at the project location. Except as otherwise shown, venting of fixtures may use any method permitted in the plumbing code.
- .2 Install suspended piping to grade, parallel and close to walls and ceilings to conserve headroom and space.
- .3 Install piping close to building structure to minimize furring. Group piping and run parallel to walls and ceilings.

3.2 Cast Iron Piping

- .1 Install cast iron drainage piping in accordance with Cast Iron Soil Pipe and Fittings (CISPF) Technical Manual.
- .2 Lay buried piping in bedding prepared in accordance with specification section 20 05 25. Support piping on 150 mm (6 in.) thick bedding material, shaped to accommodate hubs and fittings, to line and grade as shown. Backfill with cover material to 300 mm above top of pipe or to underside of floor slab whichever is less.
- .3 Assemble and tighten mechanical sleeve joints to coupling manufacturers recommended torque value with torque wrench.
- .4 Install cast iron hub-and-spigot joints with neoprene compression gasket and lubrication in accordance with manufacturer requirements.
- .5 Provide thrust restraints consisting of pipe clamps and restraint rods installed across tees, elbows, and blind plugs (cleanouts), for cast iron drainage piping NPS 5 and larger.
- .6 Provide sway braces on all horizontal piping where the hanger length is greater than 450 mm (18 in) measured from the top of the pipe to the structure connection point, as follows:
 - .1 transverse brace at 12 m (40 ft) intervals,
 - .2 longitudinal brace at 24 m (80 ft) intervals,
 - .3 a transverse brace of one pipe section may act as a longitudinal brace for a second pipe section connected perpendicular to the first section, provided the brace is located within 600 mm (24 in) of the connection.
 - .4 for clarity, these braces are required even where seismic restraint is not required.

3.3 Copper Tubing

- .1 Cut copper tube square, ream tube ends and clean tubing and tube ends before joint assembly.
- .2 Before assembling solder joints, clean inside of solder fittings and outside of mating pipe with emery paper and coat with flux.
- .3 Solder joints in copper pipe with blow torch or oxy-acetylene flame.

3.4 Pipe Supports

- .1 Support piping in accordance with specification section 20 05 29 except as specified herein.
- .2 Support horizontal copper DWV tubing in accordance with Table 1A:

Table 1A: Horizontal Pipe Support Spacing for Copper Tube		
Pipe Size NPS	Rod Diameter	Maximum Spacing
½	M10 (3/8 in)	1.5 m (5 ft)
¾ to 1¼	M10 (3/8 in)	1.8 m (6 ft)
1½	M10 (3/8 in)	2.4 m (8 ft)
2	M10 (3/8 in)	2.4 m (8 ft)
2½	M12 (½ in)	3.0 m (10 ft)
3	M12 (½ in)	3.0 m (10 ft)
4	M16 (5/8 in)	3.0 m (10 ft)

- .3 Support horizontal cast iron DWV piping in accordance with Table 1B and as follows;
- .1 one pipe support for each end of the pipe, located at or within 150 mm (6 in) of each hub or mechanical joint,
 - .2 for mechanical joints, if the pipe length between adjacent fittings is 300 mm (12 in) or less, reduce the support spacing to a maximum of 1000 mm (39 in),
 - .3 where multiple joints occur within a 1000 mm (39 in) developed pipe length;
 - (a) support may be reduced to every other hub or mechanical joint, or
 - (b) where the pipe run is made of multiple fittings connected end-to-end, provide a 1.6 mm (16 ga) galvanized steel half sleeve underneath the pipe and fittings, and support the sleeve with a support at each end of the sleeve.

Table 1B: Horizontal Pipe Support Spacing for Cast Iron DWV Piping			
Pipe Size NPS	Maximum Spacing	Clevis Hanger: Minimum Rod Diameter	MJ Hanger: Minimum Rod Diameter
1-1/2	3 m (9.8 ft)	---	M10 (3/8 in)
2	3 m (9.8 ft)	---	M10 (3/8 in)
3 to 4	3 m (9.8 ft)	M10 (3/8 in)	M10 (3/8 in)
6	3 m (9.8 ft)	M12 (1/2 in.)	M12 (1/2 in.)
8 to 12	3 m (9.8 ft)	M16 (5/8 in)	---
15	3 m (9.8 ft)	M20 (3/4 in)	---

- .4 Support vertical pipe and tube risers at the base (bottom) of the riser and as follows:
- .1 for cast iron drain and vent piping,

- (a) support piping at every floor level with a pipe clamp, arranged so that the pipe clamp is above the pipe section center of gravity,
 - (b) support the pipe below a hub, or support the pipe with a riser fitting for hub-less joints.
 - (c) support the base of a riser at a fitting hub, or for mechanical joints support the riser pipe at a riser fitting,
 - (d) for pipe sizes NPS 5 and larger, provide sway braces at the base support to limit movement in both horizontal directions.
- .2 for other piping, support piping at every other floor level with pipe riser clamps,
 - .3 for all piping and tubing, do not exceed a vertical spacing of more than 7.5 m (24.5 ft),
 - .4 in addition, for cast iron drainage piping provide lateral guides;
 - (a) at the base and top of the pipe riser,
 - (b) and at every 9 m (30 ft) except where the pipe riser clamp is restrained to prevent lateral movement.

3.5 Testing

- .1 Test drainage piping in accordance with the requirements of the plumbing code applicable at the project location.
- .2 Test before piping is concealed.
- .3 Cut-out and replace leaking soldered fittings, remake joints in cast iron piping, and retest.

END OF SECTION

PLUMBING FIXTURES 22 42 00

1 GENERAL

1.1 Scope

- .1 Provide plumbing fixtures and trim, and temperature mixing valves for fixtures.
- .2 This specification section does not apply to temperature mixing valves located remote from individual plumbing fixtures, or for process equipment; refer to specification section 22 39 13 *Domestic Water Temperature Mixing Valves*.
- .3 This specification section does not apply to temperature mixing valves for emergency shower and eye-wash stations; refer to specification section 22 45 13 *Emergency Plumbing Fixtures*.

1.2 Definitions

- .1 The following definitions apply to this section.
 - .1 **Barrier-free:** has the same meaning as the applicable building code of the place of the Work, or in its absence, means, when applied to plumbing fixtures and emergency plumbing fixtures, the fixture can be approached, entered, and used by persons with physical or sensory disabilities.

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA Z317.1 Special Requirements for Plumbing Installations in Health Care Facilities
 - .2 CSA Z318.3 Commissioning of Plumbing Systems in Health Care Facilities
- .2 Product standards:
 - .1 ASME A112.6.1 Supports for Off-the-Floor Plumbing Fixtures for Public Use
 - .2 ASSE 1016/ASME A112.1016/CSA B125.16
Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations
 - .3 ASSE 1066 Performance Requirements for Individual Pressure Balancing Valves for Individual Fixture Fittings
 - .4 ASSE 1070 Performance Requirements for Water Temperature Limiting Devices
 - .5 CSA-B45 Series Plumbing Fixtures.
 - .6 CSA-B125 Plumbing Fittings.
 - .7 NSF/ANSI 61 Drinking Water System Components – Health Effects, including Annex G
 - .8 NSF/ANSI 372 Drinking Water System Components – Lead Content
 - .9 UL 1951 Electrical Plumbing Accessories

1.4 Fixture Count and Location

- .1 Determine the number and location of plumbing fixtures from Architectural drawings in the first instance, followed by the mechanical drawings.
- .2 In the event of a conflict as to location of plumbing fixtures between the architectural drawings and the mechanical drawings, the location as shown on the architectural drawings govern.

1.5 Submittals

- .1 Submit product data sheets for materials specified herein. Organize the submission in accordance with the following requirements:
 - .1 make one consolidated submission for all products specified,
 - .2 indicate the fixture type designation for each product on each submittal page,
 - .3 where a fixture type consists of multiple product components, organize the information in a cohesive presentation by fixture type designation,
 - .4 where a data sheet includes multiple figures/options, clearly mark the applicable model number and/or option that is being proposed as meeting the specification requirement.

2 PRODUCTS

2.1 General Requirements - Fixture Quality

- .1 Fixtures and trim of the same type to be the product of one manufacturer and must have proven hospital performance from previous installations.
- .2 Finished surfaces to be clear, smooth and bright, and guaranteed not to craze, discolour or scale.
- .3 Visible parts of faucets, escutcheons, wastes, strainers, traps, shower heads, supplies and stops to be chrome plated.
- .4 Do not include aerators in water supply faucets in healthcare facilities. Provide faucets with anti-aerosolizing outlets (laminar flow) that do not retain air.
- .5 Fixtures will not have an overflow.
- .6 All electronic sensor-activated fixtures shall be hardwired and on delayed vital emergency power.
- .7 Floor mounted water closets fitted with china bolt caps; plastic bolt caps are not acceptable.
- .8 Fixtures will be "lead-free" and meet or exceed the requirement of NSF/ANSI 61 & NSF/ANSI 372.
- .9 Faucet water discharge will not discharge directly in fixture drain grid strainer. As necessary, mock-up the proposed plumbing fixtures and associated faucets to verify this compliance requirement is being met. Submit written confirmation to the consultant that the compliance requirement has been met with the proposed plumbing fixtures and associated faucets.
- .10 Provide accessible cleanouts for all sinks and lavatories. Cleanouts for sinks and lavatories shall be located above the flood-level rim of the fixture. Include provisions for cleanouts for future sinks and lavatories where indicated on the architectural or mechanical drawings.
- .11 Compression fittings shall not be used except for connection of trap primer lines run in the slab.
- .12 Where fixtures and trim are identified by manufacturers' catalogue designation these references are to establish quality standards not otherwise specified. For the purposes of this section of the specification, fixtures or trim from manufacturers listed below are equally acceptable when conforming to the same level of quality.

Standard of Acceptance

- Delta Commercial
- Kindred
- Franke
- Moen Commercial

2.2 Hand Hygiene Sink "HHS-1" (foot pedal)

- .1 Basin: White solid surface hand hygiene sink with removable shroud. 1 1/2" (DN 40) grid waste, left rear location, faucet anti-splash feature through middle of sink, bowl sloped towards drain. Overall (FB x LR x H) 16 15/16" [430mm] x 20 3/16" [512mm] x 21 1/4" [540mm]. Wall hung basin, no overflow, single hole, drilled for concealed arm carrier, fixture to include removable shroud.

Standard of Acceptance

- Franke Nightingale AHWSS1720W-OO
- .2 Faucet: Deck mounted faucet, gooseneck, 4.5" spout reach, rigid with swivel option selectable during installation, non-aerating, laminar flow outlet, vandal proof. Faucet c/w hot and cold water floor mounted pedal box with self close pedals, chrome plated finish

Standard of Acceptance

- Delta 54T5437A
- .3 Drain: NPS 1¼ chrome plated cast brass tailpiece with cleanout and open grid strainer

Standard of Acceptance

- Delta 33T260-1
- .4 Angle stops: Chrome plated NPS 3/8 rigid angle or flexible supplies with lockshield stops and associated supply kit components

Standard of Acceptance

- Brasscraft Supply Kit KTSCS400AX C
- .5 TMV: Point of use thermostatic mixing valve, nickel plated, bronze body, temperature adjusting spindle, 10mm (3/8") inlets and outlet FNPT connections, integral checks, high temperature limit stop set to a maximum 43 °C (109.4 °F), tempered water to hot water side of faucet,

Standard of Acceptance

- Delta R3270-MIXLF
- .6 P-trap: NPS 1¼ chrome plated brass "P" trap with cleanout

Standard of Acceptance

- Delta 33T311
- .7 Carrier: steel pipe legs, block base feet support, concealed arms and pedestal plate. For narrow wall installation provide 'Z' type sleeve for arms.

Standard of Acceptance

- Smith SQ-0-4437
- Zurn
- Watts – CA-401-D for back to back carrier
- Franke IWC2203

2.3 Sealant Between Fixture and Wall Finish:

- .1 One-part acetoxysilicone sealant
- .2 White or clear colour.

- .3 Formulated with fungicide

Standard of Acceptance

- Tremco - fig. Tremsil 200
- Dow Corning
- GE

3 EXECUTION

3.1 Fixture Installation - General

- .1 Support fixtures level and square and connect with supplies, drains, traps and vents.
- .2 Where a faucet has separate hot and cold water handles, position the hot water handle on the left side of the faucet.
- .3 Where fixtures on located on exterior walls, run the water supplies up through the floor. For other fixture locations, run water supplies in the wall cavity.
- .4 Provide resilient, watertight and gas-tight seals for every joint in a floor flange or between a floor-outlet fixture and the drain.

3.2 Fixture Supports

- .1 Provide plates, brackets, wall carriers, cleats, and supports to secure fixtures in place.
- .2 Fasten wall brackets with bolts attached to double steel supporting plates.
- .3 Bolt fixture to wall through cored holes under lavatory wall flange, using chrome plated carriage bolts with integral washers, and expansion shields.
- .4 Install extra-heavy-duty chair carriers for fixtures not directly supported from floor.
- .5 Conceal vertical supports and baseplates in wall construction.
- .6 Apply sealant bead between wall mounted fixture and finished wall and finish with a smooth concave profile.
- .7 Set floor mounted water closet bowls in mastic, and seal the floor flange with a resilient, watertight and gas-tight flange seal.

3.3 Plumbing Fixture Installation Heights and Clearances

- .1 Install plumbing fixtures at heights as shown on architectural drawings and specifications. Where such information is not provided therein, install fixtures at heights as described in the following table.
 - .1 Mounting heights are in reference to the top of the finished floor level unless otherwise stated.

Fixture Type	Mounting Height Reference (above finished floor)	Mounting Height Mm (inch)	
		Barrier-Free	All Other
Water Closet	Top of seat	≥ 430 and ≤ 460 (≥ 17 and ≤ 18)	≥ 430 and ≤ 460 (≥ 17 and ≤ 18)
Urinal	Front rim	400 to ≤ 430 (16 to ≤ 16.5) [Note 1]	575 to ≤ 600 (22.5 to ≤ 23.5)

Fixture Type	Mounting Height Reference (above finished floor)	Mounting Height Mm (inch)	
		Barrier-Free	All Other
Lavatory	Rim	850 to ≤ 865 (33.5 to ≤ 34)	[850 to ≤ 865 (33.5 to ≤ 34)] [885 to ≤ 910 (35 to ≤ 36)]
Shower	Valve control handle	1150 to ≤ 1200 (45 to ≤ 47)	1150 to ≤ 1200 (45 to ≤ 47)
	Hand-held shower head: Two positions	1200 and 2300 (45 and 90) [Note 2]	1200 and 2300 (45 and 90) [Note 2, 3]
Bathtub	Faucet centerline (above tub rim)	425 to ≤ 450 (16.5 to ≤ 17.5)	425 to ≤ 450 (16.5 to ≤ 17.5)
	Hand-held shower head; Two positions	1200 and 2300 (45 and 90) [Note 2]	1200 and 2300 (45 and 90) [Note 2, 3]

Notes:

[1] Where there are two or more urinals in a washroom, one urinal is to be mounted at this height.

[2] An adjustable hand-held shower head mounted on a vertical shower bar, that can be set at these positions.

[3] If specified.

- .2 Mount manually-operated flushing control for water closets;
 - .1 between 500 and 900 mm above the finished floor, and
 - .2 for barrier-free water closets, located on the transfer side of the water closet.
- .3 Mount manually-operated flushing control for urinals;
 - .1 between 900 and 1100 mm above the finished floor level for barrier-free urinals, and
 - .2 at a height to suit the urinal fixture and flush-control valve for all other urinals.
- .4 For barrier-free lavatories not equipped with a fixture-skirt barrier, arrange piping beneath the lavatory so that the hatched area shown in figure 1 is clear of any obstruction.

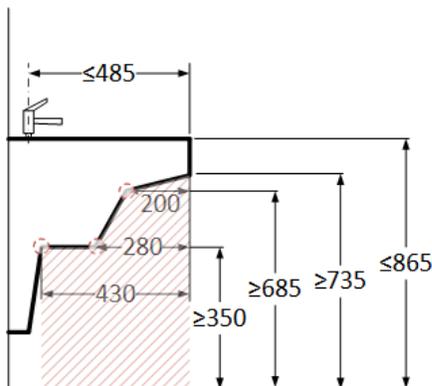


Figure 1: Barrier-Free Lavatory Clearances

3.4 Thermostatic Mixing Valve Installation

- .1 Install a fixture Thermostatic Mixing Valve at individual faucets where specified as an accessory for the fixture type, or as otherwise shown.
- .2 Provide field installed bass-bodied, in-line spring-loaded check valves on the hot and cold water supplies to each TMV unit, regardless of whether or not the TMV is equipped with integral check valves. For greater certainty, if the TMV unit is supplied with integral check valves they are deemed not to meet this requirement.

3.5 Protection

- .1 Cover plumbing fixtures and trim with plywood, cardboard or heavy paper and kept protected before, during and after installation and until work is completed and accepted.
- .2 Clean fixtures, and trim immediately prior to building completion.

3.6 Start-Up and Testing

- .1 Test, adjust and set high temperature limit stops on fixtures to supply a maximum water temperature, including faucets with integral or remote temperature mixing valves, as follows.

Fixture Type	Occupancy	Temperature Setpoint
Faucets	Healthcare, Long-Term Care, Retirement Homes	43°C (109°F)
	Other Occupancies	49°C (120°F)

3.7 Commissioning Program

- .1 Comply with the project commissioning requirements in accordance with specification section 20 08 15.
- .2 The verification and testing requirements specified in this section may be concurrent with, or conducted separately from, the commissioning program, as coordinated with the Contractor and the commissioning agent.

3.8 Test and Installation Records

- .1 Provide a report of this testing and include:
 - .1 fixture reference,
 - .2 measured maximum temperature,
 - .3 date of test(s),
 - .4 signature of person(s) conducting test.
- .2 Submit a copy of each report to the Consultant and Owner for review and acceptance.
- .3 The above tests are subject to a demonstration test audit of up to 10% of the total fixture count to verify compliance. If audit tests are not satisfactory to the Consultant, additional testing and verification will be conducted by the Contractor until such time as a demonstration audit provides satisfactory results to the Consultant.

END OF SECTION

MEDICAL GAS PIPING 22 60 13.70

1 GENERAL

1.1 Scope

- .1 Provide medical gas piping distribution systems including:
 - .1 piping, fittings, and valves,
 - .2 medical gas control panels,
 - .3 emergency oxygen inlet stations,
 - .4 line pressure regulators and safety valves,
 - .5 terminal units, including terminal units to be installed in Medical Supply Units, headwall units and ceiling mounted service columns.
 - .6 pipe hangers and accessories,
- .2 Applicable systems:
 - .1 Medical pressure gases intended for patient care:
 - (a) oxygen USP,
 - .2 Medical vacuum.
- .3 Refer to specification section 22 63 26.70 for zone valve stations and combination zone valve/zone alarm panels.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 01 02 Qualifications and Authorities
 - .2 20 05 24 Welding and Brazing
 - .3 20 05 25 Excavation and Backfilling
 - .4 20 05 29 Common Hanger and Support Requirements for Piping
 - .5 22 63 26.70 Medical Gas Control Equipment

1.3 Definitions

- .1 The following definitions apply to this section and referenced sections:
 - .1 **Certification Agency:** a testing organization of medical gas systems accredited to the requirements of ISO/IEC 17025 by Standard Council of Canada (has the same meaning as “testing body” as used in CSA Z7396.1.
 - .2 **Diameter index safety system (DISS):** threaded connections that comply with the requirements of CGA V-5.
 - .3 **Master alarm:** has the same meaning as “supply system alarm” in CSA Z7396.1.
 - .4 **Medical gas:** means all services within the scope of CAN/CSA-Z7396.1.
 - .5 **Medical pressure gas:** means only those medical gases which operated under positive pressure.
 - .6 **Medical supply units:** means those medical devices which supply medical gases within the scope of CSA Z305.8.

- .7 **Pipe (piping):** has the meaning as defined in ASME B31.3, and is used interchangeable with “tube” or “tubing”, except where the context indicates otherwise.
- .8 **Qualified installer:** a competent person or company responsible for the installation of medical gas pipeline systems or components within a medical gas system.
- .9 **Service units:** includes headwall units, ceiling-mounted service columns, ceiling-mounted articulating arms, patient service strips and medical supply units.
- .10 **Terminal unit:** an outlet assembly for medical gases in a medical gas pipeline system at which the operator makes connections and disconnections.
- .11 **USP:** United States Pharmacopeia.
- .12 **USP-NF:** USP National Formulary
- .13 **Zone, zone alarm, and zone valve:** have the same meaning as defined in CSA Z7396.1.

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Regulation 220/01 Boiler and Pressure Piping Regulation
 - .2 Ontario Regulation 213/07 Fire Code
- .2 Installation codes and standards:
 - .1 ASME B31.3 Process Piping
 - .2 CSA B51 Boiler, Pressure Vessels and Pressure Piping Code.
 - .3 CSA Z7396.1-17 Pipelines for Medical Gases, Medical Vacuum, Medical Support Gases, and Anaesthetic Gas Scavenging Systems
 - .4 CAN/CSA Z15001 Anaesthetic and Respiratory Equipment - Compatibility with Oxygen
 - .5 CGA G-4.1 Cleaning Equipment for Oxygen Service.
- .3 Product standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .2 ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - .3 ASME B16.50 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
 - .4 ASTM B819 Standard Specification for Seamless Copper Tube for Medical Gas Systems.
 - .5 AWS A5.8 Brazing Filler Metal.
 - .6 CGA V-5 Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)
 - .7 CSA Z305.8 Medical Supply Units
 - .8 CAN/CSA-Z5359 Anaesthetic and respiratory equipment — Low-pressure hose assemblies for use with medical gases, medical vacuum, medical support gases, and anaesthetic gas scavenging systems
 - .9 CSA-Z9170-1 Terminal units for medical gas pipeline systems - Part 1: Terminal units for use with compressed medical gases, vacuum, and anaesthetic gas scavenging systems
 - .10 CAN/CSA-Z10524-2 Pressure Regulators for Use with Medical Gases - Part 2: Manifold and Line Pressure Regulators

1.5 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradespersons holding applicable certificates of competency for pressure piping and brazing work.
- .2 In addition, medical gas systems shall be installed by a specialist firm that: has experienced in this type of work; is knowledgeable of the applicable regulations, installation codes and standards; has registered procedures for silver brazing; and regularly employs tradespersons qualified in pressure piping installation. Before commencing work on site, supply copies of tradespersons certificates of competency for brazing to the Owner for their records.
- .3 In addition, tradespersons performing work on medical gas systems shall be certified in accordance with *CSA Medical Gas Piping & Systems Installation Personnel Certification Program*. Prior to commencing work on site, supply copies of certification record to the Owner for each qualified tradesperson working performing work on the medical gas system.

1.6 Registration and Inspection

- .1 Pressure piping:
 - .1 Before commencing work, make arrangements and pay for registration and inspection of pressure vessels and pressure piping by the AHJ responsible for Pressure Piping safety, unless otherwise exempt by regulation.
 - .2 All materials which operate with an internal gas pressure greater than 100 kPa (15 psi) above atmospheric pressure shall have a CRN in accordance with CSA B51.
 - .3 Collect and record CRNs for components and fittings, and obtain and coordinate equipment CRNs or field registration of composite equipment.
 - .4 At the start of the Work, obtain existing pressure piping system registration numbers, if available, from the Owner and/or the AHJ.
- .2 Fire safety:
 - .1 Before commencing work, make arrangements and pay for permits and inspection of medical gas piping systems by the AHJ responsible for fire safety.

1.7 Design Criteria – Medical Gas and Vacuum Piping

- .1 Piping design and installation code:
 - .1 to ASME B31.3.
- .2 System design criteria:

System	Design Temp. °C (°F)	Maximum Operating Pressure kPa (psig)	Design Pressure kPa (psig)
Oxygen	38 (100)	415 (60)	700 (100)
Medical Vacuum	38 (100)	-70 (-20 in.Hg.)	-100 (-30 in.Hg.)

1.8 Submittals

- .1 Submit manufacturer catalogue cut-sheets for the following materials;
 - .1 tubing,

- .2 valves,
- .3 terminal units,
- .4 line pressure regulators, safety valves and assemblies,
- .5 emergency gas inlet connections.

1.9 Quality Control

- .1 Site Acceptance Testing;
 - .1 Manufacturer to provide services of manufacturer's authorized service personnel to provide field services in accordance with the requirements of Part 3 of this specification.
- .2 Brazing Quality Control;
 - .1 Maintain records of in-process examination of not less than 5% of production brazed joints in accordance with ASME B31.3. Submit copies of examination records of selected joints (or nearest examined joint) when requested by the Certification Agency or the Consultant.
 - .2 Include a copy of in-process examination records in the maintenance and operations manual.
- .3 Commissioning and Certification;
 - .1 The medical gas installation contractor shall be responsible to commission the medical gas systems in accordance with the requirements of CSA Z7396.1 and as specified herein.
 - .2 The medical gas systems will be certified by an independent Certification Agency, hired directly by the Owner, to verify that the installation is in accordance with CSA-Z7396.1. The medical gas installation contractor shall include labour, superintendence and all other costs associated with co-ordination, attendance and participation during certification testing of the medical gas systems.

1.10 Material Shipping, Handling and Storage

- .1 Where specified as to be cleaned for oxygen service, material shall be cleaned in accordance with CGA G-4.1 or CAN/CSA Z15001, sealed in a plastic bag, labelled to state that the product has been so cleaned, and shipped to the project site in packaging to prevent contamination by dirt, grease, or other foreign matter.
- .2 Where such material protection is damaged prior to installation, including damage to the packaging, the material shall not be installed and shall be removed from the site.
- .3 Store materials in clean and dry conditions.

1.11 Operating and Maintenance Data

- .1 In addition to the requirements of Division 01, submit operating and maintenance data including:
 - .1 equipment list identifying components used in each system,
 - .2 equipment manufacturer's names and addresses,
 - .3 wiring diagrams of alarms and electrical components,
 - .4 detailed drawings of equipment and components,
 - .5 manufacturers service manuals, including recommended maintenance tasks and frequency, and recommended spare parts,
 - .6 manufacturers' warranties,
 - .7 valve schedule listing valves in system with location.
 - .8 Canadian Registration Numbers (CRN) for components and fittings.

- .9 manufacturer instructions for the non-destructive and non-invasive procedures for testing of alarms,

2 PRODUCTS

2.1 Copper Tube

- .1 Hard drawn copper to ASTM B819;
 - .1 type "L" except as follows:
 - (a) type "K" for tube size NPS 3 and larger with design pressures in excess of 1275 kPa (185 psi),
 - (b) type "K" for buried (underground) services.
 - .2 factory cleaned and marked with classification symbols for medical gas use,
 - .3 cleaned for oxygen service,
 - .4 shipped with pipe end sealed.

2.2 Fittings

- .1 Wrought copper or copper alloy to ASME B16.22 or ASEM B16.50, and
- .2 For pipe sizes NPS 1/2 or less, fittings that are not made especially for soldered or brazed connections may be used, provided that the fitting as installed is visible in the room or is readily accessible for maintenance.
- .3 Dielectric fittings may be used where required by the manufacturer of special medical equipment to electrically isolate the equipment from the pipeline distribution system.
- .4 Axially swaged, elastic strain preload fittings providing metal-to-metal seal may be used provided that the fittings have pressure and temperature ratings not less than that of a brazed joint and, when complete, are permanent and non-separable.
- .5 All fittings to be cleaned for oxygen service.

Standard of Acceptance

- LOKRING Technology

2.3 Flanges and Gaskets

- .1 Flange:
 - .1 ASME Class 150 or 300 carbon steel flange, Van-stone style with copper tube adapter tailpiece, suitable for brazed connection to copper tubing. Flange designed to prevent contact of carbon steel material and the medical gasses.
 - .2 flange provided with a powder coated finish, and an EPDM insulator to isolate the copper tailpiece from contact with the flange.
 - .3 minimum MCPR:
 - (a) Class 150: 1400 kPa (250 psi) at 38°C (100°F)
 - (b) Class 300: 2800 kPa (400 psi) at 38°C (100°F)

Standard of Acceptance

- CTS Flange Canada - fig. BF / WBG

- .2 Flange gaskets:
 - .1 full flat-faced style to ANSI B16.21.

- .2 material: PTFE with silica, suitable for use in oxygen service and nitrous oxide.
 - (a) thickness: 1.6 mm (1/16 in.).
 - (b) required working pressure: 7000 kPa (1000 psi), from -268°C (-450°F) to +260°C (500°F)

Standard of Acceptance

- Garlock - fig. Gylon 3502

2.4 Joints

.1 Brazed joints:

- .1 for copper-to-copper joints: silver brazing alloy to AWS A5.8 classification BCuP-3 or BCuP-5, and no flux.
- .2 for brazing dissimilar metals: silver brazing alloy to AWS A5.8 classification BCUP-5 with brazing flux No. 3A.

Standard of Acceptance

- Handy Harmon "SIL-FOS"
- All-State Welding Alloys "SILFLO 15"

.2 Threaded joints:

- .1 for connections to valves and other equipment: NPT to ASME B1.20.1.
- .2 thread sealant: oxygen compatible Teflon tape.

Standard of Acceptance

- Masters - Oxygen compatible T-Tape

2.5 Pipe Hangers and Supports

.1 Refer to section 20 05 29 except as specified herein.

.2 Trapeze Hangers:

- .1 12 ga galvanized steel channel frames, solid backs.

Standard of Acceptance

- Taylor Figure TS
- Unistrut

.3 Pipe/Tubing Clamps:

- .1 two piece, epoxy coated clamp, with thermoplastic liner to separate piping from clamp.

Standard of Acceptance

- Taylor Figure 8500 Strut-Clamp
- Unistrut

.4 Spacers:

- .1 U-shape splice plates used as spacer control between adjacent piping clips.

Standard of Acceptance

- Taylor UF series

- Unistrut

2.6 Ball Valves

- .1 NPS 4 and under – general requirements:
 - .1 for medical gases, medical vacuum and AGSS.
 - .2 to MSS SP-110, 600 CWP, three-piece forged brass or bronze body, full port, stainless steel ball or chrome plated bronze ball, PTFE seat rings, and blow-out resistant with Viton seals, solder ends.
 - .3 required MCPR: 4100 kPa (600 psig) at 38°C (100°F).
 - .4 lever handle with locking device.
 - .5 factory assembled with type K” copper tube extensions to ASTM B819, complete with 1/8” FNPT inlet purge port, and an outlet purge/gauge ports.
 - .6 cleaned for oxygen service and with tube ends capped.

Standard of Acceptance

- Amico - fig. VV-ISO-G2L series
- Class I - fig. 7300 series
- BeaconMadaes - fig. 21160 series

- .2 Additional requirements for Zone Valves, up to NPS 3:
 - .1 application: ball valves installed inside of zone valve boxes/stations.
 - .2 ball valves as specified above. and as follows:
 - (a) copper tube extensions to a minimum of 100 mm (4 in) beyond sides or back of zone valve box,
 - (b) an additional 1/8” FNPT port on the discharge end for connection of pressure transducers,
 - (c) identification bracket bolted over valve body for application of medical gas identification label,
 - (d) fitted with line pressure gauges suitable for each gas or vacuum service,

2.7 Butterfly Valves

- .1 NPS 2-1/2 and over:
 - .1 for medical vacuum and AGSS services only.
 - .2 to MSS-SP-67, ductile iron lug body style, with flange bolt holes drilled and tapped for ANSI 150 flange pattern.
 - .3 stainless steel shaft, aluminum bronze or 316 stainless steel or ductile iron/nickel plated disc, and replaceable EPDM or BUNA-N resilient seat to provide bubble tight shut-off under system pressure from either side with flange removed from un-pressurized side.
 - .4 required MCPR: 1200 kPa (174 psi) at 93°C (200°F).
 - .5 ISO 5211 mounting pad.
 - .6 locking handles up to NPS 4, and gear operators for NPS 6 and over.
 - .7 cleaned for oxygen service.

Standard of Acceptance

- Class 1 - fig. BFC-Lug
- Nibco - fig. LD-2000

- Apollo - fig. LD 141, LD 145
- Kitz - fig. 6122EL

2.8 Check Valves

.1 In-line Silent Check, NPS 4 and under:

- .1 three-piece bronze body with swing out core, spring-loaded duo-disc, EPDM seat, socket ends.
- .2 factory assembled with type K" copper tube extensions to ASTM B819, complete with 1/8" FNPT inlet purge port, and an outlet purge/gauge ports.
- .3 cracking pressure less than 3.5 kPa (1/2 psi).
- .4 required MCPR: 2000 kPa (300 psi) at 93°C (200°F).
- .5 cleaned for oxygen service and with tube ends capped.

Standard of Acceptance

- Amico - fig. Medical Check Valve with Extensions
- Class 1 - fig. CVE series
- US Valve - fig. Medical Check Valve with Extensions

.2 In-line Silent Check Valves, NPS 2 and over:

- .1 to ASME B16.34, Class 150, ASTM A351 grade CF8M stainless steel wafer body, stainless steel trim and spring-controlled dual-disc check, EPDM or PTFE seat.
- .2 required MCPR: 1800 kPa (260 psig) at 38°C (100°F).
- .1 cleaned for oxygen service.

Standard of Acceptance

- Dezurik - fig. APCO CDD-9000T
- Crane - fig. Duo-Chek
- Mueller - fig. Sure Check 72D

2.9 Line Pressure Gauges

- .1 For source and distribution piping, not including zone valves.
- .2 To ASME B40.100 Grade 2A, direct pressure measurement, Ø115 mm (4½ in) dial type, silicone-free dampening, bronze tube, black solid front case, blow-out back, 0.5% full scale accuracy, adjustable pointer.
- .3 Measurement units and ranges:
 - .1 Gases: dual units kPa/psi;
 - (a) 0 to 700 kPa / 0 to 100 psig for all gases except Nitrogen, and Instrument Air,
 - (b) 0 to 2000 kPa / 0 to 300 psi for Nitrogen and Instrument Air,
 - .2 Vacuum: dual units kPa/in.Hg;
 - (a) -100 to 0 kPa / 30 in.Hg. to 0 for Medical Vacuum and AGSS.
- .4 Cleaned for oxygen service.

Standard of Acceptance

- Trerice - 450B

.5 Accessories:

- .1 pressure snubbers:
 - (a) brass construction, NPT threaded ends.
 - (b) cleaned for oxygen service.

Standard of Acceptance

- Terice – 872-1

- .2 needle valves:
 - (a) rising stem, brass or T316 stainless steel construction, NPT threaded ends.
 - (b) cleaned for oxygen service.

Standard of Acceptance

- Terice - 735 / 740

2.10 Medical Gas Control Panels

- .1 Recessed, wall mounted in 1.3 mm (18 ga) painted steel back box with supports to secure unit within wall or partition and anodized aluminum fascia,
- .2 Anodized aluminum front cover, with panel covered gas pressure regulation controls:
 - .1 inlet pressure gauge: 0-2000 kPa (0-300 psig) mounted ahead of shut-off valve,
 - .2 shut-off valve: integral 2000 kPa (300 psi) quarter-turn valve valve,
 - .3 pressure regulator: self-actuated, adjustable from 0 to 1700 kPa (0 to 250 psi)
 - .4 outlet pressure gauge: 0-2000 kPa (0-300 psig) mounted ahead of shut-off valve,
 - .5 DISS check body, of type to suit medical gas service.
- .3 Internal tubing: NPS 3/8 type K copper to ASTM B819, with inlet and outlet extension risers.
- .4 Maximum pressure rating: 1700 kPa (250 psi).
- .5 Cleaned for oxygen service and with tube ends capped.

Standard of Acceptance

- Amico - fig. Alert-1 Gas Control Panel
- Class 1 - fig. NCP/IP/CCP

2.11 Line Pressure Regulator Valves

- .1 Forged brass body and housing cap, large diaphragm for high flow applications, and adjustable loading handle.
- .2 Internal materials suitable for each applicable medical gas and conforming to CAN/CSA Z10524-2.
- .3 Pressure ratings:
 - .1 valve maximum inlet gas pressure rating: 2400 kPa (250 psi).
 - .2 operating nominal inlet (intermediate) pressures:
 - (a) Oxygen, Medical Air, and Nitrous Oxide: 700 kPa (100 psi)
 - (b) Nitrogen and Instrument Air: 2000 kPa (300 psi)
 - (c) Carbon Dioxide: 850 kPa (120 psi)
- .4 Cleaned for oxygen service.
- .5 Accessories:
 - .1 Ø65 mm (2-1/2 in.dia.) pressure gauge measuring outlet pressure.

Standard of Acceptance

- Amico
- Class 1
- BeaconMadaes

2.12 Pressure Safety Valves

- .1 Bronze body, re-seatable, spring loaded type, with brass or bronze trim, with NPT connections.
- .2 Relief flow rating: full flow of all connected upstream sources.
- .3 Relieving setpoint:
 - (a) Oxygen, Medical Air, and Nitrous Oxide: 514 kPa (75 psi)
 - (b) Nitrogen and Instrument Air: 1380 kPa (200 psi)
 - (c) Carbon Dioxide: 720 kPa (105 psi)
- .4 ASME Section VIII, UV code stamped.
- .5 Cleaned for oxygen service.

Standard of Acceptance

- Amico
- Class 1
- BeaconMadaes

2.13 Dual Line Pressure Regulator Station

- .1 Factory assembled line pressure regulation station with dual line pressure regulators, dual pressure relief valves, one (1) inlet pressure gauge and two (2) outlet pressure gauges, downstream test ports, and ball valves to isolate each regulator/relief valve assembly.
- .2 Silver brazed joints except at equipment connections.
- .3 Line pressure regulator valves:
 - .1 construction: as specified herein,
 - .2 number of valves: two, and each sized for full design flow.
 - .3 outlet pressure at a flow rate of 57 SCMH (2000 SCFH):
 - (a) in accordance with CSA Z7396.1.
 - (b) with pressure variation less than 15 kPa (2 psi) from full flow at required outlet pressure.
- .4 Safety valves:
 - .1 construction: as specified herein,
 - .2 number of valves: two, and each sized for full design flow.
 - .3 each safety valve installed to protect its associated line pressure regulating valve and with no intervening valve between them.
- .5 Isolation valves: two piece union-style bronze body, quarter turn, NPT threaded ends.
- .6 CRN to CSA B51 as an assembly or as individual components.
- .7 Cleaned for oxygen service.

Standard of Acceptance

- Amico - fig. M-DLRS-CSA-05 / -05HP
- Class 1 - fig. DSA-500 series

- BeaconMadaes - fig. DLRA500, with second relief valve.

2.14 Emergency Oxygen Inlet Station

- .1 Cabinet:
 - .1 stainless steel enclosure, weatherproof design conforming to NEMA 4, with hinged lockable front panel door, for recessed mounting.
 - .2 door exterior label: **"EMERGENCY LOW PRESSURE GASEOUS OXYGEN INLET"**
 - .3 operating instruction label posted on inside face of door.
- .2 Factory piping and components:
 - .1 pipe/tube size: NPS 1 unless otherwise shown on drawings.
 - .2 type K piping as specified herein with brazed joints.
 - .3 inlet connection, with NPT ends and plug.
 - .4 ball valve as specified herein with 1/8" FNPT port downstream of piping.
 - .5 Ø65mm (2-1/2 in. dia.) brass body pressure gauge, 0 to 700 kPa / 0-100 psi dual scale reading, labelled and colour coded for Oxygen. Pressure gauge located downstream of the ball valve.
- .3 Field installed accessories:
 - .1 line sized check valve of type as specified herein.
 - .2 ASME code rated pressure relief valve, with setpoint of 515 kPa (75 psi).
- .4 CRN to CSA B51 as an assembly or as individual components.
- .5 Cleaned for oxygen service.

Standard of Acceptance

- Amico - fig. M-FILL-OXY-LP
- Class 1 - fig. XM series
- BeaconMadaes - fig. EOSC

2.15 Medical Gas Terminal Units

- .1 Connector type: Diameter Index Safety System (DISS) to CGA V-5.
- .2 Main body:
 - .1 rough-in mounting box or plate,
 - .2 one-piece brass body:
 - (a) with secondary check valve rated for 1380 kPa (200 psig) for positive pressure gasses,
 - (b) designed to swivel 360° for multi-direction connection,
 - (c) O-ring seal or seats.
 - .3 type K copper tube to ASTM B819 inlet connection stubs;
 - (a) NPS 1/2 for pressure gasses,
 - (b) NPS 3/4 for medical vacuum and AGSS.
 - (c) gas service identified on tube stub.
 - .4 provided with dust-cover to protect body during construction after rough-in installation.
- .3 Primary valve body style:
 - .1 gas specific latch type with serviceable primary check valve.

- .4 Outlet cover:
 - .1 gas specific 1.5 mm (16 ga) mounting plates, and modular design to allow on-site ganging of multiple outlets, with a minimum center-to-center spacing of 127 mm (5 in.),
 - .2 colour coded front plate with English language printed service identification, and indexing pins for safety keying gas specific cover plate to appropriate steel rough-in mounting plate.
 - .3 chrome plated, satin finish, or epoxy powder-coated fascia plate,
 - .4 outlet to be adjustable for variable wall thickness at least between 12 mm (1/2 in.) and 25 mm (1 in.) wall thickness,
 - .5 pressure test plug for medical vacuum and AGSS outlets, rated for 1000 kPa (150 psi).
- .5 Model variants:
 - .1 medical gas terminal units designed for various installation locations including:
 - (a) recess wall mount for concealed piping,
 - (b) surface wall mount for exposed piping,
 - (c) recess mount for consoles,
 - (d) recess mount for ceilings,
 - (e) recess mount for suspended service columns,
 - (f) recess mount for installation in medical supply units,
 - (g) non-ferrous material compatible for installation in MRI Rooms.
 - .2 Listed to CAN/CSA-Z9170-1.
 - .3 Each unit tested for pressure-leak tested and flow tested.
 - .6 Cleaned for oxygen service and tube ends capped.

Standard of Acceptance

- Amico - fig. O-DIS series
- Class 1 - fig. M series
- BeaconMadaes - fig. B series

2.16 Medical Gas Valve Identification

- .1 Valve tags:
 - .1 plastic valve tags, nominally 115 mm x 80 mm (4-5/8 x 3-1/8 in.), rounded corners with pre-punched fastening holes, orange colour, suitable for application of a printed adhesive label.

Standard of Acceptance

- Brady - fig. 87695

- .2 Valve tag label marking system:
 - .1 labels: 50 mm (2 in.) high, low-shrinkage vinyl labels for indoor and outdoor use, high tack permanent adhesive, black lettering on white background.
 - .2 printer: portable printer with LCD display and full QWERTY keyboard, capable of multiline printing on 50 mm (2 in.) wide labels.

Standard of Acceptance

- Brady - fig. BMP71

3 EXECUTION

3.1 Field Cleaning

- .1 Field cleaning of copper tubing, valves, pressure regulators, safety valves and terminal units is not permitted. If factory shipping packaging is damaged or tube ends are missing prior to installation, these materials shall not be used and shall be removed from site.
- .2 Where fittings other than valves, pressure regulators, safety valves or terminal units are not supplied to site as "cleaned for oxygen service", they shall be cleaned on site in accordance with CGA G-4.1 as follows:
 - .1 Prepare a written site cleaning report, which describes:
 - (a) the cleaning method,
 - (b) the fittings and equipment which are subject to the field cleaning,
 - (c) the name and signature of the person supervising the field cleaning.
 - .2 Wash the part before installation with hot solution of trisodium phosphate in water 500 g in 12.5 litres (1 lb in 2.5 gal),
 - .3 Scrub inside of parts, and fittings with cleaning solution and agitate parts and fittings in bath of cleaning solution.
 - .4 Thoroughly rinse in fresh clean water and blow dry with nitrogen.
 - .5 Inspection: use the white light and UV light test method described in CGA-4.1 on a 5% random sampling basis where the number of fittings of one type exceeds 20 units, and inspect all units of a fitting type which numbers less than 20.
- .3 Keep cutting and reaming tools scrupulously clean and free from oil or grease.
- .4 Do not use organic solvents such as carbon tetrachloride under any circumstances.

3.2 Piping Fabrication

- .1 Install piping in accordance with CSA Z7396-1.
- .2 Make pipeline joints by brazing or mechanical swage coupling except as follows:
 - .1 butterfly valves and pressure relief valves: threaded or flanged,
 - .2 connections to source equipment: threaded or flanged,
 - .3 pressure sensors and switches: DISS connector,
 - .4 pipeline DISS check bodies for pressure sensors and switches: threaded,
 - .5 pressure gauges and other instruments including instrument isolation valve: threaded.
- .3 For threaded joints;
 - .1 use Sweat x NPT adapters for connection to equipment with threaded joints.
 - .2 make-up threaded joints with Teflon tape.
- .4 Use ells, tees, caps and couplings to make offsets and changes in direction and to route piping between connections. Do not bend hard drawn tubing except for long sweep cold bending with minimum bending radius of 20 x OD, without deformation or reduction in pipe diameter.
- .5 Cap off open ends of piping at the end of each work shift, using shipping dust caps overlaid with plastic and held in place with tape.

3.3 Pipe Supports

- .1 Support piping in accordance with specification section 20 05 29 except as specified herein.

- .2 For multi-service support, provide tubing clips on trapeze channels to secure piping to channel. Install U-plates or similar on each side of pipe clamp to prevent horizontal movement of each pipe,
- .3 For individual horizontal support, provide adjustable PVC coated clevis hangers, rods and anchors as specified,
- .4 Support horizontal piping at intervals in accordance with the following Table 1:

Table 1: Horizontal Tube Support for Medical Gas Piping		
Pipe/Tube Size NPS	Support Horizontal Spacing m (ft)	Support Vertical Spacing m (ft)
1/2	1.8 (6)	1.8 (6)
3/4	2.4 (8)	1.8 (6)
1	2.4 (8)	2.4 (8)
1-1/4	3.0 (10)	2.4 (8)
1-1/2	3.0 (10)	2.4 (8)
2 and larger	3.0 (10)	3.0 (10)

- .5 Support vertical tubing risers:
 - .1 at the base (bottom) of the riser by a support that is independent of any adjacent horizontal pipe supports,
 - .2 at every other floor level with pipe riser clamps, but not to exceed a vertical spacing of more than 10 m (33 ft).
- .6 Do not support medical gas piping from other building services. Do not support other building services from medical gas piping.

3.4 Brazed Joints

- .1 Make brazed joints in accordance with specification section 20 05 24 and as specified herein.
- .2 Make up joints between copper and copper materials without the use of flux. Joints between dissimilar metals may use flux as follows:
 - .1 use AWS brazing flux No. 3A,
 - .2 brush flux over end of fitting and keep inside of pipe and fittings free from flux,
 - .3 after brazing dissimilar metals, wash exterior surfaces with hot water to remove residual flux,
 - .4 wire brush joints after brazing.
- .3 During brazing, continuously purge the inside of the pipe to maintain a nitrogen atmosphere. Prior to brazing, purge air from the tube with nitrogen so that the oxygen content inside the pipe does not exceed 1% by volume (10,000 ppm) before brazing commences.
- .4 Where connections of new piping are made to an existing system, for the final connection to the existing system;

- .1 in the new piping portion, relieve the nitrogen purge gas pressure down to atmospheric pressure before making tie-in connection to the existing piping systems,
- .2 during brazing of the tie-in joint, do not introduce nitrogen purge gas to the pipeline system.

3.5 Valves

- .1 Provide valves as shown.
- .2 Provide zone valves and/or combination zone valves/zone alarm panels in accordance with specification section 22 63 26. Install zone valves or combination zone valve/zone alarm panels so that the height of the center-most valve is approximately 1500 mm (5 ft.) above floor level.
- .3 For pipeline distribution service valves other than those located in zone valve boxes, provide common-keyed padlocks on each service valve, not including zone valves. Leave valves padlocked in the open position, and turn five (5) copies of the common-key over to the owner. Padlocks are not required on valves located in a locked service room containing the medical gas source equipment.

3.6 Line Pressure Regulator Stations

- .1 Provide line pressure regulator stations where not otherwise provided as part of packaged source equipment or manifold control stations.
- .2 Install line pressure regulator stations at a nominal height of 1500 mm (5 ft) above the floor, arranged so that the pressure gauges and regulator adjustment handles are readily visible and accessible.
- .3 Set the line pressure regulator setpoints as follows:

Regulator	Line Pressure Regulator Setpoints
	kPa (psi) gauge
	Oxygen
Primary regulator	360 (52)
Secondary regulator	260 (38)

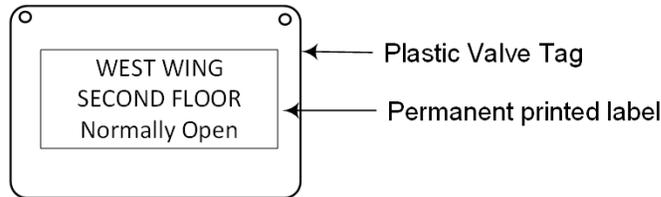
3.7 Safety Valves

- .1 Install safety valve vent piping in copper tube with brazed joints.
- .2 Pipe safety valves discharge piping for all medical pressure gases to outside of the building as follows:
 - .1 locate a minimum of 3 m (10 ft) from any door, operable window, or ventilation intake,
 - .2 terminate at a height of at least 1 m (3 ft) above roof or adjacent grade level,
 - .3 terminate relief pipe with a down-turn facing outlet, and increase relief pipe size at termination point by one NPS trade size and terminate with screened outlet fitted with T304 stainless steel plain weave 2x2 mesh, 9.3 mm (0.365 in.) opening size

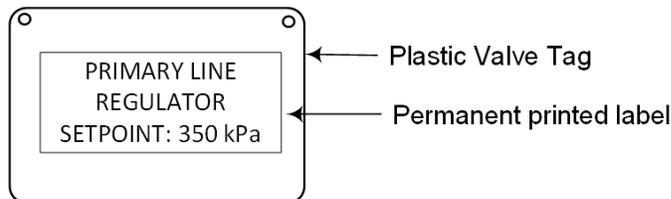
3.8 Identification

- .1 Label medical gas systems in accordance with CSA Z7396-1.
- .2 Label piping progressively on a daily basis as piping is installed.
- .3 For service valves and line pressure regulators, provide a gas specific pipeline marker identifying the gas immediately adjacent to the inlet or outlet side of the valve or regulator with no visible obstruction between the valve/regulator and the marker. For zone valves, provide the pipe marker inside the zone valve cabinet.

- .4 For service valves, provide a valve tag with a machine printed label identifying the area or zone served, and "Normally Open" or "Normally Closed" as applicable to the valve. Secure the valve tag to the valve with stainless steel tie-wire to the valve body, not the valve handle.



- .1 For line pressure regulators, provide a valve tag with a machine printed label identifying whether the regulator is the Primary or Secondary regulator, and the regulator setpoint valve in kPa units.



3.9 Terminal Units

- .1 Install terminal units in accordance with manufacturer's instructions. Protect backbody openings during rough-in stage to prevent contamination of main body.
- .2 Refer to architectural drawings for set-out heights of wall mounted individual or ganged terminal units. In the absence of such information, set wall mounted terminal outlets at a height of 1500 mm (5 ft) above the floor as measured to the center of the DISS outlet.

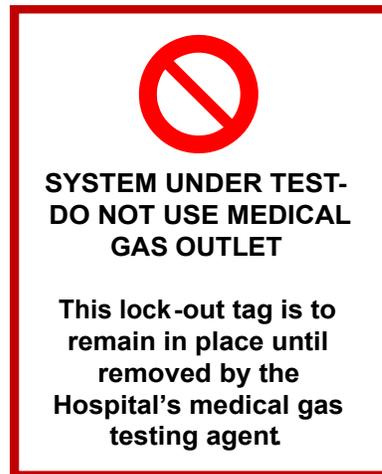
3.10 Terminal Units for Installation in Service Units

- .1 Service units are provided under Division 11 and/or Division 26 and include:
 - .1 internal medical gas piping using copper tubing or flexible hose as applicable to the equipment,
 - .2 installation of terminal units.
- .2 Supply medical gas terminal units to the vendor supplying the service units for factory installation in the service units.
- .3 Coordinate with the Division providing the service units including:
 - .1 scheduling delivery of medical gas terminal units to the service units vendor(s) manufacturing facility.
- .4 Make connections of medical gas piping to headwall units and / or patient service strips to the capped tube connections provided with the Service Units.
- .5 Make connections of medical gas piping to ceiling service columns, ceiling articulating arms and / or medical supply units as follows:
 - .1 provide a service ball valve in the ceiling immediately adjacent to the Service Unit for each medical gas,
 - .2 provide a DISS body without check valve and mount it on the Service Unit mounting plate unless it has been confirmed by the Contractor that the DISS body without check valve has been provided as part of the supply unit.

- .6 Witness the final testing of the installed service units and assist the certification agency as necessary. The responsibility for medical gas piping inside the service unit including pressure testing remains with the service unit vendor.
- .7 Refer to architectural and/or electrical design documents for locations of service units and quantity of terminal units required.

3.11 Commissioning

- .1 Conduct commissioning on piping systems in accordance with CSA Z7396-1 as summarized herein, prior to 3rd party certification testing by the independent certifier retained by the Owner,
- .2 Prepare a written commissioning test plan which verifies and documents the completed commissioning work. Provide a copy of the completed test plan/report to the Owner upon completion.
- .3 Conduct commissioning after the terminal units are installed, but before medical gas piping is concealed in walls, above ceilings or in vertical service spaces.
- .4 Tag-out / Lock-out requirements:
 - .1 Tag-out each terminal unit outlet prior to testing of associated piping system with a tag as shown or similar:



- .5 Brazing quality test:
 - .1 When requested by the hospital's inspection body (agent), cut-out a brazed joint as selected by the inspection body who will review the inside of the joint for soundness and evidence of oxidation.
 - .2 If samples show improper brazing or oxidation, cut-out the joints immediately upstream and downstream of the first joint, plus three other joints randomly selected by the inspection body. If any of these joints fail the inspection, the Contractor shall then remove additional joints as directed by the Owner until the inspection body is satisfied with the quality of the brazing work. Make good all joints which were removed.
- .6 Pressure testing and cross connection testing:
 - .1 Pressure testing and cross connection testing of medical gas piping shall conform to CSA Z7396.1, as summarized and as amended in the following articles. Perform this testing in the following order:
 - (a) disconnect flexible hoses inside of Service Units (as applicable) and install test caps on medical vacuum and AGSS DISS outlets,
 - (b) perform the "Initial pressure test",

- (c) perform the "Final pressure test".
 - (d) perform the "Purge test",
 - (e) perform the "Cross connection test",
 - (f) perform the "Combined Supply Units test".
- .2 Test gas for all tests: oil-free dry air or oil-free dry nitrogen.
- .7 Initial pressure test:
- .1 Conduct a standing 24 hour initial pressure test as follows:
 - (a) perform the test before terminal unit outlet covers are installed, and disconnect the pressure transducers and switches from their DISS bodies,
 - (b) disconnect flexible hoses inside of Service Units (as applicable) and install test caps on medical vacuum and AGSS DISS outlets,
 - (c) do not manifold piping systems together - test each system independently,
 - (d) charge each piping system with the test gas to the required test pressure, and then isolate the test gas source,
 - (e) test pressure for medical pressure gases: 150% of design pressure or 1035 kPa (150 psi) whichever is greater,
 - (f) test pressure for medical vacuum and AGSS: minimum 415 kPa (60 psig),
 - .2 Acceptance criteria: no change in pressure during the test period except due to change in ambient temperature around the piping.
 - .3 If leaks exist, identify and repair any detected leaks and retest pipe system. Use an oxygen compatible leak detector at each joint,

Standard of Acceptance

- Swagelock Snoop
 - American Gas & Chemical Co. Ltd Leak-tec
- .4 An acceptable initial test shall be completed before final acceptance pressure testing can occur.
- .8 Acceptance pressure test:
- .1 Conduct the final standing 24 hour acceptance pressure test as follows:
 - (a) install terminal unit outlet covers, and reconnect pressure transducers and switches,
 - (b) keep flexible hoses inside of Service Units (as applicable) disconnected and keep test caps on medical vacuum and AGSS DISS outlets,
 - (c) do not manifold piping systems together - test each system independently,
 - (d) charge each piping system with the test gas to the required test pressure, and then isolate the test gas source,
 - (e) test pressure for medical pressure gases: at system design pressure.
 - (f) test pressure for medical vacuum and AGSS: at system design vacuum. Medical vacuum pumps and AGSS source equipment may be used to create the vacuum conditions, and then source equipment to be isolated during the 24 hour test period.
 - .2 Acceptance criteria: no change in pressure during the test period except due to change in ambient temperature around the piping.
 - .3 Submit a report to the Owner documenting the test methodology and test results.
- .9 Purging test:

- .1 After acceptance of pressure testing, reconnect the hoses inside of Supply Units (if applicable) and purge the medical gas piping systems. Purge terminal units until test gas is clear of particulate matter and visible moisture as droplets or mist.

.10 Particulate filter test:

- .1 At completion of purging, test medical pressure gases for particulate matter:
 - (a) fabricate the test-flow apparatus in accordance with Annex D of CSA Z7396.1, including a 0.3 µm particulate filter connected to the outlet of the apparatus,
 - (b) apply the test to at least one terminal unit for each medical pressure gas in each zone,
 - (c) adjust the test apparatus to provide a flow rate of 120 l/min (4 SCFM) for 15 seconds per test, and then remove the filter.
- .2 Acceptance criteria: when examined under good light, the filter shall be free of visible particulate matter.
- .3 Maintain a test record of each outlet tested (the room and a description to identify the terminal unit), the date of the test and the name of the person who performed the test.

.11 Cross-connection tests:

- .1 Conduct cross-connection tests in accordance with Cross-connection Test - Method 2 of CSA Z7386.1, as summarized herein and as otherwise specified herein.
 - (a) Test special gas mixtures individually in accordance with Cross-connection Method 1 of CSA Z7396.1, with all other piping systems depressurized.
- .2 Disconnect flexible hoses inside of Service Units (as applicable) and install test caps on medical vacuum and AGSS DISS outlets.
- .3 Isolate vacuum transducers and vacuum switches from the test gas pressure.
- .4 Use a set of pressure gauges with each gauge equipped with a DISS nut and nipple specific for each medical gas.
 - (a) Label each gauge with the applicable medical gas name, and provide a colour coded tape around the body perimeter in accordance with the following table.
 - (b) Mark each gauge to indicate the expected test pressure for each specific medical gas terminal unit.
- .5 Apply the test gas to all systems at the same time, to pressurize each system in accordance with the following table. Use the medical vacuum pumps for medical vacuum.

Piping System	Test Pressure kPa (psi)	Gauge Marking Tape Colour
Medical vacuum	-35 (10 in.Hg.)	Yellow
AGSS	0 (0)	Red or Orange
Helium	70 (10)	Brown
Carbon Dioxide	140 (20)	Grey
Nitrogen	205 (30)	Black
Nitrous Oxide	275 (40)	Blue
Oxygen	345 (50)	Green
Medical Air	415 (60)	Half Black, Half White
Instrument Air	550 (80)	4 stripes Black, 4 stripes White

- .6 Connect the applicable pressure gauges to each terminal outlet in each room based on DISS connector at each unit, Confirm that each terminal unit is correct for DISS connector, test gas pressure, terminal unit name and colour code.
 - .7 Periodically check the distribution system test pressure. If the test pressure drops by more than 14 kPa (2 psi) in any system due to loss of test gas during application of pressure gauges, re-establish required test pressure before continuing with the test.
 - .8 If the testing indicates the presence of cross-connected terminal units or piping distribution, correct the cross-connection and re-test the system. Continue re-testing until it is demonstrated there are no cross-connections.
 - .9 Maintain a record log of each room, listing each outlet and the test confirmation results and provide a copy to the inspection body, the Owner and the Consultant (see Exhibit B).
- .12 Combined test for Supply Units:
- .1 After completion and acceptance of the main cross-contamination test (including correction of any cross-connection defects), reconnect the internal hoses in the Supply Units (as applicable) and perform a final pressure test and cross-contamination test of the Supply Units.
 - .2 Charge each piping system with the test gas to the required test pressure described above under "Acceptance pressure test" and then close the zone valves serving each applicable Service Unit. Perform a six (6) hour standing pressure test and confirm there is no loss in test pressure at the end of the test, using the zone valve pressure gauge. If a pressure loss occurs, notify the General Contractor/Construction Manager of the defective Supply Unit.
 - .3 After completion of the Supply Unit pressure test, individually test each medical gas service to the Service Units, with only the one medical gas pipeline being pressurized for each test. This can be performed with the applicable zone valves in the closed position.
 - .4 Confirm that each terminal unit is correct for DISS connector, test gas pressure, terminal unit name and colour code, and record the results in the cross-connection test record.

3.12 Contractor Responsibilities During Certification Testing

- .1 Medical gas certification testing will be performed by an independent accredited medical gas testing and certification company ("inspection body") directly retained by the healthcare facility. The certification shall be in accordance with CAN/CSA Z7396.1, including Annex C for source equipment, and Annex D for pipeline distribution. As a summary, certification testing of the medical gas pipeline distribution system includes:
 - .1 Source equipment tests.
 - .2 Master alarm system tests.
 - .3 Inspection of pipelines, valves and terminal units.
 - .4 Inspections and testing of zone alarms.
 - .5 Qualitative particulate contamination testing.
 - .6 Terminal unit gas identity/cross-contamination test.
 - .7 Terminal unit performance tests including gas quality, quantitative particulate matter and flow rates.
- .2 Medical gas installation contractor shall provide qualified representative who are knowledgeable in medical gas installations in general and the Work specifically, to witness certification testing and to assist the Certification Agency in locating pipe runs, valves, alarm sensors, alarm wiring and other components of medical gas system and repair defects in equipment, workmanship or materials discovered during certification testing.

- .3 Provide a copy of the completed commissioning test reports and as-built drawings to the independent certifier prior to certification testing.
- .4 Arrange and pay for representatives of medical gas equipment vendor to provide technical support and operating instructions during the certification process.
- .5 After completion of the contractor's commissioning tests described above and while the inspection body is present, purge the distribution piping with applicable medical gases sufficiently to remove the test gases. Purge airflow through each terminal unit.
- .6 Assist the inspection body in any subsequent retesting.

3.13 Authority Inspections

- .1 Arrange and pay for AHJ inspections for pressure piping and fire safety. Provide a copy of the AHJ inspection report to the Owner and Consultant; if the AHJ does not issue a report, provide a written record of the AHJ inspection recording the AHJ name, AHJ personnel, contractor personal, date of inspections, a description of what was inspected, and any comments provided by the AHJ.

3.14 Training and Instruction

- .1 Comply with the training requirements of specification section 20 01 01.
- .2 Arrange for manufacturers' representatives to provide instructions of Owners staff in use and maintenance of medical gas equipment.

3.15 Records and Reports

- .1 At completion of commissioning, provide the healthcare facility with the following documents:
 - .1 As-built drawings,
 - .2 completed CSA Z7396.1 form L.1 *Pipeline installation test report*, (sample form follows).
 - .3 copies of each brazer's certificate of competency (license) who performed all or part of the work,
 - .4 copies of each tradesperson's certificate issued under the *CSA Medical Gas Piping & Systems Installation Personnel Certification Program*,
 - .5 quality assurance program for pressure piping certificate number, or contractor pressure piping licence number (as applicable to the requirements of the provincial AHJ for boilers and pressure vessels),
 - .6 in-process examination records of brazed joints,
 - .7 pressure test reports,
 - .8 particulate matter test report,
 - .9 cross-contamination test records,
 - .10 operating and maintenance manuals which
 - .11 filled out, signed and dated commissioning test plant reports,
 - .12 AHJ inspections reports.
- .2 The submittal and acceptance by the Owner of the records and reports described herein is a condition precedent for obtaining substantial completion of the project.

Exhibit A – Pipeline Installation Test Report

The following is a sample report for installation contractor installation test report (CSA Z7396.1)

*Medical gas pipeline systems — Part 1: Pipelines for medical gases,
 medical vacuum, medical support gases, and anaesthetic gas
 scavenging systems*

Z7396.1-17

Annex L (informative)
Pipeline installation test report

Note: This Annex is not a mandatory part of this Standard.

Figure L.1
Pipeline installation test report
 (See Clause 11.4.1.4.)

SAMPLE

Health care facility:	Area/floor:	
Medical gas installation report		
Task	Action required	Complete
24-hour standing pressure test as per Clause B.2.2	Provide test report	
Perform final leak test as per Clause B.2.3	Verify performed	
Purge terminal units as per Clause B.2.4	Verify performed	
Perform cross connection test as per Clause B.3	Verify performed	
Perform particulate filter test as per Clause D.4	Verify performed	
CSA medical gas piping & installation personnel certification number (Each installers individual number to be submitted) As per Clause 11.4.1.2	1. 2. 3. 4. 5.	
Brazing qualification licence number (Each installers individual licence to be submitted) As per Clause 11.4.1.3	1. 2. 3. 4. 5.	
Quality assurance program certification number as per Clause 11.4.1.6		
Installer:	Date:	
Witnessed by:		
Notes:		

Note: As per Clause 12.3, all of the above tests must be performed and a copy of this form is to be submitted to the health care facility before the inspection body commences commissioning.

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Exhibit B – Cross-connection Test Report

The following is a sample report for cross-connection testing.

Issued For Tender

Medical Gas Cross-contamination Test Record

Project Name: _____
 Date of Test: _____
 Contractor Name: _____
 Test performed by: _____

Wing	Floor	Room	Number of Outlets Verified (No. outlets in rooms / No. outlets correct)								Remarks
			Ox	MA	MV	NOx	N2	CO2	IA	AGSS	
			/	/	/	/	/	/	/	/	
			/	/	/	/	/	/	/	/	
			/	/	/	/	/	/	/	/	
List of cross-connections discovered and corrected											
(Installation contractor) Results verified by:											

END OF SECTION

MEDICAL GAS CONTROL EQUIPMENT 22 63 26.70

1 GENERAL

1.1 Scope

- .1 Provide medical gas system controls including:
 - .1 supply system alarm panels,
 - .2 zone alarm panels,
 - .3 zone valve stations,
 - .4 instrumentation and accessories.
- .2 Applicable systems: refer to specification section 23 63 13.70
- .3 Comply with the requirements of Part 1-General of specification section 22 60 13.70 except/and as required herein.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 20 05 49 Seismic Restraint
 - .3 22 60 13.70 Medical Gas Piping

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 92.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .2 CSA C22.2 No. 205 Signaling Equipment
 - .3 CAN/CSA C22.2 No. 60601.1 Medical Electrical Equipment – Part 1: General Requirements for Basic Safety and Essential Performance

1.4 Seismic Qualification

- .1 Seismically qualify (certify) control panels for medical gas systems to remain operational after being subjected to the design seismic forces assuming a building height factor (NBCC) $A_x = 3.0$ with equipment rigidly mounted, by the shaker table method in accordance with Specification section 20 05 49.

1.5 Submittals

- .1 Submit manufacturer catalogue cut-sheets for the materials specified herein.
- .2 Submit shop drawings for;
 - .1 alarm wiring which are project specific.

2 PRODUCTS

2.1 General Requirements for Medical Gas Alarm Panels

- .1 General:

- .1 Common requirements for supply system alarm panels and zone alarm panels.
- .2 Listed to CSA C22.2 No. 205.
- .3 Conforms to CSA Z7396.1
- .2 Cabinet:
 - .1 Tamper-proof, painted, steel back box, for [recessed][surface] mounting with a maximum wall cavity depth of 105 mm (4 in.) from wall finish surface, and removable openings for gas piping and electrical connection.
 - .2 Tamper-proof, painted, hinged front panel, with front mounted display of gas information.
 - .3 Internal power transformers with overcurrent protection.
 - .4 Power supply: 120 VAC, 60 Hz.
- .3 Alarm display unit:
 - .1 Microprocessor based controller:
 - (a) Either:
 - i) one (1) 250 mm (10 in.) colour TFT LCD display for graphical and text display for all gases/vacuum, or
 - ii) multiple TFT colour LCD touchscreen displays for individual gases;
 - (b) virtual graphical display indicating gas pressure status, with continuous green-normal and continuous red-alarm display,
 - (c) LED indicators and controls for alarm silence,
 - (d) built-in web server for remote access to view alarm web page and data,
 - (e) web-page configurable to allow linking to other zone alarm web pages,
 - (f) alarm notification via email or text message through any SMTP gateway,
 - (g) graphical display of alarm panel to mobile devices via WIFI or cellular network.
 - (h) gas specific colour identification in accordance with CSA Z7396.1
 - .2 Programmable and operating functions:
 - (a) high and low gas pressure alarms for medical gases,
 - (b) low pressure alarm for medical vacuum and AGSS,
 - (c) configurable repeat alarm horn time delay,
 - (d) alarm history recall,
 - (e) transient signal detection and display,
 - (f) alarm history recall,
 - (g) self-test diagnostic function to test status indicators and alarm horn,
 - .3 System initiates an alarm if there is an open or shorted sensor circuit, or a sensor input is not connected.
 - .4 Alarm horn sound level: 70 dBA at 2 m (6.5 ft.).

2.2 Local Zone Alarm Panels

- .1 General:
 - .1 Complies with the general requirements for alarm panels specified above.
 - .2 Local alarm panels to monitor zone pipeline pressures for applicable medical gases.

- .3 Graphic interface to display zone or room identification, and which cannot be altered except by authorized personnel. Alternatively, cabinet door to be provided with a permanent, mechanically printed label which defines the zone being monitored/controlled, and which cannot be removed or altered from outside of the cabinet.
- .4 Display measured gas pressure/vacuum values, with selectable pressure units – kPa, psi, or in.Hg.
- .5 Custom alarm response instructions for each gas.
- .6 Capable of monitoring a minimum of eight (8) of the following gases or vacuum. Actual number and type of monitored gases or vacuum as shown on drawings:
 - (a) Oxygen,
 - (b) Nitrous Oxide,
 - (c) Nitrogen
 - (d) Instrument air
 - (e) Medical air
 - (f) Medical vacuum,
 - (g) Carbon dioxide, and
 - (h) Helium
 - (i) Anaesthetic Gas Scavenging System (AGSS)

Standard of Acceptance

- Amico - Alert-4 series
- BeaconMedaes - TotalAlert Infinity
- Tri-Tech - Med Touch Area Alarm Panel

- .2 Pressure transducers:
 - .1 Pressure transducers as specified below.
 - .2 Panel mounted with gas specific pressure transducer with DISS nut and nipple, or provided with zone valve stations.
 - .3 Minimum NPS 3/8 type K copper tube riser for each gas transducer, with matching gas specific DISS check body,
 - .4 Cleaned for oxygen service.

2.3 Zone Valves

- .1 Cabinet:
 - .1 Conform to CSA Z7396.1.
 - .2 Tamper-proof, painted steel back box, for recessed mounting with a maximum wall cavity depth measured from the finished wall opening surface of:
 - (a) 105 mm (4 in.) for valves NPS 2 and smaller,
 - (b) 170 mm (6.75 in.) for valves NPS 2-1/2 to NPS 3.
 - .3 Sliding, opaque door with pull-ring, and clear gauge window. Door designed so that in an emergency the door is pulled outwards and free of the cabinet to access the valves.
 - .4 Gas/vacuum services capacity: up to 7 separate gas valves.
 - .5 Pressure indicating gauge:
 - (a) dial indicating gauge, reading kPa and psi units, with normal operating pressure in the middle third of the gauge scale,

(b) mounted on the downstream side of zone valve.

.6 Labeling:

(a) gas/vacuum flow direction marked on piping inside of cabinet,

(b) provide labelling on panel cover in accordance with CSA Z7396.1 in both English and French.

.2 Valves:

.1 To specification section 22 60 13.70.

.2 Arranged to prevent closing of the valve box cover/door when the valve is in the closed position.

.3 Pressure transducers:

.1 Pressure transducers as specified herein.

.2 Factory installed, and located on downstream side of zone valve.

.3 Pre-wired to terminal strip(s) where field wiring to a remote zone alarm panel is required.

Standard of Acceptance

- Amico
- Class 1
- BeaconMedaes

2.4 Combination Zone Valves with Zone Alarm Panel

.1 Combination zone valves and alarm panels may be used where they comply with the following:

.1 Conforms to CSA Z7396.1.

.2 Zone valve box as specified herein, including both pressure gauge and digital zone alarm pressure display unit.

.3 Zone alarm functions as specified above except use microprocessor based, modular LED numeric pressure display with LED indicator lights for pressure normal and alarm status.

.4 Gas/vacuum services capacity: up to 7 separate gas valves.

.5 Internally mounted pressure transducer with DISS nut and nipple connection downstream of each zone valve.

Standard of Acceptance

- Amico - Combo Unit series
- Class 1 - CZVA series

2.5 Gas Pressure and Vacuum Transducers

.1 Construction:

.1 stainless steel wetted parts and pressure housing,

.2 automatic gas-specific detection feature,

.3 4-20 mA, 2 wire loop powered,

.4 gas/vacuum specific pressure sensors with DISS nut and nipple,

.5 integral interference barrier for increased RFI/EMI protection,

.6 CRN to CSA B51.

.7 CSA listed and suitable for remote installation or installation inside of alarm panels.

- .8 cleaned for oxygen service,
- .9 operating pressure range:
 - (a) Low pressure: 0 to 680 kPa (0-100 psig) for oxygen, medical air, nitrous oxide, carbon dioxide.
 - (b) Medium pressure: 0 to 1700 kPa (0-250 psi) for instrument air and nitrogen.
 - (c) Vacuum: 0 to 98 kPa (0-29 in.Hg) for medical vacuum and AGSS.

2.6 Gas Pressure and Vacuum Switches

- .1 Functions:
 - .1 Dual setting High and Low pressure switches with pressure gauge, for low pressure service for oxygen, medical air and nitrous oxide only.
 - .2 Single setting High or Low pressure switch without gauge, for medium pressure service for any medical gas.
 - .3 Single setting Low pressure switch without gauge, for high pressure manifold for “reserve in use” alarm.
 - .4 Single setting Low vacuum switch with vacuum gauge, for medical vacuum and AGSS.
- .2 Construction:
 - .1 switch type: SPDT (Form C) dry contact, 5 A at 120 VAC.
 - .2 listed to CSA C22.2 No. 14 for non-hazardous environments.
 - .3 CRN to CSA B51.
 - .4 enclosure: CSA C22.2 No. 92.1, Type 4.
 - (a) enclosure provides wiring termination access, or unit is provided with 20 mm (3/4 in.) NPT conduit connection for mounting on standard electrical junction box.
 - .5 switch suitable for remote installation or installation inside of alarm panels.
 - .6 Low Pressure gases:
 - (a) pressure rating: 860 kPa (120 psi),
 - (b) adjustment range: 3.5 to 550 kPa (0.5 to 80 psig)
 - (c) low alarm setpoint: 275 kPa (40 psig) factory set
 - (d) high alarm setpoint: 410 kPa (60 psig) factory set
 - .7 Medium Pressure gases:
 - (a) pressure rating: 1720 kPa (250 psi),
 - (b) adjustment range: 70 to 1720 kPa (10 to 250 psig)
 - (c) low alarm setpoint: field adjusted to suit specific medical gas
 - (d) high alarm setpoint: field adjusted to suit specific medical gas
 - .8 High Pressure gas manifold:
 - (a) pressure rating: 22 MPa (3200 psi)
 - (b) adjustment range: 1.1 to 22 MPa (160 to 3200 psig)
 - (c) low pressure setpoint: field adjusted to suit medical gas
 - .9 Vacuum:
 - (a) vacuum rating: 101 kPa (30 in.Hg.),
 - (b) adjustment range: -2.7 to -98 kPa (0.8 to 29 in.Hg.)

(c) low alarm setpoint: -50 kPa (-15 in.Hg. psig), factory set for medical vacuum

(d) low alarm setpoint: -34 kPa (-10 in.Hg. psig), factory set for AGSS

.10 cleaned for oxygen service.

.3 Accessories:

.1 Ø50 mm (2 in. dia.) dial pressure gauge for Low Pressure gas and vacuum switches.

.2 gas specific DISS nut and nipple.

2.7 Instrument and Control Wiring

.1 Instrumentation and control wiring in accordance with Specification section 20 05 12.

3 EXECUTION

3.1 Alarm Panels Installation

.1 Provide supply system alarm panels, zone alarm panels and combination zone/valve alarm panels configured to suit the applicable medical gas and vacuum services as shown on drawings.

.2 Install alarm panels in accordance with manufacturer instructions.

.3 Set alarm panels with top of panel at a height of 1500 mm (5 ft.) above finished floor, unless otherwise shown on drawings.

3.2 Pressure Transducers and Sensing Tubing Installation

.1 Connect pressure transducers to gas pipeline system only after the gas piping has been pressure tested.

.2 Pressure transducers for zone alarm panels shall only be installed in either the zone alarm panel, or in a zone valve box.

.3 Where pressure transducers are installed in the zone alarm panel;

.1 make tubing connections to gas main immediately downstream of zone control valve and before any connections to a terminal outlet.

.2 run NPS 3/8 type K copper medical gas tubing from the pipe main and connect to the copper sensing lines provided on the alarm panel.

.4 Manual valves shall not be installed between the gas main and the pressure transducer.

.5 Run control wiring in conduit from the transducer to the alarm panel in accordance with specification section 20 05 12.

3.3 Pressure and Vacuum Switches

.1 Install pressure and vacuum switches on source equipment and mains piping as shown, unless such instrumentation is already factory installed on packaged source equipment.

.2 Adjust and set high and low pressure and low vacuum setpoints in accordance with manufacturer instructions.

3.4 Pressure Switch Setpoints for Zone Alarm Panels

.1 Adjust and set pressure/vacuum switches for zone alarm panels in accordance with the following table 2:

Alarm	Table 2: Zone Alarm Panel Pressure Setpoints	
	kPa (psi) gauge	kPa (in.Hg.)
	Oxygen	Medical Vacuum
Low gas pressure Alarm setpoint	276 (40)	-40 (-12)
Nominal gas pressure	345 (50)	-68 (-20)
High gas pressure Alarm setpoint	413 (60)	N/A

3.5 Electrical supply and wiring

- .1 Dedicated emergency power circuits for alarm panels will be provided under Electrical Division 26 at 120 volt 60 Hz single phase and will terminate at the device power terminal strip in each alarm panel.
- .2 Provide wiring and conduit from these junction boxes to connect control devices being electrically powered in accordance with specification section 20 05 12.
- .3 Wiring between control and alarm panels and between panels and remote sensors to be provided in accordance with specification section 20 05 12.
- .4 Provide terminal junction boxes wherever signal and control wiring interfaces with alarm wiring.
- .5 Alarm wiring from main panel to terminal junction boxes to be Belden multi-pair colour coded 18 gauge wire with chrome PVC jacket run in EMT conduit.
- .6 Alarms to be wired to same terminal number in each terminal junction box and alarm panel.
- .7 Provide legend showing terminal number, colour code of wire and identifying common wire used for each alarm and each spare circuit.
- .8 25% of wire pairs and terminals to be provided as spare circuits in cable and spare terminals in terminal junction boxes and alarm panels.
- .9 Wire alarm panels in accordance with manufacturers wiring diagrams.

3.6 As-built Information

- .1 For remote mounted pressure transducers, mark-up the as-built drawings with dimensioned location of the pressure transducer.
- .2 In addition, for zone alarm panels, provide a diagram indicating the location of remotely mounted pressure transducers and place it inside the zone alarm panel.

3.7 Medical Gas System Commissioning and Certification

- .1 Refer to specification section 22 60 13.70.

3.8 Training and instruction

- .1 Arrange for manufacturers' representatives to provide instructions of Owners staff in use and maintenance of equipment associated with medical gas systems.

END OF SECTION

HVAC PIPING SYSTEMS GENERAL REQUIREMENTS 23 05 01

1 GENERAL

1.1 Scope

- .1 Provide heating and cooling piping systems in accordance with the referenced piping materials, standards, specifications and piping codes described herein.
- .2 This specification applies to;
 - .1 water based piping systems for building hydronic heating and cooling systems, and
 - .2 non-potable water systems for HVAC services.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing

1.3 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Regulation 220/01 Boiler and Pressure Piping Regulation
- .2 Installation standards and codes (as adopted and amended by the AHJ for pressure vessels):
 - .1 CSA B51 Boiler, pressure vessels, and pressure piping code
 - .2 ASME B31.1 Power Piping
 - .3 ASME B31.3 Process Piping
 - .4 ASME B31.9 Building Services Piping

1.4 Qualified Tradesmen

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesmen holding applicable certificates of competency as applicable to the work.

1.5 Registration and Inspection

- .1 Before commencing work, make arrangements and pay for registration and inspection by the AHJ responsible for boiler and pressure vessel safety for the following pressure piping systems:
 - .1 Service water piping for heating a building, at design temperatures greater than 121°C (250°F) or at design pressures greater than 1100 kPa (160 psig),
 - .2 HVAC water systems (other than building heating water systems), including chilled water and condenser water systems, at design temperatures greater than 65°C (150°F) or design pressures greater than 1717 kPa (250psig).
- .2 At the start of the Work, obtain existing pressure piping system registration numbers, if available, from the Owner and/or the AHJ.

1.6 Design Criteria - Hot Water Heating Systems

- .1 Piping design and installation code:
 - .1 To ASME B31.9 for piping system not subject to boiler and pressure vessel regulations.

- .2 To ASME B31.1 for piping systems which are subject to boiler and pressure vessel regulations.
- .2 System includes but is not limited to;
 - .1 Boilers,
 - .2 Heat exchangers,
 - .3 Pumps,
 - .4 Expansion tanks,
 - .5 Convector,
 - .6 Radiators,
 - .7 Radiant panels,
 - .8 Finned radiation,
 - .9 Unit heaters,
 - .10 Heating coils,
 - .11 Controls,
 - .12 Water treatment.
- .3 System design criteria:
 - .1 Design temperatures and pressures:

System Type	Supply Temp. °C (°F)	Return Temp. °C (°F)	Design Temp. °C (°F)	Maximum Operating Pressure kPa (psig)	Design Pressure kPa (psig)
Constant temperature heating	93 (200)	77 (170)	96 (205)	900 (125)	1030 (150)
Finned Radiation with enclosure	93 (200)	77 (170)	96 (205)	900 (125)	1030 (150)
Flat plate and cast iron radiators	60 (140)	50 (120)	93 (200)	900 (125)	1030 (150)
Terminal Reheat System	60 (140)	50 (120)	93 (200)	900 (125)	1030 (150)

1.7 Design Criteria - Cooling Water Systems

- .1 Piping design and installation code:
 - .1 To ASME B31.9 for piping system not subject to boiler and pressure vessel regulations.
 - .2 To ASME B31.1 for piping systems which are subject to boiler and pressure vessel regulations.
- .2 System includes but is not limited to;
 - .1 Refrigeration machines,
 - .2 Heat exchangers,
 - .3 Thermal storage tanks,
 - .4 Ice builders,

- .5 Pumps,
- .6 Expansion tank,
- .7 Coolers,
- .8 Cooling towers,
- .9 Indoor condenser water basin,
- .10 Condenser water filters,
- .11 Cooling coils,
- .12 Fan coil units,
- .13 Server room cooling units,
- .14 Controls,
- .15 Water treatment.
- .3 System design criteria:
 - .1 Design temperatures and pressures:

System Type	Supply Temp. °C (°F)	Return Temp. °C (°F)	Design Temp. °C (°F)	Maximum Operating Pressure kPa (psig)	Design Pressure kPa (psig)
Chilled water	5.5 (42)	14.5 (58)	38 (100)	900 (125)	1030 (150)

2 PRODUCTS

2.1 Dielectric Unions

- .1 Construction:
 - .1 Bronze or brass body with non-metallic fitting or coating the FNPT tailpiece.
 - .2 FNPT x Copper sweat connection.
 - .3 Pressure rating; ASME Class 3000 at 121°C (250°F)

Standard of Acceptance

- Hart Industrial Unions - fig. D-3136 or Polymer Composite Coating

2.2 Dielectric Flanges

- .1 Construction:
 - .1 ASME Class 150 or 300 carbon steel flange, Van-stone style with copper tube adapter tailpiece.
 - .2 Flange provided with a powder coated finish, and an EPDM insulator to isolate the copper tailpiece from contact with the flange.
 - .3 Minimum MCPR:
 - (a) Class 150: 1400 kPa (200 psi) at 121°C (250°F)
 - (b) Class 300: 2800 kPa (400 psi) at 121°C (250°F)

Standard of Acceptance

- CTS Flange Canada - fig. BF / WBG

2.3 Cam and Groove Fittings

- .1 NPS 2 size:
 - .1 Brass body cam and groove fittings, male groove end x female NPT end, with camlock female dust cap.

3 EXECUTION**3.1 Pipe Installation General Requirements**

- .1 General layout of mains, risers, run-outs and connection details of piping systems are shown.
- .2 Install concealed pipes close to building structure to keep furring spaces to minimum and minimize obstruction to other services in ceiling spaces.
- .3 Run exposed piping parallel to walls and conserve headroom and space. Group piping wherever practical.
- .4 Ream pipe after cutting to length and clean off scale and dirt inside and outside of pipe before threading, grooving or welding.
- .5 Provide clearance for installation of insulation and access for maintenance of equipment, valves and special fittings such as expansion joints.
- .6 Cap ends during construction to prevent entry of foreign matter.
- .7 Provide bends, expansion loops, hoses or joints to compensate for pipe expansion and contraction.
- .8 Anchor, guide and laterally support vertical and horizontal piping to support filled weight and absorb thrust under operating conditions.
- .9 Erect piping so that expansion forces, gravity forces and thrust from changes in direction do not stress connections to apparatus.
- .10 Do not use galvanized materials in contact with glycols.
- .11 All HVAC equipment, valves, expansion joints, and any other items requiring periodic maintenance must be installed in locations that are accessible for maintenance;
 - .1 where these items are installed inline with piping in an inaccessible location (high level above obstructions, etc.) offset and/or jog piping as required to install in an accessible location,
 - .2 provide access doors in accordance with Section 20 05 01 Basic Materials and Methods, and
 - .3 provide valve kit enclosure box in accordance with Section 23 21 16 Hydronic Piping Specialties.
- .12 Refer to piping system specifications for additional requirements.

3.2 Drainage Piping, Drain Valves and Air Vents

- .1 Provide drain valves at low points in water piping systems and in valved run-outs from risers so that system or isolated parts of system can be drained. Locate piping system drain valves as close to the system pipe as possible.
- .2 Provide an additional drain valve at the drain termination point where;
 - .1 the drain valve is not accessible from a floor with or without the use of a 2.4 m (8 ft) high ladder, or from an elevated work platform,

- .2 upstream of each isolation valve,
- .3 and as otherwise specified herein.
- .3 Provide drain valves on equipment drains.
- .4 For copper tube drains, connect copper drain tubing to the outlet side of equipment drain valves or piping system drain valves; do not make connections of copper drain tubes directly to carbon or stainless steel HVAC liquid piping.
- .5 Drain sizes:
 - .1 NPS 2 for large water-filled equipment including refrigeration equipment, boilers, and heat exchangers.
 - .2 NPS ¾ for other equipment drains, including integral or field installed condensate and drip pans.
 - .3 NPS 2 for piping system drains, unless otherwise shown.
- .6 Run other equipment drains to nearest floor drain unless otherwise shown to terminate in a specific location. Where NPS ¾ drains terminate at a floor drain, provide a funnel of at least 200 mm x 100 mm (8 in x 4 in) on the floor drain cover.
- .7 Install piping system drains as follows;
 - .1 In mechanical service rooms and permanently accessible service spaces, extend drains down along a wall or column and terminate approximately 1000 mm (40 in) above the floor level in the service room, or above the lowest accessible level in a vertical service space.
 - .2 In other service rooms including non-accessible service spaces, electrical rooms, telecom rooms or data rooms, extend drains to a location outside of these service room to a location agreed with by the Engineer unless otherwise shown and provide a drain valve at the termination point.
 - .3 Where piping system drains are located in finished areas above accessible ceilings that are not more than 3 m (10 ft) high, terminate the drains approximately 200 mm (8 in) above the top of the ceiling and provide a drain valve at this termination point.
 - .4 Where piping system drains are located above non-accessible ceilings, or where an accessible ceiling is more than 3 m (10 ft) high, extend the drain tubing to a location agreed with by the Engineer unless otherwise shown and provide a drain valve at this termination point.
- .8 Terminate drain ends with a 45° elbow and a brass body, male-end, cam-and-groove (Camlock) coupling fitting with dust cap. Supply the matching hose-end female connector and turn over to the owner.
- .9 Provide air vents with isolation ball valves at high points to allow effective drainage of the system and to facilitate removal of air from the system.

3.3 Dissimilar Metals Galvanic Isolation

- .1 Provide dielectric unions or flanges to separate copper and copper alloy tube and fitting materials from contact with carbon steel material. This includes equipment such as coils with copper header connections.
- .2 Dielectric unions or flanges are not required when all of the following conditions are met:
 - .1 the hydronic water treatment program (existing or new) includes a cathodic and/or anodic filming chemistry for mixed metals,
 - .2 copper tubing is not used in the piping system, except for the final 1 m (40 in) length connection to terminal equipment and in which the tubing is isolated from the carbon steel piping by a bronze body or carbon steel body valve (no brass) , and
 - .3 terminal equipment which contains copper or copper alloy tubing is connected to carbon steel piping with a flexible connector having an internal non-metallic hose.

- .3 For clarity, where copper tubing is installed in a part of a carbon steel piping system, dielectric unions or flanges are required.

3.4 Pressure and Leak Testing - Liquid Service Piping

- .1 This test procedure applies to piping normally containing water, including HVAC and process water and glycol/water mixes, and steam-condensate piping.
- .2 Pressure test liquid piping systems unless otherwise specified in other sections of Division 23.
- .3 Initial pneumatic leak test:
 - .1 Conduct an initial pneumatic leak test to locate and repair major leaks.
 - (a) test pressure for ASME B31.1 systems: 175 kPa (25 psig),
 - (b) test pressure for ASME B31.9 systems: 70 kPa (10 psig).
 - .2 Remove compressed air source and maintain this pressure for the time necessary to inspect for leaks, but not less than 2 hours.
 - .3 Maintain pressure and examine each joint with commercial leak detector solution.

Standard of Acceptance

- Snoop
- Leak-tec
- .4 Repair leaks where found prior to performing hydrostatic pressure tests.
- .5 During pneumatic pressure tests, comply with the site safety requirements for notification and guarding during testing with compressed gasses.
- .4 Final hydrostatic pressure test:
 - .1 Use the system design pressure for the entire installation, unless different design pressures are indicated for each floor.
 - .2 Pressure test condensate piping to the same test conditions as the steam system to which they are connected.
 - .3 Fill the system with water and gradually increase the system pressure to 150% of the design pressure and hold for 10 minutes, then reduce pressure to the design pressure.
 - .4 Inspect each pipe joint for leaks.
 - .5 As an alternative to inspection of each joint for leaks, conduct a 24 hour standing pressure test:
 - (a) raise the water pressure to 150% of the design pressure for 10 minutes, then reduce pressure to design pressure,
 - (b) record the test pressure one (1) hour after establishing the system hydrostatic test pressure at the design pressure. Record ambient air temperature at the same time.
 - (c) at the end of the 24 hour standing test period, record the test pressure and ambient air temperature. Make adjustments to the measured end-of-test pressure to account for change in fluid density due to change in ambient air temperature,
 - (d) acceptance criteria: maximum pressure loss over 24 hours not to exceed 1% of test pressure, corrected for ambient temperature,
 - (e) where acceptance criteria is not met, inspect pipe joints for leaks.
 - .6 Where leaks are found, repair leaks and retest piping as specified above.

3.5 Pressure Test Report

- .1 Maintain a log of all pressure tests, including locating of where leaks have been repaired. Submit the log to the Consultant for review when requesting prior to substantial completion of the Work. Where a piping system is subject to AHJ inspection, provide evidence of such inspection by means of an AHJ inspection report or name of the AHJ inspector and the date they witnessed the pressure test.

3.6 Piping Material Selection Schedule

- .1 Provide piping material in accordance with schedule Table 1 at the end of this specification section.

Table 1: Piping and Valve Material and Specification by System Type				
Piping System	Abbrev	Pipe Material	Pipe Specification	Valve Specification
Hydronic heating and cooling - closed loop	HTS/R HS/R CHS/R	Carbon Steel	23 21 13.23	23 05 23.13
		Copper or Stainless Steel	23 21 13.33	23 05 23.13
Equipment and piping system drainage for HVAC liquid systems	DR	Galvanized Steel	23 21 13.23	23 05 23.13
		Copper	23 21 13.33	23 05 23.13

END OF SECTION

GENERAL-DUTY VALVES FOR HVAC WATER PIPING

23 05 23.13

1 GENERAL

1.1 Scope

- .1 Provide valves for general duty service in HVAC water piping systems, including shut-off valves, check valves, and manual balancing valves, for piping systems with a design pressure of 3500 kPa (507 psig) or less and a design temperature of 121°C (250°F) or less.
- .2 This specification applies to hydronic heating and cooling water systems (with or without glycol additives) and other piping systems required to be carbon steel pipe, galvanized steel pipe, and/or copper tubing as specified in section 23 05 01, except as otherwise required for specific duty valve in other specification sections.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 23 General Requirements for Valves
 - .2 23 05 01 Heating and Cooling Piping Systems

1.3 Submittals

- .1 Conform to the requirements of Specification section 20 05 23 except/and as follows.
- .2 For double regulating valves, in addition to manufacturer data sheets, submit a schedule listing all double regulating valves and include the following information:
 - .1 a valve reference number,
 - .2 valve service (e.g. associated equipment, or distribution piping service by drawing, room, etc.)
 - .3 associated pipeline size, NPS
 - .4 valve body size, NPS
 - .5 specified design flow rate,
 - .6 valve minimum and maximum flow rate limits,
 - .7 valve pressure drop at specified design flow rate,
 - .8 expected valve open position (number of valve turns open, percent valve stroke, etc.)

1.4 Applicable Codes and Standards

- .1 Refer to section 20 05 23 and as specified herein.
- .2 Where an HVAC liquid piping system is subject to registration as a pressure piping system as identified in specification section 23 05 01, all valves shall have Canadian Registration Numbers in accordance with CSA B51. In the following valve specifications, where the identified model does not have a current CRN, provide a valve of equal or greater performance which has a current CRN from the same manufacturer.
- .3 For the purpose of this article, "current CRN" means a registration which does not expire for at least 12 months from the date of submittal of shop drawings.

2 PRODUCTS

2.1 Ball Valves – bronze/brass body

.1 NPS 2 and under:

- .1 To MSS SP-110, 600 CWP/150 SWP, two-piece bronze or DZR brass body, full port, solid stainless steel or chrome plated bronze ball, PTFE seat and seals.
- .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
- .3 Required MCPR: 2300 kPa (335 psig) at 121°C (250°F).
- .4 Solder ends:

Standard of Acceptance

- Kitz - fig. 59, 69AM-LL
- Apollo - fig. 77-200
- Nibco - fig. S-585-70
- Anvil - fig. 171S

.5 NPT threaded ends.

Standard of Acceptance

- Kitz - fig. 58, 68AM-LL
- Apollo - fig. 77-100
- Nibco - fig. T-585-70
- Anvil - fig. 171N

2.2 Ball Valves – carbon steel body

.1 NPS 2 and under:

- .1 To MSS SP-110, 1500 CWP/150 SWP, carbon steel body, regular port, stainless steel or chrome plated carbon steel ball, PTFE seat and seals.
- .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
- .3 ISO 5211 mounting pad.
- .4 Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).
- .5 Two-piece body style, NPT threaded ends:

Standard of Acceptance

- Apollo - fig. 89-100
- MAS - fig. CSCR-2
- Velan - fig. S-M1102-SSGA

.6 Three-piece body style, NPT threaded ends:

Standard of Acceptance

- Apollo - fig. 83A-140
- Nibco - fig. TM-590-CS-R-66-FS-LL
- MAS - fig. CSS-F-3N
- Velan - fig. S-K1802-SSGA

.7 Three-piece body style, socket weld ends:

Standard of Acceptance

- Apollo - fig. 83A-240
- Nibco - fig. KM-590-CS-R-66-FS-LL
- MAS - fig. CSS-F-3N-SW
- Velan - fig. W-K1802-SSGA

.2 NPS ½ to NPS 4:

- .1 To MSS SP-72, ASME Class rated, carbon steel two-piece split body, full port, stainless steel or chrome plated carbon steel ball, PTFE seat and seals, ASME Class 150 flanged ends.
- .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
- .3 ISO 5211 mounting pad.
- .4 Class 150:
 - (a) Required MCPR: 1600 kPa (230 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 150SCTDZM-N
- Apollo - fig. 88A-200
- Nibco - fig. F-515-CS-F-66-FS
- Velan - fig. SB-150

.5 Class 300:

- (a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 300SCTDZM-N
- Apollo - fig. 88A-900
- Nibco - fig. F-535-CS-F-66-FS
- Velan - fig. SB-300

2.3 Globe Valves

.1 NPS 2 and under:

- .1 To MSS SP-80, Class 150, bronze body, renewable PTFE composition disc, union bonnet, and lockshield handles where shown.
 - (a) Required MCPR: 1600 kPa (230 psig) at 121°C (250°F).
 - (b) Solder ends.

Standard of Acceptance

- Kitz - fig. 10
- Crane - fig. 1310 (class 300)
- Jenkins - fig. 106BPJ (class 300)
- Nibco - fig. S-235-Y

- (c) NPT threaded ends.

Standard of Acceptance

- Kitz - fig. 09

- Crane - fig. 7TF
- Jenkins - fig. 106BJ
- Nibco - fig. T-235-Y

- .2 To MSS SP-80, Class 300, bronze body, hardened stainless steel plug, renewable seat and union bonnet, with NPT threaded ends.

(a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 17S
- Crane - fig. 382P
- Jenkins - fig. 592J
- Nibco - fig. T-276-AP

- .3 To ASME B16.34, Class 800, forged steel body, bolted bonnet, hard faced disc and seat ring, with NPT threaded ends.

(a) Required MCPR: 12 MPa (1740 psig) at 121°C (250°F).

Standard of Acceptance

- Crane - fig. B3644XU-T
- Powell - fig. LG08TA58GB
- Beric - fig. 502-T-X-8-A-08

- .2 NPS 2½ and over, flanged:

- .1 To MSS SP-85, Class 125, cast iron body, bronze trim, OS & Y bolted bonnet, bronze disc and seat ring, flat faced flanges,

(a) Required MCPR:

- i) NPS 2-12: 1200 kPa (174 psig) at 121°C (250°F).
- ii) NPS 14-24: 860 kPa (125 psi) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 76
- Crane - fig. 351
- Jenkins - fig. 2342J
- Nibco - fig. F-718-B

- .2 To ASME B16.34, Class 300, ASTM A216 Gr WCB cast steel body, 13% chrome stellite trim, OS & Y, bolted bonnet, and raised face flanges.

(a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 300SCJS
- Crane - fig. 151XU
- Jenkins - fig. J1042B2
- Powell - fig. 3031-FC8G
- Beric - fig. 203-RF-EA08-H

2.4 Gate Valves

- .1 NPS 2 and under:

- .1 To MSS SP-80, Class 150 with bronze body, OS&Y rising stem, bronze wedge disc and union or screw-in bonnet, and NPT threaded ends.

(a) Required MCPR: 1600 kPa (230 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 42
- Crane - fig. 431UB
- Nibco - fig. T-131

- .2 To MSS SP-80, Class 300, bronze body, OS&Y rising stem, copper nickel alloy or stainless steel trim, solid wedge disc, union bonnet, and NPT threaded ends.

(a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 37
- Crane - fig. 622E
- Jenkins - fig. 2280UJ
- Nibco - fig. T-174-A

- .3 To ASME B16.34, Class 800, forged steel body, standard port, OS&Y rising stem, solid wedge disc, bolted bonnet, and NPT threaded ends.

(a) Required MCPR: 12 MPa (1740 psig) at 121°C (250°F).

Standard of Acceptance

- Bonney Forge - fig. HL-11-T
- Crane - fig. B-3604XU-T
- Powell - fig. GA08TA58GB
- Beric - fig. 501-T-X-8-A-02

- .2 NPS 2½ and over, flanged:

- .1 To MSS SP-70, Class 125, cast iron body, OS&Y rising stem, flat faced flanges, bronze trim, and bolted bonnet, and flat-faced flanges.

(a) Required MCPR:

- i) NPS 2-12: 1200 kPa (174 psig) at 121°C (250°F).
- ii) NPS 14-24: 860 kPa (125 psi) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 72
- Crane - fig. 465½
- Jenkins - fig. 454J
- Nibco - fig. F-617-O

- .2 To ASME B16.34, Class 300, ASTM A216 Gr WCB cast steel body, OS&Y rising stem, flexible disc, 13% chrome stellite trim, bolted bonnet, and raised face flanges.

(a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 300SCLS
- Crane - fig. 33XU-F

- Jenkins - fig. J1010B8F
- Powell - fig. 3003-FC8G
- Beric - fig. 103-RF-AA08-H

2.5 Butterfly Valves – Low Pressure (type “LP”)

.1 NPS 2½ to NPS 24, for flange installation:

- .1 To MSS SP-67, ductile or cast iron flange-less lug body style, flange holes drilled and tapped for ANSI 150 flange pattern.
- .2 Stainless steel shaft, bronze or ductile iron disc with nickel chrome seating edge and replaceable EPDM resilient seat to provide bubble tight shut-off under system pressure from either side with flange removed from un-pressurized side.
- .3 ISO 5211 mounting pad.
- .4 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
- .5 Required MCPR:
 - (a) NPS 2 to 12: 1380 kPa (200 psig) at 107°C (225°F).
 - (b) NPS 14 to 24: 1030 kPa (150 psig) at 107°C (225°F).

Standard of Acceptance

- Nibco - fig. LD-2000
- Crane - fig. Center Line RS-200
- Kitz - fig. 6100 series
- DeZurik - fig. BOS-US
- Bray - fig. 31H
- Watts - fig. BF-03-M2
- MAS - fig. D series

.2 NPS 2½ to 12, for grooved end pipe:

- .1 To CSA B242, malleable or ductile iron body with corrosion inhibitor finish, with grooved ends.
- .2 Stainless steel shaft, aluminum-bronze or nickel plated ductile iron or EPDM encapsulated ductile iron disc, and replaceable EPDM resilient seat for bi-directional flow and bubble tight shut-off under system pressure.
- .3 ISO mounting pad.
- .4 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
- .5 Required MCPR: 1380 kPa (300 psig) at 107°C (225°F).

Standard of Acceptance

- Victaulic - fig. 761 Vic-300
- Gruvlok - fig. 7700 series

.3 NPS 14 to NPS 24, for grooved end pipe:

- .1 To CSA B242, ductile iron body with corrosion inhibitor finish, with grooved ends.
- .2 Stainless steel shaft, corrosion-inhibitor encapsulated ductile iron disc with offset design, and replaceable EPDM resilient seat for bi-directional flow and bubble tight shut-off under system pressure.
- .3 ISO mounting pad.

- .4 Gear operator.
- .5 Required MCPR: 2065 kPa (300 psig) at 107°C (225°F).

Standard of Acceptance

- Victaulic - fig. AGS Vic-300 W709

2.6 Butterfly Valve - High Pressure (type "HP")

- .1 NPS 2½ to NPS 36:
 - .1 To MSS SP-68, high pressure offset-disc type, carbon steel lug body with flange bolt holes drilled and tapped, suitable for single flange connection to ASME/ANSI B16.5 flanges (NPS 24 and under) and ASME/ANSI B16.47 Series A flanges (NPS 30 to NPS 48).
 - .2 316 or 17-4 stainless steel disc and shaft, PTFE seat, bi-directional bubble tight shut-off under system pressure for dead-end service with flange removed from one side.
 - .3 ISO 5211 mounting pad.
 - .4 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
 - .5 Class 150 valve (NPS 2½ to 36):
 - (a) Required MCPR: 1600 kPa (230 psig) at 121°C (250°F).

Standard of Acceptance

- DeZurik - fig. BHP
- Crane - fig. Flowseal 3LA series
- Apollo - fig. 230L
- WKM - fig. DynaCentric
- Nibco - fig. LCS-6822
- Keystone - fig. K-Lok 36
- Nibco SureSeal - fig. G1L
- Bray - fig. McCannalok

- .6 Class 300 valve (NPS 2½ to NPS 24)
 - (a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- DeZurik - fig. BHP
- Crane - fig. Flowseal 3LA series
- Apollo - fig. 230L
- WKM - fig. DynaCentric
- Nibco - fig. LCS-7822
- Keystone - fig. K-Lok 37
- Bray - fig. McCannalok

2.7 Inline Silent Check Valves

- .1 NPS 2 and under, bronze, threaded:
 - .1 To MSS SP-80, Class 125, bronze body, spring-controlled inline style (non flapper), body guided disc, resilient EPDM or PTFE seat or disc; bronze, Inconel or stainless steel spring; with NPT threaded ends.
 - .2 Required MCPR: 1200 kPa (174 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 36
- Nibco - fig. T-480-Y
- Apollo - fig. CVBB 61-500
- Valmatic - fig. 1400THR

.2 NPS 2 ½ to NPS 12, wafer style:

- .1 To MSS SP-125, Class 125 or 150, cast or ductile iron body, stainless steel trim and spring-controlled inline globe-style (non flapper), body guided disc, resilient BUNA-N seat, wafer body style for installation between flat-faced flanges.
- .2 Valve design provides both a metal-to-metal and metal-to-resilient seat for zero leakage sealing.
- .3 Required MCPR: 1200 kPa (174 psig) at 65°C (150°F).

Standard of Acceptance

- Dezurik - fig. APCO 300 Series
- Valmatic - fig. 1400A series
- Mueller - fig. 101MAT
- Nibco - fig. W-910

.3 NPS 2 ½ to NPS 24, flanged ends:

- .1 To MSS SP-125, Class 125 or 150, cast or ductile iron body, stainless steel trim and spring-controlled inline globe-style (non flapper), body guided disc, resilient BUNA-N seat, with Class 125/150 flanges.
- .2 Valve design provides both a metal-to-metal and metal-to-resilient seat for zero leakage sealing.
- .3 Required MCPR:
 - i) NPS 2-12: 1200 kPa (174 psig) at 65°C (150°F).
 - ii) NPS 14-24: 860 kPa (125 psi) at 65°C (150°F).

Standard of Acceptance

- Dezurik - fig. APCO 600 Series
- Valmatic - fig. 1800 series
- Mueller - fig. 107MAT
- Nibco - fig. F-960

.4 NPS 2 ½ to NPS 24, carbon steel, flanged:

- .1 To MSS SP-126, Class 150 and 300, ASTM A216 WCB carbon steel body, stainless steel trim and spring-controlled inline globe-style (non flapper), body guided disc, stainless steel seat, with Class 150 / 300 flanges.
- .2 Valve design provides both a metal-to-metal and metal-to-resilient seat for zero leakage sealing.
- .3 Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Dezurik - fig. APCO 600 Series
- Durabla - fig. GLC
- Mueller - fig. 109MDT

2.8 Swing Check Valves

.1 NPS 2 and under:

.1 To MSS SP-80, Class 125, bronze body, bronze swing disc, screw in cap, regrindable seat.

- (a) Required MCPR: 1200 kPa (174 psig) at 121°C (250°F).
- (b) Soldered ends

Standard of Acceptance

- Kitz - fig. 23
- Crane - fig. 1342
- Jenkins - fig. 4093J
- Nibco - fig. S-413-B

(c) NPT threaded ends:

Standard of Acceptance

- Kitz - fig. 22
- Crane - fig. 37
- Jenkins - fig. 4037J
- Nibco - fig. T-413-B

.2 To MSS SP-80, Class 300, bronze body, bronze swing disc, screw in cap, regrindable seat, with NPT threaded ends.

- (a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 19
- Crane - fig. 76E
- Jenkins - fig. 4962J
- Nibco - fig. T-473-B

.2 NPS 2½ to NPS 10, cast iron, flanged

.1 To MSS SP-71, Class 125, cast iron body, flat faced flange, renewable bronze seat ring, bronze disc, bolted cap, with ASME Class 125 flanged ends.

- (a) Required MCPR: 1200 kPa (174 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 78
- Crane - fig. 373
- Jenkins - fig. 587J
- Nibco - fig. F-918-B

.3 NPS 2 to NPS 30, carbon steel, flanged:

.1 To ASME B16.34, Class 300, ASTM A216 Gr WCB cast steel body, renewable stainless steel seat ring, stainless steel or 13% Cr overlay disc, bolted cap.

- (a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 300SCOS
- Crane - fig. 159XU
- Beric - fig. 303-RF-EA08

.4 NPS 2 to NPS 12, for grooved end pipe

- .1 Ductile iron body, ductile iron or bronze disc, nickel seat, EPDM liner, stainless steel spring, with grooved ends.
- .2 Required MCPR: 2000 kPa (290 psig) at 110°C (230°F)

Standard of Acceptance

- Victaulic - fig. 716H/716
- Gruvlok - fig. 7800

2.9 Double Regulating Valves (“DRV”)

.1 NPS 3 and under:

- .1 Bronze or DZR brass body, plug type stem with flow measurement ports and tamper-proof setting.
- .2 NPT threaded or soldered ends.
- .3 Required MCPR: 1500 kPa (215 psig) at 121°C (250°F) water temperature.

Standard of Acceptance

- S.A. Armstong - fig. CBV
- Victaulic - fig. 787
- Bell and Gossett - fig. Circuit Setter Plus
- Preso - fig. B-Plus
- Nexus - fig. UltraMB(NL)
- Red White - fig. 9517

.2 NPS 2½ to NPS 12:

- .1 Cast or ductile iron body, copper alloy trim, with flow measurement ports, tamper-proof setting, with groove or Class 250/300 flanges.
- .2 Required MCPR: 1720 kPa (250 psig) at 110°C (230°F)

Standard of Acceptance

- S.A. Armstrong - fig. CBV II
- Victaulic - fig. 788/789
- Preso - fig. B-PLUS
- Nexus- fig. UltraMB
- Red White - fig. 9519

.3 Flow meter for DRVs

- .1 Differential pressure gauge with calibrated chartes or direct digital flow meter type.
- .2 Hose and fittings to suit manual double regulating valves.
- .3 In addition to equipment and materials used during start-up and testing, supply one complete set of clean un-used calibrated flow charts or one (1) digial flow meter, to the owner at the completion of the project.

2.10 Plug Valves with Flow Balancing Ports

.1 NPS 6 to 24, flanged:

- .1 To MSS SP-78, cast or ductile iron body, lubricated bronze or nickel plated cast iron plug, lubrication assembly, short pattern, with Class 125 flat-face flange ends.
- .2 Two pressure test ports with pet cocks for differential pressure measurement, and calibrated flow charts.
- .3 Worm gear operator with memory stop.
- .4 Class 125:

(a) Required MCPR:

- i) NPS 2-12: 1200 kPa (174 psi) at 121°C (250°F)
- ii) NPS 14-24: 1000 kPa (145 psi) at 121°C (250°F)

Standard of Acceptance

- Hattersley - fig. 611
- DeZurik - fig. Hilton Balancing Valve

.5 Class 250:

(a) Required MCPR:

- i) NPS 2-12: 2700 kPa (390 psi) at 121°C (250°F)
- ii) NPS 14-24: 1700 kPa (245 psi) at 121°C (250°F)

Standard of Acceptance

- Hattersley - fig. 602
- DeZurik - fig. Hilton Balancing Valve

2.11 Triple Duty Valves

- .1 Combination discharge non-slam check valve, isolation valve and balancing valve (“triple-duty”).
- .2 NPS 1-1/4 to NPS 2:

- .1 Ductile iron body, Class 125, non-slam bronze disc with stainless steel spring, EPDM seat ring, plug type stem, flow measurement ports, tamper-proof setting, with NPT threaded ends.
- .2 Required MCPR: 900 kPa (130 psig) at 110°C (230°F)

Standard of Acceptance

- S.A. Armstrong - fig. FLO-TREX FTV-T
- ITT Bell & Gossett

.3 NPS 2 to NPS 12:

- .1 Cast or ductile iron body, non-slam bronze disc with stainless steel spring, EPDM seat ring, plug type stem, flow measurement ports, tamper-proof setting, with flanged or groove pipe ends.
- .2 Class 125 required MCPR: 900 kPa (130 psig) at 110°C (230°F)
- .3 Class 250 required MCPR: 2070 kPa (300 psig) at 110°C (230°F)

Standard of Acceptance

- S.A. Armstrong - fig. FLO-TREX FTV series
- ITT Bell & Gossett

3 EXECUTION

3.1 General

- .1 Refer to section 20 05 23 and as required herein.

3.2 Valve Selection Based on Pressure Rating

- .1 Unless otherwise specified herein or shown, select valves that have a Minimum Component Pressure Rating (MCPR) which exceed the applicable piping system Design Pressure and Design Temperature specified in section 23 05 01.
- .2 Where drawings indicate either: (a) a pressure rating; or (b) a pressure rating and Class rating, by floor level then select valves as follows:
 - .1 For all valves, select a valve with a MCPR rating equal to or greater than the pressure rating indicated on the drawings for each floor level.
 - .2 For clarity, even if a valve has an ASME Class rating, do not select a valve based on its Class to match any Class rating shown on the drawings.

3.3 Butterfly valves

- .1 Where butterfly valves are used, provide high pressure HP type butterfly valves as follows:
 - .1 at hot water boiler inlet and outlet connections,
 - .2 at refrigeration equipment evaporator and condenser water inlet and outlet connections,
 - .3 where valves are installed in pipe risers in vertical service shafts,
 - .4 where valves are used to isolate piping service to a building,
 - .5 as required based on valve size and pressure ratings, or
 - .6 at other locations as shown on drawings.
- .2 For butterfly valves with automatic control actuators, select RS or HP type valves as required so that valve torque requirements do not exceed 75% of installed valve actuator torque rating.

3.4 Check Valves

- .1 Provide an inline silent check valve on the pump discharge under any of the following conditions:
 - .1 multi-parallel pump installation,
 - .2 where the pump discharge piping rises to more than 5 m (15 ft) above the pump discharge, and
 - .3 at other locations as shown on drawings.
- .2 Provide an inline silent check valve where a check-valve is shown on drawings other than at a pump discharge.
- .3 Provide swing check or silent check valves at other locations.

3.5 Double Regulating Valves Installation

- .1 Where double regulating valves are used, supply one flow meter for double regulating and triple duty valves and turn over to operating staff during operations and maintenance training. Obtain and provide a copy to the owner of a signed receipt showing time, date, and name of recipient.

- .2 Consult with double regulating valve manufacturer to ensure correct valve selection. Balancing valves to be sized according to design flow rate.
- .3 Size and select valves for flows as shown, based on at 6 kPa (2 ft) pressure drop across the valve in the fully open position, and in accordance with manufactures recommendation. Table 1 identifies the nominal valve size selection:

Table 1: Double Regulating Valve Nominal Sizing				
Valve Size NPS	Nominal Flow			
	Min.	Max.	Min.	Max.
	L/s	L/s	gpm	gpm
½	0.038	0.177	0.6	2.8
¾	0.126	0.379	2.0	6.0
1	0.246	0.631	3.9	10.0
1-¼	0.316	0.947	5.0	15.0
1-½	0.416	1.262	6.6	20.0
2	0.795	2.272	12.6	36.0
2-½	2.398	6.310	38.0	100.0
3	1.956	8.203	31.0	130.0
4	4.291	12.620	68.0	200.0
5	5.679	20.192	90.0	320.0
6	11.48	28.395	182.0	450.0
8	23.16	51.742	367.0	820.0
10	34.07	82.030	540.0	1300.0
12	60.58	94.650	960.0	1500.0

- .4 Install double regulating valves with five pipe diameters of straight pipe on inlet side, two pipe diameters on outlet side and 10 pipe diameters from any pump.
- .5 Install double regulating valves with ports facing horizontal or facing up. Do not install with ports facing down to prevent debris from falling and accumulating inside the ports.
- .6 Where double regulating valves are installed, provide an isolation valve either upstream (supply piping) or downstream (return piping). Double regulating valves shall never be used in lieu of isolation valves.

End of Section

STAINLESS STEEL VALVES FOR HVAC WATER PIPING

23 05 23.19

1 GENERAL

1.1 Scope

- .1 Provide stainless steel valves for HVAC stainless steel water piping systems, including shut-off valves, check valves, and manual balancing valves, for piping systems with a design pressure of 3500 kPa (507 psig) or less and a design temperature of 121°C (250°F) or less.
- .2 This specification applies to hydronic heating and cooling water systems (with or without glycol additives) and other piping systems required to be stainless steel as specified in section 23 05 01, except as otherwise required for specific duty valves in other specification sections.
- .3 Stainless steel may be used as an alternative to copper piping for heating and cooling water systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 23 General Requirements for Valves
 - .2 23 05 01 Heating and Cooling Piping Systems

1.3 Submittals

- .1 Refer to section 20 05 23.

1.4 Applicable Codes and Standards

- .1 Refer to section 20 05 23 except/and as specified herein.
- .2 Where an HVAC liquid piping system is subject to registration as a pressure piping system as identified in specification section 23 05 01, all valves shall have Canadian Registration Numbers in accordance with CSA B51. In the following valve specifications, where the identified model does not have a current CRN, provide a valve of equal or greater performance which has a current CRN from the same manufacturer.
- .3 For the purpose of this article, "current CRN" means a registration which does not expire for at least 12 months from the date of submittal of shop drawings.

2 PRODUCTS

2.1 Ball Valves

- .1 NPS 2 and under:
 - .1 To MSS SP-110, 1500 CWP/150 SWP, three-piece type ASTM A351 CF8M stainless steel body, full port, stainless steel ball, PTFE gaskets and seat.
 - .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
 - .3 ISO 5211 mounting pad.
 - .4 Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).
 - .5 Socket weld ends.

Standard of Acceptance

- ° M.A.Stewart – fig. G3SW <<400 psig>>

- Kitz - fig. 329FS
- Apollo - fig. 86A-200

.6 NPT threaded ends.

Standard of Acceptance

- M.A.Stewart – fig. G3
- Kitz - fig. 327F
- Apollo - fig. 86A-100

2.2 Globe Valves

.1 NPS 2 and under:

.1 To ASME B16.34 and MSS SP-42, ASTM A351 CF8M stainless steel body, CF8M disc, bolted bonnet, lockshield handles where shown, threaded ends.

.2 Class 150:

(a) required MCPR: 1600 kPa (230 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. AK150UPM
- Crane/Aloyco - fig. 310

.3 Class 300:

(a) required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. AK300UPM
- Crane/Aloyco - fig. 2310

.2 NPS 2½ and over, flanged:

.1 To ASME B16.34 and MSS SP-42, Class 150, ASTM A351 CF8M stainless steel body, CF8M disc OS & Y, bolted bonnet, and raised face flanges.

.2 Class 150:

(a) Required MCPR: 1600 kPa (230 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 150UPAM
- Crane/Aloyco - fig. 317

.3 Class 300:

(a) Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Kitz - fig. 300UPAM
- Crane/Aloyco - fig. 2317

2.3 Butterfly Valve

.1 NPS 2½ to NPS 36:

- .1 To MSS SP-68, high pressure offset-disc type, T316 stainless steel lug body with flange bolt holes drilled and tapped, suitable for single flange connection to ASME/ANSI B16.5 flanges (NPS 24 and under) and ASME/ANSI B16.47 Series A flanges (NPS 30 to NPS 48).
- .2 316 or 17-4 stainless steel disc and shaft, PTFE seat complete with titanium or 316 stainless steel spiral wound back-up ring, bi-directional bubble tight shut-off under system pressure for dead-end service with flange removed from one side.
- .3 ISO 5211 mounting pad.
- .4 Locking handles up to NPS 4, and gear operators for NPS 6 and over.
- .5 Class 150 valve (NPS 2½ to 36):
 - (a) required MCPR: 1600 kPa (230 psig) at 121°C (250°F).

Standard of Acceptance

- DeZurik - fig. BHP
- Crane - fig. Flowseal 3LA series
- Apollo - fig. 230L
- WKM - fig. DynaCentric
- Keystone - fig. K-Lok 36
- Bray - fig. McCannalok

- .6 Class 300 valve (NPS 2½ to NPS 24)
 - (a) required MCPR: 4000 kPa (580 psig) at 121°C (250°F).

Standard of Acceptance

- DeZurik - fig. BHP
- Crane - fig. Flowseal 3LA series
- Apollo - fig. 230L
- WKM - fig. DynaCentric
- Keystone - fig. K-Lok 37
- Bray - fig. McCannalok

2.4 Inline Silent Check Valves

- .1 NPS 2 and under, threaded:
 - .1 To MSS SP-80, Class 125, ASTM A351 CF8M stainless steel body, spring-controlled inline style (non-flapper), body guided disc, resilient EPDM or PTFE seat or disc; stainless steel spring; with NPT threaded ends.
 - .2 Required MCPR: 1170 kPa (170 psig) at 121°C (250°F).

Standard of Acceptance

- Apollo - fig. 62-500

- .2 NPS 2½ to NPS 24, flanged:
 - .1 To MSS SP-126, Class 150 and 300, ASTM A351 CF8M stainless steel body, stainless steel trim and spring-controlled inline globe-style (non-flapper), body guided disc, stainless steel seat, with Class 150 / 300 flanges.
 - .2 Valve design provides both a metal-to-metal and metal-to-resilient seat for zero leakage sealing.
 - .3 Required MCPR: 3500 kPa (507 psig) at 121°C (250°F).

Standard of Acceptance

- Dezurik - fig. APCO 600 Series
- Durabla - fig. GLC

3 EXECUTION

3.1 General

- .1 Refer to section 20 05 23 and as specified herein.

3.2 Valve Selection Based on Pressure Rating

- .1 Unless otherwise specified herein or shown, select valves that have a Minimum Component Pressure Rating (MCPR) which exceed the applicable piping system Design Pressure and Design Temperature specified in section 23 05 01.
- .2 Where drawings indicate either: (a) a pressure rating; or (b) a pressure rating and Class rating, by floor level then select valves as follows:
 - .1 for all valves, select a valve with a MCPR rating equal to or greater than the pressure rating indicated on the drawings for each floor level.
 - .2 for clarity, even if a valve has an ASME Class rating, do not select a valve based on its ASME Class to match any Class rating shown on the drawings.

3.3 Butterfly valves

- .1 For butterfly valves with automatic control actuators, select butterfly valves so that valve torque requirements do not exceed 75% of installed valve actuator torque rating.

3.4 Check Valves

- .1 Provide an inline silent check valve on pump discharge and as otherwise shown.

End of Section

TESTING ADJUSTING AND BALANCING FOR HVAC **23 05 93.13**

1 GENERAL

1.1 Scope

- .1 Test, adjust, and balance ("TAB") air handling systems and hydronic systems installed, modified or extended as part of this work, including:
 - .1 air handling systems, including air handling units and ventilation fans,
 - .2 hydronic systems:
 - (a) heating and cooling equipment and piping systems,
 - (b) boiler feedwater pumps and central condensate receiver transfer pumps,
 - (c) process equipment and liquid piping systems.
- .2 Test existing HVAC systems to record existing operating conditions, at the start of the Work but before any demolition or new construction work is performed.
- .3 Refer to Specification section 22 05 93 for TAB for plumbing systems.
- .4 Rechecking of TAB during alternate heating/cooling season.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 22 05 93 Testing Adjusting and Balancing for Plumbing
 - .2 23 05 93.23 Testing, Adjusting and Balancing Supplement for Healthcare
 - .3 23 33 05 Duct Accessories

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Induction units** – means a room air distribution device which uses primary supply air at high pressure to entrain room air into the primary airflow to create a room mixed supply airflow, and may or may not include a cooling or heating coil.
 - .2 **Process cooling (loads)** – means cooling equipment dedicated to a specific process equipment cooling load, and such cooling is not intended for human comfort.
 - .3 **Terminal inlet** – means a room or space return air or exhaust air grille, or other exhaust air inlet connection.
 - .4 **Terminal outlet** - means a room or space supply air grille or diffuser,
 - .5 **Terminal unit** – means a manufactured automatic airflow control-damper unit intended to control airflow to a space or a zone, with or without a reheat coil.
 - (a) **Constant Air Volume terminal unit (CAV)** – means a terminal unit where the airflow control damper is automatically controlled to maintain a constant supply airflow, and space temperature control is by other means.
 - (b) **Exhaust Air Volume terminal unit (EAV)** – means a terminal unit used to control return or exhaust air flow from a room or space, where the automatic control damper is operated to regulate space pressure.

- (c) **Variable Air Volume terminal unit (VAV)** – means a terminal unit where the airflow control damper is automatically controlled to vary supply airflow to maintain space temperature.
- (d) **Limited VAV terminal unit (VAVLM)** – a terminal unit that operates as a VAV at maximum cooling or heating demand under temperature control, and as a CAV at other times to maintain a minimum airflow rate to the room or space. For clarity, the CAV function occurs during normal occupancy times.

.6 **Zone** – means rooms or spaces, or portion thereof, that defines the supply air and return/exhaust air flow being evaluated.

.2 The following abbreviations apply to this section:

- .1 **CAABC** Canadian Associated Air Balance Council
- .2 **NEBB** National Environmental Balancing Bureau

1.4 **Applicable Codes and Standards**

.1 Installation codes and standards:

- .1 ANSI/ASHRAE 41.2 Standard Methods for Air Velocity and Airflow Measurement
- .2 ANSI/ASHRAE 111 Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems
- .3 SMACNA HVAC Systems Testing, Adjusting, & Balancing
- .4 AABC National Standards for Total System Balance
- .5 NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems

1.5 **Qualified Tradesperson**

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.
- .2 Balancing to be performed under supervision of recognized expert with an established reputation in this field.
- .3 TAB contractor to be a member of CAABC or NEBB.

Standard of Acceptance (no alternatives)

- Air & Water and Precision Balancing – Matthew Crittenden matt@awpbgroup.com – 647-896-5353

1.6 **Quality Control**

- .1 Perform testing and balancing in accordance with procedures as published by ASHRAE, SMACNA, AABC or NEBB except/and as specified herein.

1.7 **Accuracy**

- .1 Adjust systems until operating values are within the acceptance criteria stated for each system type. Where an acceptance criterion is not stated, balance the system so that measured values are within ±5% of design value.
- .2 Measurement device accuracy:

Measurement	Application	Device	Accuracy
Air Flow	Plenums	Revolving Vane Anemometer, direct reading digital type	± 5.0% of reading over 1 m/s
Air Flow	Ducts	Pitot-tube duct traverse with electronic gauge	± 10.0% of reading over 5 m/s
Air Flow	Grilles and Diffusers	Revolving Vane Anemometer, direct reading digital type	± 5.0% of reading
Air Flow	Room air currents, Hoods (0.05 to 3.0 m/s)	Thermal Anemometer	± 10.0% of reading
Liquid Flow	Piping	Installed meter	As per meter rating
Liquid Flow	Equipment	Differential Pressure and equipment data	See below
Temperature	Air, Liquids	Digital Electronic Thermometer	± 0.2°C over 0 to +40°C
Temperature	Air, Liquid	Digital Electronic Thermometer	± 0.4°C < 0°C and >+40°C
Relative Humidity	Air	Digital Electronic Humidity Sensor	± 1.5%RH over 0 to 90%RH range
Pressure	Air	Magnahelic	± 2.0% of reading
Pressure	Liquid, Gas, Steam	Bourbon type	± 1.0% of reading
RPM	Motor, fans	Chronometer tachometer	± 1.0% of reading
Voltage	All	Portable	± 2.5% of reading
Current	All	Portable clamp-on ammeter	± 2.5% of reading

1.8 Audit Verification

- .1 After review of the draft TAB report by Consultant, the Consultant may at their sole discretion require re-measurement of TAB results on an audit sample rate of [5][10][30] percent of all measured equipment, at no cost extra to the Contract Price or change to project schedule.
- .2 If audited results indicate a variance of more than 10% between the original reported value and the audit measured value for a piece of equipment, re-balance the audited device. If this excessive variance condition occurs at more than 25% of the number of audited equipment sample, re-balance the entire affected system at no cost extra to the Contract Price or change to project schedule.

1.9 Preparatory Work

- .1 Develop a TAB work plan to communicate TAB requirements to other trades:
 - .1 Review design drawings and specifications, shop drawings, interference drawings and other related documentation to become familiar with their intended performance.
 - .2 Prior to commencement of piping and ductwork installation, mark-up Consultant's Contract Drawings or contractor's fabrication drawings to identify locations where balancing damper and valve devices, temperature wells, pipe pressure gauges and pressure test plugs are to be installed.

Provide a copy to the trade contractor responsible for installation of balancing devices. Make a copy available for review when requested by Consultant.

- .2 Carry out site visits during later stages of construction to ensure that arrangements for TAB are incorporated. Confirm proper placement of thermometer wells, test ports, pressure gauge cocks, balancing valves, balancing dampers and splitter dampers, and access doors.
- .3 TAB measurements to commence when building is “closed in” and work is sufficiently advanced including;
 - .1 installation of ceilings, doors and windows is completed,
 - .2 application of sealing, caulking, and weather stripping is completed,
 - .3 allowing normal operation of mechanical systems.

1.10 Pre-Construction Air and Water Measurement Audit

- .1 Conduct an HVAC air and water audit of existing HVAC systems prior to commencement of demolition or new construction work.
- .2 Measure existing air conditions for the systems affected by the Work:
 - .1 measure airflow, pressure, and temperature at main supply and return ducts on each floor where Work is to be performed,
 - .2 for fans, measure airflow, motor amps, motor HP rating, motor volts, inlet and discharge static pressure, sheave position,
 - .3 for air handling unit systems including air conditioning units, measure total airflow, outdoor airflow, return airflow; outdoor, return air and supply air temperatures.
- .3 Measure existing service water conditions for the systems affected by the Work:
 - .1 measure water flow at on each floor where Work is to be performed,
 - .2 for each source equipment including chillers and boilers, measure inlet and outlet water pressure, inlet and outlet water temperature, water flow rates,
 - .3 for each pump, measure water flow rate, inlet and outlet static pressures, motor amps, motor rated HP, motor voltage.
- .4 Submit a report to Consultant to record all as-found measured values.

1.11 Measurement Parameters

- .1 Reporting units of measure:

Parameter	Unit	Abbreviation
Mass	kilogram	kg
Length	metre	m
Volume	litre	L
Volume flow rate	Litres per second	L/s
Time	seconds	s
Temperature	Celsius	°C
Pressure	pascal	Pa (air)

Parameter	Unit	Abbreviation
	kilopascal	kPa (liquid, vapour, compressed gas)
Pump Head	metre	m
Pump Pressure	kilopascals	kPa
Fan pressure	pascal	Pa
Mass flow rate	kg per second	kg/s
Heat flow rate	kilowatts	kW
Cooling flow rate	Kilowatts cooling	kWc
Electrical Power	kilowatts	kW
Voltage	Volts	V
Electrical Current	amps	A
Rotation speed	Rotations per minute	RPM
Vibration	Cycles per second	CPS or Hz

1.12 Submittals

- .1 Submit TAB reports in accordance with Part 7 of this section.

2 PRODUCTS

2.1 Ductwork Probe Test Plugs

- .1 Conform to Specification section 23 33 05.

3 EXECUTION - AIR MOVING SYSTEMS

3.1 Measurement Parameters

- .1 The following measurement parameters identify the minimum requirements for inclusion in the TAB process:
 - .1 Air flow parameters;
 - (a) air velocity,
 - (b) flow cross sectional area,
 - (c) static pressure,
 - (d) velocity pressure.
 - .2 Temperature parameters;
 - (a) wet bulb,
 - (b) dry bulb.
 - .3 Pressure parameters;
 - (a) gauge pressure,
 - .4 Equipment parameters;
 - (a) rotational speed (rpm),

- (b) electrical power, kW
 - (c) voltage, V
 - (d) current, A,
- .2 Measurement are required at and around equipment to establish air side performance of;
 - .1 fans,
 - .2 coils,
 - .3 filters,
 - .4 dampers - outdoor, return, recirculating, and relief,
 - .5 humidifiers.
 - .6 terminal units.
 - .3 Measurement are required to characterize system performance;
 - .1 at main ducts,
 - .2 at submain ducts,
 - .3 at branch ducts.
 - .4 at each supply air outlet diffuser or grille, and exhaust and return air inlet grille,
 - .5 in each thermostatically controlled zone.

3.2 General Requirements

- .1 Balance systems so that fans operate at lowest possible speed and static pressure consistent with delivery of specified air quantity at most remote terminal point.
- .2 Measure air quantities at each exhaust system inlet and supply system outlet.
- .3 Balance supply fans and associated return fans with their respective outdoor air dampers and exhaust air damper at their minimum airflow position.
- .4 Be responsible for supply and installation of ductwork test plugs.

3.3 Setting Grill and Diffuser Airflow Patterns

- .1 Adjust the throw and pattern at each supply outlet as shown on drawings. Where a specific pattern is not shown, set the supply outlet grilles and diffusers in accordance with the following;
 - .1 for rectangular and circular cone diffusers, set for a uniform 360° dispersion,
 - .2 for rectangular perforated-plate diffusers, set the flow pattern plates for four-direction horizontal dispersion,
 - .3 for rectangular wall-mount grilles with horizontal front blades, set the blades at an approximate 15° upward facing angle,
 - .4 for linear diffusers at exterior windows or walls, set the flow pattern blades for a downward flow towards the floor and parallel to the windows or wall,
 - .5 for linear diffusers in interior spaces within 300 mm (12 in.) of a wall, set the flow pattern blades for horizontal dispersion away from the wall,
 - .6 for linear diffusers in interior spaces other than close to a wall, set the flow pattern blades for bi-directional horizontal dispersion,

- .7 for light-troffer diffusers, set the flow pattern blades for horizontal dispersion away from the light fixture.

3.4 Use of Terminal Unit Flow Stations for Balancing Purposes

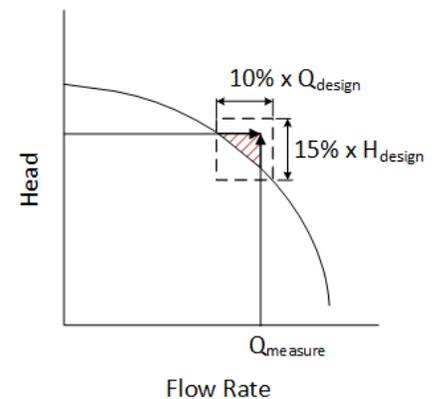
- .1 Where terminal units are equipped with integral air flow stations, do not use these air velocity stations as a proxy for manual duct traverse measurements of the zone airflow.

3.5 Transient Operating Conditions Preparation

- .1 Set-up supply fans with sufficient speed to deliver design air flow when filters are loaded to manufacturers recommended maximum pressure drop (dirty filter condition) and condensing coil air-pressure drop is at its wet coil condition;
- .2 Temporarily block portions of filter banks to achieve maximum pressure drop at design air flow, to simulate dirty filters.
 - .1 only apply blanking material to the highest MERV rated filter in the air handling unit. If there is more than one filter bank, test the remaining filter banks in their clean condition.
- .3 Temporarily block portions of cooling coils to achieve rated wet coil pressure drop at design air flow, to simulate summer condensing operation.
- .4 Uniformly distribute blocking media across filter face and coil face to minimize disruption to overall airflow pattern through the filter and coil bank.
- .5 Remove blanking material at completion of system TAB.

3.6 Fan Performance Assessment

- .1 Obtain the measured duct leakage for each system prior to balancing the duct systems and record in the TAB report. An additional 5% of terminal outlet design airflow rates may be included for balancing effects on the fan delivered airflow rate.
- .2 Measure air quantity by taking anemometer traverses across a coil or at a filter bank, or by pitot tube traverse in a straight section of duct at fan suction or discharge.
- .3 Measure static pressure difference between fan inlet and discharge, motor amperage and fan rotation speed. Determine motor input power from a curve showing power output as a function of motor amperage for the particular motor.
- .4 Plot results of measurements on fan characteristic curve supplied by fan manufacturer; the measured air volume, static pressure and fan speed lines should form a triangle enclosed by a rectangle having a dimension of not more than 15% of the design static pressure by a dimension of not more than 10% of the design airflow rate. Input power taken from the fan characteristic should be within 10% of the power determined from the motor amperage readings.
- .5 If required precision is not obtained, repeat measurements. If subsequent testing shows that the required precision is unobtainable, then fan manufacturer is to submit written report explaining actual fan performance and provide new characteristic curve showing actual performance for fan "as installed".
- .6 Measure static pressure loss across cooling coils, heating coils and individual filter banks and tabulate readings with manufacturers published pressure loss figures for the actual measured air volume.



3.7 Branch Air Quantity Measurement Procedure

- .1 Determine branch air quantities using pitot tube traverses in accordance with the procedures defined in ASHRAE 111 and ANSI/ASHRAE 41.2.
- .2 Take measurements at each riser as it is connected to fan discharge or suction header and at each floor where branches are taken from the riser. Repeat measurement until sum of branch air quantities is within 10% of fan delivery.

3.8 Constant Volume System Balancing Procedure

- .1 Application:
 - .1 single zone systems with constant airflow,
 - .2 constant volume systems using CAV terminal units,
 - .3 constant volume systems with terminal reheat coils,
 - .4 exhaust systems, constant airflow,
- .2 Where a system has CAV units, or a system has a mixture of no units and CAV units, set the CAV units for 100% design airflow at all times.
- .3 Where a system has EAV units, set EAV units to 100% design airflow prior to balancing the supply air system.
- .4 First step - balance the branch ducts:
 - .1 open all supply air terminal outlets and return/exhaust air terminal inlets to 100% full open,
 - .2 starting with the submain duct closest to the fan or the submain duct that has the highest percentage airflow, measure and balance airflow on each branch duct off that submain duct,
 - .3 repeat on other submain ducts in descending order of percent of total airflow, until all branch ducts are balanced,
 - .4 verify supply and return fans are delivering 100% design airflow.
 - .5 acceptance criteria:
 - (a) branch airflow measurement: $\pm 5\%$ of design flow.
 - (b) fan airflow measurement: $\pm 5\%$ of design flow.
- .5 Second step - balance airflows at zones:
 - .1 starting at the most remote zone, balance terminal outlets and inlets using duct balancing dampers ahead of the outlet or inlet device. Only use any integral balancing device in the terminal outlet or inlet to adjust the final airflow rate by not more than 10% of design flow,
 - .2 for supply grilles and diffusers, adjust airflow pattern controllers to prevent airflow impinging on adjacent walls.
- .6 Acceptance criteria:
 - .1 total of terminal outlets/inlets airflow measurement in each zone: $\pm 10\%$ of design flow.

3.9 Terminal Unit Balancing Procedure

- .1 For spaces or zones with ducted return, close the doors to the space and then first balance return/exhaust terminal inlets to design flow rates.
- .2 Balance terminal outlets and inlets downstream of terminal units after the associated terminal units and supply, return and exhaust fans have been balanced.

- .3 Set system to operate with 100% return air, set zone thermostats at indoor design temperature and set fan discharge temperature at design value. Where a ducted return system is used, open any doors to adjacent spaces in the room under test.
- .4 Set thermostat in each zone being balanced to full cooling. Verify terminal unit airflow is supplying 100% design airflow.
- .5 Adjust each terminal outlet grille or diffuser to design airflow rates.
- .6 Repeat for all other terminal unit zones.
- .7 After all terminal unit zones are balanced, check fan performance and adjust fan static pressure controller as required to operate the fans at the minimum static pressure required to achieve terminal unit design airflow rates.

3.10 Induction Unit Primary Air Supply System Balancing Procedure

- .1 Set system to operate with 100% return or supply air and measure plenum pressure at each induction unit on floor most remote from unit.
- .2 Adjust fan static pressure controller to provide design static pressure at most remote unit.
- .3 Check and adjust individual induction unit dampers to obtain design static pressure at each air plenum of each induction unit supplied by fan on test.
- .4 If nozzle plenum static pressure at an intermediate flow is less than that for design air quantity, reset fan static pressure controller to achieve required induction unit static pressure value and re-balance more remote units.

3.11 Outdoor Air Adjustment Procedure

- .1 After balancing of supply fan, return fan, and related exhaust fans systems, adjust the outdoor air dampers position to obtain minimum design fresh air quantity.
- .2 Measure outdoor air values by duct traverse reading across outdoor air intake, recirculation duct, and exhaust air duct.
 - .1 Where there is insufficient duct length to provide reliable traverse readings, determination of outdoor air flow rate may be estimated based on a mixed airflow coil or filter bank traverse and measurement of outdoor air, return air, and mixed air temperature, provided the temperature differential between outdoor and return air is at least 11°C (20°F).
 - .2 Where neither of the above methods can be used, a temporary outdoor air minimum damper position may be set by measuring the pressure drop across the outdoor air damper and estimating the airflow rate based on damper manufacturer pressure drop data. Once outdoor conditions are available, remeasure and reset the outdoor air damper minimum position based on mixed air temperature conditions.
 - .3 Where temperature is used to estimate the balanced minimum outdoor air flow rate, include calculations of same in the balancing report.
- .3 After the minimum outdoor air flow rate and damper position have been adjusted, operate the air handling system at 100% outdoor air. Check that supply fan and return fan are operating within 5% of their airflow rate at minimum outdoor air condition.
 - .1 If the supply or return air flow rates at 100% outdoor air exceed their respective airflow rates at minimum outdoor air condition by more than 5%, adjust the maximum outdoor and exhaust air dampers to reduce their percent opening until the airflow variance is less than 5%.
 - .2 If the supply or return airflow rates at 100% outdoor air is less than their respective airflow rates at minimum outdoor air condition by more than 5%;

- (a) reduce the minimum outdoor damper open position and return damper open position, and increase fan static pressure controller setpoint to re-establish minimum outdoor air flow rate,
- (b) recheck the supply or return fan airflow rates at 100% outdoor air damper position.
- (c) repeat above adjustment procedure until supply or return air fan airflow rates at 100% outdoor air is within 5% of their respective airflow rates at the minimum outdoor air damper position.

3.12 VFD Setpoint and Fan-Motor Sheave Change

- .1 For fans with VFD motor controllers, at completion of system balancing, if the maximum VFD control point is more than 15% below the motor rated operating speed (< 50 Hz on a 60 Hz rated motor frequency), replace the drive sheaves and pulleys so that the motor is operating within 10% of motor rated speed at full load operating conditions,

4 EXECUTION - HYDRONIC SYSTEMS

4.1 Measurement Parameters

- .1 The following measurement parameters identify the minimum requirements for inclusion in the TAB process:
 - .1 volume flow rate,
 - .2 temperature,
 - .3 pressure (gauge),
 - .4 equipment related;
 - (a) rotational speed (rpm),
 - (b) electrical power, kW
 - (c) voltage, V
 - (d) current, A,
- .2 Measurement are required at and around equipment to establish fluid side performance of;
 - .1 heat exchangers (primary and secondary sides),
 - .2 coils,
 - .3 refrigeration equipment (water side),
 - .4 boilers,
 - .5 pumps,
 - .6 PRVs,
 - .7 makeup (water) systems,
 - .8 domestic hot water heaters,
 - .9 humidifiers.
- .3 Measurement are required to characterize system performance;
 - .1 at floor branch connections (where measurement devices are installed),

4.2 General Requirements

- .1 Use calibrated venturi tubes, orifices or other metered fittings and pressure gauges in conjunction with permanent and portable type flow meters to determine flow rates for system balance.

- .2 Effect system balancing with automatic control valves open to heat transfer elements and bypasses closed.
- .3 Check and clean strainers prior to balancing.
- .4 Check expansion tanks are not waterlogged, and record expansion tank pressure before and after system pumps are turned On, and again when the system is at design operating temperatures.
- .5 Base flow balance on (in order of preference):
 - .1 double regulating valves, or globe valves associated with flow measuring elements (flow meters),
 - .2 temporary non-invasive flow meters,
 - .3 differential pressure measurement across heat transfer elements, with flowrate determined from manufacturer's literature, or
 - .4 temperature difference across various heat transfer elements in the system where flow metering devices are not installed. This method may only be used at design heat transfer conditions and at least one flow rate is known.
- .6 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing.
- .7 Perform balancing by measurement of temperature differential in conjunction with air balancing.
- .8 Adjust water distribution systems by means of double regulating valves, globe valves, balancing cocks, valves and fittings. Do not use shut-off valves for balancing unless indexed.
 - .1 Butterfly valves on discharge side of pumps may be used if they are one trade size smaller than system pipe size. Include Cv values and flow vs valve position curve with balancing report.

4.3 Variable Flow Rate Balancing Procedure

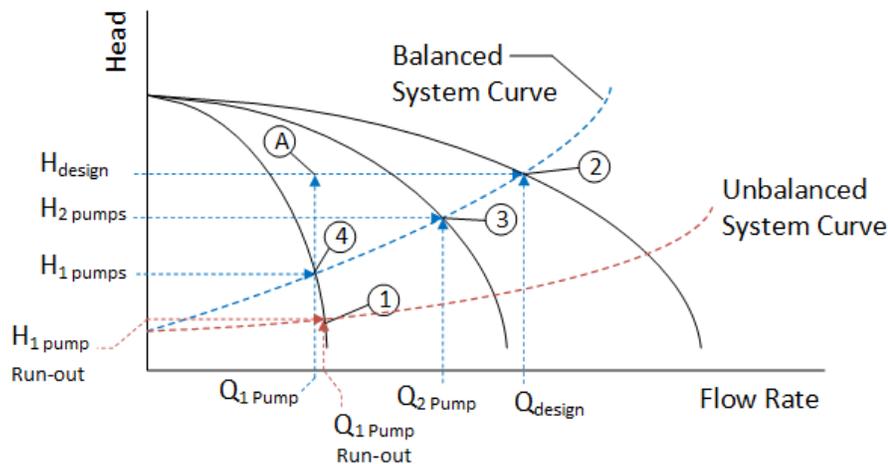
- .1 Obtain from Consultant the expected diversity value, or determine the percent diversity by dividing the pump design flow rate by the sum of all connected loads.
- .2 Where available pump capacity is less than total flow requirements of individual system parts, full flow in any part may be simulated by temporary restriction of flow to other parts.
- .3 First step - Balance pipe riser floor branches:
 - .1 applies where floor-branch riser connections are provided with measurable pipe balancing devices,
 - .2 open all load control valves to 100% open,
 - .3 run all system pumps, and balance the most remote floor-branch balancing device; floor-branch balancing devices on other floors may be partially closed. Adjust pump static pressure controller to supply the minimum required pressure to obtain required flow rate at the floor.
 - .4 repeat with other floors progressing towards the floor closest to the pump.
 - .5 acceptance criteria: $\pm 5\%$ of total design flow rate of the branch.
- .4 Second step – Balance loads:
 - .1 balance the most remote load from the branch balancing valve, with other loads on the same branch throttled at the estimated system diversity.
 - .2 repeat with other load valves on the same branch moving towards the floor balancing device.
 - .3 Acceptance criteria: $\pm 10\%$ of design flow rate at each load.

4.4 Pressure-Independent Control Valves Balancing Procedure

- .1 Where all load connections on a system are equipped with a pressure-independent balancing valve, the preceding balancing procedure may be modified as follows:
 - .1 open all control valves to 100% open and adjust pump speed or balancing valve to limit pump discharge to not exceed the maximum design flow rate,
 - .2 starting at the closest valve to the pump, set the pressure-independent control valve to the required flow rate,
 - .3 proceed with succeeding valves, moving towards away from the pump(s) towards the most remote control valve,
 - .4 if necessary, manually reduce flow rates through some control valves to obtain sufficient flow for the most hydraulically remote pressure-independent valves,
 - .5 after the pressure-independent control valves are set, reduce pump speed or adjust pump discharge balancing valve to provide the lowest differential pressure to achieve required total design flow rate.

4.5 Multiple Pump Systems Balancing Procedure

- .1 Balance multiple pump systems, which have two (2) or more pumps operating in parallel (not including stand-by pumps), in accordance with the following procedure. In the figure below, the state points are:
 - “A”: individual pump design data.
 - “1”: single pump operation at maximum run-out capacity without motor overload
 - “2”: multi-pump operation, balanced system,
 - “3”: N-1 pumps operating at balanced system demand point,
 - “4”: single pump operating at balanced system demand point.



- .2 Step 1 – establish single pump maximum run-out condition (unbalanced system):
 - .1 set all load equipment automatic control valves to 100% open,
 - .2 start one pump separately and open flow through associated source equipment (chiller, boiler, cooling tower, etc.) and run pump to full speed and open discharge valve to maximum open position without causing pump motor to exceed its power rating. This is point 1 on the figure above.

Record pump flow rate, head, and motor current. Mark this data on a multi-pump curve as maximum run-out condition.

- .3 Step 2 - balance pump discharge for all pump simultaneous operation:
 - .1 open all load valves 100% open,
 - .2 start-up all pumps which are required for maximum system design capacity along with associated chillers, cooling towers and boilers,
 - .3 concurrently throttle discharge valve at each pump to obtain total system design flow rate (point 3 in the above figure). Record this value as Maximum Rated Capacity ("MRC"),
 - (a) for pumps with VFD controllers, before throttling the pump discharge valve, reduce pump speeds until MRC is reached (point 2). If the resulting pump speed is more than 15% below pump maximum speed (50 Hz on a 60 Hz motor), increase pump speed to 50 Hz and then use pump discharge throttling valve to obtain MRC at point 2.
- .4 Step 3 – check operating points at reduced number of pumps:
 - .1 shut-down one pump and check operating point of remaining pumps on their pump curves. Check that the operating point does not cause any remaining pump from operating in a motor overload condition,
 - .2 repeat by shutting down additional pumps in sequence until one pump remains operating, and record all test values (flow, pressure, RPM and motor kW). Plot operating point on a multi-pump curve.

5 EXECUTION - EQUIPMENT TESTING

5.1 Performance Data

- .1 Submit the following data as a minimum. If contractor's standard forms provide for additional data, also submit such additional data.
- .2 Some equipment tests may need to be performed during the alternate season testing.
- .3 Include nameplate data and as-tested results.
- .4 Water chillers:
 - .1 manufacturer and model,
 - .2 refrigerant type and weight,
 - .3 cooling rating (refrigeration tons),
 - .4 condenser:
 - (a) entering and leaving water temperature,
 - (b) entering and leaving water pressure,
 - (c) flow rate (minimum, maximum),
 - (d) pressure rating (MAWP),
 - .5 evaporator:
 - (a) entering and leaving water temperature,
 - (b) entering and leaving water pressure,
 - (c) flow rate (minimum, maximum),
 - (d) pressure rating (MAWP),
- .6 motor real power (kW),

- .7 motor apparent power (kVA) or power factor (PF).
- .5 Hydronic Heating Equipment (Boilers, Heaters, etc.):
 - .1 manufacturer and model,
 - .2 heat output rating (kW),
 - .3 electric power input rating (kW),
 - .4 gas and fuel oil input flow rating,
 - .5 gas and fuel oil input pressure rating (minimum, maximum),
 - .6 gas pressure regulator inlet and outlet pressure,
 - .7 heat performance:
 - (a) entering and leaving water temperature,
 - (b) entering and leaving water pressure,
 - (c) liquid flow rate (minimum, maximum),
 - (d) steam flow rate and pressure,
 - (e) pressure rating (MAWP),
 - .8 pressure relief valve rating (pressure setpoint, heat rating, steam rating).
 - .9 combustion efficiency test at maximum rated capacity; including flue gas analysis corrected to 3% O₂, for fuel input ratings exceeding 2930 kW (10 MMBtu/h),
 - .10 thermal efficiency test at maximum rated capacity, based on ASME PTC 4 for steam boilers with fuel input ratings exceeding 2930 kW (10 MMBtu/h),
- .6 Condenser water cooling towers:
 - .1 manufacturer and type,
 - .2 inlet and outlet air temperature, dry and wet bulb,
 - .3 inlet and outlet water temperature,
 - .4 motor, pump and fan information.
- .7 Motors:
 - .1 manufacturer,
 - .2 model or serial number,
 - .3 amperage and voltage,
 - .4 power rating,
 - .5 service factor,
 - .6 RPM,
 - .7 corrected full load amperage,
 - .8 measured amperage and voltage,
 - .9 calculated BHP (kW).
- .8 Fans:
 - .1 manufacturer,
 - .2 model or serial number,

- .3 flow rate,
- .4 static pressures (suction and discharge),
- .5 RPM,
- .6 pulley size, type and manufacturer,
- .7 belt size and quantity.
- .9 Pumps:
 - .1 manufacturer,
 - .2 model or serial number,
 - .3 flow rate,
 - .4 developed pump head,
 - .5 RPM.
- .10 Heat transfer equipment:
 - .1 manufacturer and type,
 - .2 inlet and outlet temperatures,
 - .3 pressure drop,
 - .4 design pressure rating (MAWP),
 - .5 flow rate,
 - .6 pressure relief valve rating (pressure setpoint, heat rating).

6 EXECUTION - ALTERNATE SEASON TESTING

- .1 Based on the scope of the Work, it is expected that complete or final testing of some of the HVAC equipment and systems will need to be deferred to an alternate season period after Substantial Performance / date or Ready-for-Takeover of the Work, but before expiry of the warranty period.
- .2 Alternate season testing is required for heating or cooling equipment which cannot be tested at full load conditions due to ambient outdoor conditions at time of TAB work prior to achieving Substantial Performance / Ready-for-Takeover of the Work.
- .3 As the Work nears Substantial Performance, review with Consultant to determine which equipment and systems will require final TAB work to be deferred to the alternate season. For equipment and systems whose TAB work is to be deferred, provide initial balancing of the systems to a sufficient extent to allow general functional testing of associated services including building control systems.
- .4 Requirements for alternate season TAB work:
 - .1 Plan and allow for costs for alternate season TAB work to be performed at night and on weekends.
 - .2 Perform final balancing of deferred equipment and systems. Arrange with Owner's operations staff to operate equipment normally scheduled off during TAB work times.
 - .3 Where the balancing of deferred equipment and systems interfaces or interacts with previously balanced equipment or systems, check operating performance characters of previously balanced and adjusted equipment or systems to verify continued as-balanced condition.
 - .4 Include the measurement and recording of temperatures and pressures at all gauges, as well as outdoor and indoor conditions.
 - .5 Measure and record the motor amperages and drive RPM of all fans and pumps during re-checking.

- .5 Report
 - .1 Provide an addendum report to the original balancing report for all alternate season balancing results.

7 EXECUTION – MISCELLANEOUS

7.1 Balance Position Marking

- .1 Mark the balance position of dampers and valves at the completion of the final testing:
 - .1 ductwork: indicate with arrow using paint or permanent marker,
 - .2 exposed ductwork in public areas: self-adhesive label, placed adjacent to balancing damper, neatly filled in with % open or degree open value.
 - .3 valves: self-adhesive label, placed on piping (insulated or not) adjacent to valve, neatly filled in with either % valve open, or number of valve turns to open.
- .2 Additional requirements for circuit-balancing valves with test ports:
 - .1 remove valve handle or other protective device, and set memory stop to limit valve open travel. Replace valve handle or protective cover.

8 EXECUTION - REPORT PRESENTATION AND VERIFICATION

8.1 Required Reports

- .1 Provide the following reports:
 - .1 Air and water balancing report,
 - .2 Alternate season test report.

8.2 Record Keeping

- .1 Keep records of trial and final balance and submit preliminary report as each system is completed.
- .2 Do not submit the final TAB report until all audit verification re-measurements, and any required re-balancing, is completed to the satisfaction of Consultant.

8.3 Report Format

- .1 Reports to incorporate approved standard forms, with values expressed in the same units as shown on Contract Documents.
- .2 Include "as-built" system schematics, marked-up to show as-measured flow quantities and measurement points. Use as-built drawings and ventilating line diagrams for reference.
- .3 Submit an electronic PDF copy of the draft TAB report for review by Consultant. Where a report page length is more than 20 pages, include bookmarks in the PDF document organizes by system number and/or name.
- .4 After any revisions requested by Consultant have been made and final review accepted by Consultant, submit the final TAB report in the following formats:
 - .1 two (2) hard copies of the completed report, each with index tabs and bound in "D" ring binders,
 - .2 electronic file PDF copies by email or drop-box as coordinated with Owner and Consultant.

8.4 Completion

- .1 Continue TAB until reports are approved.

- .2 The Substantial Performance of the Mechanical Work will be considered reached when the initial Start-Up and Performance Testing report is accepted by the Consultant and in the opinion of the Consultant all systems have been satisfactorily installed, operated tested, balanced, and adjusted to meet the specified and intended performance.
- .3 The substantial performance of the Work is not dependent upon alternate season testing.
- .4 The total performance of the Work will not be considered reached until the alternate season testing and balancing is completed and the final report submitted has been reviewed by Consultant and accepted by the Owner.

END OF SECTION

TESTING, ADJUSTING & BALANCING SUPPLEMENT FOR HEALTHCARE 23 05 93.23

1 GENERAL

1.1 Scope

- .1 Test, adjust, and balance ("TAB") airflows for rooms and spaces in healthcare facilities.
- .2 This section is supplementary to Specification section 23 05 93.13 and is to be read in conjunction with that section.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 05 93.13 Testing, Adjusting & Balancing for HVAC

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Differential airflow** – means the difference in the aggregate airflow rates of supply terminal outlets in a room or space minus the aggregate airflow rates of return air and exhaust air terminal inlets in the room or space, for design or measured flow rates.
 - .2 **Differential pressure** – means the design or measured air pressure of an enclosed room relative to the adjacent corridor, room or space.
 - .3 **Negative pressure (room)** – means a room where the net airflow movement is from adjacent spaces into the room.
 - .4 **Neutral pressure (room)** – means a room where the net airflow movement into/out from the room is essentially zero but may be have limited airflow into or out from the room.
 - .5 **Positive pressure (room)** – means a room where the net airflow movement is from the room to adjacent spaces,
 - .6 **Specialty Rooms** – means those room types as listed in Schedule A of this Specification section.

2 PRODUCTS

2.1 Not Used

3 EXECUTION

3.1 General

- .1 Balance air systems in accordance with Specification section 23 05 93.13 before performing room differential pressure balancing as specified herein.
- .2 For differential pressure, measure the room air pressure relative to the adjacent connecting corridor or room unless otherwise shown.
- .3 Where a space has dynamic differential pressure control, coordinate with the Division 25 contractor and supply measured data to allow configuration of Division 25 control sequences.

3.2 General Room and Space Differential Pressure Balancing Process

- .1 Application: all rooms and spaces that are not Specialty Rooms or Odour/Vapour Generating rooms specified herein.
- .2 For the purpose of this balancing process, the following definitions apply;
 - .1 A “positive pressure room” is one in which the design supply airflow rate exceeds the design return/exhaust airflow rates by 25 L/s (53 cfm) or more,
 - .2 A “negative pressure room” is one in which the design return/exhaust airflow rate exceeds the design supply air flow rate by 25 L/s (53 cfm) or more,
 - .3 A neutral pressure room is one that where the difference between the design supply airflow rate and the design return/exhaust airflow rate is less than 25 L/s (53 cfm).
- .3 Calculate the design differential airflow rates from design supply and return/exhaust airflow rates as shown on drawings. Record the design differential airflow rates in the TAB report.
- .4 Adjust room pressurization based on differential airflow:
 - .1 for positive and negative pressure rooms, adjust exhaust airflow rate until a balanced differential airflow of not less than 25 L/s (53 cfm), positive or negative as applicable to the room design differential airflow rate, is achieved unless a greater value is calculated or is as otherwise shown,
 - (a) acceptance criteria: measured differential airflow is within -0/+15% of design differential airflow.
 - .2 for neutral pressure rooms, adjust exhaust airflow rate until it is within the lessor of $\pm 5\%$ or 10 L/s (22 cfm) of the measured supply airflow rate,
- .5 Alternate method for rooms which are fully enclosed and provided with doors: balance room to achieve a differential pressure relative to adjacent connecting corridor or room, measured across the closed door;
 - .1 for positive pressure rooms, adjust exhaust airflow rate until a positive pressure of between +1.5 to +2.5 Pa (+0.006 to +0.01 in.w.c) is achieved and maintained for a time period of one (1) minute,
 - .2 for negative pressure rooms, adjust exhaust airflow rate until a negative pressure of between -1.5 to -2.5 Pa (-0.006 to -0.01 in.w.c) is achieved and maintained for a time period of one (1) minute,
 - .3 for neutral pressure rooms, adjust exhaust airflow rate until a relative pressure between -1.5 and +1.5 Pa (-0.006 and +0.006 in.w.c.) is achieved and maintained for a time period of one (1) minute.

3.3 Odour or Vapour Generating Rooms Differential Pressure Balancing Process

- .1 Application: washrooms, utility rooms, bathing rooms, shower rooms, wash-down rooms, waste storage rooms, and other contaminated storage rooms.
 - .1 Adjust room exhaust airflow rates to achieve a negative room differential pressure of not less than 2.5 Pa (0.03 in.w.c.) and maintained for a time period of two (2) minutes,
- .2 Acceptance criteria: measured differential pressure is within -0/+15% of design differential pressure.

3.4 Specialty Room Differential Pressure Balancing Process

- .1 Application: all rooms with permanent differential pressure sensors used for differential pressure control (directly or indirectly) as listed in Schedule A at the end of this specification section.
- .2 Adjust room airflow rates to achieve the required room differential pressure as listed in Schedule A at the end of this specification section, and which is maintained for a test time period of ten (10) minutes,

- .1 for positive pressure rooms, adjust the return/exhaust airflow rates,
- .2 for negative pressure rooms, adjust the return/exhaust airflow rates. If necessary, the supply airflow rate may be reduced by up to 5% of design supply airflow value to achieve the required negative pressure.
- .3 For rooms which have anterooms (vestibules);
 - .1 first adjust airflow rates to achieve required differential pressure between the room and the connecting corridor,
 - .2 then adjust airflow rates in the anteroom to achieve required differential pressures.
- .4 Acceptance criteria: measured differential pressure is within -0/+15% of design differential pressure.

3.5 Site Acceptance Testing

- .1 After completion of differential pressure balancing, conduct Site Acceptance Testing ("SAT") of the Specialty Rooms in the presence and to the satisfaction of the Owner's representative(s) before equipment is permanently placed into service, for up to 10% of Specialty Rooms as selected by the Owner or Consultant.
- .2 SAT to include the following:
 - .1 Continuous measurement and recording of room differential pressure under static conditions, with all doors to the rooms closed for at least 5 minutes prior to the test, and measured for a period of ten (10) minutes,
 - .2 continuous measurement and recording of room differential pressure during an upset condition caused by the opening of a door to the connecting corridor for a period of 30 seconds;
 - (a) record the differential pressure vs time from the start of the door opening until time required after the door has closed for the room to return to 90% of the static differential pressure.

3.6 Commissioning Program

- .1 Comply with the project commissioning requirements in accordance with specification section 20 08 15 and Division 01 requirements.
- .2 The verification and testing requirements specified in this section may be concurrent with, or conducted separate from, the commissioning program, as coordinated with the Contractor and the commissioning authority.

3.7 Test and Installation Records

- .1 Provide the following test records to the Owner and a copy to Consultant.
 - .1 design and measured differential airflow and differential pressures for each room, to be included in the main TAB report,
 - .2 SAT results, to be included in the main TAB report.

3.8 Schedules

- .1 The following equipment schedules form part of this specification section.
 - .1 Schedule A: Specialty Room Differential Pressure Values

SCHEDULE A – Specialty Room Differential Pressure Values

Notes for the following table:

[1] Open areas with no physically closed interior boundary, or enclosed rooms where doors are frequently open.

[2] Unless otherwise stated, room pressure is measured relative to adjacent corridor serving the room.

Occupancy	Room Type	Measurement Parameter (minimum)	Positive or Negative [Note 2]
Healthcare	Treatment rooms, Operative birthing rooms, Operating rooms, Sterile storage and core spaces, Medical device reprocessing, Invasive imaging rooms,	2.5 Pa (0.01 in.w.c.)	Positive
	Biomedical waste treatment, Autopsy	2.5 Pa (0.01 in.w.c.)	Negative
	Protective Environment Rooms (PER)	7.5 Pa (0.03 in.w.c.)	Positive to corridor
	Airborne Isolation Rooms (AIR)	7.5 Pa (0.03 in.w.c.)	Negative to corridor
			Negative to adjacent (non-communicating) spaces
	AIR anteroom	2.5 Pa (0.01 in.w.c.)	Negative to corridor
			Positive to AIR room
	Combination PER/AIR Room	7.5 Pa (0.03 in.w.c.)	Positive to corridor (PER mode)
			Negative to Corridor (AIR mode)
	Combination PER/AIR Room Anteroom	2.5 Pa (0.01 in.w.c.)	Negative to corridor
Negative to PER/AIR room			
Airborne Isolation Process Rooms	7.5 Pa (0.03 in.w.c.)	Negative to corridor	

Occupancy	Room Type	Measurement Parameter (minimum)	Positive or Negative [Note 2]
	Combination Airborne Isolation/Protective Isolation Process Room Anteroom	2.5 Pa (0.01 in.w.c.)	Negative to corridor
			Negative to process room
Laboratories	Rooms with chemical fume hoods	2.5 Pa (0.01 in.w.c.)	Negative
	Rooms with biological hoods	5.0 Pa (0.02 in.w.c.)	Negative
Pharmacies	Hazardous compounding	2.5 Pa (0.01 in.w.c.)	Negative
	Hazardous compounding anteroom	5.0 Pa (0.02 in.w.c.)	Positive to corridor
		2.5 Pa (0.01 in.w.c.)	Positive to compounding room
	Clean compounding	12.5 Pa (0.05 in.w.c.)	Positive
	Clean compounding anteroom	7.5 Pa (0.03 in.w.c.)	Positive to corridor
		5.0 Pa (0.02 in.w.c.)	Negative to compounding room

End of Section

HYDRONIC PIPING – CARBON STEEL

23 21 13.23

1 GENERAL

1.1 Scope

- .1 Provide carbon steel pipe and fittings for HVAC liquid piping systems. Refer to section 23 05 01 for piping system applicability.
- .2 This specification applies to liquid piping systems with design pressures not exceeding 2750 kPa (400 psig) at temperatures not exceeding 121°C (250°F), except as otherwise specified.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 23 05 01 HVAC Piping Systems General Requirements
 - .3 23 25 05 HVAC Pipe Cleaning

1.3 Applicable Codes and Standards

- .1 Legislation:
 - .1 Refer to section 23 05 01.
- .2 Installation standards and codes:
 - .1 Refer to section 23 05 01.
- .3 Product standards:
 - .1 ANSI A21.11 Rubber Gasket joints for Ductile-Iron Pressure Pipe and Fittings
 - .2 ANSI B1.20.1 Pipe Threads, General Purpose (inch)
 - .3 ASME B16.1 Cast Iron Pipe Flanges And Flanged Fittings
 - .4 ASME B16.3 Malleable Iron Threaded Fittings.
 - .5 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .6 ASME B16.9 Factory Made Wrought Steel Buttwelding Fittings
 - .7 ASME B36.10 Welded and Seamless Wrought Steel Pipe
 - .8 ASME B16.11 Forged Steel Fittings, Socket-Welding and Threaded
 - .9 ASME B16.20 Metallic Gaskets for Pipe Flanges: Ring Joint Spiral Wound and Jacketed.
 - .10 ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges.
 - .11 ASME B16.39 Malleable Iron Threaded Pipe Unions: Classes 150, 250 and 300.
 - .12 ASTM A47 Standard Specification for Ferritic Malleable Iron Castings.
 - .13 ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - .14 ASTM A105 Standard Specification for Carbon Steel Forgings for Piping Applications

- .15 ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
- .16 ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
- .17 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
- .18 ASTM A536 Standard Specification for Ductile Iron Castings.
- .19 CSA B242 Groove and Shoulder Type Mechanical Pipe Couplings

2 PRODUCTS

2.1 Pipe

- .1 Carbon steel pipe:
 - .1 to ASTM A53 Grade B, seamless or electric resistance welded (type “A53”),
 - .2 to ASTM A106 Grade B (type “A106”),
- .2 Select pipe material and wall thickness/schedule (as defined in ASME B36.10), based on pipe size, design temperature and jointing method in accordance with the following table:
 - .1 Acceptable substitutions:
 - (a) where only type A53 is specified, then A106 may be used,
 - (b) where only type A106 is specified, then piping with dual certification for meeting both ASTM A53 Grade B seamless and ASTM A106 Grade B seamless may be used.

Pipe Size NPS	Piping Design Temperature	Pipe Joint Method	Pipe Material	Pipe Wall Thickness
≤ 2-1/2	≤ 105°C (220°F)	All	A106, A53	Schedule 40
	>105°C (220°F)	Threaded or cut grooved	A106	Schedule 80
		Welded, flanged, roll grooved	A106, A53	Schedule 40
3 to 10	≤ 121°C	All	A53	Schedule 40
12 to 18	≤ 121°C	All	A53	Standard – 9.5 mm (0.375 in.)
20 to 24	≤ 121°C	All	A53	Schedule 30

2.2 Pipe Joints and Fittings

- .1 Threaded fittings:
 - .1 End connections: NPT thread to ANSI B1.20.1.
 - .2 Fittings: Class 150 and Class 300, malleable iron to ASME B16.3..
 - .3 Unions: Class 150 and Class 300, malleable iron body with ground joint and bronze face to ASME B16.39.
 - .4 Threaded joint compound: pulverized lead paste or Teflon pipe tape sealant.

Standard of Acceptance

- Masters Pro-Dope
- Masters Orange or White Tape.

.2 Welding fittings:

.1 Butt weld fittings:

- (a) Forged to ASME B16.9,
- (b) wall thickness to match pipe,
- (c) long radius elbows.

.2 Welding outlet fittings:

- (a) forged to ASTM A105,
- (b) dimensions and pressure ratings to MSS SP-97, Standard Class for buttwelding branch connection and Class 3000 for threaded or socket welded branch connection,
- (c) NPT ends to ASME B1.20.1.

.3 Socket welded fittings:

- (a) forged to ASTM A105,
- (b) dimensions and pressure ratings to ASME B16.11, Class 3000.

.4 Half couplings:

- (a) forged carbon steel to ASTM A105,
- (b) dimensions and pressure rating to ASME B16.11, Class 3000 socket weld or threaded ends,
- (c) NPT ends to ASME B1.20.1.

.3 Flanges:

- .1 Flat-faced cast iron to ANSI B16.1, Class 125.
- .2 Raised-face forged carbon steel to ASME B16.5, Class 150 and Class 300, weld neck with wall thickness to match pipe, or slip on type.
- .3 Studs and bolts: to ASTM A193, Grade B7,
- .4 Nuts: to ASTM A194 Grade 2H or 2HM,
- .5 Gaskets to ANSI B16.21, ANSI B16.20 or ANSI A21.11.

Standard of Acceptance

- Chesterton - fig. 100, 195 and 450
- Beldam

3 EXECUTION

3.1 Piping Installation

- .1 Refer to section 23 05 01 for piping design criteria and general requirements for piping installation.
- .2 Slope main piping horizontal or up in direction of flow nominally at a slope of 1:500 (0.2%);
 - .1 branch piping to have greater slope,
 - .2 slope piping up in direction of terminal heating and cooling devices,

- .3 where supply and return piping are grouped together and flow is in opposite directions, arrange piping horizontal.
- .3 Use eccentric reducers at pipe size changes arranged flat-on-top to assist venting.
- .4 Cap ends during construction to prevent entry of foreign matter.

3.2 Class Rated Fittings and Flanges Selection

- .1 Select ASME Class rated fittings and flanges in accordance with the following table for design pressure limits at coincident design temperature limits unless otherwise shown on drawings.

Class	Maximum Design Pressure	Maximum Coincident Design Temperature
125 Note [1]	900 kPa (130 psi)	≤ 65°C (150°F)
125 Note [1]	700 kPa (100 psi)	≤ 121°C (250°F)
150	1720 (250 psi)	≤ 38°C (100°F)
150	1400 kPa (200 psi)	≤ 121°C (250°F)
300	3700 kPa (535 psi)	≤ 38°C (100°F)
300	3100 kPa (450 psi)	≤ 121°C (250°F)

Notes:

[1] For flanges only.

3.3 Pipe Joints and Fittings

- .1 Make pipe joints as follows.
 - .1 Piping NPS 2-1/2 and under:
 - (a) NPT threaded joint to ANSI B1.20.1 and made with Teflon tape or pipe dope, or
 - (b) socket weld joints.
 - .2 Piping NPS 2-1/2 and larger:
 - (a) welded,
 - (b) flanged.
 - .3 For clarity, pipe size of NPS 2-1/2 may be either type of joint specified.
- .2 For flange joints, select gasket materials in accordance with the following table so that gasket pressure and temperature both exceed the piping system design pressure and design temperature.

Gasket Temperature Limit	Gasket Pressure Limit	Gasket Material	Gasket Thickness	Chesterton Figure
80°C (180°F)	1720 kPa (250 psig)	Red rubber	1.6 mm (1/6 in)	100
200°C (390°F)	2400 kPa (350 psig)	Synthetic fiber with nitrile binder	1.6 mm (1/6 in)	450
400°C (750°F)	3700 kPa (535 psig)	Synthetic fiber with nitrile binder	1.6 mm (1/6 in)	195

3.4 Equipment connections

- .1 Make pipe connections to equipment as follows:
 - .1 NPS 2 and smaller: threaded fittings.
 - .2 NPS 2 ½ and larger:
 - (a) flanged connections
- .2 Where connection is made to equipment with a threaded fitting, provide a union between the isolation valve and the equipment connection.

3.5 Welding

- .1 Comply with section 20 05 24 and as specified herein.

3.6 Branch Connections

- .1 Make branch connections to mains in accordance with Table 2a and 2b.
 - .1 These tables are valid for design pressures up to 2070 kPa (300 psig), without adding reinforcement material where branch pipe is directly welded to the main. For welded branch connections at higher design pressures, use butt weld, socket weld, or integrally reinforced outlet fittings only.
 - .2 In these tables, the following abbreviations apply.

Abbreviations:

- TH Threaded fitting to ASME B16.3
- SW Socket weld fittings to ASME B16.11
- HC Half coupling to ASME B16.11
- BW Buttweld fitting to ASME B16.9
- OF Reinforced Outlet Fittings to MSS SP-97
- DP Direct welding of Branch Pipe to Main without added reinforcement.

Table 2a – Allowable Branch to Main Connections (NPS 1 to NPS 10)										
Branch NPS	Mains Pipe, NPS									
	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10
3/4	TH SW	TH SW	TH SW	TH SW	BW SW	BW, OF SW HC DP	BW, OF SW HC DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
1	TH SW	TH SW	TH SW	TH SW	BW SW	BW, OF SW DP	BW, OF SW HC DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
1-1/4	---	TH SW	TH SW	TH SW	BW SW	BW, OF SW DP	BW, OF SW DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
1-1/2	---	---	TH SW	TH SW	BW SW	BW, OF SW DP	BW, OF SW DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
2	---	---	---	TH SW	BW SW	BW, OF SW	BW, OF SW DP	BW, OF DP	BW, OF HC DP	BW, OF HC DP
2-1/2	---	---	---	---	BW SW	BW, OF SW	BW, OF SW	BW, OF DP	BW, OF DP	BW, OF DP
3	---	---	---	---	---	BW	BW, OF SW	BW, OF DP	BW, OF DP	BW, OF DP
4	---	---	---	---	---	---	BW	BW, OF	BW, OF DP	BW, OF DP
6	---	---	---	---	---	---	---	BW	BW, OF	BW, OF DP
8	---	---	---	---	---	---	---	---	BW	BW, OF
10	---	---	---	---	---	---	---	---	---	BW

Table 2b – Allowable Branch to Main Connections (NPS 12 to NPS 30)								
Branch NPS	Mains Pipe, NPS							
	12	14	16	18	20	22	24	30
¾ to 2	OF HC DP	OF HC DP	OF HC	OF HC	OF HC	OF HC	OF HC	OF HC
2-1/2	OF DP	OF DP	OF	OF	OF	OF	OF	OF
3	OF DP	OF DP	OF	OF	OF	OF	OF	OF
4	BW OF DP	OF DP	OF	OF	OF	OF	OF	OF
6	BW OF DP	BW OF DP	BW OF	OF	OF	OF	OF	OF
8	BW OF DP	BW OF DP	BW OF	BW OF	BW OF	OF	OF	OF
10	BW OF DP	BW OF DP	BW OF	BW OF	BW OF	BW OF	BW OF	OF
12	BW	BW OF DP	BW OF	BW OF	BW OF	BW OF	BW OF	OF
14	---	BW	BW OF	BW OF	BW OF	BW OF	BW OF	BW OF
16	---	---	BW	BW OF	BW OF	BW OF	BW OF	BW OF
18	---	---	---	BW	BW OF	BW OF	BW OF	BW OF
20	---	---	---	---	BW	BW OF	BW OF	BW OF
22	---	---	---	---	---	BW	BW OF	BW OF
24	---	---	---	---	---	---	BW	BW OF
30	---	---	---	---	---	---	---	BW

- .2 Use of Class 3000 half-couplings as a branch connector (“HC”), and direct welding of branch piping to main piping (“DP”), is permitted in accordance with the following requirements:
- .1 half-coupling or branch pipe sits-on mains pipe, and does not insert into the main pipe,
 - .2 the opening size in the main pipe to closely follow the inside diameter of the half-coupling or branch pipe,
 - .3 half-coupling or branch pipe attachment end is shaped and beveled to closely following the surface of the main pipe, suitable for a pull-penetration weld,

- .4 the half-coupling or direct branch pipe is attached with a groove weld and covered with a smooth finishing fillet weld in accordance with the requirements of the applicable piping code.
- .3 Where integrally reinforced outlet fittings, half-couplings or direct welding of branch pipe is used, hole saw or drill and ream mains pipe to maintain full inside diameter of branch line prior to welding.
- .4 Where multiple branch pipes are to connect to the main pipe in close proximity to each other, provide a minimum separation between the centerlines of adjacent branch pipes equal to or greater than the sum of the OD dimensions of the adjacent branch pipes.
- .5 If threaded fittings have been installed where the specification requires welded fittings, either cut-out and replace the fitting, or fully seal-weld the exposed threads.
- .6 Where saddle type branch welding fittings are used on mains, hole saw or drill and ream main to maintain full inside diameter of branch line prior to welding.

3.7 Pressure Testing

- .1 Conduct pressure and leak tests in accordance with section 23 05 01.

3.8 Flushing and Cleaning

- .1 After pressure testing, clean piping in accordance with Section 23 25 05.
- .2 For piping changes to existing systems, which consist of NPS 2 and smaller branch piping to terminal heating or cooling equipment, the following abbreviated cleaning and flushing procedure may be used:
 - .1 After cutting of threads and de-burring, and before installation of piping, manually clean the interior of the pipe with wire-brush on an extended rod, while washing the inside of the pipe with a solution of non-foaming, phosphate free detergent, 3% by weight, followed by a hose rinse flushed to drain until water runs clear.
 - .2 After installation of piping, check strainers are clean, and open isolation valves to use service water for pressure testing and final flush.
 - .3 After pressure testing, isolate new piping from existing piping, fully open control valves (where installed) and flush service water to drain. Use compressed air at not more than 70 kPa (10 psig) to assist in flushing the water.
 - .4 Refill system with service water and circulate for two hours. Inspect strainers, and repeat drain, fill and recirculate routine until strainers are free of debris.

END OF SECTION

HYDRONIC PIPING – STAINLESS STEEL

23 21 13.26

1 GENERAL

1.1 Scope

- .1 Provide stainless steel pipe and fittings for HVAC liquid piping systems. Refer to section 23 05 01 for piping system applicability.
- .2 This specification applies to liquid piping systems with design pressures not exceeding 2750 kPa (400 psig) at temperatures not exceeding 121°C (250°F, except as otherwise specified).

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 23 05 01 HVAC Piping Systems General Requirements
 - .3 23 25 05 HVAC Pipe Cleaning

1.3 Applicable Codes and Standards

- .1 Legislation:
 - .1 Refer to section 23 05 01.
- .2 Installation standards and codes:
 - .1 Refer to section 23 05 01.
- .3 Product standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose (inch)
 - .2 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .3 ASME B16.9 Factory-Made Wrought Steel Buttwelding Fittings
 - .4 ASME B16.11 Forged Fittings, Socket Welding and Threaded
 - .5 ASME B16.20 Metallic Gaskets for Pipe Flanges; Ring-Joint, Spiral-Wound, and Jacketed
 - .6 ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges.
 - .7 ASTM A182 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
 - .8 ASTM A312 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
 - .9 ASTM A269 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - .10 ASTM A351 Standard Specification for Castings, Austenitic, for Pressure Containing Parts
 - .11 ASTM A403 Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings

- .12 ASTM A182 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service.
- .13 ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature
- .14 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- .15 AWS D18.2 Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube
- .16 MSS SP-114 Corrosion Resistant Pipe Fittings Threaded and Socket Welding Class 150 and 1000

2 PRODUCTS

2.1 Pipe

.1 Stainless steel pipe:

.1 All sizes

(a) ASTM A312 Type 304/304L and 316/316L, seamless or welded, and pipe schedule in accordance with the following table.

Joint Method	Pipe Size NPS	Maximum System Design Pressure	Schedule
Welding (butt weld, socket weld)	NPS ½ to NPS 6	2750 kPa (400 psig)	10
	NPS 8 to 18	1720 kPa (250 psig)	10
		2750 kPa (400 psig)	40/40S
	NPS 20 to 24	1030 kPa (150 psig)	10
		1720 kPa (250 psig)	40/40S
		2750 kPa (400 psig)	40
Threaded	NPS ½ to NPS 2	2750 kPa (400 psig)	40/40S

2.2 Pipe Joints and Fittings

.1 Threaded fittings:

.1 End connections: NPT thread to ANSI B1.20.1.

.2 Fittings: Class 150 and Class 1000 to MSS SP-114, and material to ASTM A351 Gr. CF8 or CF8M stainless steel to match pipe grade.

.3 Unions: Class 150 and Class 1000 to MSS SP-114, and material to ASTM A182 Gr. CF8 or CF8M stainless steel to match pipe grade, with ground joint and face.

- .4 Threaded joint compound: Teflon pipe tape sealant.

Standard of Acceptance

- Masters Orange or White Tape.

- .2 Welding fittings:

- .1 Pipe fittings of same steel alloy and grade as connected pipe.

- .2 Butt-weld fittings:

- (a) forged stainless steel fitting to ASTM A403,
- (b) wall thickness to match pipe,
- (c) elbows to be long radius type.

- .3 Welding outlet fittings:

- (a) forged stainless steel to ASTM A182,
- (b) dimensions and pressure ratings to MSS SP-97, Standard Class for buttwelding branch connection and Class 3000 for threaded or socket welded branch connection,
- (c) NPT ends to ASME B1.20.1.

- .4 Socket welded fittings:

- (a) forged stainless steel to ASTM A182,
- (b) dimensions and pressure ratings to ASME B16.11, Class 3000.

- .5 Half couplings:

- (a) forged stainless steel to ASTM A351,
- (b) dimensions and pressure rating to ASME B16.11, Class 3000 socket weld or threaded ends,
- (c) NPT ends to ASME B1.20.1.

- .3 Flanges:

- .1 Raised face forged stainless steel to ASTM A182, Class 150 and Class 300, weld neck with wall thickness to match pipe, or slip on type.
- .2 Studs and bolts: to ASTM A193, Grade B8M Class 2,
- .3 Nuts: to ASTM A194 Grade B8M Class 2,
- .4 Gaskets for flanges to ANSI B16.21, ANSI B16.20 or ANSI A21.11.

Standard of Acceptance

- Chesterton - fig. 100, 195 and 450
- Beldam
- Ameraflex Sealing Products Co.

3 EXECUTION

3.1 Piping Installation

- .1 Refer to section 23 05 01 for piping design criteria and general requirements for piping installation.
- .2 Slope main piping horizontal or up in direction of flow nominally at a slope of 1:500 (0.2%);
 - .1 branch piping to have greater slope,
 - .2 slope piping up in direction of terminal heating and cooling devices,

- .3 where supply and return piping are grouped together and flow is in opposite directions, arrange piping horizontal.
- .3 Use eccentric reducers at pipe size changes arranged flat-on-top to assist venting.
- .4 Cap ends during construction to prevent entry of foreign matter.

3.2 Stainless Steel Grade Selection

- .1 Provide the grade of stainless steel piping in accordance with the following table.

Piping System	Grade
All systems	304/304L

3.3 Class Rated Fittings and Flanges

- .1 Select ASME Class rated fittings and flanges in accordance with the following table for design pressure limits at coincident design temperature limits unless otherwise shown on drawings.

Class	Maximum Design Pressure	Maximum Coincident Design Temperature
150	1720 (250 psi)	≤ 38°C (100°F)
150	1400 kPa (200 psi)	≤ 121°C (250°F)
300	3700 kPa (535 psi)	≤ 38°C (100°F)
300	3100 kPa (450 psi)	≤ 121°C (250°F)

3.4 Pipe Joints and Fittings

- .1 Make pipe joints as follows.
 - .1 Piping NPS 2-1/2 and under:
 - (a) NPT threaded joint to ANSI B1.20.1 and made with Teflon tape, or
 - (b) socket welded.
 - .2 Piping NPS 2-1/2 and larger:
 - (a) flanged or welded.
- .2 For flange joints, select gasket materials in accordance with the following table so that gasket pressure and temperature both exceed the piping system design pressure and design temperature.

Gasket Temperature Limit	Gasket Pressure Limit	Gasket Material	Gasket Thickness	Chesterton Figure

Gasket Temperature Limit	Gasket Pressure Limit	Gasket Material	Gasket Thickness	Chesterton Figure
80°C (180°F)	1720 kPa (250 psig)	Red rubber	1.6 mm (1/6 in)	100
200°C (390°F)	2400 kPa (350 psig)	Synthetic fiber with nitrile binder	1.6 mm (1/6 in)	450
400°C (750°F)	3700 kPa (535 psig)	Synthetic fiber with nitrile binder	1.6 mm (1/6 in)	195

3.5 Equipment Connections

- .1 Make pipe connections to equipment as follows.
 - .1 NPS 2 and smaller: threaded fittings.
 - .2 NPS 2 ½ and larger:
 - (a) flanged connections
- .2 Where connection is made to equipment with a threaded fitting, provide a union between the isolation valve and the equipment connection.

3.6 Welding

- .1 Comply with section 20 05 24 and as specified herein.
- .2 Weld pipe using automatic orbital tungsten inert gas (“TIG”) welding.
 - .1 Exception: use hand TIG weld for socket welds, at integrally reinforced branch outlet fittings, and slip-on flanges.
 - .2 Hand TIG tack welding for alignment of stainless steel pipe is permitted, prior to automatic welding.
- .3 Continuously purge inside of pipes with argon backing gas during welding;
 - .1 Provide a purge restrictor on pipe to maintain oxygen levels below a nominal 50 ppm inside of pipe; actual oxygen concentration is as required to obtain a heat affected zone (“HAZ”) colour of No. 3 in accordance with AWS D18.2.
 - .2 Inject argon within 150 mm of weld - use extension tubes as necessary.
 - .3 Use portable oxygen analyzers reading ppm on pipe sizes NPS 2 ½ and larger, to check oxygen levels at purge outlet.
 - .4 Time purging is acceptable on pipe sizes NPS 2 and smaller.
- .4 Use of backing gas is not required where the inside surface of the weld is accessible for removal of the HAZ weld tint by grinding or manual application of pickling compound to remove the weld tint.

3.7 Branch Connections

- .1 Make branch connections to mains in accordance with Table 2a and 2b.

- .1 These tables are valid for design pressures up to 2070 kPa (300 psig), without adding reinforcement material where branch pipe is directly welded to the main. For welded branch connections at higher design pressures, use buttweld or integrally reinforced outlet fittings only.
- .2 In these tables, the following abbreviations apply.

Abbreviations:

- TH Threaded fitting to ASME B16.3
 SW Socket weld fittings to ASME B16.11
 HC Half coupling to ASME B16.11
 BW Butt weld fitting to ASME B16.9
 OF Reinforced Outlet Fittings to MSS SP-97
 DP Direct welding of Branch Pipe to Main without added reinforcement.

Table 2a – Allowable Branch to Main Connections (NPS 1 to NPS 10)										
Branch NPS	Mains Pipe, NPS									
	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10
3/4	TH SW	TH SW	TH SW	TH SW	BW SW	BW, OF SW HC DP	BW, OF SW HC DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
1	TH SW	TH SW	TH SW	TH SW	BW SW	BW, OF SW DP	BW, OF SW HC DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
1-1/4	---	TH SW	TH SW	TH SW	BW SW	BW, OF SW DP	BW, OF SW DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
1-1/2	---	---	TH SW	TH SW	BW SW	BW, OF SW DP	BW, OF SW DP	BW, OF HC DP	BW, OF HC DP	BW, OF HC DP
2	---	---	---	TH SW	BW SW	BW, OF SW	BW, OF SW DP	BW, OF DP	BW, OF HC DP	BW, OF HC DP
2-1/2	---	---	---	---	BW SW	BW, OF SW	BW, OF SW	BW, OF DP	BW, OF DP	BW, OF DP
3	---	---	---	---	---	BW	BW, OF SW	BW, OF DP	BW, OF DP	BW, OF DP
4	---	---	---	---	---	---	BW	BW, OF	BW, OF DP	BW, OF DP

Table 2a – Allowable Branch to Main Connections (NPS 1 to NPS 10)										
6	---	---	---	---	---	---	---	BW	BW, OF	BW, OF DP
8	---	---	---	---	---	---	---	---	BW	BW, OF
10	---	---	---	---	---	---	---	---	---	BW

Table 2b – Allowable Branch to Main Connections (NPS 12 to NPS 30)								
Branch NPS	Mains Pipe, NPS							
	12	14	16	18	20	22	24	30
¾ to 2	OF HC DP	OF HC DP	OF HC	OF HC	OF HC	OF HC	OF HC	OF HC
2-1/2	OF DP	OF DP	OF	OF	OF	OF	OF	OF
3	OF DP	OF DP	OF	OF	OF	OF	OF	OF
4	BW OF DP	OF DP	OF	OF	OF	OF	OF	OF
6	BW OF DP	BW OF DP	BW OF	OF	OF	OF	OF	OF
8	BW OF DP	BW OF DP	BW OF	BW OF	BW OF	OF	OF	OF
10	BW OF DP	BW OF DP	BW OF	BW OF	BW OF	BW OF	BW OF	OF
12	BW	BW OF DP	BW OF	BW OF	BW OF	BW OF	BW OF	OF
14	---	BW	BW OF	BW OF	BW OF	BW OF	BW OF	BW OF
16	---	---	BW	BW OF	BW OF	BW OF	BW OF	BW OF
18	---	---	---	BW	BW OF	BW OF	BW OF	BW OF
20	---	---	---	---	BW	BW OF	BW OF	BW OF
22	---	---	---	---	---	BW	BW OF	BW OF
24	---	---	---	---	---	---	BW	BW OF
30	---	---	---	---	---	---	---	BW

- .2 Use of Class 3000 half-couplings as a branch connector (“HC”), and direct welding of branch piping to main piping (“DP”), is permitted in accordance with the following requirements:
 - .1 half-coupling or branch pipe sits-on mains pipe, and does not insert into the main pipe,
 - .2 the opening size in the main pipe to closely follow the inside diameter of the half-coupling or branch pipe,

- .3 half-coupling or branch pipe attachment end is shaped and beveled to closely following the surface of the main pipe, suitable for a pull-penetration weld,
- .4 the half-coupling or direct branch pipe is attached with a groove weld and covered with a smooth finishing fillet weld in accordance with the requirements of the applicable piping code.
- .3 Where integrally reinforced outlet fittings, half-couplings or direct welding of branch pipe is used, hole saw or drill and ream mains pipe to maintain full inside diameter of branch line prior to welding.
- .4 Where multiple branch pipes are to connect to the main pipe in close proximity to each other, provide a minimum separation between the centerlines of adjacent branch pipes equal to or greater than the sum of the OD dimensions of the adjacent branch pipes.
- .5 If threaded fittings have been installed where the specification requires welded fittings, either cut-out and replace the fitting, or fully seal-weld the exposed threads.
- .6 Where saddle type branch welding fittings are used on mains, hole saw or drill and ream main to maintain full inside diameter of branch line prior to welding.

3.8 Pressure Testing

- .1 Conduct pressure and leak tests in accordance with section 23 05 01.

3.9 Flushing and Cleaning

- .1 After pressure testing, clean piping in accordance with Section 23 25 05.
- .2 For piping changes to existing systems, which consist of NPS 2 and smaller branch piping to terminal heating or cooling equipment, the following abbreviated cleaning and flushing procedure may be used:
 - .1 After cutting of threads and de-burring, and before installation of piping, manually clean the interior of the pipe with wire-brush on an extended rod, while washing the inside of the pipe with a solution of non-foaming, phosphate free detergent, 3% by weight, followed by a hose rinse flushed to drain until water runs clear.
 - .2 After installation of piping, check strainers are clean, and open isolation valves to use service water for pressure testing and final flush.
 - .3 After pressure testing, isolate new piping from existing piping, fully open control valves (where installed) and flush service water to drain. Use compressed air at not more than 70 kPa (10 psig) to assist in flushing the water.
 - .4 Refill system with service water and circulate for two hours. Inspect strainers, and repeat drain, fill and recirculate routine until strainers are free of debris.

3.10 Post-weld Pickling

- .1 The following post-weld pickling procedure may be omitted when approved by the Consultant where all of the following conditions are met:
 - .1 A written welding procedure and test plan is provided for review by the Consultant prior to any welding work, which demonstrates the control measures used to ensure proper use of backing (internal purging) gas to control formation of HAZ weld tint on the inside of the pipe.
 - .2 Orbital automatic TIG welding is used for butt-weld joints.
 - .3 Three welding samples of NPS 2, NPS 4 and NPS 6 is supplied to the Consultant prior to production welding as follows:
 - (a) a complete butt-weld using automatic orbital TIG welding, with each sample split lengthwise to expose the interior weld surface for examination;

- (b) one (1) example for an integrally reinforced welding outlet fitting, using hand TIG welding, with interior surface exposed for examination;
 - (c) the interior HAZ heat tint is not greater than the No. 4 sample colour in accordance with AWS D18.2.
- .4 A completed and signed report is submitted for review by the Consultant at the completion of welding associated to each piping system, prior to flushing and cleaning of the piping.
- .2 After flushing and cleaning, provide the services of a specialist pipe cleaning company to chemically pickle the stainless steel piping and tubing, to remove weld heat tint where welded pipe joints or fittings are used.
 - .1 At completion of tests, drain down and dispose of cleaning chemicals as contaminated acid waste.

Standard of Acceptance

- CEDA - Reactor Ltd.
- .3 Select or provide a spool section with flanged ends at both ends and a butt-weld, to be used for final demonstration of pickling effectiveness. A weld-neck flange is suitable for this purpose.
 - .4 Provide test sample pipe welds of the type and size when requested by the specialist pipe cleaning company. The specialist company shall evaluate and determine the appropriate pickling method. The acceptance criteria is to achieve colour No. 4 in accordance with AWS D18.2.
 - .5 Chemically pickle inside of piping to remove weld heat tint.
 - .1 provide temporary cross connections to bypass equipment;
 - .2 temporarily remove flexible connections at pumps and install stainless steel spool pieces. Reinstall flexible connections after completion of pickling program;
 - .3 bypass piping material: stainless steel 304, threaded, flanged, or welded. Hoses as recommended by the chemical cleaning company may be used;
 - .4 provide temporary circulating pumps and power supplies.
 - .6 Continuously circulate pickling solution and periodically check concentration levels. Temporarily remove the spool test piece to permit visual inspection of the flange and butt welds. Continue to clean pipe until the acceptance criteria is achieved.
 - .7 At completion of pickling, drain down and dispose of liquid solution as contaminated waste.
 - .8 Mechanically grind or hand-pickle to remove HAZ weld tint on the outside pipe surface where the pipe is located outdoors, or where it is uninsulated indoors.
 - .9 Prepare and submit a report from the specialist cleaning company at completion of pickling and passivation treatments, which details the results of the test. Include photographs of interior surface finishes at accessible butt-weld joints.

3.11 Passivation

- .1 Passivate inside of piping with nitric acid to ASTM A380 standard.
 - .1 Passivation may form part of the pickling process, or may be post-pickling.
- .2 Provide temporary bypass piping around water storage tank.

- .3 At completion of passivation, drain down and dispose of passivation chemical as contaminated waste. Refill the system with clean municipal water for a final rinse and then completely drain the system. Do not allow municipal water to remain in the piping system.

3.12 Final Fill

- .1 Fill the piping system with reverse osmosis or deionized treated water that is pretreated to remove chlorine. The required water quality is to achieve a water resistivity of at least 60,000 $\Omega \cdot \text{cm}$. The use of other water sources including softened water, dealkalized water or municipal water is not permitted.
- .2 Circulate water for four hours. Take a water sample and have it analyzed at a accredited testing laboratory and submit the report to the Owner for acceptance.

END OF SECTION

HYDRONIC PIPING - COPPER

23 21 13.33

1 GENERAL

1.1 Scope

- .1 Provide copper tube and fittings for HVAC liquid piping systems for aboveground and underground installations for the following applications:
 - .1 (as an alternative to steel piping) final connections not exceeding 1 m (39 in) in length to terminal heating units which have copper tube coils, copper tube heating elements, and copper tube radiant panels,
 - .2 tubing located in slabs or under slab-on-grade floors to connect to terminal heating or cooling units,
 - .3 drain and vent piping for equipment and piping systems (except cooling tower drainage piping).
 - .4 non-potable make-up water piping for HVAC services, or
 - .5 where otherwise shown.
- .2 The use of copper tube is limited to nominal tube sizes NPS 3 and under.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 23 05 01 Heating and Cooling Piping Systems General Requirements
 - .3 23 25 05 HVAC Pipe Cleaning

1.3 Applicable codes and standards

- .1 Legislation:
 - .1 Refer to section 23 05 01.
- .2 Installation standards and codes:
 - .1 Refer to section 23 05 01.
- .3 Product standards:
 - .1 ASME B16.15 Cast Bronze Threaded Fittings, Classes 125 and 250
 - .2 ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
 - .3 ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
 - .4 ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - .5 ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings; Class 150, 300, 400, 600, 900, 1500, & 2500.
 - .6 ASME B16.50 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
 - .7 ASTM A307 Standard Specification for Carbon Steel Bolts and Studs 60,000PSI Tensile Strength
 - .8 ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts

.9	ASTM B32	Standard Specification for Solder Metal
.10	ASTM B88	Standard Specification for Seamless Copper Water Tube
.11	ASTM B813	Standards Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
.12	ASTM B828	Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
.13	AWS A5.8	Specification for Filler Metals for Brazing and Braze Welding
.14	AWS A5.31	Specification for Fluxes for Brazing and Braze Welding
.15	AWS C3.4	Specification for Torch Brazing
.16	MSS SP-106	Cast Copper Alloy Flanges and Flanged Fittings, Class 125, 150 and 300

2 PRODUCTS

2.1 Tube

- .1 Aboveground:
 - .1 NPS ½ to 2: to ASTM B88, type "L" hard-drawn copper tube.
 - .2 NPS 2-1/2 to NPS 3: to ASTM B88, type "K" hard-drawn copper tube.
- .2 Underground or in-slab:
 - .1 NPS ½ to NPS 3: to ASTM B88, type "K" hard-drawn or annealed copper tube.
- .3 Copper tube to be marked on the exterior surface in accordance with ASTM B88, to indicate the tube type ("K" or "L") by type designation or by colour strip (green stripe for type "K" and blue stripe for type "L"), along with identification of the manufacturer.

2.2 Tube Joints and Fittings

- .1 Fittings:
 - .1 cast bronze fittings to ASME B16.18,
 - .2 wrought copper and bronze fittings to ASME B16.22,
 - .3 brazed joints only: Wrought copper and copper alloy to ASME B16.50,
 - .4 threaded fittings including unions to ASME B16.15, Class 250.
- .2 Flanges:
 - .1 brass or bronze flanges to ANSI B16.24,
 - .2 gaskets to ANSI B16.21.
 - Standard of Acceptance*
 - Chesterton - fig. 100, 195 and 450
 - Beldam
- .3 Solder:
 - .1 95:5 tin/antimony solder to ASTM B32.
- .4 Braze filler:

- .1 silver brazing alloy: classification BCuP-5 to AWS A5.8.

3 EXECUTION

3.1 Tubing Installation

- .1 Refer to section 23 05 01 for piping design criteria and general requirements for piping installation.
- .2 Maximum tube size: NPS 3.
- .3 Slope main piping horizontal or up in direction of flow nominally at a slope of 1:1000 (c in in 10 ft).
 - .1 branch piping to have greater slope,
 - .2 slope piping up in direction of terminal heating and cooling devices.
 - .3 where supply and return piping are grouped together and flow is in opposite directions, arrange piping horizontal.
- .4 Use eccentric reducers at tube size changes arranged flat on bottom to assist venting.
- .5 Where tubing is installed to run inside of concrete slabs, support tubing to maintain tube centerline at the center of the floor slab unless otherwise shown. Where tubing is supported by ferrous metals or where it might come into contact with reinforcing steel bar, provide two layers of Denso Tape around the tubing at the point of contact.
- .6 Use copper tubing for equipment drains (pressure and non-pressure)
- .7 Provide di-electric unions or flanges in accordance with section 23 05 01.

3.2 Tube Joints and Fittings

- .1 Prepare and install tube and fittings;
 - .1 in accordance with ASTM B828 for solder joints,
 - .2 in accordance with AWS C3.4 and specification section 20 05
- .2 Use of direct butt weld style soldered or brazed joints, including pulled-Tee's, are not permitted.
- .3 Before assembling solder or brazed joints, remove working parts of valves.
- .4 Make tube joint for above-ground piping as follows:
 - .1 NPS 2 and smaller: soldered or brazed joints with socket type fittings.
 - .2 NPS 2-1/2 to NPS 3: brazed joints with socket type fittings.
- .5 Make tube joints for underground and/or in-slab piping as follows:
 - .1 all sizes: brazed joints with sweat fittings,
 - .2 arrange tubing to minimize the number of joints. Use annealed tubing wherever possible, with field-bends made with tube bending dies which provide uniform support of tubing during bending operations.

3.3 Equipment Connections

- .1 Equipment connections:
 - .1 NPS 2 and smaller: unions and threaded fittings,
 - .2 NPS 2 ½ to NPS 3: flanged connections.

3.4 Pressure and Leak Testing

- .1 Conduct pressure and leak tests in accordance with section 20 05 01.

3.5 Flushing and cleaning

- .1 After pressure testing, clean piping in accordance with Section 23 25 05.
- .2 For piping changes to existing systems, which consist of NPS 2 and smaller branch piping to terminal heating or cooling equipment, the following abbreviated cleaning and flushing procedure may be used:
 - .1 After cutting of threads and de-burring, and before installation of tubing, manually clean the interior of the tube with wire-brush on an extended rod, while washing the inside of the tube with a solution of non-foaming, phosphate free detergent, 3% by weight, followed by a hose rinse flushed to drain until water runs clear,
 - .2 After installation of piping, check strainers are clean, and open isolation valves to use service water for pressure testing and final flush.
 - .3 After pressure testing, isolate new piping from existing piping, fully open control valves (where installed) and flush service water to drain. Use compressed air at not more than 70 kPa (10 psig) to assist in flushing the water.
 - .4 Refill system with service water and circulate for two hours. Inspect strainers, and repeat drain, fill and recirculate routine until strainers are free of debris.

END OF SECTION

HYDRONIC PIPING SPECIALTIES 23 21 16

1 GENERAL

1.1 Scope

- .1 Provide water piping specialty products for hydronic heating and cooling systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 05 01 HVAC Piping Systems General Requirements.
 - .2 20 05 49 Seismic Restraint
 - .3 25 30 19.16 Building Automation Pressure Independent Control Valves

1.3 Applicable Codes and Standards

- .1 Refer to section 20 05 23 and as specified herein.
- .2 Product standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .2 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .3 CSA B51. Boiler and Pressure Vessel Code.

1.4 [Seismic Qualification

- .1 Seismically qualify (certify) piping to remain operational after being subjected to the design seismic forces assuming a building height factor (NBCC) $A_x = 3.0$ with equipment rigidly mounted, by the shaker table method in accordance with Specification section 20 05 49.

1.5 Submittals

- .1 Submit manufacturer catalogue cut-sheets for products specified herein.
- .2 Include confirmation of CRN.

1.6 Quality Control

- .1 All products are to have Canadian Registration Numbers in accordance with CSA B51.

2 PRODUCTS

2.1 Diaphragm Expansion Tanks

- .1 Construction:
 - .1 ASME code stamped to ASME BPVC Section VIII,
 - .2 Canadian Registration Number to CSA B51,
 - .3 tank: carbon-steel shell, vertical cylindrical shape pressure vessel with dished ends,
 - .4 diaphragm: BUNA-N or EPDM elastomer, non-replaceable,
 - .5 tank capacity and acceptance volume as shown,

- .6 minimum component pressure rating: 700 kPa (100 psi) at 115°C (240°F),
- .7 finish: prime and finish coat on outside of tank,
- .8 annular base mounting ring for vertical installation,
- .9 seismic restraint design:
 - (a) tanks designed to withstand water movement in the tank due to imposed seismic forces and movement,
 - (b) vertical tanks: support legs and hold-down bolt-holes designed for a horizontal seismic cyclic load equal to 50% of tank and contents weight in shear, and each leg designed for 100% of the resulting bending moment, and
 - (c) safety factor of 4:1.
- .10 factory air-charged to 84 kPa (12 psi) (initial fill pressure of system).
- .2 Nozzles and couplings:
 - .1 NPS 1 expansion line fitting at bottom of tank,
 - .2 Schraeder tank valve fitting for compressed air located near top of tank.

Standard of Acceptance

- Amtrol - fig. Extrol SX series
- Taco - fig. CBX series
- Bell & Gossett - fig. D series
- Armstrong - fig. AX series

2.2 Bladder Type Expansion Tanks

- .1 Construction:
 - .1 ASME code stamped to ASME BPVC Section VIII,
 - .2 Canadian Registration Number to CSA B51,
 - .3 tank: carbon-steel shell, vertical cylindrical shape pressure vessel with dished ends,
 - .4 bladder: BUNA-N or EPDM elastomer, replaceable and fastened to underside of man-way flange,
 - .5 tank capacity and acceptance volume as shown,
 - .6 full-acceptance design,
 - .7 suitable for glycol-water solutions up to 50% concentration,
 - .8 minimum component pressure rating: [1000 kPa (150 psi)][2000 kPa (300 psi)] at 115°C (240°F),
 - .9 finish: primed on outside,
 - .10 annular base mount for vertical installation,
 - .11 top-mounted bolted access flange for replacement of the bladder,
 - .12 seismic restraint design:
 - (a) tanks designed to withstand water movement in the tank due to imposed seismic forces and movement,
 - (b) vertical tanks: support legs and hold-down bolt-holes designed for a horizontal seismic cyclic load equal to 50% of tank and contents weight in shear, and each leg designed for 100% of the resulting bending moment, and

(c) safety factor of 4:1.

.13 factory air-charged to 84 kPa (12 psi) (initial fill pressure of system).

.2 Nozzles and couplings:

.1 NPS 1 expansion line fitting in the top flange to the bladder,

.2 Schraeder tank valve for compressed air located on top flange or at top of tank shell.

Standard of Acceptance

- Amtrol - fig. Extrol L series
- Taco - fig. CA series
- Bell & Gossett - fig. B series
- Armstrong - fig. L series

2.3 Pressure Independent Balancing Valve (Automatic Balancing valve)

.1 General

.1 Combination automatic flow limiting and commissioning pressure independent balancing valve.

Standard of Acceptance

- Bell & Gossett - Circuit Sentry Model WV Circuit Sentry

.2 Design conditions:

.1 Design pressure: NPS 2½ to 6: minimum 1700 kPa (250 psig)

.2 Design temperature: -20°C to 111°C (-4°F to 230°F).

.3 Flow control characteristics:

.1 pressure independent flow control over design flow range at an operating differential pressure range of 14 to 414 kPa (2 to 60 psi) across the valve body,

.2 minimum flow rate: 0.95 l/s (15 gpm)

.3 maximum allowable pressure drop: ●kPa (● Ft)

.4 accuracy: ± 5% of control flow rate for total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.

.4 Valve body:

.1 body construction NPS 2 ½ to 6:

(a) ductile iron body, 304 stainless steel cartridge, EPDM O-ring packing design, reinforced EPDM diaphragm and a stainless steel spring.

(b) wafer body style suitable for installation in ANSI Class 125, 150 or 250 flanges.

.5 Accessories:

.1 two (2) 100 mm (4 in) long pressure/temperature ports,

.2 identification tag indicating unit size, and balanced flow rate.

2.4 Automatic Air Vents

.1 Float operated with brass or cast iron body;

.1 minimum component pressure rating: [1000 kPa (150 psi)][2000 kPa (300 psi)] at 115°C (240°F),

Standard of Acceptance

- Armstrong - fig. AAE-750
- Bell & Gossett – fig. 87
- Maid-O-Mist - fig. 75
- Spirax Sarco - fig. AE30
- Taco - fig. Hy-Vent
- Thrush - fig. 720

2.5 Radiator Air Vents

- .1 Float operated with brass body;
 - .1 automatic type for remote installation for terminal heating units located at top of risers,
 - .2 screw-driver operated for locations inside of terminal heating unit enclosures other than when located at top of pipe risers,
 - .3 minimum component pressure rating: [700 kPa (100 psi)][1000 kPa (150 psi)][2000 kPa (300 psi)].

Standard of Acceptance

- Braukman - fig. EA122A
- Maid-O-Mist - fig. 37
- Spirax Sarco - fig. AE30
- Taco - fig. 417

2.6 Air Separator; Expansion Tank

- .1 Dip tube type air separator for installation at expansion tank,
 - .1 ASME code stamped to ASME BPVC Section VIII,
 - .2 Canadian Registration Number to CSA B51,
 - .3 cast iron body, with copper dip tubes, and stainless steel ball check,
 - .4 minimum component pressure rating: 1030 kPa (150 psi) at 121°C (250°F).

Standard of Acceptance

- Bell & Gossett - fig. Airtrol Tank Fitting
- Armstrong

2.7 Air Separator; In-Line

- .1 Inertial centrifugal (vortex) style air and dirt separator, cast iron or fabricated steel body, with stainless steel mesh strainer,
 - .1 ASME code stamped to ASME BPVC Section VIII,
 - .2 Canadian Registration Number to CSA B51,
 - .3 pipe-ends: NPT threaded NPS 2 and under, ASME Class 150 flanged NPS 2-1/2 and larger,
 - .4 minimum component pressure rating: 1030 kPa (150 psi) at 121°C (250°F).

Standard of Acceptance

- Taco - fig. 4900
- Bell & Gossett – fig. Rolairtrol
- Amtrol - fig. Tangential Air Separator

- Armstrong - fig. Vortex VAS

2.8 Pressure Reducing Valves

- .1 Pressure reducing valve with integral inlet soft-seated check-valve and stainless steel mesh strainer;
 - .1 self-contained, single-seated, type,
 - .2 brass or cast iron body, EPT diaphragm, with fast-fill/purge release handle,
 - .3 pipe ends: NPT threaded,
 - .4 minimum component pressure rating: 860 kPa (125 psi) at 100°C (212°C),
 - .5 pressure regulator setting range:
 - (a) low range: 70 to 170 kPa (10 to 25 psi),
 - (b) high range: 170 to 410 kPa (25 to 60 psi).

Standard of Acceptance

- Bell & Gossett - fig. A430H
- Taco
- Watts

2.9 Pressure Relief Valves

- .1 Bronze or cast iron body pressure relief valve;
 - .1 stamped to ASME Section IV;
 - .2 EPDM diaphragm and seat,
 - .3 minimum component pressure rating: 860 kPa (125 psi) at 121°C (250°C),
 - .4 selectable pressure setting range: 200 to 860 kPa (30 to 125 psi),
 - .5 capacity rating: not less than associated heating boiler or unfired heat exchanger heat rating,
 - .6 operating differential pressure from open to close not more than 20 kPa (3 psi).

Standard of Acceptance

- Bell & Gossett - fig. A-434E
- Watts - fig. 174A, 740

2.10 Wye-Pattern Strainers

- .1 NPS 3 and smaller:
 - .1 bronze, cast iron, or ductile iron bodies to ASME B16.1, with threaded cap,
 - .2 minimum component pressure rating:
 - (a) ASME Class 125: 1200 kPa (175 psi) at 93°C (200°F),
 - (b) ASME Class 250: 2270 kPa (330 psi) at 93°C (200°F),
 - .3 pipe end: NPT threaded or ASME flanged,
 - .4 basket: stainless steel, 0.8 mm (¹/₃₂ in) diameter perforations.
- .2 NPS 4 to NPS 24:
 - .1 cast steel or stainless steel bodies to ASME B16.5, with bolted flange cover,
 - (a) stainless steel body where installed in stainless steel piping system,

- .2 minimum component pressure rating:
 - (a) ASME Class 150: 1800 kPa (260 psi) at 93°C (200°F),
 - (b) ASME Class 300: 3400 kPa (500 psi) at 93°C (200°F),
- .3 pipe end: ASME Class raised face flanged,
- .4 basket:
 - (a) stainless steel, 3.2 mm (1/8 in) diameter perforations,
 - (b) made from 0.9 mm (0.037 in) stock reinforced with 13 mm x 0.9 mm (1/2 in x 0.037 in) bands of same material spot welded to baskets,
- .5 blow-down fitting in strainer cap: NPS 3/4 threaded connection with plug.

Standard of Acceptance

- Nibco
- Sure Flow
- Watts (Mueller)
- Zurn Wilkins

2.11 Basket- Pattern Strainers

- .1 NPS 2 to 20, simplex basket:
 - .1 in-line, single basket arrangement,
 - .2 cast steel or stainless steel bodies to ASME B16.5,
 - (a) stainless steel body where installed in stainless steel piping system.
 - .3 cover: same material as body, with quick-opening feature, to ASME Section VIII or ASME B16.5,
 - .4 bottom blow-down fitting: NPS 3/4 threaded connection with plug,
 - .5 minimum component pressure rating:
 - (a) ASME Class 150: 1800 kPa (260 psi) at 93°C (200°F),
 - (b) ASME Class 300: 3400 kPa (500 psi) at 93°C (200°F),
 - .6 pipe ends:
 - (a) NPS 2 to 2-1/2: NPT threaded to ASME B1.20.1,
 - (b) NPS 3 to 20: ASME Class raised face flanged,
 - .7 basket screens:
 - (a) perforated T304 stainless steel plate,
 - (b) NPS 2 and 3: 1.15 mm (3/64 in.) perforation, 36% open area,
 - (c) NPS 4 and over: 3.2 mm (1/8 in.) perforation, 40% open area.

Standard of Acceptance

- John Brookes (HART)
- Mueller (Watts)
- Spirax Sarco
- Sure Flow

2.12 Packaged Coil Valve Kits

- .1 Packaged installation valve-kits for terminal unit reheat coils, duct mounted reheat coils, and chilled water or dual temperature fan coils.

Standard of Acceptance

- Victaulic - fig. 79V Koil-Kit Coil Pac
 - Belimo
- .2 Terminal device connection size range: NPS ½ to NPS 2.
 - .3 Required MCPR for packaged assembly: 2100 kPa (300 psi) at 110°C (230°F).
 - .4 Each packaged kit assembly to consist of:
 - .1 as individual components or as multi-function components,
 - .2 supply side:
 - (a) service isolation ball valve, Y-body strainer, valved and capped drain port, test plug port, union pipe-end fitting,
 - .3 return side;
 - (a) service isolation ball valve, pressure-independent electronic automatic control valve, manual air vent/test port, union pipe-end fitting,
 - (b) pressure-independent control valves to conform to Specification section 25 30 19.16.
 - .4 flexible hose connectors:
 - (a) at installation contractors option,
 - (b) for supply and return connections between coil and valve assemblies,
 - (c) maximum length: 300 mm (12 in.)
 - (d) to Specification section 20 05 16 of all metal construction, or stainless steel braided guard with Teflon primary hose,
 - i) for clarity, where EPDM primary hose is used, the braided hose connector shall only be provided by the kit package manufacturer.
 - .5 Packaging coordination services:
 - .1 shrink wrap each package coil kit, and identify package with an unique reference number and which identifies as a minimum;
 - (a) the applicable room number and floor level,
 - (b) associated equipment identification tag,
 - (c) contractor name, and project name.

2.13 Valve Enclosure Box

- .1 Valve enclosure box complete with access door for valve kits for terminal unit reheat coils, duct mounted reheat coils, and chilled water or dual temperature fan coils.
- .2 Access door:
 - .1 hospital white access door (by diffuser manufacturer) complete with hinged frame & keyed fastener release,
 - .2 suitable for mounting in drywall or T-bar ceiling as required,
 - .3 enclosure supported from structure above with 3/8" hanger rods.
- .3 Enclosure:

- .1 24" wide x 24" long factory fabricated galvanized sheet metal enclosure
- .2 12" high minimum or as required to fully enclose all components

Standard of Acceptance

- Acudor
- Cendrex
- Karp Inc

3 EXECUTION

3.1 Equipment Selection Based on Pressure Rating

- .1 Unless otherwise specified herein or shown, select equipment that has a Minimum Component Pressure Rating (MCPR) which exceed the applicable piping system Design Pressure and Design Temperature specified in section 23 05 01.
- .2 Where drawings indicate either: (a) a pressure rating; or (b) a pressure rating and Class rating, by floor level then select equipment as follows:
 - .1 select equipment with a MCPR rating equal to or greater than the pressure rating indicated on the drawings for each floor level.
 - .2 for clarity, even if a valve has an ASME Class rating, do not select a valve based on its Class to match any Class rating shown on the drawings.

3.2 Expansion Tank Installation

- .1 Provide expansion tanks as shown.
- .2 Install equalizer line from [[air separator in] piping system to bottom of tank. Where multiple tanks are required for one system, provide a full size equalizing header pipe connection to each tank.
- .3 Provide domestic cold water line with ball valve, strainer, and line size backflow preventer with isolating valves connected to the equalizer line.
- .4 Provide a main system pressure relief valve on the equalizing line, with outlet piped down to within 150 mm (6 in.) of the floor adjacent to floor drain;
 - .1 select the pressure relief valve based on the total equivalent heat value of the associated heat source (heating or cooling), but not less than NPS ¾ in size,
- .5 Provide a domestic water make-up assembly consisting of:
 - .1 a reduced-pressure principle backflow preventer with inlet and outlet valves and strainer,
 - .2 a pressure reducing valve located downstream of the backflow preventer,
 - .3 a pressure gauge installed on the tank water space or on the equalizing line within 600 mm (24 in.) of the tank connection,
 - .4 drainage piping for the relief connection on backflow preventer and the make-up water assembly run to the nearest open drain,
 - .5 where shown, a compressed air line piped to each expansion tank or group of tanks with globe valve and check valve, terminating 1200 mm (4 ft) above finished floor near tanks with 6 m (20 ft) length of hose and hose end fitting compatible with Schraeder connection on the expansion tank.
- .6 Provide a lock-shield isolation valve on the expansion tank system pipe connection, and provide a key padlock on each tank isolation valve. Turn over the keys to Owner at time of hand-over of the Work.

- .7 Set-up the expansion tank(s) in accordance with the manufacturer instructions. Pre-charge the air pressure in the tank to the pressure as shown, prior to placing the system into operation. After the system is operating at the normal operating temperatures, adjust the air pressure in the tanks as follows:
 - .1 increase or decrease tank air pressure to achieve the final operating pressure as shown in equipment tank schedules,
 - .2 record the final operating tank pressure in an installation report.

3.3 Pressure Independent Balancing Valve (Automatic Balancing Valve)

- .1 Manufacturer to select and provide valves to suit flow and differential pressure requirements. Include the information as a schedule in the shop drawing submittal.
- .2 Install balancing valve assembly with shut-off valve on either end of assembly.
- .3 Install balancing valve assembly in accordance with the manufacturer installation instructions. Provide companion flanges, mounting hardware and gaskets. Install in locations to provide five (5) pipe diameters of straight pipe before and two (2) pipe diameters after, which are free of fittings and valves.
- .4 Support balancing valve assembly rigidly from adjacent piping. Support piping within 300 mm (1 ft) of unit and flanges to prevent strain transmitted to assembly.
- .5 Manufacturer to supply a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).

3.4 Air Vents Installation

- .1 Provide air vents at high points in the piping system, including at the top of all pipe risers, and in sections of piping subject to air binding, in both supply and return mains. Allow for additional air vents as directed by Consultant based on site review of installed work.
- .2 Provide isolating valves installed between unit and piping.
- .3 Pipe vent outlets to discharge to drain, over janitors sinks, over floor drains in mechanical rooms and other similar visible locations.

3.5 Radiator Air Vent Installation

- .1 Provide automatic radiator air vents on Ø20 mm (¾ in. dia.) by 50 mm (2 in) long air chambers on return side of hot water convector-radiators and wall fin heaters connected to the top of flow risers. Pipe vent outlets to drain in visible locations.
- .2 Fit other hot water convector-radiators with Ø20 mm (¾ in.dia.) by 150 mm (6 in) air chamber with manual screwdriver-operated air vent piped through front or side of cabinet. Fit similar air chamber and screwdriver operated air vent, through front or side of cabinet, on high points of other wall-fin heating elements except that air chamber to be as long as is possible to install within wall-fin enclosure height.
- .3 Install air vent assemblies clear of dampers within heating units.

3.6 In-Line Air Separator Installation

- .1 Provide in-line air separators in locations as shown. Provide an automatic air vent on top of the air separator, except where this connection is shown to be connected to a compression tank.
- .2 Provide a valved blow-down drain line from the air separator blow-down fitting, and extend piping to nearest floor drain. Arrange location of blow-down valve so that it is located within 500 to 1800 mm above the floor adjacent to the point of discharge to the floor drain.

3.7 Pressure Relief Valves Installation

- .1 Provide pressure relief valves on hot water boilers, heat exchangers, expansion tanks and other pressure vessels in accordance with relevant codes.
- .2 Select relief valve setpoints to be not greater than the maximum allowable working pressure of the protected equipment (for individual equipment).
- .3 For main pressure relief valves for piping systems, set the pressure relief valve setpoint to the value as shown.
- .4 Pipe relief valve outlets to drain.

3.8 Pressure Reducing Valves Installation

- .1 Install pressure reducing valves with shut-off valve on either side of assembly and Ø115 mm (4½ in. dia.) pressure gauges on upstream and downstream sides of the pressure reducing valve.

3.9 Strainers Installation

- .1 Provide pipeline-size strainers in each of following locations
 - .1 on the inlet side of water meters,
 - .2 on the inlet side of automatic control valves (except at reheat coils with piping connections NPS ¾ or less, radiation, or radiant panels),
 - .3 on the inlet side of pressure reducing valves (except where pressure reducing valve is equipped with an integral strainer),
 - .4 on suction side of water pumps (except where a pump suction guide with integral strainer is used),
 - .5 on inlets to heat exchangers (except where heat exchanger is equipped with integral strainers, or where a dedicated pump with strainer is directly supplying the heat exchanger).
- .2 Install wye-pattern strainers in horizontal or vertical-downflow orientation. Install basket strainers only in horizontal piping.
- .3 Install strainers with clearance for removal of basket.
- .4 For strainers NPS 2½ and over, provide NPS 1 valved blowout connection, consisting of ball valve with hose end and chained cap. Pipe valved blowout connections from strainers at pumps to open drain.

3.10 Packaged Coil Valve Kits Installation

- .1 The use of packaged coil valve-kits are at the contractor's option in lieu of providing site assembly of separate valves and fittings.
- .2 Coordinate with the trade contractor under Division 25 for the supply of pressure independent control valves for inclusion in the coil valve kits.
- .3 Create and provide a schedule of valve kits required to the manufacturer/packager, which includes the following information:
 - .1 a designation indicating the location of the applicable HVAC equipment,
 - .2 design flow rates of the applicable HVAC equipment,
 - .3 manufacturer/packager to select and size the pressure-independent control valves in accordance with Specification section 25 30 19.16.
- .4 Arrange piping to HVAC equipment so that flexible connector hoses are not bent to change direction. Flexible connector hoses may be deflected laterally by an amount not exceeding the outside diameter of the connector hose. Where necessary, provide a rigid elbow at the HVAC coil-end connections.

3.11 Valve Enclosure Box Installation

- .1 Valve enclosure box shall house valve kits for terminal unit reheat coils, duct mounted reheat coils, and chilled water or dual temperature fan coils; this requirement applies both site assembly of separate valves and fittings, or for packaged coil valve kits.
- .2 Support enclosure box from structure above with 3/8" hanger rods.
- .3 Provide installation drawings showing locations of all enclosure boxes on architectural reflected ceiling plans for approval prior to installation.

END OF SECTION

HVAC PIPE CLEANING 23 25 05

1 GENERAL

1.1 Scope

- .1 Provide chemicals and instructions for the cleaning of piping systems and equipment.
- .2 This specification only applies to piping systems within Division 23.

1.2 Qualifications of Supplier

- .1 Equipment, chemicals and services to be provided by specialist firm with an established reputation in field including:
 - .1 a verifiable minimum of five (5) years experience of providing these types of services to both Government and/or private industry customers,
 - .2 the supplier is a member in good standing of the Association of Water Technologies (AWT),
 - .3 supplier's service technicians are either a Certified Water Technologist (CWT) accredited by the AWT, or is a qualified Chemical Water Treatment Services Chemist,
 - .4 certification records or similar proof-of-training for service personnel shall be made available upon request.

Standard of Acceptance

- Klenzoid
- GE Betz
- D.H. Jutzi Limited
- Nalco Chemical Company
- Ashland

2 PRODUCTS

2.1 Pipe Cleaning Chemicals

- .1 Piping:
 - .1 Non-foaming, non-chromate, phosphate free, neutral pH chemical cleaner detergent to remove sludge oil and debris.

2.2 Temporary Strainer Screens

- .1 Conical strainer with indicating handle, 1.6 mm (1.16 in) perforations, sized to suit NPS pipe and to be clamped between ASME pipe flanges.

Standard of Acceptance

- Suyre Flow Equipment Inc

3 EXECUTION

3.1 Temporary Services and Equipment

- .1 Provide all temporary equipment, including pumps, drain and fill connections, hoses, water meters and other miscellaneous equipment necessary to circulate cleaning compounds and to flush piping.

- .2 Where permanent system pumps are to be used for circulating cleaning fluid, provide temporary 1.6 mm (1/16 in) screens in permanent strainer bodies, or provide temporary insertion style strainers of same screen size inserted into a pipe spool section on the suction side of the pump.
- .3 Where permanent system pumps are not available, or where connections are made to an existing piping system, provide temporary circulation pumps to maintain cleaning fluid minimum velocity through piping at 1.5 m/s (5 fps).
- .4 At completion of testing, temporary equipment is to be removed from site and becomes the property of the contractor.

3.2 Temporary Work

- .1 At air handling unit coils and terminal units, do not subject the control valve to the cleaning fluid even if a strainer is installed ahead of the valve. Remove the control valve and provide a spool piece, or where flexible connectors are used at terminal units, cross connect the supply and return piping with these flexible connectors, bypassing the control valve and the terminal unit.
- .2 At major equipment such as boilers and chillers, provide temporary strainer cones installed in a pipe flange ahead of the equipment. Remove strainer after completion of system cleaning.

3.3 Cleaning of New Piping in Existing Installations

- .1 For piping connections to existing systems, provide NPS 1 valved drains on the load side of the new supply and return piping service isolation valve. Blank-off or otherwise isolate connections to existing treated piping systems. Provide temporary bypass piping/hose and circulation pump to permit circulation of cleaning fluid.

3.4 Cleaning of HVAC Water Piping

- .1 After completion of piping pressure tests, chemically clean HVAC water piping systems followed by flushing piping with clean water.
- .2 For plate-and-frame heat exchangers, disconnect piping and make temporary cross-connections to bypass heat exchanger unless the heat exchanger is equipped with an integral strainer. Provide a temporary fine mesh strainer screen..
- .3 Fill piping with clean city water using permanent or temporary water meter to establish system volume. Add cleaning detergent to achieve required concentration as recommended by chemical cleaning manufacturer.
- .4 Circulate solution for minimum of seventy-two (72) hours at room temperature or as recommended by chemical cleaning manufacturer instructions.
- .5 Flush to drain with clean water until sample tests of flush-water indicate an iron residual of < 1 ppm.
- .6 Check for removal of cleaning compound; samples to be clear, not coloured, and free of foam after agitation.
- .7 At completion of water flushing, remove and clean strainers. If there is visible debris in the strainers, repeat drain, fill and recirculation routine until strainers are free of debris.
- .8 Refill system with clean water and add water treatment corrosion inhibitors in accordance with the requirements of Section 23 25 13.
- .9 After system is in operation for at least eight (8) hours, perform a final clean of strainers.

3.5 Records

- .1 Provide a cleaning test record and submit to the Consultant and the Owner. Test record to record for each piping system:
 - .1 water volume of system as measured,
 - .2 quantity of cleaner added to the system, by volume or weight,
 - .3 name of cleaner product used,
 - .4 manufacturer's recommended concentration,
 - .5 start and end times/dates of circulation,
 - .6 free-iron residual measured at end of cleaning, and name of person conducting test,

END OF SECTION

AIR DISTRIBUTION - GENERAL

23 31 01

1 GENERAL

1.1 Scope

- .1 Provide labour, materials and equipment for installation, testing and putting into operation ventilating and air conditioning systems as further specified in other Specification sections of Division 20 to 25.

1.2 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.

2 PRODUCTS

2.1 Not Used

3 EXECUTION

3.1 Ductwork

- .1 Ductwork system routing is shown diagrammatically. Drawings are not to be considered as fabrication or installation drawings.
- .2 Locate mains, risers and runouts to be concealed behind furrings or above ceilings, except in mechanical equipment rooms and access spaces where ductwork is to be exposed.
- .3 Determine areas without ceilings from Architectural drawings and Room Finish Schedules, and in these areas keep ductwork as high as possible.
- .4 Anchor, guide and support vertical and horizontal runs of ductwork to resist dead load and external live loads, and to absorb pressure thrust.

3.2 Air Supply Equipment

- .1 Install and connect air handling units, air conditioning units, fans and associated equipment, and build casing and plenums.

3.3 Air Exhaust Equipment

- .1 Install and connect exhaust fans, roof and wall exhausters and dust and fume collectors.

3.4 Terminals Units

- .1 Locate and install terminal units, registers, diffusers, and grilles. Coordinate with Architectural reflected ceiling plans for position of ceiling mounted elements.

3.5 Life Safety

- .1 Install fire dampers, smoke dampers, and combination smoke and fire dampers to protect openings in fire separations.
- .2 Provide smoke stopping around unprotected ducts passing through smoke separations.

3.6 Air Balancing

- .1 Co-operate with air balancing agency; install supplementary dampers, access openings and access doors to facilitate testing and adjustment.

END OF SECTION

METAL DUCTS 23 31 13.13

1 GENERAL

1.1 Scope

- .1 Provide metal HVAC ductwork including casings and plenums as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 01 Basic Materials and Methods
 - .2 20 05 49 Seismic Restraint
 - .3 23 33 05 Duct Accessories

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section and as applicable to related sections.
 - .1 **Casing(s)** – a fabricated metal construct of some combination of walls, roofs, and/or floors for the conveyance of air at relatively low air velocities (typically below 5 m/s (1000 fpm) and which encloses equipment such, as but not limited to, fans, coils, and filters.
 - .2 **Ductwork** – a network of metallic or flexible material distributed through a building or space for the conveyance of air: (a) from an HVAC unit to one or more spaces, or (b) exhausted from those spaces.
 - .3 **Plenums** – a form of ductwork for the conveyance of air at relatively low velocities (typically below 3.5 m/s (700 fpm)).
- .2 In SMACNA 006 - *HVAC Duct Construction Standard – Metal and Flexible*, a reference to requirements for construction of “casings” in chapter 9 applies equally to construction of plenums, except/and as specified herein.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 ASHRAE Letter and number designations, shown as “CR3-16” etc., are taken from ASHRAE Duct Fitting Data Base.(DFDB)
 - .3 ANSI/SMACNA 006 HVAC Duct Construction Standards - Metal and Flexible (4th edition)
 - .4 ANS/SMACNA 002 Rectangular Industrial Duct Construction Standards (2nd edition)
 - .5 ANSI/SMACNA 016 HVAC Air Duct Leakage Test Manual (2nd edition)
- .2 Product standards:
 - .1 ASTM A90 Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
 - .2 ASTM A653 Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process
 - .3 ASTM A924 Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

- | | | |
|-----|----------------|--|
| .4 | ASTM A1011 | Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength |
| .5 | ASTM A283 | Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates |
| .6 | ASTM A36 | Standard Specification for Carbon Structural Steel |
| .7 | ASTM A480 | Specification for General requirements for Flat Rolled Plate, Sheet, and Strip |
| .8 | ASTM A463 | Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process |
| .9 | ASTM B209 | Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate |
| .10 | ANSI/MSS SP-58 | Pipe Hangers and Supports |

1.5 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.

1.6 Design Criteria

- .1 Outdoor ductwork, rooftop duct support frames, and weather shields are to be designed to meet the local wind loading in accordance with the building code requirements at the location of the Work.
- .2 Seismic design loading for duct supports to conform to Specification section 20 05 49.

1.7 Submittals

- .1 Submit manufacturer's catalogue literature for:
 - .1 proprietary joints.
- .2 Submit fabrication shop drawings for the following ductwork elements:
 - .1 integral drain pans and external drain pans including drain pipe connection,
 - .2 water-resistant ductwork,
 - .3 casings and plenums.

1.8 As-Built Drawings

- .1 As work progresses, mark-up field drawings as to actual location of ductwork, balancing dampers and other duct accessories and submit as part of record of "As-Built" conditions.

2 PRODUCTS

2.1 Common Material

- .1 Galvanized steel:
 - .1 Ducts and connectors: lock forming quality to ASTM A653 or ASTM A924, type Z180 (G60) or Z275(G90) as specified in Part 3 – EXECUTION.
 - .2 Miscellaneous pipe, angles, strips and threaded rod in contact with ductwork: galvanized with a minimum thickness equal to ASTM A653 - Z180 (G60).
- .2 Stainless steel:
 - .1 to ASTM A480, Type 304L,

- .2 finish: 2B mill, except where otherwise shown.
- .3 Aluminum:
 - .1 To ASTM B209;
 - (a) alloy 3003-H14 or 5052-H32 for sheet material.
 - (b) alloy 6061-T6 for plate material
 - (c) alloy 6061-T4 or T6 for shapes material.
- .4 Plain mild carbon steel:
 - .1 To ASTM A1011, A283, A572 and A36 as applicable.

2.2 Joints

- .1 Fabricated joints: to ANSI/SMACNA 006 as applicable to duct pressure class, duct size, duct-wall thickness, and reinforcing requirements.
- .2 Bolted companion flange – rectangular ductwork:
 - .1 formed flanges, corner pieces, integral edge seals, gaskets and cleats.
 - .2 material to match that of ductwork being joined,
 - .3 Neoprene gaskets.

Standard of Acceptance

- Ductmate – fig. System 25/35/45
- Hardcase (Carlisle) – fig. Nexus

- .3 Barrel-rim clamped companion flange – round ductwork:
 - .1 roll-formed companion flanges, field installed, mechanically fastened and sealed to ends of duct,
 - .2 barrel ring clamp with bolted or no-tool cam locking clamp,
 - .3 Neoprene gaskets.

Standard of Acceptance

- Ductmate - fig. Spiralmate
- Nordfab - fig. Quick-Fit Ducting

2.3 Sealant and Tape

- .1 To Specification section 23 33 05.

2.4 Hangers and Supports

- .1 Upper hanger attachments;
 - .1 in new concrete: manufactured concrete inserts.

Standard of Acceptance

- Myatt Fig. 485

- .2 for steel joist: galvanized joist clamps or steel plate washer.

Standard of Acceptance

- Anvil Fig. 61 or 86
- Anvil Fig. 60 for plate washer

- .3 for steel beams: galvanized beam clamps.

Standard of Acceptance

- Anvil Fig. 60

- .2 Hanger straps:

- .1 Galvanized steel strap hangers for indoor use only.

- .3 Hanger rod:

- .1 Continuous threaded rod:

- (a) carbon steel, USS national course thread,
- (b) tension load ratings to MSS SP-58,

Standard of Acceptance

- Anvil - fig. 146
- Taylor – fig. 54

- .2 Welded eye rod:

- (a) carbon steel, USS national course thread,
- (b) tension load ratings to MSS SP-58,
- (c) tension load rating to be the same as continuous welded rod.

Standard of Acceptance

- Anvil - fig. 278
- Taylor

- .4 Seismic supports and restraints to Specification section 20 05 49.

2.5 Duct Access Doors

- .1 To Specification section 23 33 05.

3 EXECUTION

3.1 General Fabrication and Installation Requirements

- .1 Construction details, sheet gauges, reinforcing, and bracing for ductwork, casings, and plenums to be in accordance with SMACNA 006, except/and as otherwise shown.
- .2 Material selection: refer to Schedule A at the end of this section where otherwise shown.
- .3 Rectangular ductwork seams and joints:
 - .1 longitudinal seams: Pittsburgh Lock, with specified sealant applied prior to hammering of joint,
 - .2 transverse joints: to SMACNA HVAC standards based on pressure class and reinforcement used, and for sealing requirements.
- .4 Round ductwork seams and joints, 500 Pa (2 in wg) pressure class and higher:
 - .1 spiral flat type longitudinal seam, button punched.

3.2 External Drain Pans

- .1 Provide external drain pans where shown.
- .2 Materials: T304 stainless steel.
- .3 Fabricate drain pan with 50 mm (2 in.) high side walls.
- .4 Break the bottom panel in two-directions to allow water to drain to a low-point drain outlet,
- .5 Provide welded-on hanger attachments to allow support by hanger rod or support the underside of the drain pan.
- .6 Provide continuous welded joints along bottom of plenum, and extend welds up vertical joints. Mechanically grind or chemical pickle both the interior and exterior surfaces at the welds to remove the welding tint in the heat affected zone (HAZ).
- .7 Provide a NPS 3/4 x 75 mm (3 in.) long stainless steel drain tube connected to the duct drain pan at the low-point drain outlet.

3.3 Balancing Dampers

- .1 Provide splitter dampers where branch connections are taken from supply mains.
- .2 Provide single blade dampers on each branch of supply air systems downstream of terminal boxes.
- .3 Provide Opposed Blade Dampers (OBD) at branch and main connection on exhaust and return air systems.

3.4 Finishing, Fastening and Supports

- .1 Hammer edges and slips to leave smooth finished surface inside duct.
- .2 Support vertical ducts with steel angles riveted to duct and bearing on building structure;
 - .1 design and fabricate duct riser supports using supplementary structural steel supports in accordance with SMACNA 006 and Specification section 20 05 01.
 - .2 use plain carbon steel for duct riser supports located indoors,
 - .3 use galvanized carbon steel for duct riser supports located outdoors.
- .3 Duct hangers;
 - .1 for ducts with both dimensions not exceeding 500 mm (20 in):
 - (a) supported with strap hangers of same material as duct but one sheet metal thickness heavier, or on steel angles as specified below.
 - (b) extend strap hangers down duct side and turn under 50 mm (2 in) fastening securely to side and underside of duct.
 - .2 for ducts with any dimension greater than 500 mm (20 in):
 - (a) supported with trapeze hangers constructed from galvanized steel angle with steel rods in accordance with table 1;

Table 1 : Duct Hangers		
Duct size mm (in)	Angle size mm (in)	Rod size mm (in)
up to 750 (up to 30)	25x25x3 (1x1x1/8)	6 (1/4)
750 to 1050 (30 to 40)	40x40x3 (1 1/2x1 1/2x1/8)	6 (1/4)
1050 to 1500 (40 to 60)	40x40x3 (1 1/2x1 1/2x1/8)	10 (3/8)

Duct size mm (in)	Angle size mm (in)	Rod size mm (in)
1500 to 2400 (60 to 90)	50x50x3 (2x2x $\frac{1}{8}$)	10 ($\frac{3}{8}$)
2400 and over (90 and over)	50x50x6 (2x2x $\frac{1}{4}$)	10 ($\frac{3}{8}$)

.3 maximum hanger spacing: 2.4 m (8 ft) on centre.

.4 For additional requirements for seismic restraints, refer to Section 20 05 49.

3.5 Pressure Classification and Seal Class

.1 Low pressure ductwork construction classification in accordance with Table 2.

Pressure class Pa (in wg)	Operating pressure Pa (in wg)	Velocity m/s (fpm)	Leakage Test Pressure Pa (in wg)
125 ($\frac{1}{2}$)	up to 125 ($\frac{1}{2}$)	10.0 (2000)	125 ($\frac{1}{2}$)
250 (1)	125 to 250 ($\frac{1}{2}$ to 1)	12.5 (2500)	250 (1)
500 (2)	250 to 500 (1 to 2)	12.5 (2500)	500 (2)
750 (3)	500 to 750 (2 to 3)	15.0 (3000)	750 (3)
Greater than 750 (3)	High Pressure Ductwork		Not less than 1000 (4)

.2 Assemble ductwork seams and joints with joint sealant as shown in table 3.

.3 Sealant application:

.1 store duct sealant at room temperature for 24 hours before use,

.2 apply sealant on seams as noted in table 1, and brush or extrude sealant to cover fasteners,

.3 on bell and spigot style joints apply sealant on male section with caulking gun and spread sealant evenly on mating surface with brush,

(a) insert fitting and secure with sheet metal screws

(b) brush sealant onto outside of assembled joint in 50 mm (2 in) wide band covering fastener heads,

.4 allow 40 hours curing time before pressure testing.

Table 3: Duct System Pressure and Seal Class – Healthcare and Laboratories

No.	Ductwork System	Static pressure construction class Pa (in.wg.)	Seal class	Sealing requirements (1)(2)(3)(4)
1	Supply duct risers in vertical service space (duct shafts).	+1000 (4)	A	Transverse joints, longitudinal seams, ductwall penetrations, and other connections
3	Supply air ductwork from discharge side of fan to inlet of terminal units or reheat coil	+1000 (4)		
4	Return/exhaust air ductwork between a Heat Recovery Wheel and suction side of fan.	-1000 (4)		
5	Supply, return and exhaust ductwork located outdoors.	All classes as otherwise specified herein		
6	Autopsy exhaust ductwork.	-1000 (4)		
7	Process exhaust air ductwork between exhaust HEPA filters and suction side of fan.	-1000 (4)		
8	Process exhaust upstream of exhaust filters, or upstream of exhaust fan if there are no exhaust filters	-750 (3)		
9	Chemical fume hood exhaust ductwork on suction side of exhaust fan	-750 (3)		
10	Biohazard exhaust ductwork	-750 (3)		
11	Exhaust ductwork on discharge side of fans for: autopsy exhaust, process exhaust, chemical fume hood exhaust, biohazard exhaust	+500 (2)		
12	Perchloric Acid exhaust system on suction side of exhaust fan	-1500 (6)		
13	Perchloric Acid exhaust system on discharge side of exhaust fan	+500 (2)		
14	Return air and general exhaust risers in mechanical rooms and in vertical service spaces (duct shafts).	-750 (3)		

Table 3: Duct System Pressure and Seal Class – Healthcare and Laboratories

No.	Ductwork System	Static pressure construction class Pa (in.wg.)	Seal class	Sealing requirements (1)(2)(3)(4)
15	Supply air ductwork upstream of HEPA filters, including diffusers with integral HEPA filters. ⁽⁵⁾	+750 (3)		
16	Supply air ductwork downstream of terminal units or reheat coil with terminal HEPA filters	+500 (2)		
17	Return air and general exhaust air ductwork on suction side of fans <u>other than</u> in mechanical rooms and vertical service spaces.	-500 (2)	C	Transverse joints and other connections
18	Supply air ductwork downstream of terminal units or reheat coil.	-250 (1)	C	Transverse joints only
19	Relief air ductwork on discharge side of return fan; Fan coil units, suction and discharge.	+250 (1)	C	Transverse joints only

Notes for table 3:

- (1) *Transverse joints* are connections of two duct or fitting elements oriented perpendicular to flow,
- (2) *Longitudinal seams* are joints oriented in direction of flow,
- (3) *Duct wall penetrations* are openings made by screws, non-self-sealing fasteners, pipe, tubing, rod and wire,
- (4) *Other connections* such as spin-ins taps and other branch fittings inserted into cut openings in duct, access door frames, insertion type control elements and duct joints at equipment are to be treated as *transverse joints*.
- (5) *This pressure class also applies to supply ductwork downstream of a terminal unit or reheat coil which serve diffusers with integral HEPA filters.*

3.6 Fittings - Rectangular Ductwork

- .1 Refer to Schedule B at the end of this section for illustrations of referenced fitting types.
- .2 Elbows:
 - .1 Elbows are to be installed as shown, or if not shown, in descending order as listed in table 4.
 - (a) for clarity, elbows types are to be selected based on the highest order number (where 1 is the highest) which will fit the available space.

Table 4: Rectangular Duct, Elbows

Order No.	ASHRAE Fitting No.	Description	Throat Radius Ratio R/W	Duct Width Limit mm (in)	Minimum Throat Radius mm (in)	Remarks
1	CR3-1	Smooth radius Un-vented elbow	1.5	≤ 300 (12)	---	Default
			1.0	> 300 (12)	---	
2	CR3-3	Smooth radius Vaned elbow	0.75	≤ 900 (36)	150 (6)	One full radius single thickness splitter vane

Table 4: Rectangular Duct, Elbows						
Order No.	ASHRAE Fitting No.	Description	Throat Radius Ratio R/W	Duct Width Limit mm (in)	Minimum Throat Radius mm (in)	Remarks
	CR3-4	Smooth radius Vaned elbow	0.75	> 900 (36) ≤ 1500 (60)	150 (6)	Two full radius single thickness splitter vane
	CR3-5	Smooth radius Vaned elbow	0.75	> 1500 (60)	150 (6)	Three full radius single thickness splitter vane
3	CR3-15	Square Mitred Vaned elbow	Square throat; Square heel.	--	---	Double thickness turning vanes; 50 (2) heel radius vane; 54 mm (2.125 in) vane spacing.
4	CR3-2	Radius Heel Sharp Throat	0.5	---	---	Double thickness turning vanes as per CR3-3, 4 or 5 depending on duct width

.2 First elbow on discharge side of fan:

(a) fitting CR3-1, un-vaned elbow with throat radius 1.0 times duct width, with the required upstream effective length L_e of straight length of duct in accordance with fitting type SR7-5 or SR7-9 as applicable.

.3 Wye and tee branch fittings - Supply air systems:

.1 Wye and tee branch fittings are to be installed as shown, or if not shown, as selected from table 5.

Table 5 : Rectangular Duct, Wye and Tee Branch Fittings - Supply Air Systems			
Ref. No.	Supply Ductwork System	Fitting Type	ASHRAE Fitting No
1	For 750 Pa (3 in.wg) pressure class and above: branch take-off from ducts in shafts, and ducts upstream of terminal boxes, filters and reheat coils	Smooth radius wye; diverging	SR5-1
		Dovetail wye	SR5-14
		Divided flow fittings	(SMACNA) 4A or 4B
		45° entry branch diverging	SR5-13
2	Supply ducts downstream of terminal boxes, fan coil units, reheat coils or heat pumps	Tee, rectangular main to round conical tap	SR5-12
		Tee, 45° entry branch diverging	SR5-13
		Smooth radius wye; diverging	SR5-1

.4 Wye and tee branches - Return/Exhaust air systems:

- .1 Wye and tee branch fittings are to be installed as shown, or if not shown, as selected from table 6.

Ref. No.	Return/Exhaust Ductwork System	Fitting Type	ASHRAE Fitting No
1	All pressure classes including branch connections at duct shafts	Smooth radius wye; converging	ER5-1
		Dovetail wye	ER5-4
		Divided flow fittings	(SMACNA) 4A or 4B
		45° entry branch diverging, where shown on drawings	ER5-3

- .5 Transitions (Rectangular and Round):

- .1 converging: maximum 20° angle between duct side and direction of flow,
.2 diverging: maximum 15° angle between duct side and direction of flow.

- .6 Fabricate duct offsets using elbows selected in accordance with table 2 and as follows:

- .1 single offset in single plane, less than duct height: made up with two 45° elbows,
.2 single offset, of greater displacement, made up with 90° elbows,
.3 double offset in single plane, less than duct height, made up with four 45° elbows,
.4 double offset in single plane, of greater displacement than duct height, made up with 90° elbows.

- .7 Obstructions passing through duct:

- .1 covered by round nosed streamline enclosure where free area of duct is reduced by less than 15%,
.2 fitted in round nosed streamline enclosure with duct width increase, SMACNA HVAC FIG 2-10, Detail E , with converging and diverging transition angle requirements as specified above.

3.7 Fittings - Round Ductwork

- .1 Refer to Annex A at the end of this Section for illustrations of referenced fitting types.
.2 Elbows:
.1 Elbows are to be installed as shown, or if not shown, in order of available space as listed in table 6.

Ref. No.	Description	ASHRAE Fitting No.	Throat Radius Ratio R/W	Duct Width Limit mm (in)	Remarks
1	30° elbow	CD3-3*	1.5	≤ 300 (12)	Die stamped
		CD3-14*	1.5	> 300 (12)	2-Gore
2	45° elbow	CD3-3	1.5	≤ 300 (12)	Die stamped

Table 6 : Round Duct, Elbows					
Ref. No.	Description	ASHRAE Fitting No.	Throat Radius Ratio R/W	Duct Width Limit mm (in)	Remarks
		CD3-14	1.5	> 300 (12)	3-Gore
3	60° elbow	CD3-3*	1.5	≤ 300 (12)	Die stamped
		CD3-14*	1.5	> 300 (12)	4-Gore
4	90° elbow	CD3-1	1.5	≤ 200 (8)	Die stamped
		CD3-9	1.5	>200 (8) and ≤ 350 (14)	5-Gore
		CD3-10	1.5	>350 (14) and ≤ 900 (36)	7-Gore
			2.5	> 900 (36)	7-Gore

.3 Wye branches:

- .1 Wye and tee branch fittings are to be installed as shown, or if not shown, as selected from table 7.

Table 7 : Round Duct, Wye and Tee Branch Fittings			
Ref. No.	Supply Ductwork System	Fitting Type	ASHRAE Fitting No
1	Downstream of supply fan.	Wye branch plus 45° elbow	SD5-2
		Tee, tapering	SD5-12
2	Downstream of terminal boxes.	Wye branch plus 45° elbow	SD5-1
		Tee, tapering	SD5-10
3	Return or exhaust duct branches.	Wye branch plus 45° elbow	ED5-2
4	Return or exhaust duct branches; equal main and branch duct size.	Tee, tapering, with 45° elbow	SD5-2
5	Return or exhaust duct branches; smaller branch size.	Tee, tapering, with 45° elbow	SD5-12

3.8 Temporary Protection of Duct Openings

- .1 Cap off ends of unfinished ducts while plastering, drywall and other finishing operations are in progress,
 .2 Cover open ends or registers of active exhaust/return ducts with 25 mm (1 in) thick filter media secured with tape. Maintain media until dust producing finishing operations are completed.

3.9 Duct Access Coors

- .1 Provide for inspection and servicing of duct mounted components and cleaning of duct system;

- .1 located such that any section of duct is not more than 15 m (50 ft) from point of access,
 - .2 at not more than 6 m (20 ft) intervals on supply air ductwork installed after HEPA filter,
 - .3 at base of each accessible duct riser,
 - .4 in front of and behind duct mounted coils,
 - .5 at activation side of fire, smoke, and combination fire/smoke dampers,
 - .6 and motorized dampers where damper actuator is located inside of duct or plenum.
- .2 Door size:
- .1 Select access door sizes based on smallest duct dimension in accordance with table 8.

Smallest Duct Dimension mm (in)	Bottom of duct height above floor m (ft)	Location	Door Size mm (in)
≤ 350 (14)	Any	Side or bottom	300 x 150 (12x6)
>350 and ≤500 (>14 and ≤20)	Any	Side or bottom	450 x 250 (18x10)
>500 (>20)	≤3.6 (12)	Side or bottom	530x350 (21x14)
	>3.6 (12)	Bottom	635x430 (25x17)

3.10 Duct Pressure Testing

- .1 Duct pressure testing must be completed to the satisfaction of Consultant before ductwork is insulated or concealed.
- .2 Pressure test air duct systems for leaks at 1.33 times the system, or portion of the system, pressure class specified and as follows;
 - .1 between supply air handling units and terminal units,
 - .2 between supply air handling units and final connection to supply outlets on supply systems without terminal units (excluding flexible ductwork)
 - .3 between inlet grilles and the exhaust/return fan inlet,
 - .4 between the return fan discharge outlet and the mixing plenum on recirculating return systems,
 - .5 between the exhaust fan discharge outlet and the point of discharge before leaving the building, but only for process exhaust systems conveying any materials other than general building exhaust air,
- .3 The following parts of system are exempt from pressure testing;
 - .1 short duct runs of 15 metres (45 feet) or less, operating at 37 Pa (1/8 in) SP or less.
 - .2 ductwork installed downstream of terminal boxes and fan coil units.
- .4 Conduct test in accordance with Associated Air Balance Council (AABC) recommended procedures.
- .5 Where audible air noise is detected during test, remove test, pressure apply sealant to leaking joints and seams, and retest after 48 hours. Continue testing and sealing until leaks are inaudible.

3.11 Duct Leakage Testing

- .1 Duct leakage testing must be completed to the satisfaction of Consultant before ductwork is insulated or concealed.
- .2 Conduct duct leakage tests in accordance with SMACNA *HVAC and Duct Leakage Test Manual* and as specified herein.
- .3 For each duct systems, calculate the maximum allowable ductwork airflow leakage rate based on duct surface area, pressure class and duct seal class in accordance with the following:

$$L = F \times D_{SA}$$

$$\text{and } F = K \times C_L \times P^{0.65}$$

where these parameters are unique to each section of duct:

- L is the maximum allowable leakage airflow rate,
- D_{SA} is the duct surface area,
- F is the leakage rate coefficient,
- C_L is the duct leakage class, and is listed in Table 10,
- P is the duct design pressure,
- K is a conversion factor depending on the units of measure and is listed in Table 9.

	Parameter	Flow Measurement Units	
		L/s	CFM
L	Allowable leakage units	L/s	CFM
D_{SA}	Duct surface area units	m ²	ft ²
F	leakage rate coefficient	L/s per m ²	CFM per 100 ft ²
C_L	Leakage Class	Refer to table 10 below	Refer to table 10 below
P	Duct Class pressure units	Pa	in.w.c.
K	unit conversion (multiplier)	1.4 x 10 ⁻³	1

Duct Type	Seal Class		
	C	B	A
Rectangular metal	24	12	6
Round Metal	12	6	3
Unsealed rectangular metal duct	48	48	48
Unsealed round or oval metal duct	30	30	30

- .4 Conduct duct leakage tests for each duct system at an air pressure equal to the duct system pressure class. Where a duct system has multiple pressure classes for different sections, test each section of the system independently.
- .5 If leakage rate exceeds the calculated maximum allowable value, examine ductwork for excessive leakage, re-seal and then repeat the leak test until the measured leakage rate is less than the calculated maximum allowable value for the section of the system under test.
 - .1 for clarity, where a duct system consists of multiple sections of different pressure classes, the acceptance criteria is based on not exceeding the aggregate of the calculated maximum allowable leakage of all sections in the same duct system.
- .6 Maintain a set of drawings on site, coloured each day during testing to indicate extent of duct satisfying leakage criteria under test.
- .7 Submit a written report, verified by the TAB Agent, identifying each segment of duct system tested, showing calculation of maximum allowable leakage (duct surface area, pressure class, seal class, leakage class "C_L" and calculated leakage air flow rate for the section), along with the test pressure and measured leakage airflow rate, and certifying that leakage testing has been satisfactorily completed.
- .8 Submit the report for review by Consultant before duct insulation is installed and branch take-offs are made for terminal units.

3.12 Duct Cleaning

- .1 Cleaning to be performed by agent specializing in this field of work, be a member in good standing with National Air Duct Cleaners Association (NADCA), and to comply with NADCA standards.
- .2 Clean new horizontal and vertical ducts (supply, return, exhaust, transfer), as well as existing supply and return ductwork connected to new fan systems.
- .3 Clean ductwork using high powered vacuum system, hand tools and mechanical brushing systems such that metal surfaces are visibly clean.
- .4 Reset balancing dampers to original settings if moved during work. Have TAB Agent confirm damper settings.
- .5 Maintain set of drawings on site, coloured each day during cleaning to indicate extent of duct cleaning completed.
- .6 Submit a written report, verified by TAB Agent, identifying extent of duct system cleaning and certifying that NADCA standards have been met.

3.13 Schedules

- .1 The following schedules form part of this specification section.
 - .1 Schedule A – Ductwork, Casings and Plenum Materials
 - .2 Schedule B – Illustrations of Referenced Fittings.

Schedule A – Materials for Ductwork, Casings and Plenums					
<p><u>Legend</u></p> <p>“Yes” means permitted material “---” means not permitted</p> <p>Where more than one material is indicate as permitted for a particular application or location, than any of those permitted materials may be used.</p>					
Application or Location	Galvanized Steel Z180 (G60)	Galvanized Steel Z275 (G90)	Stainless Steel	Aluminum	Notes
Outdoors	---	Yes	Yes	---	[1]
Intake air plenums	---	Yes	Yes	---	[1]
Exhaust air plenums	---	Yes	Yes	---	[1]
Parking garages	---	Yes	Yes	---	[1]
Indoor swimming pools and spas	---	---	Yes	Yes	[2]
Shower rooms	---	---	Yes	Yes	
Indoor painted ductwork	---	Yes	---	---	
Owner Process Equipment Exhaust	---	---	Yes	---	[2]
Duct-mounted humidifiers	---	---	Yes	---	
Shower exhaust ducts	---	---	Yes	Yes	
Buried ductwork	---	PVC Coated	Yes	---	
All other indoor locations	Yes	Yes	---	---	

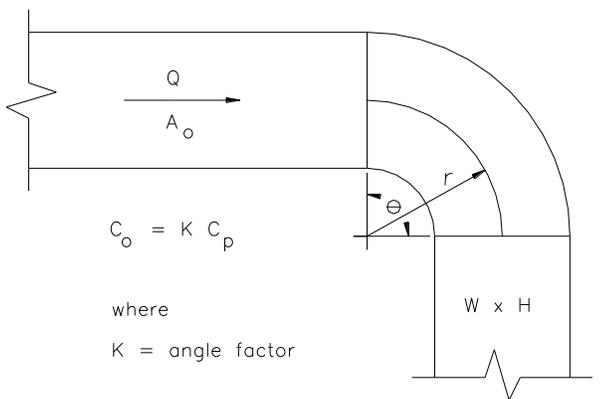
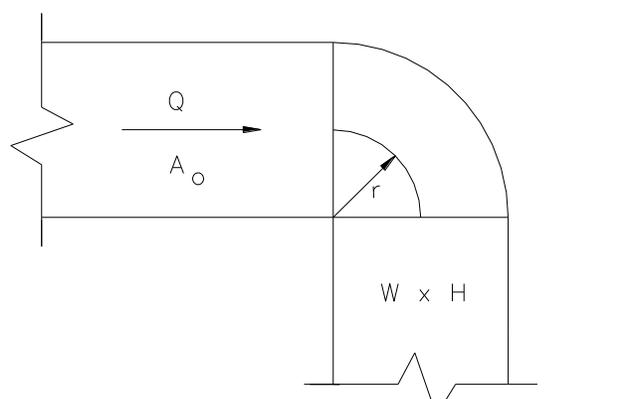
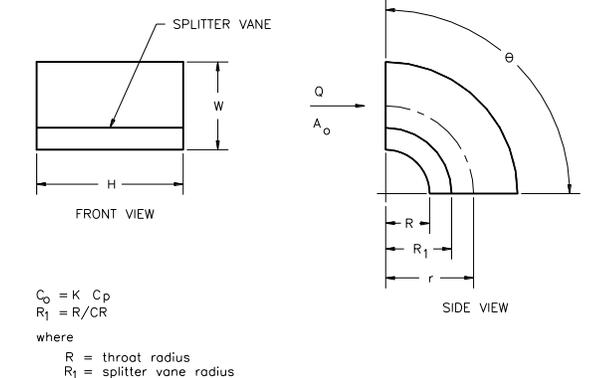
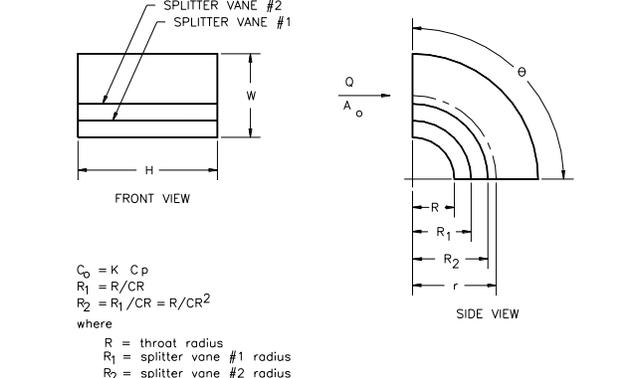
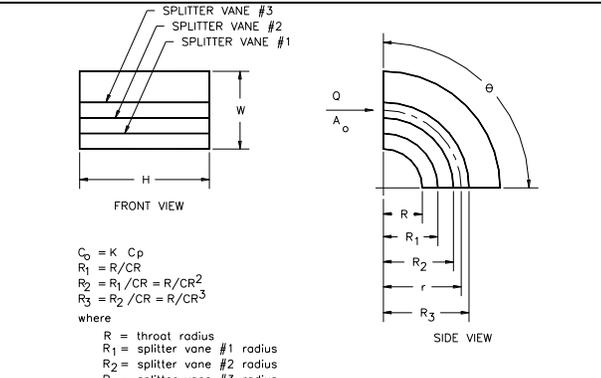
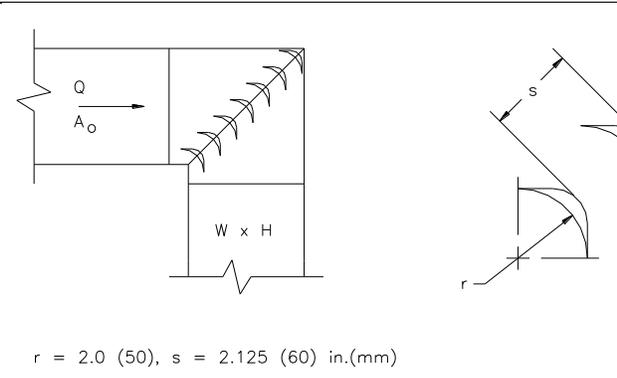
Notes:

[1] For both insulated and uninsulated ductwork.

[2] No. 4 brushed finish for exposed ductwork and hoods, No. 2B mill finish for concealed ductwork.

Schedule B – Illustration of Referenced Fittings

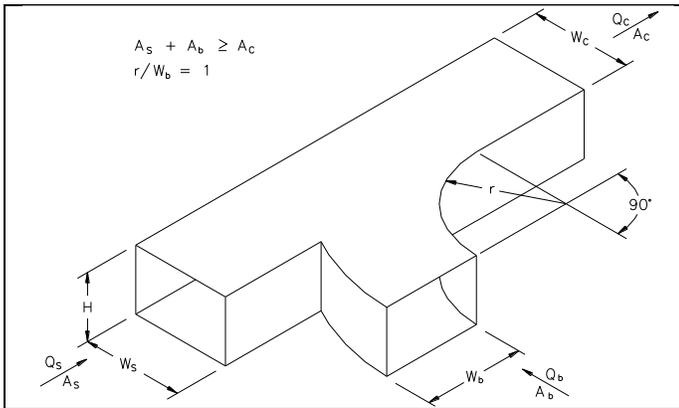
Rectangular Elbows (see Table 4 in Part 3.)

 <p>$C_o = K C_p$</p> <p>where $K = \text{angle factor}$</p> <p>W x H</p>	 <p>W x H</p>
<p>CR3-1</p>	<p>CR3-2</p>
 <p>SPLITTER VANE</p> <p>FRONT VIEW</p> <p>SIDE VIEW</p> <p>$C_o = K C_p$ $R_1 = R/CR$</p> <p>where $R = \text{throat radius}$ $R_1 = \text{splitter vane radius}$ $CR = \text{'CURVE RATIO'}$ $K = \text{angle factor}$</p>	 <p>SPLITTER VANE #2 SPLITTER VANE #1</p> <p>FRONT VIEW</p> <p>SIDE VIEW</p> <p>$C_o = K C_p$ $R_1 = R/CR$ $R_2 = R_1/CR = R/CR^2$</p> <p>where $R = \text{throat radius}$ $R_1 = \text{splitter vane #1 radius}$ $R_2 = \text{splitter vane #2 radius}$ $CR = \text{'CURVE RATIO'}$ $K = \text{angle factor}$</p>
<p>CR3-3</p>	<p>CR3-4</p>
 <p>SPLITTER VANE #3 SPLITTER VANE #2 SPLITTER VANE #1</p> <p>FRONT VIEW</p> <p>SIDE VIEW</p> <p>$C_o = K C_p$ $R_1 = R/CR$ $R_2 = R_1/CR = R/CR^2$ $R_3 = R_2/CR = R/CR^3$</p> <p>where $R = \text{throat radius}$ $R_1 = \text{splitter vane #1 radius}$ $R_2 = \text{splitter vane #2 radius}$ $R_3 = \text{splitter vane #3 radius}$ $CR = \text{'CURVE RATIO'}$ $K = \text{angle factor}$</p>	 <p>W x H</p> <p>$r = 2.0 (50), s = 2.125 (60) \text{ in. (mm)}$</p>
<p>CR3-5</p>	<p>CR3-15</p>

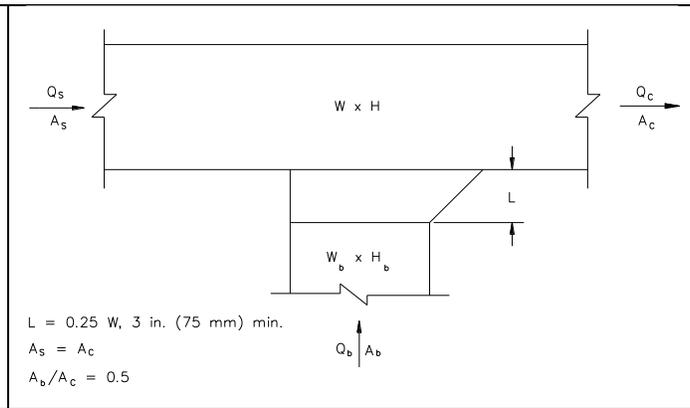
Rectangular Wyes and Tee's – Supply Ductwork (see Table 5 in Part 3)

<p> $A_s = A_b \geq A_c$ $r/W_b = 1.0$ </p>	<p> $L = 4 \text{ in. (100mm)}$ </p>
<p>SR5-1</p> <p> $L = 0.25W_b, 3 \text{ in. (75mm) min.}$ </p>	<p>SR5-12</p> <p> $r/W_c = 1.5$ $Q_{b1}/Q_c = Q_{b2}/Q_c = 0.5$ $W_{b1} = W_{b2} = W_b$ </p>
<p>SR5-13</p> <p> * S SLIP ON U CLIP OPTIONAL ALL SUCH CONNECTIONS TO BE SEALED </p> <p> TYPE 4A </p> <p> TYPE 4B </p> <p> SQUARE THROAT ELBOW OPTIONAL </p> <p> VOLUME CONTROL TO BE BY OPPOSED BLADE BRANCH DAMPERS </p> <p> $D_2 = 4" (102 \text{ mm}) \text{ MIN.}$ $D_3 = 4" (102 \text{ mm}) \text{ MIN.}$ </p> <p>SMACNA Fig. 4A/4B</p>	<p>SR5-14</p>

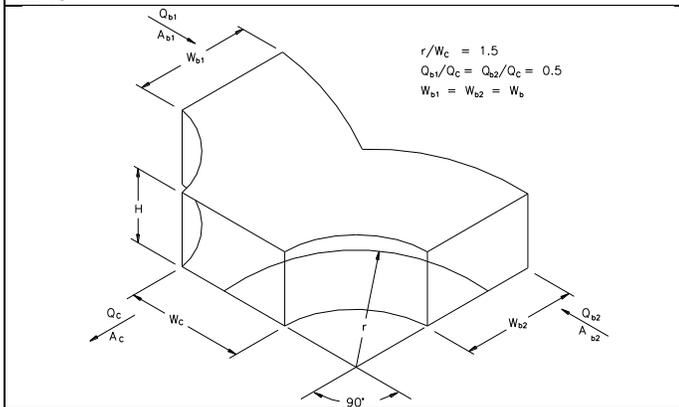
Rectangular Wyes and Tee's – Return/Exhaust Ductwork (see Table 5 in Part 3)



ER5-1

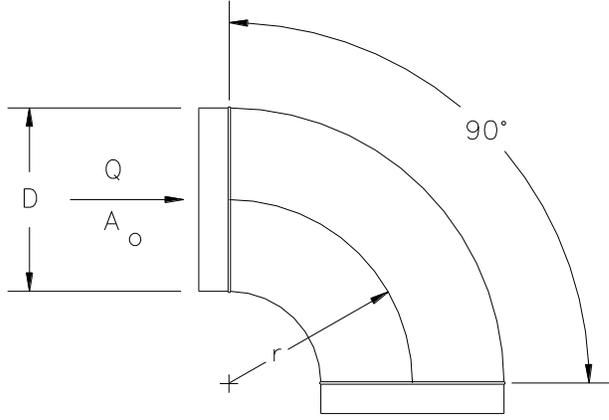
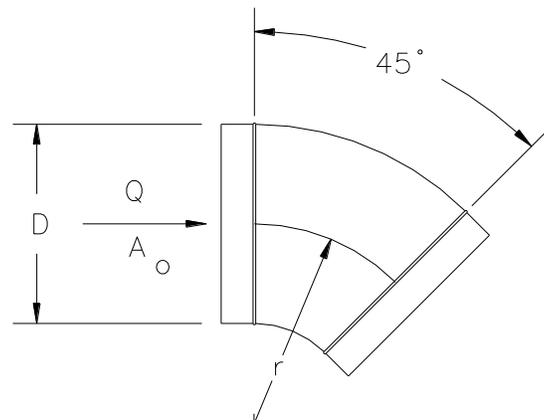
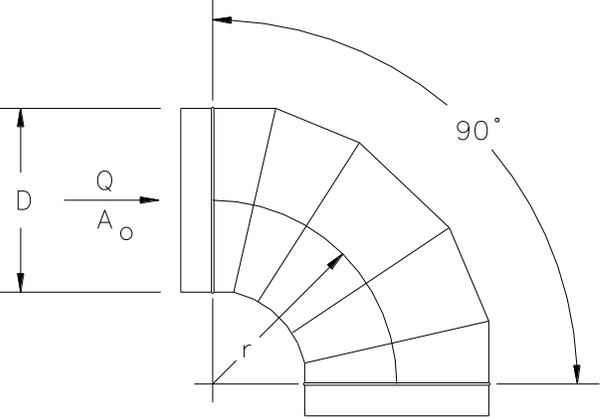
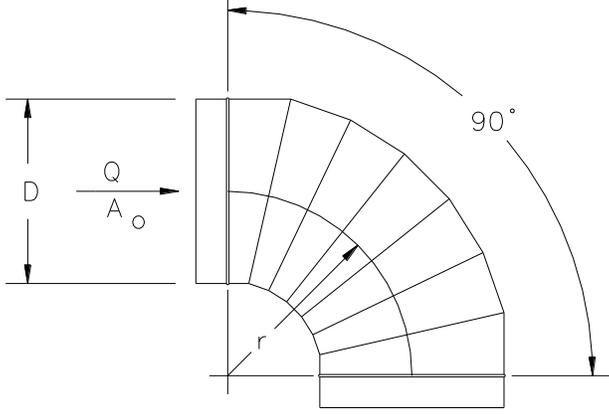
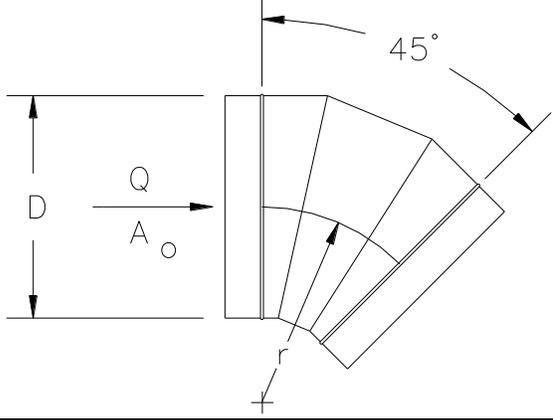


ER5-3

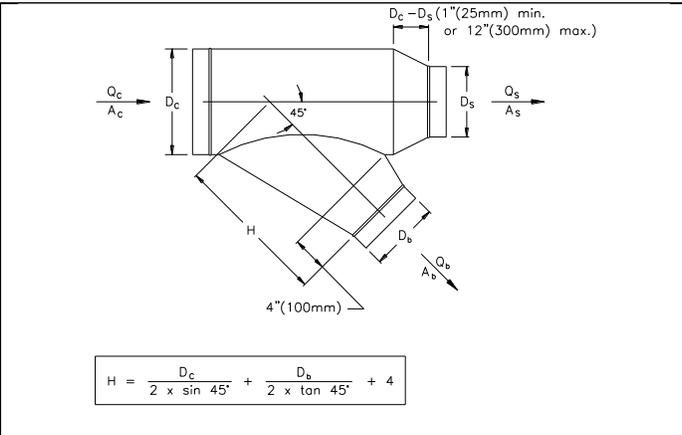
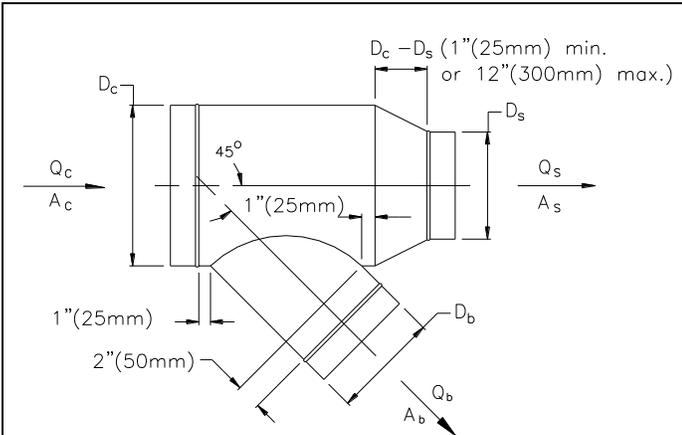


ER5-4

Round Elbows (see Table 6 in Part 3)

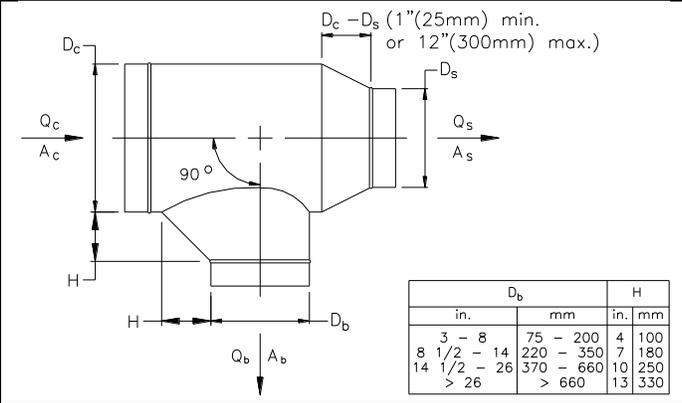
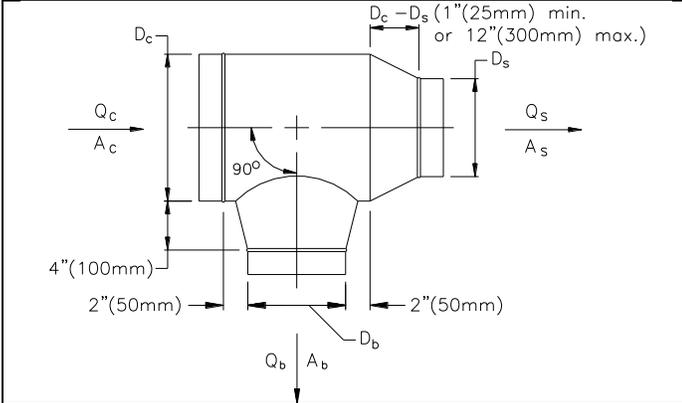
	
CD3-1	CD3-3
	
CD3-9	CD3-10
	
CD3-14	

Round Wyes and Tees (see Table 7 in Part 3)



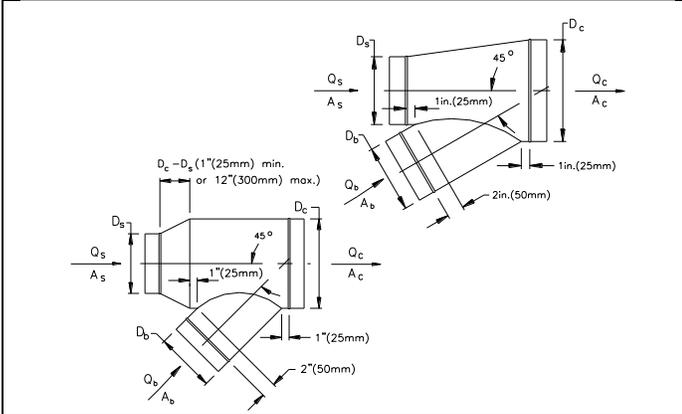
SD5-1

SD5-2



SD5-10

SD5-12



ED5-2

END OF SECTION

DUCT ACCESSORIES

23 33 05

1 GENERAL

1.1 Scope

- .1 Provide duct accessories as shown.
- .2 Access doors for kitchen grease ducts to conform to Specification section 23 31 13.23.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 31 13.23 Kitchen Grease Ductwork.

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 LEED v4 New Construction, Low-Emitting Materials credit
 - .2 UL 1978 Grease Ducts
 - .3 ULC-S110 Standard Methods of Test for Air Ducts

1.4 Submittals

- .1 Submit product data sheets for:
 - .1 flexible fan connectors,
 - .2 sealants,
 - .3 tapes,
 - .4 duct access doors and hardware,
 - .5 instrument test ports.

2 PRODUCTS

2.1 Duct Sealant

- .1 Water-based polymer emulsion type, flame resistant duct sealing compound.
- .2 Operating temperature range: -29°C to 93°C (-20°F to 200°F).
- .3 Operating pressure: tested to operate at 2.5 kPa (10 in.w.c.) duct static air pressure,
- .4 Meets requirements for SMACNA Class A, B and C duct sealing requirements.
- .5 Listed to ULC-S102 with flame-spread rating of 25 or less and smoke-development classification of 50 or less.
- .6 LEED requirements:
 - .1 meets requirements for LEED BD+C v4 credit for low emitting material – Paints and Coatings.
 - .2 manufacturer to supply documentation demonstrating compliance.

Standard of Acceptance

- ° Bakor - fig. Duck-Seal

- RCD - fig. #6 Mastic
- Childers - fig. CP-146
- McGill Air Seal - fig. United Duct Sealer (Water Based)
- Duro Dyne - fig, DWN (water based)

2.2 Tape

- .1 Polyvinyl treated open weave glass fibre tape, 50mm (2") wide.

2.3 Access Doors for Standard-Duty Ducts

- .1 Application: for general purpose HVAC ductwork.
- .2 Low-pressure access doors:
 - .1 manufactured duct access doors, of same material as associated duct,
 - .2 pressure rating: 500 Pa (2 in.w.c.) positive and negative pressure,
 - .3 door panel:
 - (a) double-wall construction encapsulating 25 mm (1 in.) thick fibreglass insulation,
 - (b) minimum 0.7 mm (24 ga.) sheet thickness for both inner and outer panel,
 - (c) inside face of access door does not protrude into interior space of duct,
 - .4 door frame: minimum 0.7 mm (24 ga.) thick channels, with mounting tabs and neoprene door gasket,
 - .5 door size: 150x150 mm (6 x 6 in.) up to 600x600 mm (24x24 in.)
 - .6 door hardware:
 - (a) hinge: continuous length, galvanized steel piano hinge of same material as door,
 - (b) latch - standard: galvanized steel cam-latch,
 - (c) latch – secured: common-key operated latch,
 - (d) security chain when only provided with cam-latches.

Standard of Acceptance

- Ductmate
- Duro-Dyne

- .3 High-pressure access doors – framed style:
 - .1 similar construction as for low-pressure framed access doors, except/and as specified below,
 - .2 pressure rating: 2500 Pa (10 in.w.c.) positive and negative pressure without measurable leakage under laboratory testing,
 - .3 hardware: cam-latch only,
 - (a) one (1) latch per door edge (total of 4) for 150x150 mm (6 x 6 in.) doors,
 - (b) two (2) latches per door edge (total of 8) for larger doors.

Standard of Acceptance

- Ductmate
- Duro-Dyne

- .4 High-pressure access doors – frameless style:

- .1 manufactured duct access doors, of same material as associated duct, for rectangular, round and flat-oval ducts,
- .2 pressure rating: 2500 Pa (10 in.w.c.) positive and negative pressure without measurable leakage under laboratory testing,
- .3 door panel:
 - (a) inner sandwich double-wall construction, encapsulating 25 mm (1 in.) thick fibreglass insulation, spot-welded seams, with smooth-faced finish where exposed to the airstream,
 - (b) outer pressure panel: stamped reinforced-exterior panel,
 - (c) neoprene gasket applied to inner panel face, positioned for positive or negative pressure applications,
 - (d) inside face of access door does not protrude into interior space of duct,
- .4 door frame: none.
- .5 door size: 200x100 mm (8 x 4 in.) up to 600x450 mm (24 x 18 in.)
- .6 door hardware:
 - (a) two (2) spring-loaded pressure-retaining bolting system, with tool-less polypropylene knobs.

Standard of Acceptance

- ° Ductmate - fig. Sandwich Access Doors

2.4 Access Doors for Plenums

- .1 Shop fabricated doors:
 - .1 double-wall construction, fully encapsulating 25 mm (1 in.) thick glass-fibre insulation,
 - .2 same material as duct, with both inner and outer panels of same thickness as associated plenum wall but not less than 0.6 mm (26ga.) thick,
 - .3 door frame: structural angles, galvanized steel minimum 2.0 mm (14 ga.) thickness, with continuous welded joints,
 - .4 gasket: automotive-style Neoprene gaskets bonded to door frame,
 - .5 door size: 500 mm wide x 1370 mm high (20 in. x 54 in.) except as otherwise shown,
 - .6 door swing:
 - (a) inwards for positive pressure plenums,
 - (b) outwards for negative pressure plenums.
- .2 Door hardware:
 - .1 hinges: continuous piano hinge, zinc-plated steel or stainless-steel,
 - .2 handles: two (2) handles operable from both sides.

Standard of Acceptance

- ° Duro-Dyne - fig. SP-20 (door handles)

2.5 Instrument Test Ports

- .1 Manufactured test ports:
 - .1 nominal size: Ø25 mm (1 in) minimum inside diameter, length to suit insulation thickness,
 - .2 extended body to accommodate 25 and 50 mm (1 and 2 in.) insulation thickness as applicable to the duct system,

- .3 1.6 mm (16 ga.) thick steel body zinc plated after manufacture,
- .4 chain-secured neoprene expansion plug with cam lock handle,
- .5 Neoprene mounting gasket: flat for rectangular duct and moulded for round duct.

Standard of Acceptance

- Duro-Dyne - fig. TH1 or IP2

- .2 Sealant for test port: high temperature silicone.

Standard of Acceptance

- Duro-Dyne - fig. Red High Temperature Silicon

3 EXECUTION

3.1 Sealant and Tape

- .1 Apply sealant to ductwork joints and seams as detailed in other sections.
- .2 Use of tape is limited to low-pressure systems requiring Class C

3.2 Access Doors for Standard Ducts

- .1 Provide access doors in HVAC standard ducts in accordance with the following table:

Access Point	Location
Reheat coils	Both sides of coil
Fire dampers - replaceable thermal link type	Either side of damper
Motorized fire dampers, smoke dampers and combination smoke fire	On actuator side of damper
Motorized Dampers	Either side of damper
Duct smoke detectors	Across from or beneath sensor tube
Bottom of duct risers	Bottom of duct riser, or on backside of elbow

- .2 Weld door frames in place for high velocity ductwork having air velocities in excess of 10 m/s (2500 fpm).
- .3 Access door sizes:
 - .1 as large as possible, with 1:1.5 aspect ratio, for duct sides up to and including 360 mm (14 in),
 - .2 300 mm x 380 mm (12 in x 15 in) for duct sides 380 mm (15 in) and larger,
 - .3 1500 mm (60 in) high by 450 mm (18 in) wide in casings and plenums.

3.3 Instrument Test Ports

- .1 Install test ports for duct velocity traverse readings and for duct air temperature readings.
- .2 Locate across duct or plenum at right angles to flow, at not more than 250 mm (10 in) intervals for traverses and at not more than 500 mm (20 in) for temperature measurements.

- .3 Install test ports for velocity traverses in the following locations:
 - .1 at ducted inlets to roof and wall exhausters,
 - .2 at inlet to and outlet from other fan systems, and
 - .3 at main and branch ducts where branch serves more than one outlet. Ports in main to be upstream of branch in both diverging and converging flow.
- .4 Install test ports for temperature measurement;
 - .1 at outside air intakes,
 - .2 at inlet and outlet of coils, and
 - .3 downstream of intersection of converging air streams of different temperatures.

END OF SECTION

MANUAL BALANCING DAMPERS

23 33 13.11

1 GENERAL

1.1 Scope

- .1 Provide manual balancing dampers.
- .2 This section does not apply to dampers installed in kitchen grease exhaust duct systems.

2 PRODUCTS

2.1 Splitter Dampers

- .1 Shop-fabricated, single thickness construction, of same material as duct but one sheet metal gauge thickness heavier where both dimensions of damper blade are less than 300 mm (12 in).
- .2 Double thickness construction, one metal gauge thickness lighter than duct, where either dimension of damper blade is 300 mm (12 in) or larger,
- .3 Height equal to full depth of branch duct, and length 1½ times branch duct width.
- .4 Fitted with piano hinge pivot, control rod, and locking device accessible from outside fitting.

2.2 Single Blade Dampers in Rectangular Ductwork

- .1 Manufactured product.
- .2 Blades and shaft:
 - .1 constructed of same material as the duct, with longitudinal V-grooves,
 - .2 blade thickness: 1.0 mm (20 ga.) minimum,
 - .3 blade length: 915 mm (36 in) maximum.
 - .4 bronze bearings,
 - .5 shaft extension with locking quadrant with 50 mm (2 in.) stand-off bracket.
- .3 Frame:
 - .1 channel section of same material as duct, minimum 1.3 mm (18 ga.) thickness,
 - .2 angle blade stop.

Standard of Acceptance

- Nailor - fig. 1870
- Ruskin
- Greenheck

2.3 Multi-Blade Dampers in Rectangular Ductwork

- .1 Manufactured product.
- .2 Blades and shaft:
 - .1 constructed of same material as the duct, with longitudinal V-grooves,
 - .2 opposed blade configuration, with link assembly located out of airstream,
 - .3 blade thickness: 1.6 mm (16 ga.) minimum,
 - .4 blade height: 150 mm (6 in) maximum,

- .5 blade length: 1200 mm (48 in) maximum.
 - .6 synthetic polymer or bronze bushings,
 - .7 shaft extension with locking quadrant with 50 mm (2 in.) stand-off bracket.
- .3 Frame:
- .1 channel section of same material as duct, minimum 1.6 mm (16 ga.) thickness,
 - .2 angle blade stop,

Standard of Acceptance

- Nailor - fig. 1820
- Ruskin
- Greenheck

2.4 Single Blade Dampers in Round Ductwork

- .1 Manufactured product.
- .2 Blades and shaft:
 - .1 constructed of same material as the duct,
 - .2 blade thickness: 0.86 mm (22 ga.) minimum,
 - .3 blade diameter: Ø100 to 500 mm (4 to 20 in. dia.),
 - .4 bearings: synthetic self-lubricating bushing,
 - .5 shaft extension with locking quadrant with 50 mm (2 in.) stand-off bracket.
- .3 Frame:
 - .1 round duct section of same material as duct, minimum 0.86 mm (22 ga.) thickness, with stiffening beads,
 - .2 angle blade stop,
 - .3 stand-off bracket for locking quadrant for insulated ducts.

Standard of Acceptance

- Nailor - fig. 1890
- Ruskin
- Greenheck

2.5 Single Blade Dampers in Round Ductwork with Remote Cable Adjustment

- .1 Manufactured product.
- .2 Blades and shaft:
 - .1 constructed of same material as the duct,
 - .2 blade thickness: 1.0 mm (20 ga.) minimum with V brake centreline,
 - .3 blade diameter: Ø100 to 500 mm (4 to 20 in. dia.),
 - .4 bearings: synthetic self-lubricating bushing,
 - .5 shaft extension with 50 mm (2 in.) stand-off bracket.
- .3 Frame:
 - .1 round duct section of same material as duct,

- .2 wall thickness:
 - (a) Ø100 to 250 mm (4 to 10 in. dia.): 0.7 mm (24 ga.)
 - (b) Ø300 to 500 mm (12 to 20 in. dia.): 1.0 mm (20 ga.).
- .3 angle blade stop,
- .4 stand-off bracket for insulated ducts.
- .4 Remote cable operator:
 - .1 damper blade gear operator:
 - (a) self-locking worm-gear regulator, suitable for 9.5 mm (3/8 in.) square or Ø13 mm (½ in. dia) damper shaft,
 - .2 flex-shaft cable:
 - (a) Ø6 mm (1/4 in. dia.) multi-core wound cable in flexible non-binding protective sheath,
 - (b) length: standard and custom lengths up to 15 m (50 ft),
 - (c) with brass end caps and threaded end fittings to attached to damper gear operator and adjustment operator,
 - .3 remote cable operator fixture:
 - (a) cable termination end for tool access,
 - (b) termination kit:
 - i) Ø60 mm (2-1/4 in. dia) zinc coated termination access housing, with prime coated cover plate, for self-clamping installation in drywall ceilings,
 - ii) remote cable operator kit for installation in slot diffuser plenum to allow tool access through diffuser slot.

Standard of Acceptance

- Young Regulators - fig. 5020CC with 270-275 cable operator

3 EXECUTION

3.1 Balancing Damper Locations and Type

- .1 Provide balancing dampers in the following locations:
 - .1 at floor branches from a duct riser, use a single or multiple blade damper in the branch duct,
 - (a) where a wye-fitting is installed directly after the duct riser take-off, provide a balancing damper in each outlet branch after the wye fitting,
 - .2 for supply branch ducts that do not directly serve outlet grilles or diffusers, use a single or multiple blade damper in the branch duct,
 - .3 for exhaust or return branch ducts that do not directly serve inlet grilles, use a single or multiple blade damper in the branch duct,
 - .4 for branch duct which directly serve three or more grilles or diffusers (supply, return or exhaust), use splitter damper in the take-off fitting, or use a single or multiple blade damper in the branch duct,
 - .5 on the inlet to a supply air terminal unit, use a damper of the style to match the inlet duct connection to the air terminal unit,
 - .6 on the outlet from a return or exhaust air terminal unit, use a single or multiple blade damper in the branch duct.
- .2 Provide other manual dampers as shown.

3.2 Access for Adjustment

- .1 Locate dampers to allow adjustment of blade position and for locking of the quadrant.

3.3 Remote Cable Adjustment Station

- .1 Use round balancing dampers with remote cable operators where:
 - .1 ceiling height is greater than 3.0 m (10 ft),
 - .2 ceiling height is less than 3.0 m (10 ft) and is not accessible, or
 - .3 elsewhere at the Contractor's discretion.
- .2 Review with Consultant approximate location for each group of remote cable operators;
 - .1 exception: Consultant's review is not required when remote cable operator is located in a slot diffuser plenum.
- .3 Group operators together within the limits of the allowable cable length.
- .4 For ceilings up to 3.0 m (10 ft) in height, remote cable operators may be located in the following locations:
 - .1 within slot diffuser plenums, or
 - .2 mounted in or immediate above ceilings, with termination kit which passes through the ceiling to allow adjustment tool access from below ceiling.
- .5 For ceilings greater than 3.0 m (10 ft) in height, group remote operators together in wall chase access in locations agreed by Consultant, positioned between 1200 and 1800 mm (4 and 6 ft) above the floor. Provide a wall mounted access cover with screwdriver door operator and prime coated finish.
- .6 Where a service room, including mechanical rooms, electrical rooms, and janitor closets are available, mount the remote cable operator in those rooms on a wall mounted bracket. A panel enclosure is not required.
- .7 Label each remote cable operator with a unique reference number, and mark-up as-built drawings to include the reference number for each applicable balancing damper.

END OF SECTION

DAMPERS - OPERATING

23 33 13.13

1 GENERAL

1.1 Scope

- .1 Provide motorized control dampers as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 25 30 13 Building Automation Actuators and Operators
 - .2 25 30 23.13 Building Automation Control Dampers

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 AMCA 511 Product Rating Manual for Air Control Devices

1.4 Submittals

- .1 Submit product data sheets for materials specified herein and include:
 - .1 performance charts, pressure drop vs approach velocity for range of blade angles from 0 to 90°,
 - .2 torque requirements,
 - .3 construction details.

2 PRODUCTS

2.1 Multi-Blade Operatable Control Dampers

- .1 Performance:
 - .1 control dampers listed to AMCA 511.
 - .2 leakage in closed position: AMCA Class 1A at 250 Pa (1 in.wc.) and Class 1 at 1000 kPa (4 in.w.c.).
 - .3 pressure drop in open position: maximum 12 Pa (0.05 in wg) differential at 5 m/s (1000 fpm).
 - .4 operating temperature range: -40 to 100°C (-40 to 212°F)
- .2 Construction:
 - .1 non-insulated dampers:
 - (a) blades: extruded aluminum interlocking blades,
 - (b) frame: extruded aluminum,
 - .2 insulated dampers:
 - (a) blades: extruded aluminum interlocking double thickness insulated blades,
 - (b) frame: extruded aluminum, thermally broken,
 - .3 seals: extruded vinyl seals, and spring stainless steel side seals,

- .4 bearings: Celcon or similar inner bearing with polycarbonate outer bearing,
- .5 maximum blade width: 150 mm (6 in),
- .6 maximum blade length: 1200 mm (4 ft).
- .7 blade linkage: aluminium and zinc-plated steel tie rods, brass pivots and steel brackets, for parallel blade and opposed blade operation as required for damper control operation.

3 EXECUTION

3.1 Damper Movement Style Selection

- .1 Blade movement type (for control function other than recirculating air handling units):
 - .1 parallel blade style for two position operation.
 - .2 opposed blade style for modulating applications.

3.2 Installation

- .1 Secure dampers within ductwork, air handling units and at air inlets and exhaust outlets.
- .2 Caulk around frames and between multiple damper modules with UL listed silicone-free duct sealant.

3.3 Start-Up and Testing

- .1 Stroke dampers fully open and fully closed ten times. Check for free movement of damper blades. Check dampers full close along blade edge seals and end seals.

End of Section

DAMPERS - FIRE AND SMOKE

23 33 13.16

1 GENERAL

1.1 Scope

- .1 Provide fire dampers and ceiling fire stop flaps.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 13.16 Wiring Requirements for Mechanical Services

1.3 Definitions

- .1 The following definitions apply for this specification section:
 - .1 **Damper:** means a smoke damper, motorized fire damper or combination smoke/fire damper.
 - (a) **Balancing damper:** : a damper with an electric actuator that is listed for operation as a modulating damper in normal service, to allow setting the damper at a position between open and closed, for system air balancing purposes.
 - (b) **Dynamic damper:** a fire damper rated to close with airflow through damper at specified air velocities and operating pressure.
 - (c) **Modulating damper:** a damper with an electric actuator that is listed for operation as a modulating damper in normal service, to allow modulating control of the damper in response to a normal (non-emergency) process control requirement.
 - (d) **Reopenable damper:** a motorized fire damper of combination smoke/fire damper that can be electrically re-opened by bypassing the primary heat detection device.
 - (e) **Static damper:** a fire damper rated only to close with essentially no airflow through the damper.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 NFPA 80 Installation, Testing, and Maintenance of Fire Dampers
- .2 Product standards:
 - .1 AMCA 500-D Laboratory Methods of Testing Dampers for Ratings.
 - .2 ANSI/CAN/UL/ULC 33 Heat Responsive Links for Fire-Protection Services
 - .3 CAN/ULC - S112 Standard Method of Fire Test of Fire Damper Assemblies
 - .4 CAN/ULC - S112.2 Standard Method of Fire Test of Ceiling Firestop Flap Assemblies
 - .5 ULC-S505 Standard for Fusible Links for Fire Protection Services

1.5 Submittals

- .1 Submit manufacturer catalogue cut-sheets for the following materials;
 - .1 fire dampers,
 - .2 fire stop flaps.
- .2 When requested by an AHJ for building safety, submit confirmation data that the fusible link is listed to ULC-S505 or ANSI/CAN/UL/ULC 33.

2 PRODUCTS

2.1 General

- .1 Approvals:
 - .1 Fire dampers listed to CAN/ULC-S112.
 - .2 Ceiling fire stop flaps listed to CAN/ULC-S112.2.
 - .3 Fusible links for fire dampers listed to ULC-S505 or ANSI/CAN/UL/ULC 33.

2.2 Fire Dampers - General Requirements

- .1 Curtain damper styles:
 - .1 Type A: blade pack and frames in airstream,
 - .2 Type B: blade pack out of airstream,
 - .3 Type C:
 - (a) blade pack and frame out of airstream,
 - (b) for rectangular, round and flat oval ductwork, and
 - (c) sleeve joints and damper/sleeve joints sealed.
- .2 Fire damper fire-resistance rating:
 - .1 Fire separation ratings 2 hr and less: 1-1/2 hrs.
 - .2 Fire separation rating 3 hr or more: 3 hr.
- .3 Installation orientation:
 - .1 Dynamic and static dampers suitable for installation in vertical and horizontal separations.
 - .2 Dampers that are only listed for one orientation are not permitted.
- .4 Rating class, dynamic dampers:
 - .1 Standard performance;
 - (a) air velocity, maximum 10 m/s (2000 fpm),
 - (b) operating static pressure, maximum 1000 Pa (4 in.w.c.)
 - .2 Extended performance ("EPxx");
 - (a) air velocity, maximum 15 m/s (3000 fpm),
 - (b) operating static pressure, maximum 1000 Pa (4 in.w.c.)
 - .3 High velocity performance ("HVxx");
 - (a) air velocity, maximum 20 m/s (4000 fpm),
 - (b) operating static pressure, maximum 1000 Pa (4 in.w.c.)
- .5 Manufacturers:

Standard of Acceptance

- Nailor
- EH Price (National Controlled Air)
- Ruskin

2.3 Fire Dampers - Curtain Type

- .1 Construction:

- .1 Frame: G60 roll formed galvanized steel frame.
- .2 Blades: curtain type, interlocking blades, G60 galvanized steel.
- .3 Sleeve:
 - (a) same material as damper frame, length to suit application with steel enclosure and transition collars, and retaining angles.
 - (b) for type B damper sleeves, top of sleeve is formed closely around top of damper; sleeve construction that leaves the blade pack in the airstream is not permitted.
- .4 Sleeve type: type A, B, or C as specified in Part 3.
- .5 Fusible link: 71°C (160°F) unless otherwise shown.
- .6 Notwithstanding the above, frame, sleeve, and blades to be stainless steel where damper is installed in a duct system which is stainless steel.
- .7 Dynamic dampers: fitted with stainless steel closure spring, and rated for velocity and operating pressure based on rating class.
- .8 Static dampers: fitted with stainless steel closure spring.

2.4 Fire Dampers - Multiblade Type

- .1 Construction:
 - .1 Type: dynamic.
 - .2 Frame: G60 galvanized steel hat channel.
 - .3 Blades: airfoil multiblade type, interlocking blades, G60 galvanized steel;
 - (a) Parallel blade for Open-Closed operation,
 - (b) Opposed blade for modulating control or balancing control.
 - .4 Blade linkage: plated steel, concealed in frame (out of airstream).
 - .5 Bearings:
 - (a) On-Off control, and balancing: self-lubricated oil-tight bronze,
 - (b) modulating control: stainless steel.
 - .6 Jackshaft: cadmium plated steel.
 - .7 Internal locking quadrant for balancing maximum opening position.
 - .8 Sleeve: same material as damper frame, length to suit application with steel enclosure and transition collars, and retaining angles.
 - .9 Sleeve type: type A, B, or C as per listing requirements.
 - .10 Notwithstanding the above, the frame, sleeve, and blades to be stainless steel where damper is installed in a duct system that is stainless steel.
- .2 Operator - fusible link:
 - .1 Torsion spring, with 74°C (165°F) fusible link unless otherwise shown.
- .3 Operator – electric damper actuator:
 - .1 Factory installed electric damper actuator in accordance with article on Damper Actuators as required
 - (a) by certification listing for large dampers/damper bank applications, or
 - (b) where otherwise shown.

- .2 Electric resettable heat detection switches, Normally Closed contacts opening on temperature rise above setpoint;
 - (a) setpoint temperature, non-reopenable damper: 74°C (165°F),
 - (b) setpoint temperature, reopenable damper:
 - i) primary switch: 74°C (165°F),
 - ii) secondary switch: 176°C (350°F).

2.5 Special Sleeve Modifications

- .1 Special sleeve and damper arrangements for:
 - .1 single-sided retention angle installation,
 - .2 sleeve mounting tags for air diffusers and grilles directly attached to fire damper sleeve and wall opening. Dampers positioned in sleeve to allow for balancing damper installed on back-side of grille or diffuser.

2.6 Fire Stop Flaps (Ceiling Radiation Dampers)

- .1 Construction:
 - .1 Galvanized steel frame and blades for round or square neck diffusers.
 - .2 Fitted with corrosion resistant steel springs and replaceable 71°C (160°F) fusible link.
 - .3 Supplied with thermal blanket cut to suit diffuser face plate dimensions and diffuser neck size.
 - .4 Labeled or listed and rated for both steel duct and flexible duct installations.
 - .5 Fitted with adjustable volume controllers where shown.

3 EXECUTION

3.1 Installation – General Requirements

- .1 Install fire dampers and fire stop flaps throughout supply, return and exhaust air systems in fire separations marked as having a fire resistance rating and as shown.
- .2 Install fire dampers in accordance with manufacturer's instructions, with sleeve, duct connections and angle supports to comply with terms and conditions of listing or classification and maintain integrity of fire wall and/or fire separation.
- .3 Install stainless steel dampers in stainless steel duct systems and/or wherever ductwork is specified to be watertight construction.

3.2 Fire Damper Selection

- .1 Select fire damper types as follows:
 - .1 "Dynamic" - all locations unless otherwise shown,
 - .2 "Static" - restricted to un-ducted transfer air openings.
- .2 Select curtain-type fire damper styles as follows:
 - .1 For dynamic and static dampers:
 - (a) duct height in the following tables is the duct dimension perpendicular to blade length orientation.

Damper Velocity Class	Duct Height mm	Curtain Damper Style
Standard Performance (≤ 10 m/s)	> 300	A
	≤ 300	B
Extended Performance (10 to ≤ 12.5 m/s)	> 200	B
	≤ 200	C
High Velocity Performance (> 12.5 m/s)	Any	C

Damper Velocity Class	Duct Height In.	Curtain Damper Style
Standard Performance (≤ 2000 fpm)	> 12	A
	≤ 12	B
Extended Performance (2000 to ≤ 2500 fpm)	> 8	B
	≤ 8	C
High Velocity Performance (> 4000 fpm)	Any	C

3.3 Fire Damper Installation

- .1 Where the duct size exceeds the maximum listing size of a multiple curtain damper assembly, provide multiblade fire dampers.
- .2 Where fire dampers are shown to be motorized, provide multiblade fire damper with electric operator.

3.4 Damper Sleeves

- .1 Provide factory-made damper sleeves in accordance with damper listing requirements, and as described herein.
- .2 For multiblade dampers, smoke dampers, and combination smoke/fire dampers, fabricate sleeve style based on damper size listing requirements.
- .3 Install damper sleeves with retaining angles in accordance with the damper manufacturer instructions.
- .4 Where a diffuser or grille is shown at a fire damper, smoke damper or combination smoke/fire damper, provide sleeves specifically listed for single sided retention angles and which provide brackets for securing of the grille or diffuser to the sleeve.
- .5 Where permitted by the damper manufacturer installation instructions, smoke dampers may be fastened directly to the duct without requiring the use of a sleeve.

3.5 Damper Access Doors

- .1 Provide duct access door at each fire damper to permit visual inspection and replacement of fusible link. Do not locate access doors in a vertical service space (shaft).
- .2 Provide duct access door at each smoke damper and combination smoke/fire damper, to permit visual inspection and service of fire detection/actuation mechanism. Provide such access doors even where dampers are provided with electrically supervised damper position indication.
- .3 For curtain-type fire dampers in vertical ducts, the preferred access location is from the floor above the damper.

- .4 For motorized fire dampers, smoke dampers and combination smoke/fire dampers installed in vertical ducts, position the damper actuator assembly so that it is not located in a vertical service space (shaft). Preferred position in order of priority and applicability are:
 - .1 above floor level in a service room,
 - .2 in the ceiling space below the bottom of a vertical service space.
- .5 Install damper actuator assemblies on the room side of a damper isolating the room from a corridor, except where the duct ends at a wall grill.

3.6 Fire Stop Flap Installation

- .1 Install fire stop flaps in accordance with manufacturers' instructions. Position supplied thermal blankets to cover ceiling diffusers.

3.7 Damper Power Supplies; Non-Controlled Dampers

- .1 This article applies to fire dampers requiring electric actuators due to the limitations of damper size in accordance with each manufacturer product listing, but are otherwise not remotely controlled.

3.8 Testing

- .1 Conduct installation tests of all fire dampers in accordance with NFPA 80, NFPA 90A and NFPA 105 as applicable to damper type and summarized as follows.
- .2 Field test all fire dampers and fire stop flaps as follows:
 - .1 operate dampers to demonstrate unobstructed operation of the damper from open-to-close-to open state. These tests are to be performed while the fan systems are not in operation (static test),
 - .2 for dynamic dampers, confirm air velocity through the open dampers under normal HVAC system operation, once air balancing is completed. Select dampers to confirm operation for ducts operating within 80% of the maximum air velocity of the damper listing,
 - .3 confirm accessibility to components of fire damper to permit maintenance and testing,
 - .4 where a damper is provided with an indicating device, confirm device functions and annunciates to the supervised location or system when the damper is in both the open and closed state, as applicable.
- .3 In addition, for multiblade fire dampers with electric operators, smoke dampers or combination smoke/fire dampers, cycle test dampers under normal HVAC operating conditions (dynamic test).
- .4 Record test results as per the attached test form or similar containing the same information, and submit to Owner and Consultant as part of the Operations and Maintenance manual.
- .5 Upon completion of testing, provide labour and resources necessary to conduct a demonstration re-test for up to 10% of curtain-type dampers on each floor as selected and witnessed by Engineer.

3.9 Test Form

- .1 Test form follows at the end of this section.

Fire Damper Test Record

<i>Project</i>							<i>System</i>		
<i>Testing Company</i>							<i>Technician Name</i>		
Damper location	Inspection Date YYYY-MM-DD	Damper Type ⁽¹⁾	Static Op. Test ⁽²⁾	Dyn Op. Test ⁽³⁾	Access Test ⁽⁴⁾	Air Flow ⁽⁵⁾	Confirmed/ Deficiencies	Deficiency Corrected	Damper Audited

- (1) Damper Type : FD, MFD, SD, or CSFD
- (2) Static Operating Test without airflow
- (3) Dynamic Operating Test with balanced airflow; multiblade FD, SD and CSFD only.
- (4) Damper and components are accessible for inspection and testing
- (5) Identify which damper air velocity is checked in accordance with the test selection criteria.

END OF SECTION

AIR TERMINAL UNITS

23 36 13

1 GENERAL

1.1 Scope

- .1 Provide air terminal units as shown.
 - .1 supply air terminal units,
 - .2 supply air terminal units with reheat coils

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 23 82 16.16 Hydronic Duct Mounted Air Coils
 - .3 25 14 17 Building Automation Terminal Unit Controllers
 - .4 25 30 13 Building Automation Actuators and Operators

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 AHRI 880 Standard for Performance Rating of Air Terminals
 - .2 ANSI/ASHRAE 130 Laboratory Method of Testing Air Terminal Units
 - .3 ASTM C1071 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorption Material)
 - .4 CSA C22.2 No. 66.3 / UL 5085-3
Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers
 - .5 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .6 CAN/ULC-S102.2 Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies.

1.4 Submittals

- .1 Shop drawings:
 - .1 Submit manufacturer's data sheets with;
 - (a) equipment model numbers, performance and design data, outline dimensions, enclosure details, support and connection arrangements and electrical power requirements where applicable.
 - (b) schedules listing discharge and radiated sound power level for each of the second through seventh octave bands (125 - 4000 Hertz) at specified differential static pressures.

2 PRODUCTS

2.1 General Requirements

- .1 Factory-assembled terminal units, with performance ratings in accordance with AHRI 880, and bearing the AHRI seal for an air volume control terminal with damper assembly and flow sensor.

Standard of Acceptance

- E.H. Price
 - Titus
 - Environmental Technologies
 - Nailor Industries.
 - Carnes
 - Metalaire
- .2 Airflow performance tested and rated in accordance with ASHRAE standard 130.
 - .3 Unit performance rating to be over the following inlet static pressure range:
 - .1 maximum inlet air pressure: 750 Pa (3 in wg),
 - .2 minimum inlet air pressure: 75 Pa (0.3 in wg),
 - .4 Except where the terminal unit size is shown on drawings and/or schedules, select terminal unit sizes so that design airflow rates as shown do not exceed 70% of manufacturers published maximum air flow rate.
 - .5 Terminal unit sizes (e.g. size 6 as shown on drawings or equipment schedules) are based on E.H.Price model SDV for physical dimensions and airflow performance range.
 - .6 Acoustic performance:
 - .1 maximum room sound pressure level (referenced at 2×10^{-4} microbar) at 250 Pa (1 in.w.c.) inlet pressure to be less than:
 - (a) NC 40 at discharge and NC 42 radiated for units with attenuator mounted exposed (without ceiling).

2.2 Single Duct Air Terminal Units

- .1 Casing:
 - .1 galvanized steel, minimum 0.76 mm (22 ga) thickness, with lock-seam longitudinal joints,
 - .2 casing leakage: not to exceed 1.0% of maximum rated airflow at an inlet pressure of 250 Pa (1 in.w.c.) as tested in accordance with ASHAE 130,
 - .3 entire casing lined on all faces with acoustic attenuation liner,
 - .4 inlet connection: circular with slip end and rolled bead duct-stop,
 - .5 discharge connection: rectangular with slip-and-drive connection,
 - .6 minimum unit length with reheat coils;
 - (a) reheat coil to be mounted at the outlet of attenuator or silencer,
 - (b) where no attenuator or silencer is required to meet acoustic performance, terminal unit length to be not less than 900 mm (26 in) between the outlet of the air valve and the inlet face of the reheat coil,
 - (c) unit extensions provided with liner through entire length.
- .2 Control damper / valve assembly:

- .1 minimum 1.2 mm (18 ga) thick galvanized steel damper blade with solid shaft rotating in bearings,
 - .2 damper position indicator permanently attached or formed into damper shaft,
 - .3 damper blade edge gasket for tight airflow shut-off, and two reference stop pins for the 0% and 100% open positions,
 - .4 air leakage in closed position: $\leq 2\%$ of unit maximum airflow at 750 Pa (3 in.w.c.) inlet static pressure and tested in accordance with ASHRAE 130.
- .3 Control enclosure:
- .1 factory mounted on side of terminal unit,
 - .2 painted steel electrical enclosure, Type 1 listed to CSA C22.2 No. 94.21 (NEMA 1), with
 - (a) removable cover,
 - (b) wiring knockouts,
 - (c) integral backplane for mounting of control devices, constructed so there are no exposed screw tips.
 - .3 control transformer:
 - (a) factory mounted and wired 120/24 VAC Class 2 current limited control transformer,
 - (b) listed to CSA C22.2 No. 66.3,
 - (c) of size to suit terminal unit DDC controller, and disconnect switch.
 - .4 enclosure side-mounted disconnect switch.
- .4 Airflow velocity sensor:
- .1 airflow sensor fully removable for cleaning,
 - .2 total and static differential pressure sensor, mounted in inlet duct,
 - .3 fire-resistant plastic elements conforming to UL 94,
 - .4 not less than 12 total pressure sample ports and four (4) static pressure ports, with center averaging chamber,
 - .5 sensor accuracy after field calibration: velocity sensor measured flow to be within $\pm 5\%$ of externally measured value, over the terminal unit published flow range, and independent of inlet duct arrangement,
 - .6 sample tubing provided with protective grommets where tubing passes through metal duct and enclosure.
- .5 Sound attenuator:
- .1 sound attenuators used on terminal unit sizes 10 and smaller,
 - .2 constructed as an extension of the terminal unit casing assembly,
 - .3 attenuator construction: same as for terminal general casing complete with liner,
 - .4 attenuator length: not less than 900 mm (3 ft),
 - .5 attenuator liner: as specified in article "Liner".
- .6 Liner – fiberglass:
- .1 liner acoustic/thermal media:
 - (a) flexible or semi-rigid, dual-density, fibrous glass duct liner, with air-facing side factory sealed with acrylic coating and flexible glass cloth reinforcement, and factory sealed edges, to ASTM C1071,

- (b) listed to UL 2818 for low VOC content,
 - (c) surface mat treated with EPA-registered anti-microbial agent,
 - (d) insulation resistance: RSI 0.74 (R4.2)
 - (e) thickness: 25 mm (1 in),
 - (f) maximum air velocity: 30 m/s (6000 fpm),
 - (g) service temperature: 121°C (250°F) to ASTM C411,
 - (h) listed to CAN/ULC-S102, with flame spread rating not to exceed 25 and a smoke development rating not to exceed 50,
 - (i) field applied sealer applied to cut edges and damaged surfaces, as recommended by duct lining manufacturer, so there are no exposed unprotected media surfaces.
- .2 liner media fastened to inside of unit casing with 100% adhesive coverage and mechanical pin fasteners and retention heads:
- (a) 2.0 mm (1/16 in) diameter pins,
 - (b) length selected to suit thickness of insulation,
 - (c) 32 mm (1¼ in) square Nylon retaining clips.
- .3 liner media protective coverings:
- (a) a Mylar or Tedlar film, encapsulating the air-facing surface and all cut-end edges,
 - (b) an additional protective overlay of perforated galvanized steel.

Standard of Acceptance

- Steri-Liner

.7 Access doors

- .1 factory installed access doors;
 - (a) field installation of access doors are prohibited.
- .2 where required:
 - (a) in unit cabinet after control damper,
 - (b) upstream of reheat coil,
 - (c) located on underside or side of unit depending on site conditions.
- .3 fabricated from galvanized steel, minimum 0.76 mm (22 ga) thickness,
- .4 19 mm (3/4") thick internal insulation, same material as liner,
- .5 size: 150 x 100 mm (6 x 4 in),
- .6 fastening: screws,
- .7 location: bottom of unit to allow access to damper assembly.

2.3 Silencer

- .1 Silencers used on all terminal units.
- .2 Construction:
 - .1 aero-dynamic shaped sound absorbing baffles, with perforated metal liners and acoustic media,
 - .2 acoustic media: fiberglass acoustic media, encapsulated within a Mylar or Tedlar film to separate acoustic media from the airstream,
 - .3 lengths:

(a) minimum 900 mm (36 in)

2.4 Hydronic Reheat Coils

- .1 Conform to specification section 23 82 16.16.
- .2 Heat output as shown.
- .3 Factory mount reheat coil at the outlet of the attenuator, silencer, or terminal unit casing extension.]

2.5 Controllers

- .1 DDC controller – Supplied Free-Issue by BAS Contractor:
 - .1 Direct Digital Control (DDC) controller with damper actuator to be supplied by BAS contractor under Division 25, free-issue (FOB destination, freight prepaid) to terminal unit manufacturer for factory mounting by terminal unit manufacturer,
 - .2 costs associated with receiving, storage, installation and calibration to be included by Terminal Unit Manufacturer.

3 EXECUTION

3.1 Terminal Unit Installation

- .1 Support terminal units independent of connecting ductwork and piping. Support terminal units from building structure with angles, hangers and supplementary steel before installation of piping and connecting ductwork.
- .2 Provide seismic restraints for terminal units independent of restraints for joining ductwork, where seismic restraints are required for the project.
- .3 Provide access door in ductwork on the downstream side of reheat coil:
 - .1 size: minimum 150 mm x 100 mm (6 in x 4 in),
 - .2 located with 100 mm (4 in) of discharge face of reheat coil.

3.2 Ductwork Connections

- .1 Connect inlet ductwork with spiral flat seam round duct of same diameter as terminal unit inlet.
- .2 Size connecting discharge ductwork as same size as terminal unit outlet.
- .3 Support outlet ductwork independent from terminal unit.
- .4 Seal openings in box and attenuator for reheat coil and connections, control, and power wiring.

3.3 Piping Services

- .1 Provide heating piping, valves and accessories in accordance with specification section 23 82 16.16.

3.4 Electrical Services

- .1 Control power supply to terminal units to be provided in accordance with specification section 20 05 12 and 25 05 11.
- .2 Power supply for electric reheat coils to be provided under Division 26.

3.5 Leakage Testing

- .1 Terminal units and attenuators to be included in ductwork leakage testing as part of the upstream ductwork pressure.

END OF SECTION

GRILLES, REGISTERS AND DIFFUSERS

23 37 13

1 GENERAL

1.1 Scope

- .1 Provide grilles, registers, and diffusers as shown.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 ASHRAE 70 Method of Testing the Performance of Air Outlets and Air Inlets
 - .2 ASTM D610 Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
 - .3 ASTM D714 Test Method for Evaluating Degree of Blistering of Paints
 - .4 ASTM D1308 Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes
 - .5 ASTM D1654 Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
 - .6 ASTM D4752 Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub

1.3 Submittals

- .1 Submit manufacturer's data sheets with product data including:
 - .1 equipment model numbers, configuration, dimensions, support requirements, general assembly and materials,
 - .2 catalog performance ratings that indicate air flow, static pressure, throw distance at air velocity, and noise criteria (NC) data.

1.4 Samples

- .1 Submit examples of each type and style of register, diffuser and grille with sample finishes when requested by Consultant or the Owner.

2 PRODUCTS

2.1 General Requirements

- .1 Grilles, registers and diffusers:
 - .1 product of one manufacturer where same model or type identification is used,
 - .2 performance data determined in accordance with ASHRAE 70,
 - .3 standard catalogue products selected to meet capacity, throw, and noise level,
 - .4 frames with full perimeter gaskets, plaster stops where set into plaster or gypsum board, and concealed fasteners.
- .2 Type designations:
 - .1 floor plans indicate a diffuser, register or grille type that is referenced on equipment schedules; this unit type includes model numbers taken from listed manufacturer catalogues and which represents the basis-of- design selection.

- .2 the listed manufacturer model (basis-of-design) reference establishes the esthetic (visual) appearance of the equipment and other quality requirements not otherwise specified herein. Products from other manufacturers listed herein may be used where they meet these aesthetic requirements as determined by Consultant.
- .3 Painted finishes:
 - .1 baked-on powder coat finish, minimum build thickness of 0.05 mm (2.0 mils), with a finished hardness of 2H.
 - .2 paint finishes to demonstrate no degradation when tested in accordance with ASTM D1308 and ASTM D4752,
 - .3 paint finish to withstand a minimum salt-spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering when tested in accordance with ASTM D610 and ASTM D714.
 - .4 finish colour: as shown or as selected by Consultant.
- .4 Manufacturers:

Standard of Acceptance

- Carnes
- Hart & Cooley
- MetalAire
- Nailor
- Price Industries
- Titus

2.2 Square Plaque Diffuser (ref. "SPD")

- .1 Application: supply air.
- .2 Style: square plaque-type with single outlet opening;
 - .1 backpan: one piece die-formed construction with smooth aerodynamically designed surfaces and no corner joints, with integral inlet collar,
 - .2 plaque face panel: removable plate, protruding not more than 6 mm (1/4 in.) below the ceiling plane, with smooth edges and rounded corners,
 - .3 designed to provide a 360° radial direction horizontal airflow pattern, for VAV operation.
 - .4 beaded extended neck, minimum depth of 65 mm (2-1/2 in.),
 - .5 suitable for lay-in to T-bar with drop frame,
- .3 Frame: none.
- .4 Material: [steel][aluminium]
- .5 Damper: [steel radial opposed blade][duct mounted full-flow damper][none]
- .6 Specials: all aluminium construction for magnetic resonance imaging (MRI) rooms.

2.3 Plenum Slot Diffusers (ref. "PSD")

- .1 Application: supply air.
- .2 Style: linear diffuser with integral plenum for installation in a T-bar ceiling or drywall ceiling;
 - .1 side-inlet with circular duct connection,
 - .2 1, 2, 3 or 4 linear slots with intermediate aluminium Tee, number of slots as shown,
 - .3 slot width as shown,

- .4 center notch where diffusers span across a cross Tee,
- .5 suitable for lay-in to T-bar or into a drywall ceiling plaster frame.
- .3 Frame: none.
- .4 Material: painted steel.
- .5 Pattern controller: [pincer][curved][blade][as shown].
- .6 Damper: none.
- .7 Insulation: diffuser externally insulated with 12 mm (1/2 in.) foil-backed fibreglass insulation.
- .8 Specials: aluminium plaster frame for dry-wall ceiling installation.

2.4 Hospital-Grade Louvred Grille (type "LG-H")

- .1 Application: supply, return and exhaust air.
- .2 Style: rectangular louvred with frame and removable core;
 - .1 removable louvre and border assembly with quick-release fasteners,
 - .2 fixed single-deflection louvres,
 - .3 louvres and frame materials: stainless steel,
 - .4 blade spacing: 13 mm (1/2 in.) unless otherwise shown,
 - .5 deflection: 45°.
 - .6 blade orientation: horizontal for vertical grilles, parallel to the long dimension for horizontal grilles,
 - .7 border: nominal 32 mm (1-1/4 in.) flat face for surface mount, unless otherwise shown,
- .3 Frame: 9mm (3/8 in.) flat border.
- .4 Fasteners: retained quick-release type.
- .5 Finish:
 - .1 blades: No. 2B finish
 - .2 frames: No. 4 finish
- .6 Damper:
 - .1 supply air: opposed blade damper, stainless-steel with mill finish, with manual operator.
 - .2 Return air and exhaust air: none.
- .7 Specials: as shown.

2.5 Eggcrate Grilles (type "ECG")

- .1 Application: return and exhaust air.
- .2 Style: square-grid bladed grille;
 - .1 louvres and frame materials: aluminium,
 - .2 blade spacing: 25 mm x 25 mm square by 25 mm deep (1 in. x 1 in. x 1 in.),
 - .3 deflection: 0°.
 - .4 blade orientation: not applicable,
 - .5 border:
 - (a) lay-in tile ceilings: none
 - (b) gypsum board ceilings: nominal 32 mm (1-1/4 in.) flat face, suitable for ducted connections.
- .3 Frame: none.

- .4 Fasteners: countersunk holes
- .5 Finish: painted, standard white unless otherwise shown,
- .6 Damper:
 - .1 ceiling plenum return: none
 - .2 ducted return: [none][opposed blade damper with manual operator].
- .7 Specials: as shown.

3 EXECUTION

3.1 Layout

- .1 Drawings showing position of air distribution outlets are essentially diagrammatic. Coordinate exact location of diffusers with other elements in ceiling and shown on Architect's reflected ceiling drawings and select trim to suit ceiling materials listed in the Architectural drawings room finish schedules.

3.2 Installation of Grilles and Diffusers

- .1 For duct-mounted grilles installed in ceiling or walls constructed of gypsum board, coordinate and arrange with general trades to provide channel framing around ceiling/wall opening to provide backing-blocking for attachment of the grille or diffuser.
- .2 Install grilles and diffusers with oval head cadmium plated screws in countersunk holes where fastenings are visible. Use colour-matching screws.
- .3 Install diffusers with concealed fastenings.
- .4 Provide round, square and rectangular diffusers with equalizing deflectors, mounted in the connecting duct neck, accessible from diffuser face, with blades oriented at right angles to direction from which air is flowing.
- .5 Except for last diffuser on branch, where diffusers are installed directly underneath a supply duct provide an extract volume control damper at the duct diffuser-branch connection.
- .6 Where a supply air diffuser includes an air pattern controller, provide labour and services to adjust the pattern controller in conjunction with the TAB contractor during system balancing.

3.3 Special installations

- .1 Grilles, registers and diffusers penetrating fire walls and fire partitions, to have steel sleeves secured to structure in accordance with NFPA 90A-1985.
- .2 In gymnasium provide safety chain on each diffuser face and core and bolt diffuser in place.
- .3 For grilles and diffusers exceeding 5 kg (12 lbs) weight, mechanically fasten grille/diffuser to ceiling or wall structure, independent of ductwork connection or support.

END OF SECTION

HYDRONIC DUCT-MOUNTED AIR COILS

23 82 16

1 GENERAL

1.1 Scope

- .1 Provide hydronic duct-mounted heat transfer coils (reheat coils) and accessories as shown.
- .2 This section applies to:
 - .1 reheat coils for terminal units.

1.2 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code
- .2 Product standards:
 - .1 AHRI 410 Forced-Circulation Air-Handling and Air-Conditioning Coils
 - .2 ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .3 ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

1.3 Design Criteria

- .1 Coils to have a Canadian Registration Number ("CRN") in accordance with CSA B51.

1.4 Submittals

- .1 Submit manufacturers product sheets with performance data for products specified herein.
- .2 Coil shop drawing data to include:
 - .1 coil size: face area, tube length, tube face, number of rows, circuiting arrangement,
 - .2 construction: tube material and size, fin material and spacing, header material and connection sizes, casing and tube support material,
 - .3 heat transfer fluid performance: working pressure, fluid flow rate, entering and leaving fluid temperatures, entering steam pressure and leaving condensate pressure, tube fluid velocity, and fluid pressure drop,
 - .4 air side performance: air flow rate, entering air dry-bulb and wet-bulb temperatures, leaving air dry-bulb and wet-bulb temperatures, and air side pressure drop.
 - .5 AHRI certified performance.

2 PRODUCTS

2.1 Water Reheat (Booster) Coils

- .1 General:
 - .1 coil performance certified to AHRI 410 where the water supply temperature is greater than 49°C (120°F).
 - .2 coil design criteria to be in accordance with the following table except as otherwise shown on equipment schedules or drawings:

Parameter	Value SI	Value IP
Minimum design pressure	1720 kPa	(250 psig)
Airside face velocity, maximum	3.5 m/s	(700 FPM)
Airside pressure drop, maximum	50 Pa	(0.2 in.w.c)
Fluid tube velocity, maximum	2.5 m/s	(8.3 fps)
Fluid side pressure drop - water	15 kPa	(5 ft)

.2 Construction:

- .1 tubes: copper, minimum 0.5mm (0.20 in) wall thickness, serpentine circuited,
- .2 fins: aluminum,
- .3 fin density: not more than 640 fins/m (16 fins/in),
- .4 maximum tube length: 750 mm (2 ft-6in).
- .5 factory leak tested with air under water between 120 and 150% of design pressure.
- .6 coil connections:
 - (a) NPS 2 and smaller: threaded to ASME B1.20.1.
- .7 Casings and tube supports:
 - (a) 1.6 mm (16 ga) thick galvanized sheet steel with out-of-face flange for bolting to ductwork or equipment, or with slip and drive connections.

Standard of Acceptance

- Aerofin
- Cancoil
- Carrier
- Coil Company
- Daikin
- RAE Coils
- Engineered Air
- Heatcraft
- Marlo Heat Transfer Solutions
- McQuay
- RefPlus
- Trane
- USA Coil & Air
- Ventrol
- York

3 EXECUTION**3.1 Coil Installation**

- .1 Install coils in accordance with manufacturer's instructions, with specific attention given to air inlet flow direction.
- .2 Support reheat coils located in ductwork independently of the ductwork with use of threaded rod at each corner of the reheat coil;
 - .1 for factory mounted terminal unit reheat coils, coils are supported as part of the terminal unit.

3.2 Ductwork Installation

- .1 For terminal unit reheat coils, make duct connections to coil at full size of coil connections.
- .2 Provide access doors on both sides of reheat coil;
 - .1 size: 300 x 300 mm (12 in x 12 in),
 - .2 where duct width/height dimension is less than 350 mm (14 in), access door dimension is to be duct width/height less 50 mm (2 in).
 - .3 install access doors on bottom of duct (preferred position); access doors may be installed on side of duct where bottom access is obstructed.

3.3 Piping Installation

- .1 Make piping connections to reheat coils as follows:
 - .1 supply piping: provide manual shut-off valve, strainer, union, and flexible connector,
 - .2 return piping: provide manual shut-off valve, pressure independent control valve, union and flexible connector,
 - .3 make supply connections to lower coil connection,
 - .4 provide unions between the flexible connector and pipeline, unless flexible connector is provided with an integral union joint.
- .2 Flexible connector installation:
 - .1 locate flexible connectors between the coil connections and valves and strainers,
 - .2 arrange flexible connectors to remain in a single plane, with the maximum offset in any direction not exceeding 25 mm (1 in.).
 - .3 do not bend flexible connectors; provide an elbow fitting on coil connection.
- .3 Provide coil drain on supply side piping.
- .4 Provide screwdriver air vents on both supply and return piping between valves and flexible connectors.
- .5 Refer to Section 23 21 16 for Valve Enclosure Box for associated requirements.

END OF SECTION

BUILDING AUTOMATION COMMON WORK RESULTS

25 05 01

1 GENERAL

1.1 Scope

- .1 Extend/modify existing hospital Building Automation System (BAS) with Direct Digital Control (DDC), and Energy Management for new mechanical systems and interface with other microprocessor based building subsystems.
- .2 During the tender period, the contractor must perform a site inspection of the place of work and surroundings as well as, areas where access would be considered reasonable and make a thorough investigation of as-built conditions to determine the scope of work required relating to existing controls equipment and main trunk locations, prior to submitting their tender price.
- .3 Controls contractor is to include for all upgrades required to the existing system (including software/hardware/controllers/licenses/etc) as required to interface all new points and controllers into BAS.
- .4 Power and data will be terminated by Division 26. A new control panel shall be installed in these locations only and all new controls taken to/from this location.
- .5 Controls Contractor must use previously agreed "Open Book Pricing" for this Project. Consultant will request confirmation of this.

1.2 Dependent Sections

- .1 The BAS Work is further defined in the following specification sections:

25 05 06	Work on Existing Building Automation
25 05 11	Building Automation Control Panels and Wiring
25 14 17	Building Automation Terminal Unit Controllers
25 30 13	Building Automation Actuators and Operators
25 30 16.13	Building Automation Instrumentation
25 30 19.13	Building Automation Control Valves
25 30 19.16	Building Automation PICV and Energy Valves
25 30 23.13	Building Automation Control Dampers
25 90 01	Building Automation Control Sequences

1.3 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the BAS system is further described in the following the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 20 08 11 Testing of Mechanical Life Safety and Fire Protection Requirements
 - .3 23 36 13 Terminal Units

1.4 Equipment Supplied for Installation under Other Sections

- .1 Supply the following equipment for installation under other Sections of Division 20;
 - .1 automatic control valves and pressure independent control valves,
 - .2 instrumentation to be installed in piping systems,
 - .3 temperature wells for controllers and sensors provided under this Section, for installation in piping systems,
 - .4 instrumentation including air flow stations to be installed in ductwork systems,
 - .5 motorized dampers.

1.5 Factory Installation of Controls for Terminal Units

- .1 Supply control equipment for terminal units (as specified in section 23 36 13) free-issue to the place of the manufacturer of the terminal unit equipment, for factory installation of the control equipment by that manufacturer, including factory wiring and tubing installation. Such control equipment includes:
 - .1 TU-ASC controller,
- .2 Provide information on sizing requirements for electrical transformer or power supply, sized for all control loads including controller, damper actuator, and for control of any associated heating valves.
- .3 Coordinate with terminal unit manufacturer for delivery of controls material to suit their production schedule.
- .4 All costs associated with such method of factory installation is to be borne by the mechanical subcontractor and controls subcontractor as determined between them; the Owner shall not be responsible for any such costs.

1.6 Equipment Provided under Other Divisions

- .1 The following equipment is provided under other Sections of Division 20;
 - .1 manual dampers, non-motorized fire dampers, and gravity dampers,

1.7 Definitions and Abbreviations

- .1 The following definitions, abbreviations, and acronyms apply to this Division of the Work:
 - .1 AI Analog Input: continuously variable value, usually a sensor, referenced to a controller
 - .2 AO Analog Output: continuously variable value, usually a control signal to an actuator device, referenced to a controller.
 - .3 ASC Application Specific Controller
 - .4 DI Digital Input: a two-state (On-Off) value, usually associated with a switch or state, referenced to a controller.
 - .5 DO Digital Output: a two-state (On-Off) value, usually associated with starting or stopping equipment or generating an alarm, referenced to a controller.
 - .6 FC Fail Close (valve or damper action on failure of the controller)
 - .7 FO Fail Open (valve or damper action on failure of the controller)
 - .8 FAS Fire Alarm System

- .9 GUI Graphic User Interface: an LED, LCD or monitor display
- .10 I/O Input/Output
- .11 LAN Local Area Network
- .12 NC Normally Closed: position of device in a de-energized state.
- .13 NO Normally Open: position of device in a de-energized state.
- .14 NSC Network Supervisory Controller
- .15 OEM Original Equipment Manufacturer
- .16 OWS Operator workstation: a PC based server or computer
- .17 Tier 1 Building level network providing communication between NSCs and workstations.
- .18 Tier 2 Field level network providing communications between ASCs and NSCs
- .19 WAN Wide Area Network

1.8 Applicable Codes and Standards

- .1 Product standards:
 - .1 ANSI/ASHRAE 135 BACnet – A Data Communication Protocol for Building Automation and Control Networks
 - .2 ANSI/CEA 709.1 Control Network Protocol Specification (Lonworks)
- .2 Interfacing Standard:
 - .1 Input/output devices to use ASCII (American Standard for Communication and Information Interchange) code and standard EI (Electronic Industry Association) interfaces.
 - (a) CSA T530 Commercial Building Standard for Telecommunications Pathways and Spaces
 - (b) IEEE 802.3 Ethernet

1.9 Qualified Tradesperson

- .1 Work to be performed by Johnson Controls Inc. using tradespersons holding applicable certificates of competency.

Standard of Acceptance

- Johnson Controls (Metasys NAE)

1.10 Design Services

- .1 Provide engineering services for the design of the BAS including product selection, wiring details, and all installation details to meet the prescribed and performance requirements described in the specifications sections of Division 25. Issued design documents are to be sealed by a professional engineer licensed in the province of the Work.
- .2 Prior to preparation of shop drawings for the BAS, provide a design assist to review Consultant's sequence of operation and provide feedback on any recommendation that may improve the installation or ease of operation, while remaining within the hardware scope as originally designed and specified herein.

1.11 Licences and Ownership

- .1 Ownership of, and licences for, hardware and software supplied or used for this project or for ongoing system operation, maintenance and modification to be registered, without restrictions, in Owner's name.
- .2 This is applicable to System Software, Workstation Application Editors, and Controller Software.
- .3 Licensing to permit an unlimited number of users to access system without additional fees.
- .4 At the time of substantial performance of the Work, upgrade the BAS software to the most current release version at that time, at no additional cost to the Owner.
- .5 Project-developed software and resulting documentation to be treated as part of system and subject to these same requirements for ownership and licensing. This material includes;
 - .1 project graphic images,
 - .2 CAD generated record drawings,
 - .3 project database,
 - .4 project-specific application programming code and documentation.

1.12 Submittals

- .1 Submit one (1) completely engineered and coordinated shop drawing package. Partial or incomplete submission of data and/or drawings will be returned without review.
- .2 Submit shop drawings for designed elements;
 - .1 list of materials of equipment to be used indicating manufacturer, model number, and other relevant technical data,
 - .2 BAS riser diagram showing system controllers, operator workstations, network devices, and network wiring,
 - .3 control panel internal wiring diagrams, .
 - .4 single-line schematics and system flow diagrams showing location of control devices,
 - .5 wiring diagrams identifying interface hard-wire terminations to controlled equipment OEM control panels,
 - .6 points list for each system controller, including: Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Panel, Reference Drawing, and Cable Number,
 - (a) points to be named by function, and list to include software points such as programmable set-points, range limits, time delays, and so forth,
 - .7 detailed analysis of each Sequence of Operation from Consultant's design documents, ready for development of actual programming code,
 - .8 written Sequence of Operations to cover normal operation and operation under various alarm conditions applicable to that system.
- .3 Submit shop drawing schedules for;
 - .1 control dampers: spreadsheet type, to include separate line for each damper and columns for damper attributes.
 - .2 control valve: spreadsheet type, to include separate line for each valve and separate columns for valve attributes.
- .4 Submit catalogue cut-sheets for;

- .1 manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for equipment and hardware items as follows;
 - (a) controllers (NSC's and ASC's),
 - (b) instrumentation, including
 - i) accuracy data, range and scale information,
 - ii) one sheet for each device marked with applicable options. Where several devices of same type are to be used, submit one sheet for each device, individually marked.
 - (c) actuators,
 - (d) valves and dampers,
 - (e) relays/switches,
 - (f) control panel enclosures,
 - (g) power supplies,
 - (h) batteries,
 - (i) GUI operator interfaces,
 - (j) wiring and wiring accessories.
- .5 Submit supporting documentation:
 - .1 representative examples of graphics for GUI to include;
 - (a) BAS network schematics,
 - (b) typical terminal unit floor plan graphic that shows conditions on occupied floor,
 - (c) typical equipment room floor plan graphic,
 - (d) typical graphics for each system and terminal unit at least one sample graphic for each type of equipment,
 - (e) one sample graphic for chilled water system,
 - (f) one sample graphic for hot water system,
 - (g) description of techniques used for dynamic display of information on graphics and method of how building operator drills down to secondary information and affects control of equipment.
 - .2 Protocol Implementation Conformance (PIC) statement for BACnet devices,
 - .3 where interfaces occur with control or wiring diagrams of other sections, obtain reproducible copies of those diagrams and revise to show terminal numbers at interface and include diagrams as part of interconnection schematic shop drawings.

1.13 Quality Control

- .1 Continuity of staff and subcontractors:
 - .1 Controls contractor's project manager is to be nominated at time of shop drawing submission and is to remain involved with the project, from shop drawing preparation through to project acceptance, unless a request for change of personnel is submitted to and approved by Owner.
 - .2 Subcontractors listed in preliminary design submission are to execute the Work defined as sublet in preliminary design document, unless request for change is submitted to and approved by Owner.
 - .3 Requests for changes in staff, subcontractors, or extent of work subcontracted are to be submitted for approval by Owner and such approval is not to be unreasonably withheld.
- .2 Identification of non-conforming materials and equipment:

- .1 Submit documentation at time of bid, identifying nature and extent of non-conformance and variances from specifications or referenced standards.
- .2 Failure to submit this documentation at time of bid will be interpreted as confirmation that materials, workmanship, hardware and software will be in strict accordance with specifications and standards.
- .3 All products that are connected to a piping system that is subject to registration under applicable boiler and pressure vessel legislation are to have current Canadian Registration Numbers in accordance with CSA B51.
- .4 Site Acceptance Testing
 - .1 Manufacturer to provide services of manufacturer's authorized service personnel in accordance with the requirements of Part 3 of this specification.

1.14 Warranty

- .1 At completion of Work, submit written guarantee undertaking to remedy defects in work for period of two (2) years from date of acceptance, which includes:
 - .1 rectification of control system failures attributable to defects in workmanship, materials, hardware, and software,
 - .2 service technician to arrive on site within 24 hours of warranty service request, to install and debug software patches, to replace defective parts, materials or equipment, and to provide incidental supplies, and labour for remedial work,
 - .3 technician to remain in attendance until system is returned to operating condition.
- .2 Submit similar guarantee for any part of the Work accepted by Owner, before completion of whole work.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges unless otherwise specified in other specification sections of Division 25:
 - .1 temperature: 0°C to 40°C (32°F to 104°F)
 - .2 relative humidity 10% to 90% non-condensing
 - .3 electrical power service of single phase, 120 VAC +/- 10%, 60 Hz nominal.
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices.

2.2 Equipment Standard

- .1 Products and software: manufacturer/developer/supplier's catalogued current stock.
- .2 This installation is not to be used as test site for newly developed product or software, without explicit written approval by Owner.
- .3 Equipment and systems installed to meet;
 - .1 performance specifications when subjected to VHF, UHF, FM, AM or background RFI as generated by commercial or private, portable or fixed transmitters that meet regulatory codes,

- .2 Federal Communication Commission (FCC) Rules and Regulations, Part 15, Subpart J for computing devices.

2.3 BAS General Functional Requirements

- .1 Control mechanical and electrical equipment as specified in control sequences, shown on control schematics, and described in equipment schedules.
- .2 Scalable system architecture to be modular, permitting stepped expansion of application software, system peripherals, and field hardware.
- .3 Control system:
 - .1 high-speed, peer-to-peer network of microprocessor based Direct Digital Control (DDC) controllers with web-based operator interface,
 - .2 each mechanical system, building floor plan, and control device to be displayed through point-and-click graphics,
 - .3 Web server with network interface card to gather data from this system and generate web pages that can be accessed through conventional web browser on any PC connected to network,
 - .4 operators to access this system through web browser on connected PC's, wireless tablet PCs and smart phones to perform normal operator functions,
 - .5 scalable, modular, automatic process and optimized workflows, with automatic data acquisition and energy performance analytics,
- .4 Each controller;
 - .1 operates with local closed loop programming, independent from server, able to continue functional control if peer-to-peer communication is interrupted;
 - .2 performs resident control routines;
 - (a) receiving information from field mounted sensors and switches and
 - (b) transmitting instructions to actuators to perform control sequences.
 - .3 manages local hardware and software alarms;
 - (a) to collect historical data,
 - (b) to facilitate operator input and output,
 - (c) to communicate with Central BAS web server and GUI.
- .5 Central BAS Web server;
 - (a) extend existing.

2.4 Network Integration Functional Requirements

- .1 Open protocol:
 - .1 Provide an integrated, open protocol building automation system using BACnet to ANSI/ASHRAE Standard 135, with native integration with:
 - (a) Lonworks,
 - (b) Modbus,
 - (c) OPC (OLE for process control).
 - (d) ONVIF,
 - (e) DALI.
 - .2 Integral systems integration functionality:

- .1 provide hardware and software to allow bi-directional digital communications between BAS and facility control subsystems including:
 - (a) HVAC,
 - (b) fire safety including fire alarm systems,
 - (c) security systems,
 - (d) power control and monitoring systems,
 - (e) lighting control systems,
 - (f) 3rd party integration with other facility systems.
- .3 OEM Controller integration:
 - .1 provide hardware and software to allow bi-directional digital communications between BAS and 3rd party manufacturers' equipment control panels including but not limited to;
 - (a) boilers,
 - (b) chillers,
 - (c) variable frequency drives,
 - (d) packaged HVAC equipment,
 - (e) power monitoring equipment,
 - (f) medical gas equipment.
 - .2 integrate real-time data from these systems.

2.5 BMS Network Architecture

- .1 Refer to specification section 25 05 06 for work required on existing BAS networks

2.6 Performance

- .1 General:
 - .1 information transmission and display times are based upon network connections,
 - .2 test systems using manufacturer's recommended hardware and software for operator interface.
- .2 Performance criteria:
 - .1 Graphic Display;
 - (a) display graphic with 50 dynamic points with current data within 10 seconds.
 - .2 Graphic Refresh;
 - (a) update graphic with 50 dynamic points with current data within 10 seconds and
 - (b) automatically refresh every 15 seconds.
 - .3 Configuration and Tuning Screens;
 - (a) special screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic to refresh every 5 seconds.
 - .4 Object Command response;
 - (a) time between command of binary object at GUI and onset of reaction by device to be less than 5 seconds,
 - (b) time between command of analog object at GUI and start of adjustment to be less than 5 seconds.

- .5 Alarm Response Time;
 - (a) time between when an object goes into alarm and when it is annunciated at GUI to be less than 15 seconds.
- .6 Program Execution Frequency;
 - (a) execution repeat frequency to be selected in manner consistent with process under control,
 - (b) custom and standard applications to be capable of executing as often as once every 5 seconds.
 - (c) programmable controllers to be able to perform PID control loop routines at selectable frequency, adjustable at GUI down to once every second.
 - (d) workstations connected to network to receive alarms with not more than 5 seconds spread between first and last annunciation.

2.7 Wiring and Conduit

- .1 Wire and conduit for power wiring, control wiring, and communication wiring to conform to specification section 20 05 12.

3 EXECUTION

3.1 Examination

- .1 Inspect site and thoroughly examine documents to establish locations for control devices and equipment and report discrepancies, conflicts, or omissions for resolution before starting rough-in work.
- .2 Be responsible for correction of defects caused through neglect of inspections and examinations or failure to report and resolve discrepancies.

3.2 Protection

- .1 Protect work and material against damage during construction and be responsible for work and equipment until inspected, tested, and accepted.
- .2 Protect material not immediately installed and seal connector terminations with temporary covers or plugs during storage and construction to prevent entry of foreign objects.
- .3 Protect electronic equipment from elements during construction.

3.3 Coordination

- .1 Coordinate and schedule BAS work with other work in same area to ensure orderly progress.
- .2 Testing and balancing:
 - .1 Supply sets of tools of sufficient quantity for Testing and Balancing Technicians to interface to control system, train these technicians in use of tools, and provide qualified Control Technician to assist with testing and balancing the first 10 terminal units.
 - .2 Tools to be turned over to Owners on completion of testing and balancing.
- .3 Controls work by others:
 - .1 Integrate and coordinate this control work with controls and control devices provided or installed by others.
 - .2 Each supplier of control product to configure, program, start up, and test that product to satisfy requirements of Sequence of Operation regardless of where within contract documents product is specified or described.

- .3 Resolve compatibility issues between control products provided under this Division and those provided under other Divisions of the Work.

3.4 General Workmanship

- .1 Installation to be performed by skilled and certified technicians.
- .2 Install equipment, piping, and wiring or raceways horizontally, vertically, and parallel to building lines.
- .3 Provide sufficient slack and flexibility in connections to allow for vibration isolation between conduit, raceways, piping and equipment.
- .4 Install instrumentation and devices in locations providing adequate ambient conditions.
- .5 Protect components placed in areas of potentially high humidity.

3.5 Wiring for Power, Control and Communications

- .1 Provide wire and raceways (conduit) for power wiring, control wiring, and communications wiring for BAS controllers and associated instrumentation and actuation devices, at voltages of 120 V and under, in accordance with specification section 20 05 12 and, for greater clarity, Schedule A appended to that specification section.
- .2 Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

3.6 Cleaning

- .1 Clean up debris, remove packaging material, collect waste and place in designated location, on a daily basis.
- .2 Keep work areas free from dust, dirt, and debris.
- .3 On completion of work, check finish of equipment provided under this section for damage and repair damaged factory-finished paint, replace deformed cabinets and enclosures with new material, and repaint to match original.
- .4 Prior to hand-over to the Owner, clean the inside of control panels;
 - .1 remove debris and vacuum clean internal components,
 - .2 the use of low-pressure dry nitrogen or inert compressed gases may be used to blow dust and debris out of panels where the use of such pressurized gases will not damage equipment or loosen wiring terminations,
 - .3 after cleaning, apply a label to the exterior side of the panel to identify the date the panel was cleaned and the initial of the person who cleaned the panel.

3.7 Field Quality Control

- .1 Ensure work, materials, and equipment comply with this specification and reviewed shop drawings.
- .2 Monitor field installation for applicable safety and building code compliance and workmanship quality.
- .3 Arrange and pay for inspections by local or provincial authorities having jurisdiction over the work.

3.8 Identification of Equipment

- .1 Manufacturers' nameplates and product certification labels to be visible and legible after equipment is installed.

- .2 Identify discrete items of equipment with plastic nameplates or plasticized labels, identifying equipment and function. Identification plates are in addition to manufacturers nameplates.
- .3 Identification plates:
 - .1 provided for equipment identified with number designations in schedules and equipment shop drawings.
 - .2 marked with equipment type, number and service following wording and numbering used in contract documents and shop drawings,
 - .3 plastic laminated labels,
 - .4 white face and black background field,
 - .5 minimum size 75 mm x 40 mm x 3 mm (3 in x 1½ in x 1/8 in),
 - .6 engraved or printed with 6.5 mm (1/4 in) high lettering.
 - .7 securely attached to equipment with brass chains.
- .4 Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 50 mm (2 in) of termination.
- .5 Label pneumatic tubing at each end within 50 mm (2 in) of termination with descriptive identifier.
- .6 Permanently label or code each point of field terminal strips to show instrument or item served.
- .7 Label each control component with permanent label. Label plug-in components so that label remains stationary during component replacement.
- .8 Label room sensors related to terminal boxes or valves with nameplates. Place labels on back of sensors.
- .9 Identify motor controllers that are remotely controlled by the BAS with self-adhesive labels, black letters on white background with a red border and electric shock warning icon, with wording as follows;



3.9 Checkout and Testing

- .1 Provide schedule for start-up and testing.
- .2 Calibrate and prepare for service equipment, instruments, controls, and accessories.
- .3 Start-up testing to verify completion of control system before system demonstrations begin;
 - .1 verify that control wiring is connected and free of shorts and ground faults. Verify that terminations are tight,
 - .2 enable control systems and verify input device calibration,
 - .3 verify that binary output devices operate and that normal positions are correct,

- .4 verify failure positions of dampers and control valves are correct when power/compressed air is deenergized to the device,
 - .5 verify that analog output devices are functional, that start and span are correct, and that direction and normal positions are correct,
 - .6 check control valves and automatic dampers for proper action and closure and adjust valve stroke/rotation and damper blade travel,
 - .7 verify that damper and control valve feedback signals are correct when device is stroked fully open and closed (two position) and at any opening position between zero and fully open (modulating devices),
 - .8 verify that system operates according to Sequences of Operation. Simulate changes in variables by overriding and varying inputs and schedules and observe and record each operational mode response.,
 - .9 tune PID loops and control routines to provide stable operation and to minimize valve and damper hunting,
 - .10 check each alarm with an appropriate signal at value that will trip alarm,
 - .11 trip interlocks using field contacts to check logic and to ensure that actuators fail in proper direction,
 - .12 test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.
- 4 Prepare and submit test log documenting start-up testing of each input and output device and each control routine, with technician's initials certifying each device and each routine is functioning correctly and sensors have been calibrated. Include list of deficiencies and a workplan schedule setting out rectification program with time lines.

3.10 Testing of Integrated Life Safety and Fire Protection Systems

- .1 Comply with the requirements of specification section 20 08 11 for the testing of the integration of controls and communications between the BAS and life safety and fire protection systems.

3.11 Control System Demonstration

- .1 Obtain approval of start-up testing log and rectification program before scheduling demonstrations.
- .2 Provide notification to Owner and Consultant not less than 10 business days before system demonstration begins.
- .3 Demonstration to follow previously submitted and approved procedures;
 - .1 submit checklists and report forms for each system as part of demonstration,
 - .2 lists and forms to have initials of technicians conducting demonstrations,
 - .3 date of each demonstration and signatures of Owner's representatives witnessing each demonstration section.
- .4 Prior to acceptance, perform the following operating tests in the presence of the Owner or Owner's representative and Consultant to demonstrate system operation and compliance with specification after and in addition to tests specified above in article Checkout and Testing.
- .5 Demonstrate field operation of;
 - .1 each Sequence of Operation,
 - .2 Operator Interface,

- .3 control loop response with graphical trend data output showing;
 - (a) each control loop response to set point change producing an actuator position change of at least 25% of full range.
 - (b) trend sampling rate to be from 10 seconds to 3 minutes, depending on loop speed,
 - (c) loop trend data to show set point, actuator position, and controlled variable values,
 - (d) documentation of further tuning of any loop that displays significantly under- or over-damped control
- .4 demand limiting routine with trend data output showing demand-limiting algorithm action;
 - (a) trend data to document action sampled each minute over at least 30-minute period and to show building kW, demand-limiting set point, and status of set-points and other affected equipment parameters.
- .5 control integration with life safety and fire protection systems,
- .6 trend logs for system points as selected by the Owner with;
 - (a) trend data to indicate set-points, operating points, valve positions, and other data as specified in points list provided with each Sequence of Operation,
 - (b) each log to cover three 48-hour periods and to have sample frequency not less than 10 minutes, except where a Control Sequence specifies other time intervals,
 - (c) show that trend logs are accessible through operator interface and can be retrieved for use in other software programs.
- .7 substantiate calibration and response of any input and output points requested,
- .8 provide at least two technicians equipped with two-way communication,
- .9 provide and operate test equipment to establish calibration and prove system operation.
- .6 Tests that fail to demonstrate system operation are to be repeated after repairs and/or revisions to hardware or software is completed.

3.12 Training

- .1 Materials:
 - .1 provide course outline and materials for each class at least four (4) weeks before first class,
 - .2 provide training through instructor-led sessions, with computer-based, or web-based techniques,
 - .3 instructors to be factory-trained and experienced in presenting this material,
 - .4 perform classroom training using network of working controllers representative of installed hardware.
- .2 Operating staff training:
 - .1 provide training for Owners operating staff using abovementioned training materials in self-paced mode, web-based or computer-based mode, classroom mode, or combination of these methods,
 - .2 allow for three (3) repeat sessions for each category to cover operator shift rotation.
- .3 Training to enable students to accomplish following objectives:
 - .1 Group 1:
 - (a) proficiently operate system,
 - (b) understand control system architecture and configuration,
 - (c) understand BAS system components,

- (d) understand system operation, including BAS system control and optimizing routines (algorithms),
 - (e) understand Sequence of Operations,
 - (f) operate workstation and peripherals,
 - (g) log on and off system,
 - (h) access graphics, point reports, and logs,
 - (i) adjust and change system set-points, time schedules, and holiday schedules,
 - (j) recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools,
 - (k) understand system drawings and Operation and Maintenance manual,
 - (l) understand project layout and location of control components,
 - (m) access data from BAS controllers,
 - (n) set-up trend logs,
 - (o) operate portable operator's terminals
- .2 Group 2:
- (a) create and change system graphics,
 - (b) create, delete, and modify alarms, including configuring alarm reactions,
 - (c) create, delete, and modify point trend logs (graphs) and multi-point trend graphs,
 - (d) configure and run reports,
 - (e) add, remove, and modify system's physical points,
 - (f) create, modify, and delete application programming,
 - (g) add and configure GUIs,
 - (h) add new controller to system,
 - (i) download firmware and advanced applications programming to controller,
 - (j) configure and calibrate I/O points.
- .3 Group 3:
- (a) maintain software and prepare backups,
 - (b) interface with job-specific, third-party operator software,
 - (c) add new users and understand password security procedures.
- .4 Divide presentation of objectives into three sessions:
- .1 Group 1: Day-to-day Operators,
 - .2 Group 2: Advanced Operators,
 - .3 Group 3: System Managers and Administrator,
 - .4 participants will attend one or more sessions, depending on knowledge and expertise level required,
 - .5 provide each student with one copy of training material.

3.13 Record Submittals

- .1 Submit record documents to the Owner.

- .2 Document language: English
- .3 Submit three copies of project record documents and obtain approval during acceptance procedures.
- .4 Submit AHJ inspection certificates.
- .5 Provide as-built drawings;
 - .1 as-built interconnection wiring diagrams, or wire lists of field installed system with identified, ordering number of each system component and service,
 - .2 floor plans with accurate depiction of location of system devices, controllers, and trunk wiring. Drawings to be constructed using Architectural backgrounds provided,
 - .3 provide copies of as-built drawings on two (2) removable storage devices,
 - .4 provide five (5) full size hard copies of floor plan drawings.
- .6 Operation and Maintenance (O&M) Manuals:
 - .1 provide two (2) paper copies of material and copies on five (5) removable storage devices in portable document format.
 - .2 describe operation, maintenance and servicing requirements of system and associated equipment,
 - .3 provide the following information in separate sections, each with an index:
 - (a) Service and parts;
 - i) names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems,
 - ii) list of recommended spare parts with part numbers and suppliers.
 - (b) System description;
 - i) outline of BAS system and system architecture,
 - ii) as-built versions of shop drawing product data,
 - iii) reduced size (11 in x 17 in) copies of record drawings,
 - iv) graphic files, programs, and database on magnetic or optical media,
 - v) licenses, guarantees, and warranty documents for equipment and systems.
 - (c) Technical literature for equipment, including;
 - i) catalogue sheets,
 - ii) calibration, adjustments and operation instructions,
 - iii) installation instructions,
 - iv) hardware and software manuals, with information supplied by original product developer, on application programs and on computers and controllers supplied,
 - v) 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,
 - vi) engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware,
 - vii) original-issue documentation with installation and maintenance information for third-party hardware including computer equipment and sensors,

- viii) recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions,
 - ix) programming manual or set of manuals with description of programming language and syntax, explanation of statements for algorithms and calculations used, procedures for point database creation and modification, documentation of techniques for program creation and modification, and instructions for use of editor,
 - x) documentation of programs created using custom programming language including set-points, tuning parameters, and object database. Electronic copies of programs to modify and create control logic, set-points, tuning parameters, and objects that can be viewed using programming tools.
- .7 Original Software:
- .1 Furnish one original set of application and system software on original media. Disks to bear manufacturer's label. Field copies are not acceptable.
 - .2 Original-issue copies of software to include operating systems, custom programming language, application generation, graphic support, maintenance support, operator workstation or web server software, and other utilities provided in support of installed system. [
- .8 On-line record documentation:
- .1 After completion of testing and adjustment, install the following additional information on the server OWS.
 - (a) as-built record drawing files,
 - (b) detailed catalog data on all installed system components, with supplier contact information for purchasing and factory authorized repair service.]]

3.14 Acceptance

- .1 Application for substantial performance of the Work requires as a prerequisite the completion of the BAS including testing, demonstration, and submittal of required documentation, except where the Owner agrees to differ any work to a later date.
- .2 In support of an application for substantial performance, submit a signed declaration to the Owner certifying that:
 - .1 the BAS is complete and operating in accordance with the contract documents,
 - .2 control system checkout and testing is completed,
 - .3 control system demonstration is completed,
 - .4 training is completed,
 - .5 as-built documentation is completed and turned-over to the owner.
- .3 Certification document may identify tests that cannot be performed due to extenuating circumstances such as weather conditions, where previously agreed to be deferred to a later date by the Owner. Append a program for completion of deferred work to the certification document for rectification and completing these tests during warranty period.

3.15 Correction After Completion

- .1 After start-up, testing, and commissioning phase has been completed and satisfactory and reliable operation of equipment and systems has been demonstrated, acceptance of the system is to be given by Owner. Warranty period to begin on date established on certificate of acceptance.

-
- .2 Provide updates and patches to resolve software deficiencies in operator workstation or web server software, project-specific software, graphic software, database software, and firmware during warranty period.
 - .3 Provide upgrades that improve routines and procedures of operator workstation software, web server software, project-specific software, graphic software, or database software, free of charge, during warranty period.
 - .4 Provide details of proposed changes and obtain written authorization from Owner before installation of updates, patches, or upgrades.
 - .5 Include preventative maintenance, with allowance for spare parts, labour, and emergency (24 hour) service for system and equipment during warranty period.
 - .6 Equipment manufacturers to submit written undertakings to make circuit board repairs and provide spare parts, software support and patches, and technical assistance for at least five years after acceptance is certified.

End of Section

WORK ON EXISTING BUILDING AUTOMATION 25 05 06

1 GENERAL

1.1 Scope

- .1 Modifications to existing building control systems including:
 - .1 connection to of new BAS networks to the existing building BAS networks,
 - .2 connection of new control devices to existing BAS networks,
 - .3 selective demolition of existing building controls,
 - .4 modifications and upgrades of existing BAS.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 26 Pipeline Hot-Tapping and Line Stopping
 - .2 25 05 01 Building Automation Common Work Results

1.3 Definitions and Abbreviations

- .1 Refer to specification section 25 05 01.

1.4 Designated Controls Contractor

- .1 Refer to specification section 25 05 01.

1.5 Design Criteria

- .1 Existing BAS networks:
 - .1 Tier 2: BACnet MSTP

1.6 Submittals

- .1 Shop drawings:
 - .1 In addition to the requirements of section 25 05 01, submit the following information as a shop drawing:
 - (a) documentation of existing sequence of operations for applicable equipment and systems affected by the Work.

2 PRODUCTS

2.1 General

- .1 Conform to specification section 25 05 01 and other sections of Division 01 except as specified herein.

3 EXECUTION

3.1 Existing Equipment

- .1 Reuse of control components:
 - .1 reuse existing equipment and components as listed below where condition and conformance with this specification permits;
 - (a) valves and operators,
 - (b) dampers and operators,
 - (c) thermocouple wells,
 - (d) freezestats,
 - (e) firestats,
 - (f) limit, end, or level switches and air or liquid flow switches,
 - (g) static pressure sensors and controllers,
 - (h) wiring and conduit for safety controls and I/O points,
 - (i) relays,
 - (j) cabinets,
 - (k) other items specifically noted as existing, to be re-used.
 - .2 Remove and replace existing temperature and humidity sensors with new units, throughout the installation,
 - .3 Check and re-calibrate existing indicator gauges,
 - .1 under no circumstances are existing gauges or thermometers be removed.
 - .4 Re-calibrate valves and dampers as part of installation of this system.
 - .5 Existing thermowells for conventional control system may be reused for new sensors,
 - .1 repack temperature wells, both new and reused, with heat conductive grease.

3.2 Existing Programming and Configuration

- .1 Document existing control device programming, configuration, and setpoint values at the start of the work, prior to any demolition or other work on existing control equipment.
- .2 For each NSC or ASC being replaced, review the existing control programming and/or configuration settings, and prepare a written sequence of operation in laymen terms that describes the operating control of each control device. Where multiple control devices of the same type exist (e.g. terminal units), review at least three (3) randomly selected controllers to verify the same control functions; a single written control sequence for each type controller is sufficient.
- .3 Provide a copy of these documentation to the Owner.
- .4 Except where otherwise specified for new sequence of operations, program and/or configure software for replacement NSC and ASC to achieve the same control functionality and sequence of operation of the pre-existing NSC and ASC controllers, and configure setpoints to match pre-existing controller values.

3.3 Existing Condition Survey

- .1 Conduct a condition survey of existing control devices:

- .1 test, inspect and report on existing devices which are to be incorporated into the BAS, for satisfactory operation within 30 days of award of contract and prior to installation of any new devices,
- .2 for those items found in unacceptable condition, provide with report test data, original specification sheets or written functional requirements to confirm conclusion,
- .3 Owner to arrange for repair or replacement of those existing items judged defective, but shown to be re-used in BAS and control system,
- .4 items thus repaired or replaced by Owner will be returned to site and handed over to Contractor under this Section for storage, installation, testing, and commissioning.,
- .5 warrant reused devices that have been rebuilt or repaired. Demonstrate satisfactory operating condition of reused devices at time of acceptance,
- .6 responsibility for existing control devices that have been reused is to terminate at end of warranty period.

3.4 Demolition and Removals

- .1 Unless specifically noted or shown otherwise, remove existing control components made redundant:
 - .1 room thermostats, controllers, auxiliary electronic devices, pneumatic controllers and relays, control valves, electronic sensors, and transmitters: to be removed and placed in storage as directed by Owner.
 - .2 local control panels: removed and placed in storage as directed by Owner.
- .2 Remove and dispose of existing conduits, wiring and tubing in all areas (including above accessible ceilings) as they become redundant;
 - .1 remove existing control compressed air systems and, where applicable, connect to new control air system;
 - .2 existing hardwired interlocks to remain installed in systems.
- .3 In existing areas not otherwise involved in renovations, arrange and pay for holes and marks left by decommissioning and removal of control components, wiring, conduit, and tubing to be patched and refinished to match existing.

3.5 Maintaining Existing System Operation

- .1 Mechanical systems to remain in operation and to maintain space conditions between hours of 6 a.m. and 9 p.m., Monday through Friday.
- .2 In these periods mechanical control system shut downs of up to 15 minutes may be permitted, after obtaining written agreement from Owner.
- .3 When time required for cut-over of controls will not meet these constraints, perform work outside of operating hours after making application; outlining areas affected; and likely length of interruption, and obtain written agreement from Owner. .
- .4 Maintain fan scheduling using existing or temporary time clocks or control systems throughout period of control system installation.
- .5 Modify existing motor controllers to incorporate new local operator control switches for motors to be controlled through BAS system.

3.6 Installation of New Thermowells

- .1 Existing piping services to remain in service during installation of thermowells.

- .2 Coordinate with the trade contractor under Division 23 to install thermowells for new temperature sensors mounted on steel piping by hot-tapping in accordance with specification section 20 05 26.

3.7 Interfacing Between New and Existing Control Systems

- .1 Certain building systems are to operate in event of building power failure or fire alarm. Under no circumstances should interfacing of equipment or controls modify these existing sequences of operation.
- .2 Where tying new system into existing control equipment, show on shop drawings;
 - .1 signal levels,
 - .2 wire type,
 - .3 wire numbers, and
 - .4 terminal numbers.
- .3 Before attempting replacement of existing control systems, install new field panels, controllers and associated devices loose-ended ready for system changeover.
- .4 Submit written request to Owner setting out proposed starting time for changeover, duration of system down time, and establishing extent of interruption to operation of existing control system.
- .5 Do not proceed with work until Owner's written approval of time for, duration of, and extent of interruption is received.
- .6 Subsequent decommissioning and removal of control components to be carried out without interfering with normal operations or creating an interruption in service of any building systems except through an approval process similar to that noted above.

End of Section

BUILDING AUTOMATION CONTROL PANELS AND WIRING

25 05 12

1 GENERAL

1.1 Scope

- .1 Provide building automation control panels for mounting and securing building automation control equipment and devices.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 25 30 16 Building Automation Instrumentation

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Control wiring** – has the meaning as defined in specification section 20 05 12.
 - .2 **Extra-low voltage** – any voltage not exceeding 30 V (has the same meaning as per CSA C22.1)
 - .3 **GUI** means “graphic user interface”, to display system data to the user and to allow the user to enter operating commands and data selection.
 - .4 **Power wiring** - has the meaning as defined in specification section 20 05 12.

1.4 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 0.3 Test Methods for Electrical Wires and Cables
 - .2 CSA C22.2 No. 14 Industrial Control Equipment
CSA C33.3 No. 18.5/UL 1565
Positioning Devices
 - .3 CSA C22.2 No. 66.2 Low Voltage Transformers – Part 2: General Purpose Transformers
CSA C22.2 No. 66.3 / UL 5085-3
Low Voltage Transformers – Part 3: Class 2 and Class 3
Transformers
 - .4 CSA C22.2 No. 72 Heater Elements
 - .5 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .6 CSA C22.2 No. 223 Power Supplies with Extra-Low-Voltage Class 2 Outputs.

1.5 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.

1.6 Registration and Inspection

- .1 Where control panels are not listed in accordance with CSA C22.2 No. 14, arrange and pay for field inspection by the AHJ for electrical safety.

1.7 Submittals

- .1 Shop drawings:
 - .1 submit product data sheets for materials specified herein.
 - .2 submit shop drawings for control panels including wiring diagrams and panel layout details.

2 PRODUCTS

2.1 General

- .1 Provide custom factory-made building automation control panels including all factory-installed devices and equipment required for operation of associated building equipment or systems including but not limited to DDC controllers, GUI, power supplies, transducers, solenoid air valves, relays and accessories.
- .2 Comply with the requirements of specification section 20 05 12 for products not otherwise specified herein.
- .3 Provide equipment which functions and meets detailed performance criteria when operating under the following conditions:
 - .1 ambient temperature:
 - (a) indoors: 4°C to 40°C (39°F to 104°F)
 - (b) outdoors: -30°C to + 40°C (-22°F to 104°F)]
 - .2 ambient relative humidity: 10% to 90% non -condensing,
 - .3 electrical power service: 120 VAC +/- 10%, 1 phase, 60 Hz nominal.

2.2 Control Panels

- .1 Panel enclosure:
 - .1 indoors: type 2 with sprinkler shield, 3R or 4 to CSA C22.2 No. 94.1 (NEMA 2, 3R, or 4),
 - .2 material: galvanized steel,
 - .3 with hinged door and lock,
 - .4 integral cooling fans and vents with power supplies, wiring and circuit protection,
 - .5 mounting backplate and/or DIN rails for mounting of wiring devices, controllers, sensors, transducers, and relays,
 - .6 conduit openings and adapters in sufficient quantities and sizes to accommodate wiring terminating within enclosure,
 - .7 document holder inside panel, to include one set of as built, plasticized control Shop Drawings for equipment served by that panel permanently affixed to cabinet frame,
 - .8 enclosure finish: vendors standard colour,
- .2 GUI display:

- .1 surface mounted on or semi-recessed in panel front door where GUI is required by other specification sections of Division 25.
- .2 where GUI is mounted on the controller inside the panel, provide panel door cut-out with viewing glass to allow viewing only of GUI with panel door closed.
- .3 Control panel layout and construction:
 - .1 enclosures to be of sufficient size to house control components including controllers and associated transformers, control relays, wiring, conduits and other auxiliary equipment, so as to allow access for maintenance and replacement of components without requiring removal of other components.
 - .2 permanent engraved labels with black lettering on white background indicating:
 - (a) stating applicable building system name and reference number.
 - (b) function of each panel door mounted device.
 - .3 mount air pressure gauges on front of panel door to allow viewing from outside the panel,
 - .4 support wiring in cable ducts; arrange cable ducting and install wiring in a neat and workmanlike manner,
 - .5 provide numbered terminal strips for field wiring terminations; do not terminate field wiring directly on control devices or controllers. Arrange terminal strips in a common location adjacent to minimize routing and quantity of field wiring inside of panel.
 - .6 label both ends of internal wiring with label markers using name of cable function, or to identify wire number as shown on panel shop drawings,
 - .7 layout circuit fuses to facilitate location and replacement; provide labels at each fuse holder identifying fuse number and replacement fuse type and size,
- .4 Control devices mounted on panel door-front:
 - .1 Key-lock operated main panel power ON-OFF switch,
 - .2 alarm buzzer silence pushbutton (where applicable),
 - .3 alarm reset pushbutton (where applicable),
 - .4 indicating lights:
 - (a) main panel power ON (white),
 - (b) summary alarm (red),
 - (c) other indicating lights as specified by control sequences.
- .5 Panel mounted alarm devices:
 - .1 alarm buzzer (where applicable).
- .6 Cable Ducts
 - .1 non-metallic cable ducting with removable cover, slotted access cable restraints,
 - .2 ambient temperature rating: -40 to +60°C (-40 to +140°F)
 - .3 listed to CSA C33.3 No. 18.5/UL 1565.
- .7 Terminal strips:
 - .1 NEMA finger-safe terminal blocks, spring-clamp or screw fastened,
 - .2 directly fastened to panel backplane or DIN rail mounted.

2.3 Power Supplies and Line Filtering

- .1 For control panels and for field installed devices.
- .2 Transformers and Power Supplies:
 - .1 industrial control transformers to be listed to CSA C22.2 No. 66-2, and temperature rated for 40°C,
 - .2 control transformers to be listed to CSA C22.2 No. 66-3,
 - .3 AC/DC power supplies to be listed to CSA C22.2 No. 223,
 - .4 provide over-current protection in primary and secondary circuits,
 - .5 limit connected loads to 80% of rated capacity.
- .3 DC power supplies:
 - .1 output to match equipment current and voltage requirements,
 - .2 units to be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation to be 1.0% line and load combined, with 100-microsecond response time for 50% load changes,
 - .3 units to have built-in over-voltage and over-current protection and to be able to withstand 150% current overload for at least three seconds without trip-out or failure,
 - .4 units to operate between 0°C and 50°C (32°F and 120°F).
 - .5 EM/RF to meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
- .4 Power Line Filtering:
 - .1 provide internal or external transient voltage and surge suppression for workstations and control modules,
 - .2 surge protection:
 - (a) dielectric strength of 1000 V minimum,
 - (b) response time of 10 nanoseconds or less,
 - (c) transverse mode noise attenuation of 65 dB or greater,
 - (d) common mode noise attenuation of 150 dB or greater at 40-100 Hz.

2.4 Miscellaneous Electrical Control Devices

- .1 Control Relays:
 - .1 plug-in type, UL listed, with dust cover and LED "energized" indicator.
 - .2 contact rating, configuration, and coil voltage suitable for application.
 - .3 NEMA 1 enclosure for relays not installed in local control panels.
- .2 Time Delay Relays:
 - .1 solid-state plug-in type, UL listed, with adjustable time delay adjustable $\pm 100\%$ from set point shown.
 - .2 contact rating, configuration, and coil voltage suitable for application.
 - .3 NEMA 1 enclosure for relays not installed in local control panels.
- .3 Override Timers:
 - .1 spring-wound line voltage, UL Listed, with contact rating and configuration by application unless implemented in control software.

- .2 0-6 hour calibrated dial.
- .3 flush mounted on local control panel face.
- .4 Electronic signal isolation transducers:
 - .1 provided whenever;
 - (a) an analog output signal from BAS is connected to an external control system as an input (such as chiller control panel) or
 - (b) BAS is to receive an analog input signal from an external remote system.
 - .2 designed for ground plane isolation between systems.

2.5 Electro-Pneumatic (E/P) Transducers

- .1 To convert 4-20 mA, 0-5 Vdc, or 0-10 Vdc analog control input signal to a 20-100 kPa (3-15 psig) output signal;
 - .1 separate span and zero adjustments,
 - .2 manual output adjustments,
 - .3 output pressure gauge assembly,
 - .4 feedback loop control,
 - .5 mid-range air consumption of 0.05 NL/s (0.1 SCFM).

2.6 Pressure-Electric (P/E) Switches

- .1 To convert pressure signal to activate electric switch;
 - .1 diaphragm operated SPDT. snap acting contacts with electrical rating suitable for application,
 - .2 designed to withstand up to 170 kPa (25 psi) input pressure,
 - .3 adjustable cut-in and cut-out settings between 25 and 140 kPa (3 and 20 psi).

2.7 Additional Requirements for Outdoor Panels

- .1 The following additional requirements apply where control panels are installed outdoors, or indoors in unheated spaces.
- .2 Enclosure: type 4, 4X or 12 to CSA C22.2 No. 94.1 (NEMA 4, 4X or 12),
- .3 Thermally insulated on all interior surfaces
 - .1 minimum thickness: 25 mm (1 in) at a maximum thermal conductivity of 0.0365 W/mK (0.0211 Btuh/ft²F) , or equivalent minimum RSI= 0.68 m²K/W (R = 3.86 ft²F/BTUH).
- .4 Mount GUI and other front-mount devices on inner front panel behind main panel door.
- .5 Electric resistance panel heater:
 - .1 electric resistant heaters listed to CAN/CSA C22.2 No. 72,
 - .2 sized to maintain panel interior temperature at not less than 4.5°C (40°F), at the ambient design temperature.
 - .3 integral or line mounted thermostat control, set with a temperature deadband of ON at 4.5°C (50°F) and OFF at 12°C (55°F).

2.8 Wiring and Raceways

- .1 Electrical materials, equipment and installation procedures to conform to the electrical safety code applicable to the location of the Work, in accordance with the requirements of specification section 20 05 12, and as specified herein.
 - .1 conductors for digital functions: 18 AWG minimum, twisted and shielded,
 - .2 conductors for analog functions: 18 AWG minimum, twisted and shielded, 2 or 3 wire to match analog function hardware.
 - .3 conductors for transformer current wiring: 16 AWG minimum,
 - .4 conductors for sensor wiring: 22 AWG minimum, twisted and shielded, 2 or 3 wire to match analog function hardware. Provide additional conductors as to support supplemental features of sensor (i.e. set-point adjustment, override, etc.).
- .2 Non-continuous cable supports:
 - .1 Sling strap:
 - (a) Galvanized steel support bracket with adjustable polyethylene support sling.

Standard of Acceptance

- nVent – fig. Caddy Cable 425

3 EXECUTION

3.1 Control Panel Installation

- .1 Install transmitters, transducers, controllers, solenoid air valves and relays in control panels.
- .2 Mount control panels to poured concrete or concrete block walls on mounting channels; do not fasten directly to the wall.
- .3 Where control panels are located away from concrete walls, provide a fabricated floor-mounted galvanized-steel channel support frame to mount control panels. Design support frame to withstand applicable seismic loads.
- .4 Install control panels with user interface devices on the panel door so that the centerline of the principle interface device is between 1500 and 1600 mm (60 to 64 in) above floor level.
- .5 Install other panels so that the top of the panel is located between 1800 and 1900 mm (72 to 76 in) above the floor.
- .6 Trim-back or neatly collect excess field wiring inside of control panels.

3.2 Field Wiring Installation

- .1 Provide power wiring and control wiring as needed to support operation of the building automation system. Refer to Section 20 05 12 for description of division of work and responsibility.
- .2 Installation of field wiring for power wiring and control wiring to conform to specification section 20 05 12 except/and as specified herein.
- .3 During installation follow cable manufacturer's specified cable pulling tension, and recommended minimum bend radius.
- .4 Verify entire network's integrity following cable installation using appropriate tests for each cable.

- .5 Install lightning arrester according to manufacturer's recommendations between cable and ground wherever cable enters or exits the building.
- .6 Each run of communication wiring to be continuous length without splices.
- .7 Label communication wiring to indicate origin and destination.
- .8 Ground coaxial cable according to Division 26 requirements.
- .9 Fiber optic cable installation:
 - .1 do not exceed pulling tensions specified by cable manufacturer. Post-installation residual cable tension to be in accordance with cable manufacturer's specifications,
 - .2 do not exceed minimum cable and unfaceted fiber bend radii specified by cable manufacturer.

3.3 Conduit and Raceways

- .1 Run power wiring and control wiring in conduit except where otherwise specified herein.
- .2 Extra-low voltage control wiring located in horizontal service spaces above dropped ceilings may be run exposed (without conduit) provided that wiring is;
 - .1 installed neatly and parallel to building lines,
 - .2 supported from J-hooks at intervals not exceeding 1200 mm (4 ft),
 - .3 have a FT6 rating in accordance with CSA C22.2 NO. 0.3 when installed in a supply or return air ceiling plenum
- .3 Do not run any BAS wiring in IT infrastructure cable trays.
- .4 Run conduit and raceways parallel to building lines and be secured to building structure.
- .5 Where conduit leaves heated areas and enters unheated areas, seal conduit with weather-tight sealant at the first junction box in the unheated space.

3.4 Power Conversion and Control Relays

- .1 Provide interposing and motor control relays at local item of equipment or at associated MCC as applicable.
- .2 Provide control transformers and power supplies for system components requiring power supply that do not have integral control transformers.
- .3 Where point schematics and specifications indicate auxiliary contact provision, provide instrumentation, wiring, conduit, power supplies and services as to integrate these points into BAS.
- .4 Mount transformers in enclosures adjacent to equipment served.

3.5 Cleaning

- .1 Prior to handover to the Owner, remove all debris from and vacuum clean inside of control panels. Clean exterior surfaces of panels including GUI displays.

End of Section

Master revised: July 15, 2021

BUILDING AUTOMATION TERMINAL UNIT CONTROLLERS 25 14 17

1 GENERAL

1.1 Scope

- .1 Provide application specific controller for terminal units ("TU-ASC").

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 35 13 Terminal Units
 - .2 25 05 01 Building Automation Common Work Results
 - .3 25 05 12 Building Automation Control Panels and Wiring
 - .4 25 15 16 Building Automation Software for Control and Monitoring

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .2 CSA C22.2 No. 205 Signal Equipment
 - .3 CAN/CSA-E60730-2-14 Automatic Electrical Controls - Part 2: Particular Requirements for Electric Actuators
 - .4 UL 864 Standard for Control Units and Accessories for Fire Alarm Systems

1.4 Network Integration Requirements

- .1 Controller Tier 2 network communications:
 - .1 in accordance with specification section 25 05 01.
 - .2 BACnet MSTP native device

1.5 Coordination with Terminal Unit Manufacturer

- .1 Terminal unit controllers and actuators to be factory-installed on terminal units by terminal unit manufacturer in accordance with specification section 20 35 13. Direct costs for factory installation of controllers and actuators on terminal units are directly born by terminal unit manufacturer.
- .2 Coordinate with the terminal unit manufacturer for delivery of products and requirements for product installation, including requirements for power supplies and overcurrent protection.
- .3 Arrange, pay, and be responsible for shipment of terminal unit controllers free-issue to the terminal unit manufacturer factory, without charge to the terminal unit manufacturer (FOB destination, freight prepaid).

1.6 Submittals

- .1 Shop drawings:
 - .1 Submit product data sheets for materials specified herein,
 - .2 Clearly mark each version type along with the applicable control sequence reference.

2 PRODUCTS

2.1 Environmental Conditions

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges:
 - .1 temperature: - 0°C to 32.2°C (32°F to 90°F)
 - .2 relative humidity: 10% to 90% non -condensing
 - .3 electrical service: single phase, 120 VAC +/- 10%, 60 Hz nominal,
 - .4 operating voltage: operate at 90% to 110% of nominal voltage rating and to perform an orderly shutdown below 80% nominal voltage,
 - .5 electrical noise: operation to be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices.

2.2 Terminal Unit Application Specific Controllers (TU-ASC)

- .1 General:
 - .1 stand-alone, multi-tasking, multi-user, real time digital processors with hardware, software, and communications interfaces, power supplies, and input/output modular devices,
 - .2 fully programmable to create custom control logic to meet requirements of the sequence of operations as shown,
 - .3 listed to CAN/CSA-E60730-2-14 or CSA C22.2. No. 205,
 - .4 listed to UL864 for smoke control and smoke venting applications,
 - .5 BTL or LonMark certified as an Application Specific Controller (as applicable to network integration requirements),
 - .6 native BACnet or Lonworks firmware (as applicable to network integration requirements),
 - .7 removable (hot swappable) without disconnection of terminals and wiring,
 - .8 have access to data within network to accomplish global control strategies,
 - .9 support firmware upgrades without need to replace hardware,
 - .10 both firmware and controller database can be loadable over the BAS network or by local service port,
 - .11 continuously perform self-diagnostics, communication diagnosis, and provide both local and remote annunciation of any detected component failures, low battery condition; and upon failure to assume predetermined failure mode.
 - .12 monitor status of overrides and inform operator if automatic control has been inhibited, and allow operator to manually override automatic or centrally executed inhibit command.
- .2 Memory:
 - .1 sufficient non-volatile memory to support its own BIOS and programming information in the event of loss of power.
- .3 GUI:
 - .1 face mounted LED type annunciation to display operational mode, and power and communication status.

- .4 Time clock:
 - .1 controllers that perform scheduling operations to have on board real-time clock.
 - .2 in network application, time clock synced to associated Network Supervisory Controller.
- .5 BACnet devices, Tier 2 Network;
 - .1 Conformance Class 3,
 - .2 support the BACnet functional groups for
 - (a) Change-of-Value (COV) Event Initiation,
 - (b) Change-of-Value (COV) Event Response,
 - (c) Event Initiation,
 - (d) Event Response,
 - .3 support the BACnet standard application services of;
 - (a) Read Property,
 - (b) Write Property.
 - .4 support the standard BACnet object types of;
 - (a) Device,
 - (b) Analog Input,
 - (c) Analog Output,
 - (d) Analog Value,
 - (e) Binary Input,
 - (f) Binary Output and Binary Value,
 - (g) Loop,
 - (h) Multi-State Input,
 - (i) Multi-State Output,
 - (j) Notification Class at a minimum.
 - .5 The described functionality provides reading and writing of all analog or digital inputs and outputs between BACnet devices on the network and provides for change-of-value initiation and reporting.
- .6 Communications:
 - .1 communication port (RS-232 DB-9, RJ-11 or RJ-45) for connection to laptop computer or operator interface device to allow memory downloads and other commissioning and troubleshooting operations.
 - .2 TU-ASCs reside on BAS Tier 2 network for network communications.
 - .3 communication services over BAS networks to support operator interface performance, and value passing as follows;
 - (a) connection of an operator interface device to any one controller on network to allow operator to interface with other controllers as if that interface were directly connected to those other controllers.
 - (b) data, status information, control algorithms, inputs, outputs, etc., from any controller on network is to be available for viewing and editing through operator interface device that is connected to any controller on network.
 - (c) links to execute control strategies to be programmed and tested so that an operator with appropriate password privileges is able to edit these links either by typing in standard object addresses, or by using simple point and click commands.

- (d) daily routine automatically synchronize time clocks in controllers. An operator initiated change to master time clock setting to be automatically broadcast to other controllers on network.
 - (e) minimum baud rate for peer-to-peer communication between controllers in system LAN to be at 10 Mbps and communication with low level controllers, to be at 76 Kbps.
- .7 Input/Output isolation:
- .1 I/O protected such that shorting of point to itself, shorting of point to another point, or shorting of point to ground will not damage controller.
 - .2 I/O protected such that voltage spikes of up to 24 V, of any duration, and any polarity will not damage controller.
- .8 Input/Output capacity:
- .1 I/O capacity as required to suit control sequence plus specified spare I/O.
 - .2 Analog Inputs:
 - (a) for monitoring of variable measurement properties,
 - (b) field selectable for 0-10 VDC, 4-20 mA, or resistance values for thermistors or RTD.
 - .3 Analog Outputs:
 - (a) for control of modulating control devices,
 - (b) modulating electronic signal, either 0 -10VDC or 4 -20mA.
 - .4 Digital Inputs:
 - (a) for monitoring of on/off signals from remote devices,
 - (b) provide wetting current of at least 12 ma and to be compatible with commonly available control devices.
 - .5 Digital Outputs:
 - (a) for On/Off. Open/Close control operation, or pulsed low voltage signal for pulse width modulation control,
 - (b) relays contacts: minimum 0.5 A @ 24 Volts AC or DC maximum,
 - (c) each relay to be configured as normally open or normally closed, and either dry contact or bussed.
 - .6 Universal Inputs:
 - (a) field configurable for analog or digital inputs,
 - (b) thermistor, dry contacts, or 0-5VDC with 0-10K Ohm input impedance.
 - .7 Spare I/O capacity, each TU-ASC:
 - (a) minimum of two (2) spare I/O point capacity for each point type, which may be met by two (2) only universal type,
 - (b) future use of spare capacity to involve provision of field device, field wiring, point database definition, and custom software,
 - (c) these spare points to be configurable without additional controller boards or point modules,
 - (d) wiring connections to be made to field-removable, through modular terminal strips or termination cards connected by ribbon cable.
 - .9 Airflow differential pressure sensor:
 - .1 integral, factory calibrated true differential pressure sensor, range of 0 – 250 Pa (0 – 1 in.w.c.)

- .2 calibration data stored in non-volatile memory for at least 15 velocity/pressure points within terminal unit range,
- .3 two (2) silicon sample tubing (for connection to terminal unit flow sensor station),
- .4 software conversion to airflow rate based on terminal box duct size.
- .10 Airflow station:
 - .1 air flow sensor element supplied with terminal unit.
- .11 Specific control of ancillary devices:
 - .1 for specific control of ancillary equipment as required by sequence of operations,
 - .2 Input points:
 - (a) room pressurization control based on calculated volumetric offset or direct differential pressure measurement,
 - (b) room occupancy sensor and/or override switch,
 - .3 Output points:
 - (a) modulating (non-floating point) hydronic control valves for reheat coil or SCR electric reheat coil,
 - (b) modulating (non-floating point) hydronic control valves for perimeter heating units,
 - (c) slave operation of return air/exhaust air terminal boxes,
 - (d) lighting On/Off control.
- .12 Power/communications interruption:
 - .1 controller continue to provide control functions in event of network communication failures,
 - .2 incorporate sufficient non-volatile memory to store critical configuration data in event of loss of normal power, and sufficient battery backup to support real time clock and volatile memory for minimum of 72 hours,
 - .3 after loss of power and then subsequent return of mains power, controller to;
 - (a) automatically reboot and return to service,
 - (b) zero output values prior to reinitiating controls sequence,
 - (c) restart control sequence at "Normal Operation" unless a supervisory controller provides a command to operate in a different mode of operation.

2.3 TU-ASC Damper Actuator

- .1 Damper actuator to conform to specification section 25 30 13 and as follows.
- .2 Damper actuator is field replaceable without requiring replacement of the TU-ASC controller.

2.4 Application Specific Controller Software

- .1 Software for TU-ASC to conform to specification section 25 15 16 except/and as specified herein.

3 EXECUTION

3.1 Installation

- .1 Provide TU-ASC's of type and I/O capacity to suit control and instrumentation strategies as detailed in sequence of operation, and as shown.
- .2 Install equipment in accordance with manufacturer's recommendations.

- .3 Mount controllers inside terminal unit control enclosures which meet a Type 1 enclosure to CSA C22.2 No. 94.1.

3.2 Power and Wiring

- .1 Provide control power transformer and overcurrent protection to suit controller requirements.
- .2 Provide power wiring from electrical circuits or junction boxes provided by Division 26 and extend to each TU-ASC; refer to specification section 20 05 12 and to mechanical and/or electrical drawings for locations of circuits or dedicated junction boxes.
- .3 Provide control wiring in accordance with specification section 25 05 11 for field installed instrumentation and control devices.
- .4 Where controlled room is served by terminal units on both supply and return, either:
 - .1 use a single TU-ASC to control dampers on both supply and return terminal units, or
 - .2 use separate TU-ASCs for both supply and return terminal units.

3.3 Tier 2 LAN Device Density

- .1 Total number of devices on each Tier 2 LAN not to exceed 80% of maximum device limitations (with the use of repeater devices).

3.4 Programming

- .1 Provide custom programming to meet the control strategies as called for in the sequence of operation sections.
- .2 Calculate the room air change rate per hour ("ACH") based on each room volume and supply air terminal unit measured flow rate;
 - .1 calculate ACH and update current value on a one (1) minute sample rate,
 - .2 where more than one (1) terminal unit serves the same room, aggregate the airflow rates of all terminal units to represent to the total ACH of the room,

3.5 TU-ASC Database

- .1 Provide a terminal unit configuration database for each TU-ASC. Data to include as a minimum:
 - .1 room type,
 - .2 room number,
 - .3 number of terminal units serving the room,
 - .4 device number,
 - .5 terminal unit type (VAV, CAC, Dual Duct, etc.),
 - .6 terminal unit size,
 - .7 minimum and maximum air flows,
 - .8 room design air change rate,
 - .9 room design differential airflow rate (where terminal units are provided on both supply and return terminal units),
 - .10 reheat air flow: minimum turndown air flow prior to use of reheat,
 - .11 calibration factor for field calibration determined by air balancing,
 - .12 occupied temperature setpoint, cooling,

- .13 occupied temperature setpoint, heating,
 - .14 occupant selectable maximum room temperature setpoint,
 - .15 occupant selectable minimum room temperature setpoint,
 - .16 unoccupied cooling temperature setpoint,
 - .17 unoccupied heating temperature setpoint,
 - .18 afterhours maximum Timer: maximum time occupant may override unoccupied cycle,
 - .19 internal cooling Signal: used to reset supply air temperature if more cooling is required,
 - .20 internal Heating Signal: used to reset supply air temperature is less cooling is required.
- .2 Configuration database updates:
- .1 allow updating of control configuration by individual room number.
 - .2 allow updating of control configuration by grouped "Room Type"; create room type groups as follows:
 - (a) private offices,
 - (b) open plan offices,
 - (c) corridors,
 - (d) common elements (washrooms, janitor closets),
 - (e) lobbies,
 - (f) kitchens, cafeterias and dining spaces,
 - (g) maintenance, workshops. storage rooms,
 - (h) service rooms,
 - (i) patient rooms,
 - (j) protective isolation rooms,
 - (k) airborne isolation rooms,
 - (l) operating rooms - organized by same minimum ACH rates,
 - (m) treatment rooms – organized by same minimum ACH rates,
- .3 Database to also include current measured values:
- .1 current measured room temperature,
 - .2 current measured airflow per TU-ASC,
 - .3 current measured total room airflow rate where multiple TU-ASC serves the same room,
 - .4 current calculated supply/exhaust differential airflow rate (where terminal units are provided on both supply and return terminal units),
 - .5 current measured room pressure (if differential pressure sensors are provided),
 - .6 current actual calculated air change rate.

END OF SECTION

**BUILDING AUTOMATION ACTUATORS AND OPERATORS
 25 30 13**

1 GENERAL

1.1 Scope

- .1 Provide actuators and operators for building systems automation.
- .2 Provide actuators for operating control dampers provided as part of factory built air handling units.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 35 13 Terminal Units
 - .2 25 05 01 Building Automation Common Work Results
 - .3 25 30 23 Building Automation PICV and Energy Valves
 - .4 25 30 26 Building Automation Control Valves
 - .5 25 30 33 Building Automation Control Dampers

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Emergency equipment** means engine-driven electrical generators and diesel-engine driven fire pumps.
 - .2 **Terminal units** has the meaning in accordance with specification section 23 35 13.
 - .3 **Valves** means a water, glycol, or steam control valve in accordance with specification sections 25 30 23 or 25 30 26.

1.4 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 24 Temperature-Indicating and -Regulating Equipment
 - .2 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .3 CAN/CSA-E60730-2-14 Automatic Electrical Controls - Part 2: Particular Requirements for Electric Actuators

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in the following minimum ambient condition ranges except where otherwise specified:
 - .1 ambient temperature:

Actuator Location	Service Temperature Range	Notes
Indoor	4°C to 40°C (39°F to 104°F)	(a)

Notes:

- (a) *Unheated spaces to be treated as outdoor spaces.*
- .2 Ambient relative humidity 10% to 90% non -condensing
- .2 Components installed within motor controllers to be designed to operate with transient electrical fields occurring within these devices.

2.2 Damper Actuators - General Purpose Electric/Electronic

- .1 General purpose damper actuators for air handling unit dampers and plenum/duct mounted dampers.
- .2 Listed to CAN/CSA-E60730-2-14.
- .3 Control action:
 - .1 electric/electronic operation for two position (OPEN-CLOSE) and proportional-modulating operation as shown,
 - (a) floating-point modulation not acceptable.
- .4 Enclosure:
 - .1 Type 2 to CSA C22.2 No. 94.1, or NEMA 2, for indoor applications,
 - .2 Type 4 or 12 to CSA C22.2 No. 94.1 or NEMA 4 or 12, for outdoor use and where dampers are exposed to the airstream inside an air intake plenum.
- .5 Construction:
 - .1 gear type mechanism with spring-return to failed position, or electronically fail-safe,
 - .2 adjustable motor rotation direction,
 - .3 mechanical position indicator,
 - .4 directly mounted to damper shaft,
 - (a) remote mounted with connecting linkage and with fastening clamp assembly are permitted only where there is insufficient space for mounting actuator directly onto damper shaft.
 - .5 electronic overload or digital rotation sensing circuitry to protect damper operator through entire range of rotation,
 - .6 angle of rotation adjustable between 0° to 90°,
 - .7 input control signals:
 - (a) proportional-modulation service: 0 - 10V, 2-10 V, or 0 - 20mA,
 - (b) two position service: power On-Off
 - .8 feedback signals:
 - (a) proportional-modulating service: 2 - 10 V position feedback signal.
 - (b) two position service: two (2) x SPDT auxiliary switches for end stop position indication (open and closed), 3 A resistive @ 250 VAC
 - .9 power supply:
 - (a) modulating service: 24 VAC/VDC, 50/60 Hz.
 - (b) two position service: 120 VAC or 24 VAC.
- .6 Selection:
 - .1 sized and selected in accordance with manufacturer's instructions,

- .2 minimum torque rating for dampers: sufficient to operate damper to provide smooth response up to fan dead-head pressure plus 15%,

2.3 Damper Actuators - Specific Purpose Electric/Electronic for Emergency Equipment

- .1 Specific purpose damper actuators for ventilation dampers serving emergency equipment.
- .2 Type: as above for general purpose damper actuators and as follows.
- .3 Operating temperature: -40°C to + 50°C (-40°F to 122°F).
- .4 Control action:
 - .1 spring return to fail position on loss of power supply:
 - (a) combustion air dampers : fail-to-open
 - (b) ventilation inlet air dampers: fail-to-open
 - (c) recirculation air dampers: fail-to-close
 - (d) exhaust air dampers: fail-to-open.
 - .2 spring operating cycle time: <20 seconds at -20°C to 50°C (-4°F to 122°F)
- .5 Enclosure:
 - .1 integral heating element for low temperature operation, 24 VAC.
- .6 Operating control:
 - .1 combustion air dampers: two position open/closed
 - .2 all other dampers: proportional-modulating with 0-10VDC or 4-20 mA input signal

Standard of Acceptance

- Belimo - EFB24-S N4/EFB120-S N4 series for two position dampers
- Belimo - EFB24-SR-S N4 series for modulating dampers

2.4 Damper Actuators - Specific Purpose Electronic for Terminal Units

- .1 Specific purpose damper actuators for terminal units.
- .2 Listed to CAN/CSA-E60730-2-14.
- .3 Control action:
 - .1 proportional-modulating type control,
- .4 Enclosure:
 - .1 Type 2 to CSA C22.2 No. 94.1, or NEMA 2, for indoor applications,
- .5 Construction:
 - .1 gear drive, direct coupled type operators mounted to terminal box damper shaft with universal V-bolt clamp,
 - .2 selectable / reversible rotation direction,
 - .3 input type and range as suitable for interfacing to output of terminal unit controller,
 - .4 angle of rotation adjustable between 0 to 90° with adjustable mechanical limit stops,
 - .5 damper position indication visible without cover removal,
 - .6 manual override to set damper position without power applied to actuator,

- .7 electronic stall protection,
- .8 actuator running time of not more than 100 seconds,
- .9 failure mode on loss of power to the actuator:
 - (a) non-smoke control or smoke venting applications: fail in last position,
- .10 power supply: 24 VAC/VDC, 50/60 Hz.
- .6 Selection:
 - .1 sized and selected in accordance with terminal unit manufacturer's requirements.

2.5 Valve Actuators - General Purpose Electric/Electronic

- .1 General purpose valve actuators for liquid and steam control valves for ball valves and globe valves.
- .2 Listed to CAN/CSA-E60730-2-14 or CSA C22.2 No. 24.
- .3 Control action:
 - .1 electric/electronic operation for two position (OPEN-CLOSE) and proportional-modulating operation as shown,
 - (a) floating-point modulation not acceptable,
 - .2 rotary or linear acting to suit valve action.
- .4 Enclosure:
 - .1 Type 2 to CSA C22.2 No. 94.1, or NEMA 2, for indoor applications,
 - .2 Type 4 or 12 to CSA C22.2 No. 94.1 or NEMA 4 or 12, for outdoor use and where dampers are exposed to the airstream inside an air intake plenum.
- .5 Construction:
 - .1 high alloy gear type mechanism with spring-return to failed position, or electronically fail-safe,
 - .2 adjustable motor rotation direction,
 - .3 mechanical position indicator,
 - .4 directly mounted to valve shaft, or with linear linkage drive assembly,
 - .5 compatible for installation on ISO 5211 mounting pad,
 - .6 electronic overload or digital rotation sensing circuitry to protect actuator through entire range of rotation,
 - .7 running time: < 160 seconds, independent of load,
 - .8 input control signals:
 - (a) proportional-modulation service: 0 - 10V, 2-10 V, or 0 - 20mA,
 - (b) two position service: power On-Off
 - .9 feedback signals:
 - (a) proportional-modulating service: 2 - 10 V position feedback signal.
 - (b) two position service: two (2) x SPDT auxiliary switches for end stop position indication (open and closed), 3 A resistive @ 250 VAC
 - .10 power supply:
 - (a) modulating service: 24 VAC/VDC, 50/60 Hz.

(b) two position service: 120 VAC or 24 VAC.

.6 Selection:

- .1 sized and selected in accordance with valve manufacturer's instructions,
- .2 minimum torque ratings for valves: sufficient to suit valve opening or closing requirements against a fluid differential pressure on:
 - (a) closed loop piping system of not less than 280 kPa (40 psig), plus 15%.
 - (b) open loop piping systems of not less than 700 kPa (100 psig), plus 15%.
- .3 actuators may be supplied as multiple units to achieve required torque.

2.6 Valve Actuators - Specific Purpose Electric/Electronic for Large Valves

- .1 Specific purpose valve actuators for large rotary operation butterfly valves with high torque requirements.
- .2 Listed to CAN/CSA-E60730-2-14 or CSA C22.2 No. 24.
- .3 Ambient temperature: -40°C to + 40°C (-40°F to 104°F),
- .4 Control action:
 - .1 electric/electronic operation for two position (OPEN-CLOSE) and proportional-modulating operation as shown,
 - (a) floating-point modulation not acceptable,
- .5 Enclosure:
 - .1 die-cast aluminum alloy,
 - .2 Type 4X to CSA C22.2 No. 94.1 or NEMA 4 or 12.
 - .3 integral heating element for internal humidity control and low temperature operation, same voltage as actuator motor.
- .6 Construction:
 - .1 single or dual-winding bidirectional motor driven actuator,
 - .2 spring-return or electronically fail-safe to failed position,
 - .3 self-locking high alloy steel gear type mechanism,
 - .4 electronic interface control board, solid state drive,
 - .5 span and zero travel adjustment,
 - .6 adjustable motor rotation direction,
 - .7 mechanical position indicator,
 - .8 directly mounted to valve shaft,
 - .9 compatible for installation on ISO 5211 mounting pad,
 - .10 thermal or electronic overload to protect actuator through entire range of rotation,
 - .11 running time: < 60 seconds, independent of load,
 - .12 duty cycle:
 - (a) On/Off valves: minimum 30%
 - (b) Proportional valves: minimum 75%
 - .13 declutching handwheel override,

- .14 valve position indicator,
- .15 input control signals:
 - (a) 0 - 10VDC or 0 - 20mA for proportional-modulation control,
 - (b) power On-Off for two position service,
- .16 feedback signals:
 - (a) proportional-modulating service: 2 - 10 V position feedback signal.
 - (b) two position service: two (2) x SPDT auxiliary switches for end stop position indication (open and closed), 3 A resistive @ 250 VAC
- .17 power supply:
 - (a) modulating service: 24 VAC/VDC or 120 VAC, 50/60 Hz.
 - (b) two position service: 120 VAC or 24 VAC, 50/60 Hz.
- .7 Selection:
 - .1 sized and selected in accordance with valve manufacturer's instructions,
 - .2 minimum torque ratings for valves: sufficient to suit valve opening or closing requirements against a fluid differential pressure on:
 - (a) closed loop piping system of not less than 280 kPa (40 psig), plus 15%.
 - (b) open loop piping systems of not less than 700 kPa (100 psig), plus 15%.

2.7 Valve and Damper Actuators - Pneumatic

- .1 Construction:
 - .1 piston and rolling diaphragm type or diaphragm type rated for operating pressure and not less than 140 kPa (20 psig).
 - .2 replaceable diaphragm: molded neoprene,
 - .3 pressure rating: 1030 kPa (150 psi)
 - .4 operating signal pressure range: 0-140 kPa (0-20 psi)
- .2 Enclosure (housing):
 - .1 housings: molded or die-cast from zinc or aluminum,
- .3 For sequencing terminal unit air control damper actuators and actuators on valves for radiation, radiant panels or terminal reheat coils;
 - .1 use spring ranges selected to prevent overlap, or use positive positioners.
- .4 Selection:
 - .1 selected in accordance with damper or valve manufacturer's instructions,
 - .2 of sufficient torque rating to operated damper or valve with smooth action at proper response speed,
 - .3 minimum torque rating for dampers: sufficient to operate damper to provide smooth response up to fan dead-head pressure plus 15%,
 - .4 minimum torque ratings for valves: sufficient to suit valve opening or closing requirements against a fluid differential pressure on:
 - (a) closed loop piping system of not less than 280 kPa (40 psig), plus 15%.

(b) open loop piping systems of not less than 700 kPa (100 psig), plus 15%.

3 EXECUTION

3.1 Application

- .1 Use electric/electronic actuators for damper and actuators.

3.2 Installation

- .1 General:
 - .1 Mount actuators and provide adapters according to manufacturer's recommendations.
- .2 Electric and Electronic Damper Actuators:
 - .1 Mount damper actuators directly on damper shaft or jackshaft; linkages may be used only where there is insufficient space to install and remove the actuator directly on the damper shaft.
 - .2 Mount valve actuator directly on shaft or with linkages according to manufacturer's recommendations.
 - .3 For low-leakage dampers with seals, mount actuator with minimum 5° travel available for damper seal tightening.
 - .4 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close damper, then tighten linkage.
 - .5 Provide mounting hardware and linkages for actuator installation.

3.3 Power and Control Wiring

- .1 Provide power and control wiring to each electric/electronic operator in accordance with the manufacturer requirements and in accordance with specification section 25 05 13.
- .2 Where required by actuator manufacturer instructions for parallel actuator installation, provide power isolation relays to isolate forward and reverse motor windings.

3.4 Compressed Air

- .1 Provide compressed air service to each pneumatic actuator in accordance with specification section 25 35 26.
- .2 Provide a manual isolation valve for each actuator.

3.5 Testing

- .1 Test each actuator by applying appropriate control signal and inspect for smooth operation while operating under normal load conditions.
- .2 Alternatively, where there are more than ten (10) actuators serving the same application, a timed cycle test may be used for all valves in each application:
 - .1 randomly select ten samples for each application, and measure open and closed timing of the sample valve set, and then estimate the average time of the set.
 - .2 Using the BAS, cycle open and then closed and record the time duration for each half cycle for each actuator. Test acceptance criteria is where each damper opens and closes within 90% of the tested average time.]

End of Section

Master revised: May 10, 2021

BUILDING AUTOMATION INSTRUMENTATION 25 30 16.13

1 GENERAL

1.1 Scope

- .1 Provide measurement switches, sensors, and transmitter instrumentation for building automation.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 01 13 Definitions and Abbreviations – Mechanical
 - .2 20 05 26 Pipeline Line Stopping
 - .3 25 05 01 Building Automation Common Work Results

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Finished rooms/spaces** means a room or space that is not a service room.
 - .2 **Instrumentation** means products covered by this specification section.
 - .3 **Service rooms** has the meaning as defined in specification section 20 01 13.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B51 Boilers, Pressure Vessels, and Pressure Piping Code
- .2 Product standards:
 - .1 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations.

1.5 Design Criteria

- .1 Pressure rating of instrumentation connected to pressure piping to be equal to or greater than the design pressure at the design temperature of the associated piping system.

1.6 Submittals

- .1 Submit manufacturer product data sheets in accordance with the requirements of Division 01.
- .2 Include Canadian Registration Numbers for applicable products.

1.7 Quality Control

- .1 Products that are in contact with the process fluid of a piping system that is subject to registration under applicable boiler and pressure vessel legislation are to have Canadian Registration Numbers in accordance with CSA B51.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in the following minimum ambient condition ranges except where otherwise specified:

- .1 ambient temperature:

Instrument Location	Service Temperature Range	Notes
Indoor	4°C to 40°C (39°F to 104°F)	(a)

Notes:

(a) *Unheated spaces to be treated as outdoor spaces.*

- .2 Ambient relative humidity 10% to 90% non -condensing
- .2 Components installed within motor controllers to be designed to operate with transient electrical fields occurring within these devices.

2.2 Temperature Switches

- .1 Low temperature limit temperature switch:
 - .1 6m (20 ft) of sensing capillary sensitive to freezing air over any 400mm (15 in) section,
 - .2 automatic reset with fixed differential temperature,
 - .3 installed in multiples with one unit serving not more than 5 m² (40 sq. ft) of duct area.
 - .4 single pole double throw (SPDT) contacts,
 - .5 operating temperature range: 1.7°C to 7.2°C (35°F to 45°F),
 - .6 adjustable set point within specified range,
 - .7 protective enclosure.
- .2 Temperature switches:
 - .1 sensing element of liquid, vapour or bimetallic type,
 - .2 adjustable set-point and differential of at least 0.22°C to 1.7°C (0.4°F to 3.0°F),
 - .3 snap action type rated at 120 volts, 15 amps or 24 volts DC,
 - .4 automatic in-operation and automatically reset when condition returns to normal,
 - .5 type:
 - (a) suitable for wall mounting on standard electrical box with protective guard, or suitable for insertion into air ducts with insertion length of 450 mm (18 in), or
 - (b) thermowell type with compression fitting for 20 mm (0.8 in) NPT well, mounting length of 100 mm (4 in), and immersion wells of type 316 stainless steel, or
- .3 Strap-on-type temperature switch with helical screw stainless steel clamps:
 - .1 operating temperature range: 23°C to 57°C (75°F to 138°F)
 - .2 adjustable set point within specified range,
 - .3 single pole double throw (SPDT) contacts,
 - .4 protective enclosure.

2.3 Temperature Sensors – General Requirements

- .1 Sensor element types:
 - .1 Resistance temperature device (RTD) of precision thin film platinum element type;
 - (a) linear characteristics over sensor range,
 - (b) reference resistance: 1000 ohm, [± 20 ohms (2%)] [± 2 ohms (0.2%)] at 0°C (32°F),
 - (c) temperature resistance coefficient: 0/.0385 ohms/ohm/°C (0.0212 ohms/ohm/°F),
 - (d) accuracy: ± 0.36 °C at 21°C (± 0.65 °F at 70°F) accuracy [[to Din IEC 751]
 - .2 Resistance temperature device (RTD) of precision thin film nickel element type;
 - (a) linear characteristics over sensor range,
 - (b) reference resistance: 1000 ohm, [± 20 ohms (2%)] [± 2 ohms (0.2%)] at 21°C (70°F),
 - (c) temperature resistance coefficient: 5.4 ohm/°C (3.0 ohm/°F)
 - (d) accuracy: ± 0.18 °C at 21°C (± 0.34 °F at 70°F)
 - .3 Thermistor;
 - (a) non-linear negative temperature coefficient of resistance,
 - (b) reference resistance: 10,000 ohms at 25°C (77°F),
 - (c) accuracy: curve matched to ± 0.2 °C (± 0.36 °F) over 0°C to 70°C (32°F to 158°F),
 - (d) long term stability: 0.025°C (0.045°F) drift per year
- .2 Sensor construction general requirements:
 - .1 2 integral anchored lead wires,
 - .2 waterproof sensor to sheath seal,
 - .3 strain minimizing construction,
 - .4 standard conduit box termination with cover,
 - .5 pig-tail wire leads with wire nuts or screwed terminal connector block,
 - .6 factory calibrated and capable of end to end (sensing element to BAS) accuracy of ± 0.25 °C (± 0.5 °F) over full range of measured variable,
 - .7 transducing circuit to convert output to signal compatible with equipment controller.

2.4 Temperature Sensors – for Ducts and Piping

- .1 For installation in duct and piping systems.
- .2 Averaging element type temperature sensors:
 - .1 averaging style element sensors, with minimum of four (4) encapsulated platinum 1 kohm RTD sensors per length,
 - .2 bendable aluminium or copper tubing construction,
 - .3 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F).
 - .4 ambient relative humidity: 5 to 95% RH non-condensing,
 - .5 minimum immersion length: 1800 mm (6 feet).
 - .6 probe field-formable to minimum radius of 100mm (4 in) at any point along probe length, other than with 200 mm (8 in) of connector box, without degradation of specified performance,
 - .7 galvanized steel or polycarbonate junction box,

- .8 provided as multiple RTD sensors where single averaging element cannot be located to provide proper duct or plenum temperature sampling.
- .3 Duct mount probe type temperature sensors:
 - .1 provided for ducts of cross section less than 0.4 m² (4 sq. ft),
 - .2 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F),
 - .3 copper or brass or stainless steel sheathed construction,
 - .4 ambient relative humidity: 5 to 95% RH non-condensing,
 - .5 metal mounting plate,
 - .6 probe length such that sensing element is between 35 and 70% of duct width or diameter,
 - .7 provided as multiple sensors where single element cannot be located to provide proper duct or plenum temperature sampling.
- .4 Pipe thermowell-mounted temperature sensors:
 - .1 for measurement of fluid temperatures in piping,
 - .2 insertion elements for measurement of fluid temperatures with stainless steel sheath,
 - .3 sensor operating temperature range: -40°C to 121°C (-40°F to 250°F),
 - .4 spring loaded construction with compression fitting for 20mm (NPS ¾) well mounting,
 - .5 length suitable for application,
 - .6 stainless steel or chrome plated brass thermowells of size and material to suit relevant sensor, pipe and service.
- .5 Outside air temperature sensors:
 - .1 insertion type for through-the-wall installation with stainless steel sheath,
 - .2 sensor operating temperature range: -25°C to 60°C (-13°F to 140°F),
 - .3 waterproof seal at wall,
 - .4 ambient relative humidity: 5 to 95% RH non-condensing,
 - .5 total active probe length: 100 mm to 150 mm (4 in to 6 in),
 - .6 non-corroding outdoor shield to minimize solar heating effect,
 - .7 inert section passing through wall to allow precise measurement of outdoor temperature.

2.5 Temperature Sensors – General Purpose Space Sensors

- .1 For general use space/room temperature measurement.
- .2 General purpose space temperature sensors – no display (type TS):
 - .1 hard-wired sensor only, no display,
 - .2 sensor operating temperature range: 4°C to 60°C (40°F to 140°F),
 - .3 enclosure: surface mounted, blank (no interface) plastic mono-chromatic guard with surface mounting plate and wall anchors,
 - .4 guard secured to mounting plate by screws or snaps.
- .3 Space temperature sensors with display (type TSD):
 - .1 BAS network sensor with user interface display,

-
- .2 user interface:
 - (a) LCD display, for measured values and setpoint values,
 - (b) temperature display resolution: 0.1°C (0.2°F)
 - (c) physical or virtual buttons for user adjustment of setpoints and selection of measured values.
 - .3 Programmable user input selection (buttons):
 - (a) physical or touchscreen buttons,
 - (b) sensor reading selection,
 - (c) sensor setpoint adjustment (temperature only),
 - .4 ambient relative humidity: 5 to 95% RH non condensing,
 - .5 temperature sensor: 10 kOhm,
 - .6 temperature sensor accuracy: $\pm 0.2^{\circ}\text{C}$ ($\pm 0.36^{\circ}\text{F}$)
 - .7 adjustable setpoint range (programmed default is 20°C to 25°C (68°F to 78°F)),
 - .8 BAS field-bus connector to allow local access to sensor and BAS controller and network,
 - .9 temperature setpoint remotely resettable from BAS,
 - .10 minimum/maximum limit set point values adjustable locally and remote from BAS,
 - .11 surface mounted plastic mono-chromatic guard with surface mounting plate and wall anchors,
 - .12 network connection: BACnet MSTP.
 - .13 guard secured to mounting plate by screws or snaps.
 - .4 Space temperature sensors with display and additional features (type TSD/x):
 - .1 Type TSD space temperature sensors with the following additional sensor elements, singly and in combination.
 - .2 Relative humidity sensor (type TSD/H)
 - (a) accuracy: $\pm 3\%$ RH of reading,
 - .3 Carbon Dioxide sensor (type TSD/C):
 - (a) dual beam, self-calibrating NDIR detection,
 - (b) range: 0 – 2000 ppm
 - (c) accuracy: ± 50 ppm + 2% of measured value at 25°C (77°F)
 - (d) stability: 20 ppm/year
 - .4 Occupancy sensor (type TSD/O):
 - (a) passive infrared motion sensor,
 - (b) range: 5 m (16 ft) minimum,
 - (c) sweep coverage: 100° horizontal.
 - .5 Special purpose space temperature sensors - Secure Areas (type TSS):
 - .1 hard-wired sensor only, no display,
 - .2 sensor operating temperature range: 4°C to 60°C (40°F to 140°F),
 - .3 enclosure:
 - (a) stainless steel flat plate surface type with sensor epoxy-bonded to back of cover plate,
 - (b) secured to standard electrical junction box with Torx head fasteners with center-pin.

2.6 Humidity Sensors – General Purpose

- .1 Sensor construction general requirements:
 - .1 measurement operating ranges of 10 to 100% R.H.
 - .2 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F)
 - .3 solid state sensing element,
 - .4 accuracy of $\pm 3\%$ RH reading over range of 5 to 95% R.H.,
 - .5 independent, non-interactive span and zero adjustments,
 - .6 0-100% linear proportional output signal indicating relative humidity, 4-20 mA, 0-5 Vdc or 0-10 Vdc,
 - .7 strain minimizing construction,
 - .8 screwed terminal connector block.
- .2 Duct mount probe type humidity sensors:
 - .1 metal mounting plate,
 - .2 constructed with 304 stainless steel element enclosure,
 - .3 length such that sensing element is between 35% and 70% of duct width or diameter from duct wall.
- .3 Outside air type humidity sensors:
 - .1 weatherproof enclosure with cover,
 - .2 waterproof seal.
- .4 Space humidity sensors (not included as part of a space temperature sensor):
 - .1 surface mounted plastic guard with surface mounting plate and wall anchors
 - .2 guard secured to mounting plate by screws,
 - .3 analogue LCD humidity display.

2.7 Duct Type Combination Temperature and Humidity Sensors – General Purpose

- .1 Where both temperature and humidity are shown to be measured at same location or in same airstream, use of single measuring unit is permitted provided that features and performance of both the temperature sensor and the humidity sensor are in accordance with requirements of this specification.

2.8 [[High Accuracy Space Combination Temperature and Humidity Transmitter (type THTS)

- .1 For spaces requiring high accuracy measurement as shown.
- .2 Wall mounted humidity and temperature transmitter, with LCD display.
 - .1 traceable calibration certificate, to NIST, ISO 9001 or ISO 17025,
 - .2 field calibration adjustment through front cover, and by PC or service tool through service port connection,
 - .3 user replaceable temperature and humidity sensor modules.
 - .4 user selectable humidity parameters – relative humidity, dew point, mixing ratio, enthalpy, wet bulb temperature, absolute humidity.
- .3 Humidity sensor:

- .1 measurement range: 0 - 100% RH,
- .2 accuracy: $\pm 1.7\%$ RH over 0-90% RH range at a temperature of +10 to +40°C (+50 to 104°F)
- .3 stability: $\pm 0.5\%$ RH/year
- .4 Temperature sensor:
 - .1 measurement range: -5 to +55°C (+23 to +131°F)
 - .2 accuracy: $\pm 0.2^\circ\text{C}$ between +20 to +30°C ($\pm 0.36^\circ\text{F}$ between +68 to +86°F).
- .5 Service port: RS 485 for temporary connection for service.
- .6 Comm port: RS 485 (for network models only),
- .7 Enclosure: polycarbonate or ABS, with viewing window
- .8 Network connection: BACnet MS/TP and Modbus RTU.
- .9 Power: 24 VAC/VDC.]

Standard of Acceptance

- ° Vaisala - fig. HMW95D]

2.9 [High Accuracy Duct Temperature and Humidity Transmitter (type THTD)

- .1 For spaces requiring high accuracy measurement as shown.
- .2 Duct mounted humidity and temperature transmitter,
 - .1 traceable calibration certificate, to NIST, ISO 9001 or ISO 17025,
 - .2 field calibration adjustment through front cover, and by PC or service tool through service port connection,
 - .3 user selectable humidity parameters – relative humidity, dew point, frost point, mixing ratio, enthalpy, wet bulb temperature, absolute humidity.
- .3 Humidity sensor:
 - .1 sensor type: Pt1000 RTD,
 - .2 measurement range: 0 - 100% RH,
 - .3 accuracy:
 - (a) $\pm 1.5\%$ RH over 0-90% RH range at a temperature of 0 to +40°C (+32 to 104°F)
 - (b) $\pm 2.5\%$ RH over 90-100% RH range at a temperature of 0 to +40°C (+32 to 104°F)
 - .4 stability: $\pm 0.5\%$ RH/year
- .4 Temperature sensor:
 - .1 measurement range: -40 to +80°C (-40 to +176°F)
 - .2 accuracy: $\pm 0.1^\circ\text{C}$ at 20°C ($\pm 0.18^\circ\text{F}$ at 68°F).
- .5 Service port: RS 485 for temporary connection for service.
- .6 Comm port: RS 485,
- .7 Enclosure:
 - .1 cast aluminum,
 - .2 Type 4X to CSA C22.2 No. 94.1, or NEMA 4X or IP66,

- .8 Output:
 - .1 Analog output: 2 @ 0-10 V for temperature and humidity
- .9 Network communications: BACnet MS/TP and Modbus RTU.
- .10 Power: 24 VAC/VDC

Standard of Acceptance

- Vaisala - fig. HMD65]

2.10 [Remote Display for High Accuracy Combination Temperature and Humidity Transmitters (type REMD)

- .1 For remote display of duct mounted high accuracy combination temperature and humidity transmitter type THTD.
- .2 Suitable for clean room environments.
- .3 Construction:
 - .1 parameter selectable, two line LCD display,
 - .2 housing:
 - (a) low profile, sealed housing, without openings or grooves, for each surface cleaning,
 - (b) front panel materials: brushed stainless steel case with glass viewing window.
 - (c) backplane mount: polypropylene,
 - (d) suitable for cleaning with common detergents and disinfectants, as well as liquid and gasified hydrogen peroxide.
- .4 Inputs: RS485.
- .5 Power supply: 24 VDC, or dedicated power cable fed from associated temperature/humidity sensor.

Standard of Acceptance

- Vaisala - fig. RDP100]

2.11 [Outdoor Combination Temperature and Humidity Transmitter (type THT-OUT)

- .1 For building reference outdoor conditions.
- .2 Exterior wall mounted humidity and temperature transmitter;
 - .1 traceable calibration certificate, to NIST, ISO 9001 or ISO 17025,
 - .2 on-site field calibration by PC or service tool through service port connection,
 - .3 user selectable humidity parameters – relative humidity, dew point, enthalpy, wet bulb temperature.
- .3 Humidity sensor:
 - .1 sensor: HUMICAP 180R
 - .2 measurement range: 0 - 100% RH,
 - .3 accuracy:

Temperature Range	Humidity Range	Accuracy
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-40 to -20°C (-40 to -4°F)	0 – 100% RH	±4% RH
-20 to +10°C (-4 to +50°F)	0 – 90%	±3% RH
	90 – 100%	±4% RH
+10 to +30°C (+50 to +86°F)	0 – 90%	±2% RH
	90 – 100%	±3% RH
+30 to +60°C (+86 to +140°F)	0 – 90%	±3% RH
	90 – 100%	±4% RH

- .4 stability: ±0.5% RH/year
- .4 Temperature sensor:
 - .1 sensor type: Pt1000 RTD,
 - .2 measurement range: -40 to +60°C (-40 to +140°F)
 - .3 accuracy: ±0.2°C at +20°C (±0.36°F at +68°F).
- .5 Calculated parameters:
 - .1 Built-in math processor calculates other air properties based on measured temperature and relative humidity.
 - (a) alternate properties selected by configuration settings.

Calculated Parameter	Range	Accuracy (at 20°C and 80% RH)
Dewpoint	-40 to +60°C (-40 to +140°F),	±0.7°C (±1.2°F)
Wet Bulb	-40 to +60°C (-40 to +140°F),	±0.5°C (±0.9°F)
Enthalpy	-40 to +460 kJ/kg (-10 to +190 BTU/lb)	±1.6 kJ/kg (±0.7 BTU/lb)

- .6 Ambient operating conditions:
 - .1 temperature: -40 to +60°C (-40 to +140°F),
 - .2 humidity 0- - 100% RH.
 - .3 maximum wind speed: 30 m/s (67 mph).
- .7 Service port: RS 485 for temporary connection for service.
- .8 Output: 2 @ 4-20 mA, one each for temperature and relative humidity,
- .9 Comm port: RS 485 (for network models only),
- .10 Housing:
 - .1 glass-reinforced polycarbonate, with rain shrouds and sun-shield,
 - .2 stainless steel wall mounting bracket with backing plate and hardware.

.11 Outputs:

- .1 2 @ 4-20 mA, loop powered transmitter.

.12 Power: 24 VAC/VDC

Standard of Acceptance

- ° Vaisala - fig. HMS110]

2.12 Pressure Switches

.1 General:

- .1 device pressure ratings – water, compressed gases and vapours: not less than the design pressure of the applicable piping system specification.
- .2 device pressure rating – ventilation ducts: minimum 14 kPa (2 psi).

.2 Differential pressure switches:

- .1 spring loaded diaphragm type,
- .2 suitable for use with air, inert gas, water, glycol, steam,
- .3 adjustable set-point and differential,
- .4 snap acting SPDT contacts rated at 120 volts, 15 amps AC or 24 volts DC,
- .5 switch mounted with diaphragm in vertical plane,
- .6 automatic in operation and automatically reset when condition returns to normal,
- .7 operating temperature range: 0°C to 60°C (35°F to 140°F),
- .8 operating humidity: 10 to 90% RH non-condensing,
- .9 high and low pressure ports, brass hose barbed pressure fittings suitable for Ø8 mm (¼ in) tubing,
- .10 mounting bracket suitable for duct mounting,
- .11 dust proof enclosure,
- .12 screw terminal block.

.3 Pressure switches:

- .1 bourdon tube, bellows or diaphragm type,
- .2 suitable for use with air, inert gas, water, glycol, steam, ammonia or non-corrosive refrigerants,
- .3 selected with span of not greater than twice maximum set pressure,
- .4 adjustable set-point,
- .5 snap acting SPDT contacts rated at 120 volts, 15 amps AC or 24 volts DC,
- .6 automatic in operation and automatically reset when condition returns to normal,
- .7 dust proof enclosure,
- .8 screw terminal block.

2.13 Pressure Sensors/Transmitters

.1 General:

- .1 device pressure ratings – water, compressed gases and vapours: not less than the design pressure of the applicable piping system specification.
- .2 device pressure rating – ventilation ducts: minimum 14 kPa (2 psi).
- .2 Duct static pressure sensors:
 - .1 for static and differential static pressure measurement of duct airflow,
 - .2 type: diaphragm driven, capacitance change type, 0-100% linear proportional output signal indicating static pressure or differential pressure at station,
 - .3 selected with span of not greater than twice the maximum static pressure and not less than twice differential pressure at shut-off.
 - .4 output: 4-20 mA, 0-5 Vdc or 0-10 VDC,
 - .5 power supply: 24 VAC/VDC,
 - .6 stainless steel duct probe, with length equal to between 35% and 70% of duct width or diameter,
- .3 Piping static pressure and differential pressure sensors:
 - .1 for static and differential static pressure measurement for liquids, gases and vapours,
 - .2 type: diaphragm driven, capacitance change type, 0-100% linear proportional output signal indicating static pressure or differential pressure at station,
 - .3 stainless steel wetted parts,
 - .4 output: 4-20 mA, 0-5 Vdc or 0-10 VDC,
 - .5 power supply: 24 VAC/VDC,
- .4 Piping static pressure and differential pressure transmitters:
 - .1 for static and differential static pressure measurement for liquids, gases and vapours,
 - .2 type:
 - (a) type 316L stainless steel diaphragm driven, capacitance change type,
 - (b) signal conditioning electronics for 0-100% linear proportional output signal,
 - .3 operator interface: LCD display of measured process value, with selectable units.
 - .4 wetted parts: type 316L stainless steel,
 - .5 process connections:
 - (a) type 316L stainless steel threaded fitting,
 - (b) NPT to ASME B1.20.1,
 - .6 output: 4-20 mA
 - .7 field adjustable zero and span,
 - .8 selected with span of not greater than twice maximum static pressure and not less than twice differential pressure at shut-off.
 - .9 accuracy, including non-linearity, hysteresis and non-repeatability: $\pm 0.05\%$ full scale,
 - .10 operating temperature range; -40°C to 80°C (-40°F to 185°F),
 - .11 operating humidity range; 0 to 100% relative humidity,
 - .12 mounting bracket, suitable for pipe mounting,
 - .13 enclosure;
 - (a) cast aluminium,

- (b) Type 4X to CSA C22.2 No. 94.1 or NEMA,
 - (c) polyurethane finish paint,
 - (d) screw terminal connector block.
- .5 Differential pressure transmitters for terminal units:
- .1 suitable for use in air with pressure independent terminal units (constant volume, variable volume or fan powered),
 - .2 capacitive sensor technology,
 - .3 pressure range: 0 to 373 Pa (0 to 15 in.w.g.),
 - .4 linear output proportional to velocity pressure of unit inlet air stream, and suitable as analog input to terminal unit controller,
 - .5 accuracy including non-linearity, hysteresis, and non-repeatability: $\pm 1\%$ full scale
 - .6 operating temperature range: 0°C to 50°C (32°F to 122°F)
 - .7 operating humidity range: 10 to 90% non-condensing
 - .8 high and low pressure ports, barbed pressure fittings suitable for $\varnothing 8$ mm ($1/4$ in) tubing for connection to air flow pick up device provided with terminal box,
 - .9 mounting kit, suitable for installation within terminal unit controller enclosure,
 - .10 coded screw terminals .

2.14 **[[Carbon Dioxide Transmitters**

- .1 Carbon dioxide (CO_2) transmitter – spaces/rooms:
- .1 dual element, non-dispersive, thermally compensated lithium tantalite infrared detector,
 - .2 LCD display of ppm level, trip set point and time delay,
 - .3 LED's indicating normal operation and alarm,
 - .4 range: 0 to 2000 ppm CO_2 in air,
 - .5 accuracy: ± 40 ppm CO_2 + 2% of reading,
 - .6 drift: less than $\pm 5\%$ full scale over five years without calibration,
 - .7 repeatability; $\pm 1.0\%$ of full scale
 - .8 warm-up time: 30 minutes maximum to full specified operation,
 - .9 response time: less than 60 seconds at minimum of 63% of step change,
 - .10 operating temperature range; 0°C to 45°C (32°F to 113°F)
 - .11 operating humidity range; 0 to 85% RH non-condensing,
 - .12 output signals:
 - (a) 4-20 mA, 0-5 Vdc or 0-10 Vdc, and
 - (b) SPST relay, 0.5 A @ 30 VAC, with field adjustable trip point and adjustable time delay for remote alarm.
 - .13 power supply: 24 VAC/VDC,
 - .14 enclosure: polycarbonate or PVC, white finish,
 - .15 warranty: 3 years.

- .2 Carbon dioxide (CO₂) transmitter – duct mounted
 - .1 same as for room type CO₂ transmitter and with duct insertion sensor bar,
 - .2 suitable for duct air velocities up to 15 m/s (3000 fpm).]

2.15 Hazardous Gas Detection Transmitters

- .1 Hazardous atmosphere detection transmitter – spaces/rooms:
 - .1 for measurement of carbon monoxide (CO) and nitrogen dioxide (NO₂),
 - (a) single or combined gas sensors in one enclosure,
 - (b) if combined gases, the nitrogen dioxide sensor is supplied loosed for remote mounting,
 - .2 sensor type: electrochemical,
 - .3 LCD display of ppm level, trip set point and time delay,
 - .4 LED's indicating normal operation and alarm,
 - .5 audible alarm 65dBA at 1 meter (3 feet) and visual alarm,
 - .6 performance:

Parameter	Carbon Monoxide	Nitrogen Dioxide
Range	0 - 100, 0 - 150, 0 - 300, 0 - 400 ppm selectable	0 - 10 ppm
Response time	< 30 secs	< 30 secs
Accuracy	±5 ppm,	±0.2 ppm
Drift	<5% per year	Zero: < 2 ppm/yr Span: <2%/month
Sensor coverage area	7m ² (700 sq. ft)	7m ² (700 sq. Ft)

- .7 operating temperature range; -20°C to 50°C (-4°F to 122°F)
- .8 operating humidity range; 0 to 85% RH non-condensing,
- .9 output signals:
- .10 output signals:
 - (a) 4-20 mA, 0-5 Vdc or 0-10 Vdc,
 - (b) BACnet MSTP, and
 - (c) DPDT relay, 5 A @ 120 VAC, with field adjustable trip point and adjustable time delay for remote alarm.
- .11 power supply: 24 VAC/VDC,
- .12 enclosure: Type 4X to CSA C22.2 No. 94.1, or NEMA 4X or IP65.]

2.16 Occupancy Sensors

- .1 Passive infrared sensor with temperature compensated pyro-electric dual active element,
 - .1 ceiling or wall mounted,
- Issued For Tender

- .2 LED indication light(s),
- .3 digital time delay adjustable: from 30 seconds to 30 minutes,
- .4 area coverage: 200 m² (2000 ft²),
- .5 output: SPDT isolated output relay, rated for 1 A at 24 VDC/VAC,
- .6 power supply: 24 VDC,
- .7 with 120 VAC/24 VDC transformer power supply unit.

Standard of Acceptance

- Watt Stopper Model CX-100]

2.17 Air Flow Measuring Devices

- .1 Multiple head pitot tube type stations:
 - .1 diamond shape cross-section averaging Pitot tube-style sensor with multiple tube structure, averaging chambers and bidirectional flow sensing capability,
 - .2 sheet metal duct collars,
 - .3 selected for operating flow range, duct size and air temperature,
 - .4 integral differential pressure sensor with analog output signal proportional to differential pressure across sensor, 4-20 mA, 0-5 Vdc or 0-10 Vdc,
 - .5 accuracy: $\pm 1\%$ of actual value,
 - .6 repeatability: $\pm 0.1\%$ of actual value,
 - .7 flow turndown: greater than 10:1,
 - .8 differential pressure range: 0 to 1250 Pa (0 to 5 in wg),
 - .9 operating pressure: up to 34.3 kPa (5 psig),
 - .10 operating temperature rating: -4°C to 95°C (-20°F to 200°F),
 - .11 operating pressure rating: 1725 kPa (250 psig)
- .2 Thermal anemometer probe type airflow measuring stations:
 - .1 sensors mounted in sheet metal duct collars of [aluminum][stainless steel],
 - .2 each thermistor mounted in solid thermoplastic housing,
 - .3 probe length equal to greater of two inside dimensions of rectangular and oval ducts and equal to duct diameter for round ducts,
 - .4 minimum two sensing points per probe,
 - .5 independent averaging of multiple sensing points,
 - .6 averaging amplifier with adjustable offset and span for multiple probe applications,
 - .7 temperature compensated linear analog output signal indicating average velocity at station, 4-20 mA, 0-5 Vdc or 0-10 Vdc,
 - .8 velocity accuracy: $\pm 2\%$ of reading,
 - .9 temperature accuracy: 0.10°C (0.18°F),
 - .10 resolution: 0.4% of scale,
 - .11 repeatability: $\pm 0.2\%$ of reading,

- .12 velocity range; 0 to 25m/s (0 to 5000 fpm),
 - .13 maximum allowable pressure drop: 1.2 Pa at 10m/s (0.005 in wg at 2000 fpm),
 - .14 flow station operating temperature range: [0°C to 70°C (30°F to 160°F)][-29°C to 71°C (-20°F to 160°F)],
 - .15 electronics operating temperature range: 0°C to 70°C (30°F to 160°F),
 - .16 flow station operating humidity range: 0 to 99% RH non-condensing,
 - .17 dedicated electronic, solid state digital processing control panel with general purpose NEMA 2 enclosure,
 - .18 provided with upstream and/or downstream flow conditioning.
- .3 Thermal anemometer type airflow measuring stations for installation at fan inlets:
- .1 fan inlet bell mouth mounted with adjustable steel strut and mounting feet,
 - .2 minimum of two flow sensing thermistors and temperature sensors per station, two stations for DWDI fans,
 - .3 sensors mounted in aluminum casing and recessed within strut,
 - .4 independent averaging of multiple sensing points,
 - .5 temperature compensated linear analog output signal indicating average velocity at station, 4-20 mA, 0-5 Vdc or 0-10 Vdc,
 - .6 velocity accuracy: $\pm 2\%$ of reading,
 - .7 temperature accuracy: $\pm 0.2^\circ\text{C}$ (0.36°F),
 - .8 resolution: 0.4% of scale,
 - .9 repeatability: $\pm 0.2\%$ of reading,
 - .10 velocity range: 0 to 25m/s (0 to 5000 fpm),
 - .11 maximum allowable pressure drop: 1.2 Pa at 10m/s (0.005 in.w.c. at 2000 fpm),
 - .12 flow station operating temperature range: 0°C to 71°C (30°F to 160°F),
 - .13 electronic operating temperature range: 0°C to 71°C (30°F to 160°F),
 - .14 flow station operating humidity range: 0 to 99% RH non-condensing,
 - .15 dedicated electronic, solid state digital processing control panel with general purpose dustproof enclosure.
- .4 Provide mounting hardware for installation of airflow measuring stations by sheet metal contractor.

2.18 Air Flow Switches

- .1 For indication of air flow within duct.
- .2 Differential pressure activated, diaphragm type,
 - .1 snap-action SPDT switch, 10 A @ 120 VAC,
 - .2 field adjustable set point,
 - .3 minimum air velocity: 1 m/s (200 fpm),
 - .4 maximum air velocity: 10.2 m/s (2000 fpm),
 - .5 operating ambient temperature range: 0°C to 40°C (32°F to 104°F),
 - .6 dustproof enclosure with mounting plate and gasket seal.

2.19 Liquid Flow Switches

- .1 For indication of fluid flow in piping systems.
- .2 Suitable for use with water, ethylene or propylene glycol, chlorinated or treated water
 - .1 snap-action SPDT switch, 10 A @ 120 VAC,
 - .2 operating ambient temperature range; [0°C to 82°C (32°F to 180°F)][-34°C to 82°C (-30°F to 180°F)]
 - .3 operating liquid temperature range: [0°C to 121°C (32°F to 250°F)][-29°C to 121°C (-29°F to 250°F)]
 - .4 general purpose dust proof enclosure for use indoors with fluids at temperature greater than 0°C (32°F)
 - .5 NEMA 3R vapour tight enclosure for use indoors or outdoors with fluids at temperatures below 0°C (32°F).

2.20 Water Detection Devices

- .1 Leak Detection – Tape Type (type “WD1”):
 - .1 for detection of water included condensate from water vapour,
 - .2 sensor type: continuous tape 3 mil copper fiber, ¼” gap, with self-adhesive backing,
 - .3 sensor tape length: based on width of area being monitored,
 - .4 control type: two (2) relays, trouble and alarm,
 - .5 local indicator: red alarm pilot light,
 - .6 relay output rating: 1A @ 24 VAC/VDC, 0.5 A @ 120 VA,
 - .7 operating temperature: 0 to 70°C (32 to 158°F)
 - .8 enclosure: cast aluminum, type 4 to CSA C22.2 No. 94.1,
 - .9 power: 11 – 27 VAC/VDC, with associated 120/24 V power supply unit.

Standard of Acceptance

- Kele - fig. WD-2-T

- .2 Leak Detection – Float Level Switch (type “WD2”):
 - .1 for detection of water included condensate from water vapour,
 - .2 sensor type: stainless steel float, magnetically-coupled sealed reed-switch,
 - .3 control type: one (1) SPST switch, 50 VA contact rating,
 - .4 field-adjustable for normally open or normally closed contacts,
 - .5 power: 120 – 240 VAC

Standard of Acceptance

- Kele - fig. FS7-SS.

- .3 Leak Detection – Spot Leak Detector (type “WD3”)
 - .1 for detection of water containing mineral content including HVAC water and potable city water,

- .2 sensor type:
 - (a) conductivity sensing probe,
 - (b) for direct contact to surface with adjustable height between 0 to 4.8mm (0 to 0.19 in.),
- .3 control type: one (1) DPST relay,
- .4 relay output rating: 1A @ 24 VAC/VDC, 0.5 A @ 120 VA,
- .5 operating temperature: 0 to 50°C (32 to 122°F)
- .6 enclosure: cast aluminum, type 4 to CSA C22.2 No. 94.1, with mounting flanges to fasten to floor,
- .7 power: 24 VAC/VDC, with associated 120/24 V power supply unit.

Standard of Acceptance

- RLE - fig. SD-R01

.4 Leak Detection – Conductivity Cable (Rope) Type Leak Detector:

- .1 for detection of water containing mineral content including HVAC water and potable city water,
- .2 sensor type: conductivity style detection system consisting of:
 - (a) detector module,
 - (b) conductivity sensing cable,
 - (c) leader cable (as required).
- .3 sensor cable: conductivity for detection of water,
- .4 control type: two (2) DPST relays, trouble and alarm,
- .5 relay output rating: 1A @ 24 VAC/VDC, 0.5A @120 VAC,
- .6 local indicator: red alarm pilot light,
- .7 operating temperature: 0 to 50°C (32° to 122°F),
- .8 enclosure: ABS with hinged and gasket cover Type 3R or 4X to CSA C22.2 No. 94.1,
- .9 sensing cable length: as shown,
- .10 leader cable: FT-6 Plenum Rated,
- .11 power: 12 – 27 VAC/VDC, with associated 120/24 V power supply unit.

Standard of Acceptance

- Greystone - fig. WLDC
- RLE - fig. LD310
- Kele - fig. WD-2PR

2.21 Fuel Oil Detection Devices

- .1 Refer to Specification section 23 11 33.

2.22 Electric Power Instrumentation

- .1 Current sensing relays:
 - .1 metering transformer ranged to match load being metered,
 - .2 plug in base and shorting shunt to protect current transformer when relay is removed from socket,
 - .3 current transformer for single or three phase metering connected into single relay,

- .4 adjustable latch level, adjustable delay on latch and minimum differential of 10% of latch setting between latch level and release level,
 - .5 discrimination between phases in three phase applications to allow worst case selection,
 - .6 mounted in motor starter enclosure and fed from starter control transformer,
 - .7 relay contacts capable of handling 10 amps at 240 volts.
- .2 Current switches:
- .1 self-powered, solid-state type with adjustable trip current,
 - .2 integral current transformers and relays to indicate motor status,
 - .3 SPDT output relay suitable for use as digital input to the BAS,
 - .4 field adjustable output relay trip setting, over 0-100% of range. Deadband adjustment to maximum of 10% of range,
 - .5 integral zero-leakage LED's indicating sensor power and switch status,
 - .6 long term setting drift of current transformer and relay combination not more than 5% full range over 6 months,
 - .7 over current and over voltage protection for current transformer and relay,
 - .8 operating temperature range; -10°C to 50°C (14°F to 122°F),
 - .9 operating humidity range; 5% to 90% RH non condensing.
- .3 Current transducer:
- .1 output signal proportional to measured line current,
 - .2 output signal in one of following ranges; 4-20 mA, 0-5 Vdc or 0-10 Vdc
- .4 AC Current Transmitters:
- .1 self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output,
 - .2 full-scale unit ranges of 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment,
 - .3 accuracy: $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - .4 UL/CSA listed and meet or exceed ANSI/ISSA 50.1 requirements.
- .5 AC Voltage Transmitters:
- .1 self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
 - .2 adjustable full-scale unit ranges; 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac.
 - .3 Accuracy: $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - .4 UL/CSA listed, 600 Vac rated and conforming to ANSI/ISSA 50.1.
- .6 Power Monitors:
- .1 three-phase type with three-phase disconnect and shorting switch assembly,
 - .2 UL listed voltage transformers, and
 - .3 UL listed split-core current transformers.
 - .4 selectable output either rate pulse for kWh reading or 4-20 mA for kW reading.
 - .5 maximum error of $\pm 2\%$ at 1.0 power factor or $\pm 2.5\%$ at 0.5 power factor.

3 EXECUTION

3.1 Instrumentation Installation – General Requirements

- .1 Mount instrumentation;
 - .1 in clean areas wherever possible,
 - .2 to be accessible to allow for replacement and servicing without interfering with access for adjacent equipment and personnel traffic in surrounding space,
- .2 Provide access doors where instrumentation is concealed behind solid surfaces.
- .3 In finished spaces and rooms, install room instrumentation on concealed junction boxes;
 - .1 fully recessed in gypsum board, wood, or similar construction,
 - .2 fully recessed in new concrete block construction, with conduit run block void spaces,
 - .3 fully recessed in new poured concrete construction, with conduit and outlet box roughed-in before concrete pour.
 - .4 surface mounted with exposed conduit on existing concrete block walls and existing poured concrete walls.
- .4 In service rooms, loading docks, and parking garages, install room instrumentation on surface mounted junction boxes with exposed surface-mounted conduit.
- .5 Rigidly support field mounted instrumentation on pipe stands or channel brackets.
- .6 Rigidly support duct mounted instrumentation to side of duct, in a location that will allow full removal of the instrumentation including duct probes.
- .7 Orient instrumentation sensing elements to correctly sense measured variable and to be isolated from vibrations and environmental conditions that could affect measurement or calibration.
- .8 Identify each cable and wire at every termination point.
- .9 Air seal wires attached to sensors at entry into junction box.

3.2 Power and Control Wiring

- .1 Provide power and control wiring to each instrument in accordance with the manufacturer requirements and in accordance with specification section 25 05 13.

3.3 Temperature and Humidity Instrumentation

- .1 Averaging duct temperature sensors:
 - .1 Use averaging sensors in the following locations:
 - (a) mixing plenums in front of the first downstream component,
 - (b) ducts with cross sectional area greater than 1.5 m² (16 sq. ft),
 - (c) downstream of the supply air leaving side of a thermal heat wheel, located approximately 200 mm (8 in) from leaving face of wheel.
 - .2 Install averaging sensors in serpentine manner vertically across duct. Support each bend with capillary clip. Provide sensor element length of 3 m per m² (1 ft per ft²) of plenum/duct cross sectional area.
- .2 Low-temperature switch:

- .1 Install mixing plenum low-limit temperature switches in serpentine manner horizontally across duct. Support each bend with capillary clip. Provide sensor element length of 3 m per 1 m² (1 ft per 1 sq. ft) of coil area.
- .3 Pipe mounted temperature sensors:
 - .1 Thermowells to be installed by the trade contractor under the applicable Division of the Work for each piping system. Supply the thermowells to the trade contractor and coordinate with them as to installation location and orientation.
 - .2 For existing steel piping systems, coordinate with the piping trade contractor to install the thermowells by hot-tapping in accordance with specification section 20 05 26 except where the Owner permits draining of the piping system.
 - .3 Install pipe-mounted liquid temperature sensors in thermowells with heat-conducting material.
 - .4 Orientate thermowells and transmitters to be located from the side of the pipe or top of pipe for horizontal piping.
 - .5 Cut and recover piping insulation to 300 mm (12 in) either side for installation of strap-on temperature sensors. Provide removable insulation box over sensor and patch insulation to match existing.
- .4 Space temperature and humidity sensors:
 - .1 Mount space temperature or combination temperature/humidity sensors / transmitters at 1200 mm (4 ft) above finished floor.
- .5 Humidity sensors:
 - .1 Locate humidity sensors adjacent to temperature sensors except as follows.
 - .2 Locate humidity sensors in the supply air downstream of a thermal heat wheel in a location that represents the average relative humidity when hand-measured at the upstream face of the next component in the air handling unit.
- .6 Outdoor temperature and humidity transmitters:
 - .1 Install outdoor air combination humidity and temperature transmitters on north facing wall, in a location readily accessible for maintenance access.

3.4 Space Temperature Sensor Selection

- .1 Select general purpose space temperature sensor types in accordance with the following table unless otherwise shown on drawings or in control sequences:

Space Types	Temperature Sensor Type
Private offices	TSD/O
Open plan offices	TSD
Meeting rooms, class rooms, private dining rooms, faith congregation spaces, gymnasias	TSD/C/O
Public dining areas, libraries, art galleries	TSD [TSD/C]

Service rooms, corridors, data centers, distributed electrical and data rooms, janitorial rooms, loading docks, storage rooms	TS
Building entrances, lobbies, elevator lobbies, stairwells	TS
Kitchens, laundry rooms	TS [TSD]
Maintenance workshops	TS
Non-specific process spaces	TS
Healthcare operating rooms	TSD/H
Healthcare treatment rooms and procedure rooms	TSD [TSD/O]
Laboratories	TSD [TSD/O]
Mental health patient rooms, secure rooms	TSS
All other spaces not identified above	TS [TSD]

3.5 [High Accuracy Temperature and Humidity Transmitters

- .1 Provide high accuracy space temperature sensors in space types in accordance with the following table unless otherwise shown on drawings or in control sequences:

Space Types	Temperature Sensor Type	Remote Display Unit
<<>> laboratory	THTS	---
<<process department>>	THTS	---
Level 3 and 4 Biological containment rooms	THTD	REMD
Clean rooms	THTD	REMD

]

3.6 Differential Air Static Pressure Sensors

- .1 Install duct static pressure sensors rigidly to side of duct to ensure duct probe is at 90° to the direction of airflow.
- .2 Supply duct static pressure;
- .1 pipe high-pressure tap to duct using pitot tube,
 - .2 make pressure tap connections according to manufacturer's recommendations.
- .3 Return duct static pressure;
- .1 pipe high-pressure tap to duct using pitot tube,
 - .2 make pressure tap connections according to manufacturer's recommendations.

- .4 Building static pressure;
 - .1 pipe pressure sensor's low-pressure port to static pressure port located on outside of building through high-volume accumulator,
 - .2 pipe high-pressure port to location behind thermostat cover.
- .5 Piping to air pressure transducer pressure taps to contain capped test port adjacent to transducer.
- .6 Install duct differential pressure sensors across fans, filters and other devices as shown.
- .7 Trim impulse lines to use the shortest length while maintaining adequate bending radius without kinking impulse tubes.
- .8 Locate air pressure transducers, except those controlling terminal unit boxes;
 - .1 in control panels, not on monitored equipment or on ductwork,
 - .2 mount transducers in vibration-free location accessible for service without use of ladders or special equipment.

3.7 Airflow Measuring Stations

- .1 Provide transducers, relays, and interconnection wiring to perform Sequences of Operations as detailed and Monitoring in accordance with Controls Schematics.

3.8 Fluid Pressure Switch

- .1 Mount pressure switch tees adjacent to fluid pressure gauge taps. Install shut-off valves before tee for water gauges.
- .2 Install pressure snubbers on pressure switches at;
 - .1 suction and discharge sides of oil pumps, and positive displacement pumps,
 - .2 for compressed air at compressors, dryers and receivers.
- .3 Install coil syphons on steam and condensate pressure switches.

3.9 Fluid Pressure Sensors and Transmitters

- .1 Provide isolation valve and snubber between pressure sensor/transmitter and pressure source.
- .2 Install coil syphons on steam and condensate pressure sensors/transmitters.
- .3 Provide two pressure transducers with software calculation at controller for differential pressure measurements in fluid piping systems.

3.10 Flow Switch Installation

- .1 Fit correct length paddle for diameter of pipe.
- .2 Adjust switch for specified flow condition in accordance with manufacturer's instructions

3.11 [Air Quality Instrumentation

- .1 Carbon dioxide sensors:
 - .1 install CO₂ sensors at between 900 - 1200 mm above floor level.
- .2 Carbon monoxide transmitter:
 - .1 install CO sensors at 900 - 1200 mm above floor level,

- .2 adjust CO alarm setpoints:
 - (a) warning: 40 ppm
 - (b) alarm: 70 ppm
- .3 Nitrous Dioxide transmitter:
 - .1 install NO₂ sensors at 300 to 450 mm above floor level,
 - .2 adjust NO_x alarm setpoints:
 - (a) warning: 0.5 ppm
 - (b) alarm: 1.0 ppm.]

3.12 **[[Occupancy Sensors**

- .1 Install occupancy sensors in ceiling as shown.]

3.13 **Leak Detection Devices**

- .1 Provide leak detection devices where shown.
- .2 Unless otherwise shown, select leak detection types as follows:

Location	Fluid Detected	Type	Limits
HVAC condensate trays (beneath trays)	Condensate water	WD1	Locate tape beneath and along length of tray overflow
HVAC condensate trays (inside of tray)	Condensed water	WD2	One detector per tray set at highest detection level, to detect water at a depth of 25 mm (1 in.)
Containment trays beneath CRAC, CRAH units	HVAC water (unit leaks)	WD3	Containment area ≤ 1.2 m ² (12.9 ft ²): two detectors per containment area.
		WD4	Containment area > 1.2 m ² (12.9 ft ²): Continuous cable around containment perimeter
HVAC water piping (along length of pipe)	HVAC water (pipe leaks)	WD4	Installed on bottom of pipe underneath insulation.
Raised floors, along path of water piping (beneath piping)	HVAC water (pipe leaks) and condensate water	WD1	Continuous tape applied to floor beneath pipes.
Piping trench	HVAC water, city water, ground water	WD4	Locate cable on side of trench, mounted 12 mm (0.5 in.) above bottom of trench

- .3 Install leak detection devices in accordance with manufacturer's instructions and as follows:

- .1 for type WD1 (tape), do not fold, bend or cross the tape over itself,
 - .2 for type WD2 (float), provide a support bracket to suspend the float to activate at the indicated depth,
 - .3 for type WD3 (spot), attach the device directly to the floor,
 - .4 for type WD4 (cable), use plastic clips on 200 mm (8 in.) centres to keep cable straight, without sags or offsets. Route cable at corners using the required minimum bending radius as specified by the manufacturer.
- .4 Test each device for operation at indicated water depth. Use water of the type appropriate to the device as follows:
- .1 for type WD1 and WD2, use distilled or similar pure (demineralized) water – do not use potable city water,
 - .2 for type WD3 and WD4, use HVAC or potable city water.

3.14 Safety Controls

- .1 Unless otherwise shown, safety devices including smoke detectors, freezestats, low- and high-pressure cut-offs, and other safety switches and controls, are to be hard-wired to de-energize equipment as described in Sequence of Operation.
- .2 Provide contacts that allow BAS software to monitor safety control status.

End of Section

Master revised: July 24, 2023

BUILDING AUTOMATION CONTROL VALVES

25 30 19.13

1 GENERAL

1.1 Scope

- .1 Provide automatic control valves, other than those valves specified in section 25 30 19.16.
- .2 Provide valve actuators in accordance with specification section 25 30 13.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 25 30 13 Building Automation Actuators and Operators
 - .2 25 30 19.16 Building Automation Pressure Independent Control Valves

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B51 Boilers, Pressure Vessels, and Pressure Piping Code.
- .2 Product standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .2 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .3 CSA B242 Groove and Shoulder Type Mechanical Pipe Couplings

1.4 Design Criteria

- .1 Refer to applicable piping specification sections for piping system design pressure and design temperature.

1.5 Quality Control

- .1 Valves to have current Canadian Registration Numbers in accordance with CSA B51.

1.6 Submittals

- .1 Shop drawings:
 - .1 submit product data sheets for materials specified herein,
 - .2 submit a schedule of control valves, identifying at a minimum the control valve tag, flow rate, pressure drop, Kv (Cv) values, valve body type, valve body pressure rating at design temperature, and CRN number.

2 PRODUCTS

2.1 Control Valves General Requirements

- .1 Body and trim materials selected in accordance with specification for globe valves, ball valves, or high performance butterfly valves in applicable piping system valve specifications, and in accordance with manufacturer's recommendations for design conditions and service.

- .2 Control valve type selections are shown on drawings, schematics and schedules.
- .3 Pipe end connections:
 - .1 NPS ½ to NPS 2: NPT to ASME B1.20.1.
 - .2 NPS 2-1/2 and larger: flanged to ASME B16.5, or grooved to CSA.

2.2 Water Solenoid Valves

- .1 Refer to piping specification sections for specific-duty solenoid valves.
- .2 General duty solenoid valves, NPS 1 and smaller:
 - .1 Two-port, two position operation,
 - .2 body: bronze, brass or stainless steel valve with EPDM seals and disc,
 - .3 for normally closed or normally open operation as shown,
 - .4 pilot operated electric solenoid with general purpose enclosure and conduit hub,
 - .5 minimum allowable working pressure: 1035 kPa (150 psig),
 - .6 minimum operating differential pressure: 820 kPa (120 psi)
 - .7 minimum design temperature: 93°C (200°F)
 - .8 manual override operator for normally-closed valves,
 - .9 pipe ends: ASME B1.20.1 NPT threaded ends,
 - .10 listed to CSA C22.2 No. 139,
 - .11 power supply: 24 VAC, 24 VDC or 120 VAC
- .3 Valve size: pipeline size.

2.3 Water and Glycol Valves – Two Position, Two- and Three-Way

- .1 Valves for two-position service
 - .1 ON-OFF for two-way valve,
 - .2 Open port A - Open port B for three-way valve (non-isolation of ports simultaneously).
- .2 Valve pattern:
 - .1 two-way: straight through type, single seated, with replaceable ball, seats and/or disc.
 - .2 three-way: dual seated for globe valves, three way flow pattern for ball valves,
- .3 Valve size: pipeline size.
- .4 Valve type selection:
 - .1 full port ball valves, sizes NPS 2 and smaller,
 - .2 butterfly valves, sizes NPS 2 and larger.
- .5 Valve flow characteristic:
 - .1 quick opening or linear flow characteristics.

2.4 Water and Glycol Valves – Modulating Two-Way

- .1 Valves for two-way modulating service.
- .2 Valve pattern: straight through two port type, single seated, with replaceable disc or ball.

- .3 Valve type:
 - .1 globe valves for all flow rates.
 - .2 characterized ball valves for flow coefficient $K_v = 35$ ($C_v = 40$) and smaller,
 - .3 butterfly valves for flow coefficient greater than $K_v = 35$ ($C_v = 40$), based on flow coefficient rating at 70° rotation
- .4 Valve size:
 - .1 size valves based on design flow rates at a pressure drop not greater than the design pressure drop as shown, and not less than 90% of that design pressure drop.
 - .2 where valve pressure drops are not shown, size valve pressure drop (at design flow) to be the greatest of;
 - (a) 200% of pressure drop through heat exchanger,
 - (b) 100% of pressure drop through coil, or
 - (c) 35 kPa (5 psi).
 - .3 for terminal box units and duct mounted reheat coils, size valves on a pressure drop of between 20 to 35 kPa (3 to 5 psi).
- .5 Valve flow characteristic:
 - .1 equal percentage flow characteristics for heat transfer coils and heat exchangers,
 - .2 linear flow characteristic for tank filling operation (water flow discharges to atmosphere).

2.5 Water and Glycol Valves – Modulating Three-Way

- .1 Valves for three-way modulating mixing/diverting service:
- .2 Valve pattern: three-way type with dual seated for globe valves, three way flow pattern for ball valves,
- .3 Valve type:
 - .1 globe valves for all flow rates,
 - .2 characterized ball valves for flow coefficient $K_v = 35$ ($C_v = 40$) and smaller,
- .4 Valve size:
 - .1 unless otherwise shown, size valve pressure drop (at design flow) to be the smaller of;
 - (a) twice the pressure drop through coil or heat exchanger, or
 - (b) 35 kPa (5 psi).
- .5 Valve flow characteristic:
 - .1 linear flow characteristic for each port to give constant total flow, or,
 - .2 equal percentage flow characteristics with 25% valve authority (valve pressure drop equal to 33% pressure drop through load at full flow).

2.6 Water and Glycol Valve Actuators

- .1 Conform to section 25 30 01 and as specified herein.
- .2 Actuator and valve trim selected for close-off pressure ratings:
 - .1 two-way modulating or two position service: 150% of pump shut off head.
 - .2 three-way modulating service; 300% of pressure differential between ports A and B at design flow or 100% of pump shut off head.

- .3 shut off head to be based on maximum pump RPM when pump is controlled with a VFD.
- .3 Valve failed position on isolation from control signal:
 - .1 spring-return or electronically fail safe,
 - .2 heating terminal/zone valves: normally open,
 - .3 heating coil valves in AHU; normally open,
 - .4 heating differential pressure by-pass control valves; normally closed,
 - .5 chilled water terminal, zone and AHU coil valves; normally closed,
 - .6 chilled water valves serving process loads: normally open,
 - .7 chilled water differential pressure by-pass control valves: normally open,

2.7 Steam Valves

- .1 Valves for two-way modulating service.
- .2 Valve pattern: straight through two port type, single seated, with replaceable disc or ball.
- .3 Valve type: globe.
- .4 Valve size:
 - .1 two-position service;
 - (a) pressure drop at design flow equal to 10%-20% of inlet steam gauge pressure.
 - .2 modulating service at inlet steam gauge pressure of 100 kPa (15 psig) or less;
 - (a) pressure drop at design flow equal to 80% of inlet steam gauge pressure.
 - .3 modulating service at inlet steam gauge pressure of 101-350 kPa (16-50 psig);
 - (a) pressure drop at design flow equal to critical pressure drop (45% of absolute inlet pressure).
 - .4 modulating service with inlet steam gauge pressure over 350 kPa (50 psig);
 - (a) pressure drop as shown.
 - .5 modulating steam loads greater than 570 kW (2000 lbs/hr) at all pressures;
 - (a) provide two valves, connected in parallel and controlled in sequence, with first valve in opening sequence sized for 1/3 and second for 2/3 of steam load.
- .5 Valve flow characteristic:
 - .1 equal percentage flow characteristics.
- .6 Actuator and trim:
 - .1 conform to section 25 30 01 and as specified herein.
 - .2 selected for close-off pressure rating equal to 150% of operating (inlet) pressure.

3 EXECUTION

3.1 General

- .1 Select control valves for the applicable flow rates and pressure drops.

3.2 Installation

- .1 Supply control valves to the applicable trades contractor for installation. Provide instruction to the trades contractor as to:
 - .1 any required straight pipe lengths upstream and downstream of the valve,
 - .2 correct installation orientation including requirements for valve actuator,
 - .3 for steam systems, location of steam trap drips ahead of the valve on horizontal piping.

3.3 Cleaning

- .1 Coordinate with the applicable installation trades contractor to provide protection of the control valve during pipeline cleaning. Ensure control valves are 100% open during pipeline cleaning.
- .2 After completion of pipeline cleaning, clean strainers located ahead of control valves.

3.4 Start-Up and Testing

- .1 Confirm control valves stroke fully open and fully closed under applied control signal.
- .2 Conduct tests at part load < 30% to check for control loop instability; adjust control parameters to eliminate valve hunting under steady part load conditions.

End of Section

BUILDING AUTOMATION PRESSURE INDEPENDENT CONTROL VALVES 25 30 19.16

1 GENERAL

1.1 Scope

- .1 Provide pressure independent control valves (“PICV”) for modulating control of water or glycol for the following equipment:
 - .1 VAV/CAV terminal units with reheat coils, and duct mounted reheat coils,
- .2 Refer to specification section 20 05 19 for all other control valves.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 25 30 13 Building Automation Actuators and Operators
 - .2 25 30 19 Building Automation Control Valves

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Energy valves** means a PICV that includes two temperature sensors and has control functionality to manage the energy (power) output of the control valve.
 - .2 **PICV valve** means a control valve that will maintain stable flow rates under varying inlet water pressure.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B51 Boilers, Pressure Vessels, and Pressure Piping Code.
- .2 Product standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .2 ASME B16.5 Pipe Flanges and Flanged Fittings

1.5 Design Criteria

- .1 Refer to applicable piping specification sections for piping system design pressure and design temperature.

1.6 Quality Control

- .1 Valves to have current Canadian Registration Numbers in accordance with CSA B51.

1.7 Submittals

- .1 Shop drawings:
 - .1 submit product data sheets for materials specified herein,

- .2 submit a schedule of control valves, identifying at a minimum the control valve tag, flow rate, pressure drop, Kv (Cv) values, valve body type, valve body pressure rating at design temperature, and CRN number.

2 PRODUCTS

2.1 Pressure Independent Control Valve

.1 General

- .1 two-way, pressure independent control valve assembly including valves, actuator, and means of differential pressure regulation, manufactured as a single package.
- .2 pressure test ports on inlet and outlet of valve,
- .3 100% valve authority across full operating range,
- .4 minimum differential-pressure control range for pressure-independence: 35 to 350 kPa (5 to 50 psi)
- .5 selected for valve operating differential pressure of 35 kPa (5 psi) at design flow rate, unless otherwise shown,
- .6 minimum close-off differential pressure: 700 kPa (100 psig),
- .7 combination of control valve and controller to provide valve control characteristic of:
 - (a) equal percentage flow regulation for valves serving hydronic coils, heat exchangers, and source equipment,
 - (b) linear flow regulation for hydronic system bypass valves.
- .8 user adjustable maximum flow within valve control range,

Standard of Acceptance

- Belimo - fig. PIQCV, ePIV
- Bell & Gosset - fig. Ultra Setter
- Danfoss - fig. AB-QM
- Griswold Controls - fig. PIC-V, MVP,
- Honeywell - fig. VRW
- Johnson Controls - fig. VP140
- Siemens - fig. PICV
- Victaulic - fig. TA 7MP

.2 Differential pressure regulation:

- .1 maintain flow accuracy of +/-5% or better regardless of system pressure fluctuations using either:
 - (a) a wet calibrated ultrasonic or electromagnetic flow meter providing dynamic feedback to adjust valve position, or
 - (b) integral mechanical differential pressure regulator maintaining constant pressure drop across valve seat to decouple valve flow from system pressure changes.

.3 Control valve:

- .1 valve type:
 - (a) characterized ball, or

- (b) globe-style with characterized guide cage.
 - .2 body material:
 - (a) NPS ½ to NPS 2: DZR brass, bronze, or cast iron.
 - (b) NPS 2-1/2 to NPS 6: cast iron or ductile iron.
 - .3 pressure rating at 121°C (250°F):
 - (a) NPS ½ to NPS 2: minimum 1580 kPa (230 psi),
 - (b) NPS 2-1/2 to NPS 6:
 - i) ANSI Class 125 for piping system design pressures up to 1100 kPa (160 psig),
 - ii) ANSI Class 250 for piping system design pressures up to 2400 kPa (350 psig).
 - .4 end connections:
 - (a) NPS ½ to NPS 2: NPT to ASME B1.20.1.
 - (b) NPS 2-1/2 to NPS 6: flanged to ASME B16.5
 - .5 valve internals: nickel-plated brass or stainless steel,
 - .6 stem: nickel-plated brass or stainless steel,
 - .7 seat seals: EPDM or PTFE,
 - .8 O-Rings: EDPM.
- .4 Actuator:
- .1 to specification section 25 30 13 and/except as specified herein,
 - .2 modulating proportional control with 4-20 mA or 0-10 VDC modulating input signal,
 - .3 power supply: 24 VDC or 24 VAC.
 - .4 manually override function,
 - .5 spring-return or electronically fail-safe:
 - (a) fail closed for cooling applications (coil, heat exchanger and chiller),
 - (b) fail open for heating applications (coil, heat exchanger and boilers).
 - .6 fail in last command position for system bypass control valves,
 - .7 stroke range: 100% of valve stroke range.

2.2 Energy Valve

- .1 General
 - .1 two-way pressure-independent control valve as previously specified,
 - .2 flow measurement:
 - (a) integrated ultrasonic or electromagnetic flow meter, or
 - (b) calculated flow value based on control valve position and differential pressure.
 - .3 matched supply and return water temperature sensors, platinum 1000 ohm, RTD type,
 - (a) temperature sensors shipped loose for field installation,
 - (b) one sensor may be factory integrated with valve assembly,
 - (c) includes bronze temperature sensor wells with NPT pipe attachment.
 - .4 integrated microprocessor based direct-digital controls,

- .5 manufacturer to provide training for the BAS contractor in the integration and operation of the valve.

Standard of Acceptance

- Belimo - fig. Energy Valve
- Danfoss - fig. AB-QM

.2 Controller:

- .1 direct digital controller, BTL Listed as a BACNet Application Specific Controller,
- .2 power supply: 24 VDC or 24 VAC.
- .3 Building Automation System integration:
- (a) Analog Input/Output: 2-10 VDC, 0-10VDC, and/or 4-20mA to control valve position and obtain valve position feedback, and
 - (b) BACnet MS/TP communications.
- .4 minimum BACnet MS/TP objects:

(a) Read Objects (to BAS):

- i) valve relative position,
- ii) valve absolute position,
- iii) valve flow rate,
- iv) supply water temperature,
- v) return water temperature,
- vi) valve thermal power,
- vii) delta T management status,
- viii) valve maximum possible flow rate,
- ix) configured alarms.

(b) Write Objects (to valve):

- i) valve control mode,
- ii) maximum desired flow rate,
- iii) select operating mode,
- iv) temperature difference setpoint,
- v) maximum thermal power setpoint,
- vi) minimum delta-T flow value setpoint,
- vii) delta T management flow saturation value.

.3 field selectable integrated control program functions:

.1 Position Control:

- (a) valve changes position in proportion to the analog signal being provided (non-pressure independent function),
- (b) default operating mode when minimum valve differential pressure is not achieved.

.2 Flow Control:

- (a) valve maintains a flow rate that is in proportion to the analog signal being provided (pressure independent function).
- .3 Power Control:
 - (a) valve maintains a thermal power output that is in proportion to the analog signal being provided.
 - (b) matched temperature sensors used to override valve position to manage thermal power output of the coil or heat exchanger,
 - (c) field selectable operating modes:
 - i) mode 1: controller overrides Flow Control function to maintain constant thermal power output at all times,
 - ii) mode 2: controller overrides Flow Control function to prevent thermal power output exceeding a set value,
- .4 Delta T Control:
 - (a) matched temperature sensors used to override valve position to manage temperature differential drop across the coil or heat exchanger,
 - (b) field selectable operating modes:
 - i) mode 1: controller overrides Flow Control function to maintain constant temperature differential at all times,
 - ii) mode 2: controller overrides Flow Control function to prevent pressure differential decreasing below a set value,
- .5 field-settable minimum flow rate disable function (applies to thermal power and delta-T operation modes): thermal power or delta-T control is disabled when flow rate decreased below field set minimum flow value.

3 EXECUTION

3.1 General

- .1 Select control valves for the applicable flow rates at a valve differential pressure of 35 kPa (5 psig) unless otherwise shown.
- .2 Supply control valves to the applicable trades contractor for installation. Provide instruction to the trades contractor as to:
 - .1 any required straight pipe lengths upstream and downstream of the valve,
 - .2 correct installation orientation including requirements for valve actuator.
- .3 Provide PICV and Energy valves in accordance with the following table unless otherwise shown on drawings.

Service	Application	PICV	Energy Valve
Terminal box and duct mounted reheat coils	All	●	

3.2 Installation

- .1 Install PICV/Energy valves in accordance with manufacturer instructions.

- .2 Provide straight length of pipe upstream of valve of at least five (5) pipeline diameters, unless manufacturer instructions required longer straight lengths.
- .3 Install an isolation valve and strainer on the upstream side of the PICV/Energy valve.
- .4 For Energy Meters, install the temperature sensors in thermowells on the pipeline, and connect sensors to controller.
- .5 As applicable and unless otherwise factory set,
 - .1 set the control valve mechanical limiting device to the required design flow rate, or
 - .2 program the actuator controller to the required design flow rate.
- .6 Program the valve controller to provide control characteristics of:
 - .1 equal percentage flow regulation for valves serving hydronic coils and heat exchangers,
 - .2 linear flow regulation for hydronic system bypass valves, and source equipment.

3.3 Power and Control Wiring

- .1 Provide power and control wiring to each PICV and Energy valve in accordance with the manufacturer requirements and in accordance with specification section 25 05 13.

3.4 Cleaning

- .1 Coordinate with the applicable installation trades contractor to provide protection of the control valve during pipeline cleaning. Ensure control valves are 100% open during pipeline cleaning.
- .2 After completion of pipeline cleaning, clean strainers located ahead of PICV and Energy valves.

3.5 Start-Up and Testing – PICV

- .1 Confirm control valves stroke fully open and fully closed under applied control signal and maximum system dead-head differential pressure.

3.6 Follow-Up Testing and Configuration

- .1 After start-up and testing, conduct additional testing and tuning of the valves after the valves have been in service for at least four (4) weeks.

3.7 Training

- .1 Provide training to Owners operations staff on control functions of PICV and Energy valves. Include instruction on how to analyze flow and energy performance data and to refine flow rate settings based on actual in-service flow and energy demand.

End of Section

BUILDING AUTOMATION CONTROL DAMPERS
25 30 23.13

1 GENERAL

1.1 Scope

- .1 Provide ductwork control dampers for building systems automation.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 33 13.13 Dampers - Operating
 - .2 25 30 13 Building Automation Actuators and Operators

1.3 Submittals

- .1 Submit product data sheets for materials specified herein.

2 PRODUCTS

2.1 Motorized Control Dampers

- .1 Construction:
 - .1 conform with section 23 33 13.13.
- .2 Actuators:
 - .1 conform with section 25 30 13.

3 EXECUTION

3.1 Coordination

- .1 Coordinate with the trade contractor under Division 23 to confirm control damper quantity, sizes, blade orientation, actuator position, and damper linkage.
Supply control dampers to the trade contractor under Division 23 for installation by that trade.

3.2 Selection

- .1 Select control damper type (parallel blade, opposed blade) in accordance with section 23 33 14.

End of Section

BUILDING AUTOMATION CONTROL SEQUENCES

25 90 01

1 GENERAL

1.1 Scope

- .1 This section describes the control sequences and monitoring requirements for building services and other facility equipment or services.

1.2 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ASHRAE 36 High Performance Sequences of Operation for HVAC Systems

1.3 Definitions

- .1 The following definitions apply to this section:
 - .1 **Auto (alarm reset)**: an alarm that automatically resets once the exit hysteresis conditions have been met.
 - .2 **Exit hysteresis**: the conditions which must be met before an alarm can be reset or cleared.
 - .3 **Latch (alarm reset)**: an alarm that must be manually reset by the Operator through the BAS, even if the exit hysteresis conditions have been met.
 - .4 **Post-exit suppression**: the time duration after an alarm has been reset/cleared before the same alarm (in the same system) can be annunciated by the BAS.
- .2 The following group headings are used in the control sequences:
 - .1 **Reference**: the drawing which includes the control schematic.
 - .2 **Applicable System**: the systems for which the control sequence applies; may include multiple instances of the equipment or system.
 - .3 **General**: (if included) general background information concerning the system.
 - .4 **OEM Control**: (if included) a general description of control functions included in equipment OEM control panel – provided to clarify control functionality that is not directly controlled by the BAS.
 - .5 **System Start**: actions required at system start-up under schedule control or on re-start after power failure.
 - .6 **Normal Operation**: normal control sequence after initial start-up requirements are satisfied.
 - .7 **System Overrides**: control functions that automatically, or by user input, disable or change the control sequence for a defined period of time.
 - .8 **Unoccupied Mode Override**: a user input command to enable a control system during times when the system is disabled by an operating schedule.
 - .9 **Demand Limiting**: special operation parameters during normal utility power outages (emergency generator operation)
 - .10 **System Stop**: shut-down of system under schedule control and fail-safe position of system in event of loss of normal power.
 - .11 **Integrated FPLS Function**: control functions which are integrated with other fire protection and/or life safety systems.
 - (a) **Fire Alarm**: action required in the event of a signal from the fire alarm system (FA).
 - (b) **Smoke Control**: action required where the system functions as part of a smoke control or smoke venting system.

- .12 **Network Integration:** control points (hardware or software) which are communicated over a serial network.
- .13 **Monitoring:** control point data which is collected and included in graphical displays but are not used as part of a control loop.
- .14 **Schedule:** scheduled operation of system.
- .15 **Alarm:** alarm points required.
 - (a) **Level 1:** alarms which affect life safety,
 - (b) **Level 2:** alarms which affect critical equipment,
 - (c) **Level 3:** alarms which require urgent notification to the operator, and which affect non-critical equipment,
 - (d) **Level 4:** alarms which are non-urgent, affect non-critical components, and generally relate to pending maintenance.
- .16 **Control Power Type:** control system elements to be fed from the designated source of power.

2 PRODUCTS

- .1 Not applicable.

3 EXECUTION

3.1 Sequence of Operation and Control Drawings

- .1 Control sequences for HVAC systems are to conform to ASHRAE 36. Requirements prescribed herein may summarize selected elements of ASHRAE 36 for convenience, but such requirements do not limit or restrict the application of that standard except as otherwise specified herein.
- .2 Control sequences that follow describe and detail method of control of systems.
- .3 Control drawings listed for each control sequence illustrate required inputs and outputs for the control and monitoring of systems.
- .4 Review sequence of operation described for each system and allow for additional input and output points to achieve method of control described. Review documents to determine quantity of each piece of equipment or system.

3.2 Rebooting of BAS Controllers on Resumption of Power

- .1 Except where a BAS controller is supported on UPS power, upon resumption of power to a BAS controller after a power interruption program each controller so that;
 - .1 once the controller has rebooted, wait 30 seconds before attempting to automatically restart the associated equipment except as follows:
 - (a) cooling towers not equipped with VFDs: 60 second time delay,
 - (b) centrifugal chillers: 120 second time delay,
 - (c) heating and steam boilers: 120 second time delay.
 - .2 the controlled equipment restarts from a System Start condition.

3.3 Restart of Major Equipment on Return to Utility Power Supply

- .1 Where a BAS controller and associated controlled equipment are supported on site-generated power, use a "pre-transfer to utility" signal from the site-generated power control system to cause the following equipment to shut-down (but associated pumps may continue to operate) before transfer to utility power is implemented:

- .1 refrigeration equipment,
- .2 heating boilers,
- .3 steam boilers.

3.4 VFD Minimum Speed Setpoints

- .1 The BAS is to maintain a software setpoint for each VFD based on the requirements for each sequence of operation. Every 60 minutes, the BAS is to read the VFD's internal minimum speed setpoint. If a mismatch exists between the VFD internal minimum speed setpoint and the BAS software setpoint, the BAS is to overwrite the VFD internal setpoint via network integration.

3.5 VFD Power Failure Configuration

- .1 Unless otherwise specified in a control sequence, program VFD's for flying restart after restoration of power following a power failure event.
- .2 Where a VFD includes a kinetic recovery function, program the VFD for kinetic recovery to keep the VFD controller DC voltage bus energized by using momentum of driven equipment during a short term power interruption of the mains AC bus.

3.6 VFD Trip Resets

- .1 Unless otherwise specified in a control sequence, the BAS is automatically attempt not more than three reset attempts. If the VFD trips after the 3rd restart attempt, the VFD is to be disabled and an alarm notification sent to the operator of the original trip event(s) and restart attempts.
 - .1 Exception: does not apply to overcurrent or overload trips (if uniquely alarmed).
- .2 Where the same VFD trip condition occurs more than two times in any sliding 60 minute window, an alarm notification is to be sent to the operator of the recurring trip event.

3.7 Operator Adjustable Setpoints

- .1 Where setpoint values are indicated in square brackets [] this means the setpoint is adjustable by the facility operator with appropriate security access rights.

3.8 Power Supply to Controls

- .1 Provide the type of power supply to the applicable controller as shown in the control sequence.

3.9 Alarm Management

- .1 Unless otherwise shown in a control sequence,
 - .1 Level 1 and Level 2 alarms are Latch reset,
 - .2 Level 3 and Level 4 alarms are Auto reset.
- .2 Alarm exit hysteresis conditions are as shown for each alarm:
 - .1 for analog inputs alarms, the conditions are listed in the format "X% / Y time";
 - (a) X%: the percent change of alarm setpoint value in the direction of the normal condition value,
 - (b) Y time: the time duration in seconds or minutes in which the percent change value must exist before the reset can occur.
 - .2 for discrete input alarms for measurement instruments, the conditions are listed in the format " Δ X / Y time";
 - (a) Δ X: the absolute change in units of the alarm setpoint value in the direction of normal condition values,

- (b) Y time: the time duration in seconds or minutes in which the change value must exist before the reset can occur.
- .3 for discrete input alarms for equipment status, the conditions are listed in the format "COS/ Y time":
 - (a) COS: change of state
 - (b) Y time: the time duration in seconds or minutes in which the change value must exist before the reset can occur.
- .3 Post-exit suppression times:
 - .1 Unless otherwise shown, suppress the recurrence of the same alarm after exiting from the previous alarm state:
 - (a) Level 1 – Life Safety: 0 minutes,
 - (b) Level 2 – Critical Equipment: 5 minutes,
 - (c) Level 3 – Urgent Message: 1 hour,
 - (d) Level 4 – Normal Message: 1 day.
- .4 Suppression of contingent alarms:
 - .1 Program an automatic hierarchical suppression scheme, to suppress alarm notifications of a fault alarm condition at a load component, which is contingent (caused by) the impact of a related fault alarm condition at a source component that serves the load
 - .2 Exceptions: alarms at load components are not suppressed where:
 - (a) a fault alarm at a source component in a redundant component arrangement does not affect the ability of the source system from supplying resources to the load component.
 - .3 Alarm suppression applies to audible and visual alarm notifications to Operator interfaces, including email notifications. Load alarms are still to be registered in the alarm database.
- .5 Suppression of time-based alarms:
 - .1 Program an automatic suppression of alarms using time delays following a change in setpoint as follows:
 - (a) for thermal zone temperature alarms: 18 minutes per 1°C change, but not to exceed 120 minutes.
 - (b) for thermal zone temperature cooling requests: 9 minutes per 1°C change, but not to exceed 30 minutes.
 - (c) for thermal zone temperature heating requests: 9 minutes per 1°C change, but not to exceed 30 minutes.
- .6 Suppression of alarms due to change in operating modes:
 - .1 Suppress alarms for 15 minutes as a result of change of setpoint.
 - .2 Unless otherwise shown, suppress alarms when a system is in Unoccupied mode, Warmup mode, or Cooldown mode.

3.10 Schedules

- .1 The following schedules form part of this specification.
 - .1 Schedule A: List of Control Sequences of Operation

Schedule A: Control Sequences of Operation	
Control Sequence Number	Title
CS171.01	Terminal Units with Reheat (Healthcare)

END OF SECTION

CS171.01 – Terminal Units with Reheat

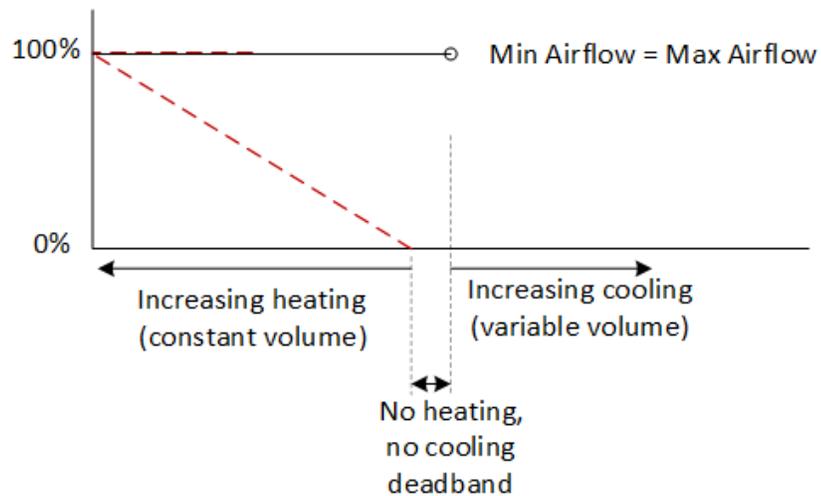
Reference: Refer to drawings.

Applicable System: Terminal units with reheat coils.

System Start: Terminal boxes are enabled when associated AHU system is commanded to start.

General: Terminal units are setup as constant volume operation at minimum airflow rate (“Qmin”) setting.

Maximum Airflow = Minimum Airflow (Constant Volume – Heating and Cooling)



Normal Operation:

Airflow Control

Supply terminal unit airflow sensor (F) modulates terminal unit damper (D) in response to changes in inlet system static pressure (pressure independent control).

Space Temperature Control – $Q_{max} = Q_{min}$

Space temperature sensor (T1) modulates reheat valve (V) to maintain space temperature setpoint.

System Overrides: None.

Unoccupied Mode Override: None.

System Issued For Tender

Stop: On shut-down of associated AHU for any reason other than occupancy schedule or life-safety requirements, terminal unit damper (D) goes to fully closed, reheat valve V1 goes to fully closed, and perimeter heating valve V2 operates to maintain setback temperature.

Integrated
FPLS
Function:

Fire Alarm Response

[Not applicable]

Monitoring: Monitor the following inputs and include in the graphics display:

- AI-F Terminal unit airflow
- AI-H Space humidity
- AI-T2 Duct supply temperature.

Alarms:

Point	Alarm Description	Initiating Condition	Exit Hysteresis	Alarm Level
AI-T1	Space Temperature Low	2°C < SP for 10 min	10% / 5 min	L4
AI-T1	Space Temperature Low-Low	3°C < SP for 10 min	10% / 5 min	L3
AI-F	Airflow Low during occupied mode	<85% Qmin for 10 min	10% / 5 min	L3

Controller Power
Type:

- Normal Life-Safety Standby
 Vital Delayed-Vital UPS

Notes:

[1] Where the terminal unit minimum airflow rate is the same as the maximum airflow rate, the terminal unit is constant volume under all loads.

[2] "Minimum flow" means the minimum flow during occupancy. For airflow rate during unoccupied mode, refer to control sequence CS401.

End of Control Sequence