

FISHERIES AND OCEANS CANADA

Canadian Coast Guard Base-Selkirk, MB  
HVAC Refurbishment  
DFO Central and Arctic Region

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Draft/Final:

Project Specifications -  
Issued for Construction

KGS Group Project No.:

19-0139-002

Contract #:

F2301-190157

Date:

September 23, 2020

Prepared by:

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**Martin Kosciuczyk,**

Mechanical EIT

Approved by:

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**Ray Bodnar, P.Eng**

Senior Mechanical Engineer



Fisheries and Oceans  
Canada

Pêches et Océans  
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**Division 0 – Procurement and Contracting Requirements**

- Section 00 01 08 – Contact List
- Section 00 01 10 – Table of Contents

**Division 1 – General Requirements**

- Section 01 11 00 – General Instructions
- Section 01 33 00 – Submittal Procedures
- Section 01 35 29.06 – Health and Safety Requirements
- Section 01 52 00 – Construction Facilities
- Section 01 60 00 – Product Requirements
- Section 01 74 11 – Cleaning
- Section 01 78 00 – Closeout Submittals
- Section 01 79 00 – Demonstration and Training
- Section 01 91 13 – General Commissioning Requirements

**Division 7 – Thermal and Moisture Protection**

- Section 07 84 00 – Fire Stopping

**Division 9 – Finishes**

- Section 09 91 99 – Painting for Minor Works

**Division 23 – Heating Ventilating and Air-Conditioning (HVAC)**

- Section 23 01 31 – Air Duct Cleaning for HVAC Systems
- Section 23 05 01 – Common Work Results for Mechanical
- Section 23 05 05 – Installation of Pipework
- Section 23 05 13 – Common Motor Requirements for HVAC Equipment
- Section 23 05 17 – Pipe Welding
- Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment
- Section 23 05 48 – Vibration and Seismic Controls for HVAC
- Section 23 05 53 – Identification for Mechanical Piping and Equipment
- Section 23 05 93 – Testing, Adjusting and Balancing for HVAC Systems
- Section 23 07 13 – Duct Insulation
- Section 23 07 15 – Thermal Insulation for HVAC Piping
- Section 23 08 02 – Cleaning and Startup of Mechanical Piping Systems
- Section 23 09 33 – Electric and Electronic Control System for HVAC
- Section 23 21 14 – Hydronic Piping Specialities
- Section 23 21 23 – Hydronic Pumps
- Section 23 31 13 – Metal Ducts - Low Pressure to 500 Pa
- Section 23 33 00 – Air Duct Accessories
- Section 23 33 15 – Dampers – Operating
- Section 23 34 00 – HVAC Fans
- Section 23 52 00 – Heating Boilers
- Section 23 74 00 – Packaged HVAC Equipment
- Section 23 82 36 – Finned Tube Radiation Heaters
- Section 23 82 39 – Unit Heaters

Section 23 83 00 – Radiant Heating Units

**Division 26 – Electrical**

Section 26 05 00 – Common Work Results – Electrical  
Section 26 05 05 – Electrical Work in Existing Buildings  
Section 26 05 20 – Wire and Box Connectors  
Section 26 05 21 – Wires and Cables  
Section 26 05 22 – Connectors and Terminations  
Section 26 05 28 – Grounding - Secondary  
Section 26 05 29 – Hangers and Supports for Electrical Systems  
Section 26 05 31 – Splitters, Junction, Pull Boxes and Cabinets  
Section 26 05 32 – Outlet Boxes, Conduit Boxes and Fittings  
Section 26 05 34 – Conduits, Conduit Fastenings and Conduit Fittings  
Section 26 05 53 – Identification for Electrical Systems  
Section 26 05 63 – Connections to Mechanical Equipment  
Section 26 08 01 – Electrical Testing Requirements  
Section 26 27 26 – Wiring Devices  
Section 26 28 21 – Moulded Case Circuit Breakers  
Section 26 28 23 – Disconnect Switches – Fused and Non-Fused

**Appendices**

Appendix A            Selkirk Coast Guard Existing Control Drawings

**END OF SECTION**

**Part 1            General**

**1.1                DEFINITIONS**

- .1            The word “provide” means “supply and install”.

**1.2                DESCRIPTION OF WORK**

- .1            The work site is located in Selkirk, Manitoba.
- .2            The scope of work under this Contract includes, but is not limited to, the following:
  - .1            Refurbish/replace the HVAC system which services the main building at the Selkirk Coast Guard Base.
- .3            The work to be done by the Contractor under this Contract includes all superintendence, overhead, labour, materials, equipment, tools, supplies, insurance, and all things necessary for and incidental to the satisfactory performance and completion of all work as specified herein. All work to be done in accordance with details shown on the accompanying drawings and as specified herein.

**1.3                MEASUREMENT FOR PAYMENT**

- .1            General:
  - .1            Provide advanced notice to Contact Administrator to permit required confirmation of measurements for payment.
  - .2            At least 14 days prior to submittal of first application for payment, provide to DFO Representative (DFO) a cost breakdown, Progress Payment in detail as directed by DFO for parts of work aggregating total amount of Contract Price, to allow evaluation for payment. After approval by DFO, cost breakdown will be used as basis for progress payments.
- .2            Mobilization and Demobilization:
  - .1            Lump sum payment provided for all works required, including:
    - .1            Mobilize equipment, materials, tools, supplies, labour and supervisors.
    - .2            Insurance required for duration of construction.
    - .3            Fees, certificates, and work permits.
    - .4            Temporary construction facilities.
    - .5            Signage.
    - .6            Security work and storage areas.
    - .7            Vehicle and pedestrian protection.
    - .8            Daily site cleaning, and
    - .9            Demobilization of aforementioned items upon completion of project.

**1.4                WORK SCHEDULE**

- .1            Provide within 10 working days after contract award, a construction schedule indicating anticipated progress stages and final completion of work within time period indicated herein.

- .2 Interim reviews of work progress based on work schedule will be conducted as determined by DFO Representative. Contractor to update schedule in conjunction with DFO Representative's review and approval.
- .3 Work under this Contract is to be performed in a timely manner. Commence planning and preparatory work immediately upon receipt of official notification of acceptance of Contract. Schedule work according to the DFO Procurement Policy.
- .4 Before work is undertaken ensure all materials and trades required are available to complete the work with no delay.
- .5 Obtain DFO Representative's approval prior to scheduling any weekend work.

#### **1.5 CERTIFICATES AND TRANSCRIPTS**

- .1 Immediately following award of Contract, submit Workers' Compensation Board status.

#### **1.6 FEES, PERMITS, AND CERTIFICATES**

- .1 Provide authorities have jurisdiction with information requested. Pay fees and obtain certificates and work permits as required.
- .2 Provide certificates and permits when requested.

#### **1.7 INTERPRETATION OF DOCUMENTS**

- .1 Drawings and Specifications are to be read together. All work indicated on the Drawings or within the Specifications, whether reflected in both documents or not, is included in this Contract.
- .2 The sub-division of the Specification into sections, identified by title and number, is for convenience only and does not modify the singularity of the document, nor does it operate to make or imply that the DFO Representative is an arbiter to establish the limits or extent of Contract between Contractor and Subcontractors or to determine the limits or extents of work that may be decided by trade unions or contractors' organizations. Extras to the Contract will not be considered based on the grounds of differences in interpretation of the Specification and/or Drawings as to which trade performs the work.
- .3 Do not scale off drawings.

#### **1.8 CONTRACTOR'S USE OF SITE**

- .1 Co-ordinate use of premises under direction of DFO Representative.
- .2 Do not unreasonably encumber the site with materials and equipment.
- .3 Contractor assumes full responsibility for protection and safekeeping of products under this Contract.

#### **1.9 AS-BUILT RECORD DRAWINGS**

- .1 Contractor to supply 3 copies of As-Built Drawings to DFO Representative following completion of project.



**1.10 EXISTING SERVICES**

- .1 Establish location and extent of service lines in area of work prior to start of work.
- .2 Notify DFO Representative and utility companies of intended interruption of services and obtain required permissions.
- .3 Where work involves connecting to existing services provide DFO Representative 72 hours notice.
- .4 Submit schedule to and obtain approval from DFO Representative for any shut-down or closure of active service or facility including power and communications services. Adhere to approved schedule and provide notice to affected parties.
- .5 Where unknown services are encountered, immediately advise DFO Representative and record findings in writing.
- .6 Protect, relocate, or maintain existing active services. When inactive services are encountered, terminate in manner approved by authorities having jurisdiction.
- .7 Record locations of maintained, re-routed, and abandoned service lines.

**1.11 DOCUMENTS REQUIRED**

- .1 Refer to Section 01 78 00 – Closeout Submittals.

**1.12 PROJECT MEETINGS**

- .1 DFO Representative will arrange project meetings and assume responsibility for setting times, recording of minutes, and distribution of minutes.

**1.13 SITE INSPECTION**

- .1 The submission of a tender is deemed to be a confirmation that the Tenderer has inspected the site and is fully conversant with the site and all conditions under which the work is to be carried out.

**1.14 SECURING WORK AREA**

- .1 Refer to Section 01 52 00 – Construction Facilities.

**1.15 CONSTRUCTION FACILITY**

- .1 Refer to Section 01 52 00 – Construction Facilities.
- .2 Provide heated, lighted, and ventilated office space of sufficient size to accommodate site meetings, and laydown table.

**1.16 DRAWINGS**

- .1 The following Drawings are to be read in conjunction with this specification:
  - .1 E01 – Electrical – General Notes, Symbol Legend, and Drawing List
  - .2 E02 – Electrical – Main Floor Plan – Demolition
  - .3 E03 – Electrical – Main Floor Plan – New
  - .4 E04 – Electrical – Mechanical Equipment – Schedule

- .5 M01 – Mechanical – General Notes, Symbol Legend, and Drawing List
- .6 M02 – Mechanical – Main Floor Plan – HVAC Demolition
- .7 M03 – Mechanical – Main Floor Plan – HVAC New
- .8 M04 – Mechanical – Piping Schematic and Details
- .9 M05 – Mechanical – Control Schematic
- .10 M06 – Mechanical – Schedules
- .11 M07 – Mechanical – Existing HVAC Equipment Photos

**1.17 CLEANING**

- .1 Refer to Section 01 74 11 – Cleaning.

**1.18 CLOSEOUT**

- .1 Refer to Section 01 78 00 – Closeout Submittals.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not used.

**END OF SECTION**

**Part 1            General**

**1.1                ADMINISTRATIVE**

- .1        Submit to Consultant submittals listed for review. Submit promptly and in orderly sequence to not cause delay in Work. Failure to submit in ample time is not considered sufficient reason for extension of Contract Time and no claim for extension by reason of such default will be allowed.
- .2        Do not proceed with Work affected by submittal until review is complete.
- .3        Present shop drawings, product data, samples and mock-ups in SI Metric units.
- .4        Where items or information are not produced in SI Metric units converted values are acceptable. Review submittals prior to submission to Consultant. This review represents that necessary requirements have been determined and verified, or will be, and that each submittal has been checked and co-ordinated with requirements of Work and Contract Documents. Submittals not stamped, signed, dated and identified as to specific project will be returned without being examined and considered rejected.
- .5        Notify Consultant, in writing at time of submission, identifying deviations from requirements of Contract Documents stating reasons for deviations.
- .6        Verify field measurements and affected adjacent Work are co-ordinated.
- .7        Contractor's responsibility for errors and omissions in submission is not relieved by Consultant's review of submittals.
- .8        Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved by Consultant review.
- .9        Keep one reviewed copy of each submission on site.

**1.2                SHOP DRAWINGS AND PRODUCT DATA**

- .1        The term "shop drawings" means drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are to be provided by Contractor to illustrate details of a portion of Work.
- .2        Indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes and other information necessary for completion of Work. Where articles or equipment attach or connect to other articles or equipment, indicate that such items have been co-ordinated, regardless of Section under which adjacent items will be supplied and installed. Indicate cross references to design drawings and specifications.
- .3        Allow 14 days for Consultant's review of each submission.
- .4        Adjustments made on shop drawings by Consultant are not intended to change Contract Price. If adjustments affect value of Work, state such in writing to Consultant prior to proceeding with Work.
- .5        Make changes in shop drawings as Consultant may require, consistent with Contract Documents. When resubmitting, notify Consultant in writing of revisions other than those requested.

- .6 Accompany submissions with transmittal letter, containing:
  - .1 Date.
  - .2 Project title and number.
  - .3 Contractor's name and address.
  - .4 Identification and quantity of each shop drawing, product data and sample.
  - .5 Other pertinent data.
- .7 Submissions include:
  - .1 Date and revision dates.
  - .2 Project title and number.
  - .3 Name and address of:
    - Subcontractor.
    - Supplier.
    - Manufacturer.
  - .4 Contractor's stamp, signed by Contractor's authorized representative certifying approval of submissions, verification of field measurements and compliance with Contract Documents.
  - .5 Details of appropriate portions of Work as applicable:
    - Fabrication.
    - Layout, showing dimensions, including identified field dimensions, and clearances.
    - Setting or erection details.
    - Capacities.
    - Performance characteristics.
    - Standards.
    - Operating weight.
    - Wiring diagrams.
    - Single line and schematic diagrams.
    - Relationship to adjacent work.
- .8 After Consultant's review, distribute copies.
- .9 Submit electronic (PDF format) copies of product data sheets or brochures for requirements requested in specification Sections and as requested by Consultant where shop drawings will not be prepared due to standardized manufacture of product.
- .10 Submit electronic (PDF format) copies of test reports for requirements requested in specification Sections and as requested by Consultant.
  - .1 Report signed by authorized official of testing laboratory that material, product or system identical to material, product or system to be provided has been tested in accord with specified requirements.
- .11 Submit electronic (PDF format) copies of certificates for requirements requested in specification Sections and as requested by Consultant.

- .1 Statements printed on manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that product, system or material meets specification requirements.
- .2 Certificates must be dated after award of project contract complete with project name.
- .12 Submit 3 copies of Operation and Maintenance Data for requirements requested in specification Sections and as requested by Consultant.
- .13 Delete information not applicable to project.
- .14 Supplement standard information to provide details applicable to project.
- .15 If upon review by Consultant, no errors or omissions are discovered or if only minor corrections are made, copies will be returned and fabrication and installation of Work may proceed. If shop drawings are rejected, noted copy will be returned and resubmission of corrected shop drawings, through same procedure indicated above, must be performed before fabrication and installation of Work may proceed.
- .16 Additional submittals:
  - .1 Contractor to produce refrigerant piping layout shop drawing for submission to condensing unit manufacturer for review and approval.
  - .2 If upon review by manufacturer, no errors or omissions are discovered or if only minor corrections are made, copies will be returned and fabrication and installation of Work may proceed. If shop drawings are rejected, noted copy will be returned and resubmission of corrected shop drawings, through same procedure indicated above, must be performed before fabrication and installation of Work may proceed.

### **1.3 OPERATION AND MAINTENANCE (O&M) MANUALS**

- .1 Submit one (1) electronic PDF copy of Operation and Maintenance Data for requirements requested in specification Sections for review and approval of Consultant.
- .2 Incorporate review comments and submit three (3) hard copies in 3-ring binders. Each binder to also have a USB storage device with the PDF format of the O&M manual.

### **1.4 PHOTOGRAPHIC DOCUMENTATION**

- .1 Submit electronic copy of colour digital photography in jpg format, standard resolution monthly with progress statement and as directed by Consultant.
- .2 Project identification: name and number of project and date of exposure indicated.
- .3 Frequency of photographic documentation: weekly, and as directed by Consultant.

### **1.5 CERTIFICATES AND TRANSCRIPTS**

- .1 Immediately after award of Contract, submit Workers' Compensation Board status.
- .2 Submit transcription of insurance immediately after award of Contract.

**Part 2            Products**

**2.1                NOT USED**

.1                Not used.

**Part 3            Execution**

**3.1                NOT USED**

.1                Not used.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1        Canada Labour Code, Part 2, Canada Occupational Safety and Health Regulations
- .2        Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1        Material Safety Data Sheets (MSDS).
- .3        Manitoba
  - .1        Workplace Safety and Health Act and Regulation C.C.S.M. C. W210.

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1        Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2        Submit site-specific Health and Safety Plan: Within 7 business days after date of Notice to Proceed and prior to commencement of Work.
- .3        Submit copies of incident and accident reports.
- .4        Submit WHMIS MSDS - Material Safety Data Sheets.
- .5        Departmental Representative will review Contractor's site-specific Health and Safety Plan and provide comments to Contractor after receipt of plan. Revise plan as appropriate and resubmit plan to Departmental Representative within 5 business days after receipt of comments from Departmental Representative.
- .6        Departmental Representative's review of Contractor's final Health and Safety plan should not be construed as approval and does not reduce the Contractor's overall responsibility for construction Health and Safety.
- .7        On-site Contingency and Emergency Response Plan: address standard operating procedures to be implemented during emergency situations.

**1.3                FILING OF NOTICE**

- .1        File Notice of Project with Provincial authorities prior to beginning of Work.

**1.4                SAFETY ASSESSMENT**

- .1        Perform site specific safety hazard assessment related to project.

**1.5                PROJECT/SITE CONDITIONS**

- .1        Work at site will involve contact with:
  - .1        Confined spaces.

**1.6                GENERAL REQUIREMENTS**

- .1        Develop written site-specific Health and Safety Plan based on hazard assessment prior to beginning site Work and continue to implement, maintain, and enforce plan until final demobilization from site. Health and Safety Plan must address project specifications.

- .2 Departmental Representative may respond in writing, where deficiencies or concerns are noted and may request re-submission with correction of deficiencies or concerns.
- .3 Observe and enforce construction safety measures required by Canadian Construction Safety Code, Provincial Government, Worker's Compensation Board and municipal statutes and authorities.
- .4 In the event of a conflict between any provisions of above authorities, the most stringent provision will apply.

## **1.7 RESPONSIBILITY**

- .1 Be responsible for health and safety of persons on site, safety of property on site and for protection of persons adjacent to site and environment to extent that they may be affected by conduct of Work.
- .2 Comply with and enforce compliance by employees with safety requirements of Contract Documents, applicable federal, provincial and local statutes, regulations, and ordinances, and with site-specific Health and Safety Plan.

## **1.8 COMPLIANCE REQUIREMENTS**

- .1 Comply with Workplace Health and Safety Act and Regulations.

## **1.9 UNFORSEEN HAZARDS**

- .1 Should any unforeseen or peculiar safety-related factor, hazard, or condition become evident during performance of Work, immediately stop work and advise Departmental Representative verbally and in writing.
- .2 Follow procedures in place for Employee's Right to Refuse Work as specified in the Workplace Safety and Health Regulations for Manitoba.

## **1.10 HEALTH AND SAFETY CO-ORDINATOR**

- .1 Employ and assign to Work, competent and authorized representative as Health and Safety Co-ordinator. Health and Safety Co-ordinator must:
  - .1 Have working knowledge of occupational safety and health regulations.
  - .2 Be responsible for completing Contractor's Health and Safety Training Sessions and ensuring that personnel not successfully completing required training are not permitted to enter site to perform Work.
  - .3 Be responsible for implementing, enforcing daily and monitoring site specific Contractor's Health and Safety Plan.
  - .4 Be on site during execution of Work.

## **1.11 POSTING OF DOCUMENTS**

- .1 Ensure applicable items, articles, notices and orders are posted in a conspicuous location on site in accordance with Acts and Regulations of authority having jurisdiction, and in consultation with Departmental Representative verbally and in writing.



**1.12 CORRECTION OF NON-COMPLIANCE**

- .1 Immediately address health and safety non-compliance issues identified by authority having jurisdiction or by Departmental Representative.
- .2 Provide Departmental Representative with written report of action taken to correct non-compliance of health and safety issues identified.
- .3 Departmental Representative may stop Work if non-compliance of health and safety regulations is not corrected.

**1.13 WORK STOPPAGE**

- .1 Assign responsibility and obligation to Health and Safety Coordinator to stop or start Work when, at Health and Safety Coordinator's discretion, it is necessary or advisable for reasons of health or safety. Departmental Representative may also stop Work for health and safety considerations.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not used.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCED STANDARDS AND DOCUMENTS**

- .1 Canadian Standards Association International (CSA)
  - .1 CSA S269.2, Access Scaffolding for Construction Purposes.
  - .2 CSA Z321, Signs and Symbols for the Workplace.
- .2 Contract Documents included in the Invitation to Tender (ITT).

**1.2                INSTALLATION AND REMOVAL**

- .1 Prepare site plan indicating proposed location and dimensions of area to be fenced and used by Contractor, trailer size to be used, avenues of ingress/egress to fenced area and details of fence installation. Due to area limitations on site only 1 (one) small trailer can be accommodated.
- .2 Secure work areas in an approved manner. This includes fencing or barricades to prevent public access to areas of construction or areas where construction materials are stored.
- .3 Indicate use of supplemental or other staging area.
- .4 Provide construction facilities in order to execute work expeditiously.
- .5 Remove from site all such work after use.

**1.3                SCAFFOLDING**

- .1 Scaffolding in accordance with CSA S269.2.
- .2 Provide and maintain scaffolding, ladders and platforms.

**1.4                HOISTING**

- .1 Provide, operate and maintain cranes required for moving of materials and equipment.
- .2 Cranes to be operated by qualified operator.
- .3 Crane work to be scheduled with Owner.

**1.5                SITE STORAGE/LOADING**

- .1 Confine work and operations of employees by Contract Documents. Do not unreasonably encumber premises with products.
- .2 Do not load or permit to load any part of Work with weight or force that will endanger Work.

**1.6 EQUIPMENT, TOOL AND MATERIALS STORAGE**

- .1 Provide and maintain, in clean and orderly condition, lockable weatherproof sheds for storage of tools, equipment and materials.
- .2 Locate materials not required to be stored in weatherproof sheds on site in manner to cause least interference with work activities.

**1.7 CONSTRUCTION SIGNAGE**

- .1 No other signs or advertisements, other than warning signs, are permitted on site.
- .2 Signs and notices for safety and instruction in both official languages Graphic symbols to CSA Z321.
- .3 Maintain approved signs and notices in good condition for duration of project, and dispose of off site on completion of project or earlier if directed by Departmental Representative.

**1.8 CLEAN-UP**

- .1 Perform cleaning in accordance with Section 01 74 11 – Cleaning and GC3.12, “Cleanup of site”.
- .2 Remove construction debris, waste materials, packaging material from work site daily.
- .3 Clean dirt or mud tracked onto paved or surfaced roadways.
- .4 Store materials resulting from demolition activities that are salvageable.
- .5 Stack stored new or salvaged material not in construction facilities.

**1.9 WASHROOM FACILITIES**

- .1 Contractor shall provide washroom facilities for all trades in accordance with OHSA. Contractor is not to use the washroom facilities within the building.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not used.

Canadian Coast Guard Base – Selkirk, MB  
HVAC Refurbishment  
DFO Central and Arctic Region  
September 23, 2020

Section 01 52 00  
CONSTRUCTION FACILITIES  
Page 3 of 3

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCE STANDARDS AND DOCUMENTS**

- .1        Contract Documents included in the Invitation to Tender (ITT).
- .2        Within text of each specifications section, reference may be made to reference standards and documents.
- .3        Conform to these reference standards and documents, in whole or in part as specifically requested in specifications.
- .4        If there is question as to whether products or systems are in conformance with applicable standards, Departmental Representative reserves right to have such products or systems tested to prove or disprove conformance.

**1.2                QUALITY**

- .1        Refer to applicable General Conditions and clauses (GC) included in the ITT.
- .2        Procurement policy is to acquire, in cost effective manner, items containing highest percentage of recycled and recovered materials practicable consistent with maintaining satisfactory levels of competition. Make reasonable efforts to use recycled and recovered materials and in otherwise utilizing recycled and recovered materials in execution of work.
- .3        Defective products, whenever identified prior to completion of Work, will be rejected, regardless of previous inspections. Inspection does not relieve responsibility but is precaution against oversight or error. Remove and replace defective products at own expense and be responsible for delays and expenses caused by rejection.
- .4        Should disputes arise as to quality or fitness of products, decision rests strictly with Departmental Representative based upon requirements of Contract Documents.
- .5        Unless otherwise indicated in specifications, maintain uniformity of manufacture for any particular or like item throughout building.
- .6        Permanent labels, trademarks and nameplates on products are not acceptable in prominent locations, except where required for operating instructions, or when located in mechanical or electrical rooms.

**1.3                AVAILABILITY**

- .1        Immediately upon signing Contract, review product delivery requirements and anticipate foreseeable supply delays for items. If delays in supply of products are foreseeable, notify Departmental Representative of such, in order that substitutions or other remedial action may be authorized in ample time to prevent delay in performance of Work.
- .2        In event of failure to notify Departmental Representative at commencement of Work and should it subsequently appear that Work may be delayed for such reason Departmental Representative reserves right to substitute more readily available products of similar character, at no increase in Contract Price or Contract Time.

**1.4                STORAGE, HANDLING AND PROTECTION**

- .1        Refer to applicable GCs included in the ITT.

- .2 Handle and store products in manner to prevent damage, adulteration, deterioration and soiling and in accordance with manufacturer's instructions when applicable.
- .3 Store packaged or bundled products in original and undamaged condition with manufacturer's seal and labels intact. Do not remove from packaging or bundling until required in Work.
- .4 Store products subject to damage from weather in weatherproof enclosures.
- .5 Store cementitious products clear of earth or concrete floors, and away from walls.
- .6 Keep sand, when used for grout or mortar materials, clean and dry. Store sand on wooden platforms and cover with waterproof tarpaulins during inclement weather.
- .7 Store sheet materials, solid supports and keep clear of ground. Slope to shed moisture.
- .8 Store and mix paints in heated and ventilated room. Remove oily rags and other combustible debris from site daily. Take every precaution necessary to prevent spontaneous combustion.
- .9 Touch-up damaged factory finished surfaces Departmental Representative's satisfaction. Use touch-up materials to match original. Do not paint over name plates.

#### **1.5 TRANSPORTATION**

- .1 Pay costs of transportation of products required in performance of Work.
- .2 Transportation cost of products supplied by Owner will be paid for by Departmental Representative. Unload, handle and store such products.

#### **1.6 MANUFACTURER'S INSTRUCTIONS**

- .1 Unless otherwise indicated in specifications, install or erect products in accordance with manufacturer's instructions. Do not rely on labels or enclosures provided with products. Obtain written instructions directly from manufacturers.

#### **1.7 QUALITY OF WORK**

- .1 Refer to applicable GCs included in the ITT.
- .2 Ensure Quality of Work is of highest standard, executed by workers experienced and skilled in respective duties for which they are employed.
- .3 Do not employ anyone unskilled in their required duties

#### **1.8 CO-ORDINATION**

- .1 Ensure co-operation of workers in laying out Work. Maintain efficient and continuous supervision.
- .2 Be responsible for coordination and placement of openings, sleeves and accessories.

#### **1.9 REMEDIAL WORK**

- .1 Refer to applicable GCs included in the ITT.
- .2 perform remedial work required to repair or replace parts or portions of Work identified as defective or unacceptable. Co-ordinate adjacent affected Work as required.

- .3 Perform remedial work by specialists familiar with materials affected. Perform in a manner to neither damage nor put at risk any portion of Work.

#### **1.10 LOCATION OF FIXTURES**

- .1 Consider location of fixtures, outlets, and mechanical and electrical items indicated as approximate.
- .2 Inform Departmental Representative of conflicting installation. Install as directed.

#### **1.11 FASTENINGS**

- .1 Provide metal fastenings and accessories in same texture, colour and finish as adjacent materials, unless indicated otherwise.
- .2 Prevent electrolytic action between dissimilar metals and materials.
- .3 Use non-corrosive hot dip galvanized steel fasteners and anchors for securing exterior work, unless stainless steel or other material is specifically requested in affected specification Section.
- .4 Space anchors within individual load limit or shear capacity and ensure they provide positive permanent anchorage. Wood, or any other organic material plugs are not acceptable.
- .5 Keep exposed fastenings to a minimum, space evenly and install neatly.
- .6 Fastenings which cause spalling or cracking of material to which anchorage is made are not acceptable.

#### **1.12 FASTENINGS - EQUIPMENT**

- .1 Use fastenings of standard commercial sizes and patterns with material and finish suitable for service.
- .2 Use heavy hexagon heads, semi-finished unless otherwise specified. Use No. 304 stainless steel for exterior areas.
- .3 Bolts may not project more than one diameter beyond nuts.
- .4 Use plain type washers on equipment, sheet metal and soft gasket lock type washers where vibrations occur. Use resilient washers with stainless steel.

#### **1.13 PROTECTION OF WORK IN PROGRESS**

- .1 Prevent overloading of parts of building. Do not cut, drill or sleeve load bearing structural member, unless specifically indicated without written approval of Departmental Representative.

#### **1.14 EXISTING UTILITIES**

- .1 When breaking into or connecting to existing services or utilities, execute Work at times directed by local governing authorities, with minimum of disturbance to Work, and/or building occupants.

- .2 Protect, relocate or maintain existing active services. When services are encountered, cap off in manner approved by authority having jurisdiction. Stake and record location of capped service.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not Used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not Used.

**END OF SECTION**



**Part 1            General**

**1.1                PROJECT CLEANLINESS**

- .1        Maintain project cleanliness as referred to in GC3.12, “Cleanup of site”.
- .2        Remove waste materials from site at daily regularly scheduled times or dispose of as directed by Owner’s Representative. Do not burn waste materials on site.
- .3        Make arrangements with and obtain permits from authorities having jurisdiction for disposal of waste and debris.
- .4        Provide on-site container for collection of waste materials and debris.
- .5        Dispose of waste materials and debris off site.
- .6        Clean interior areas prior to start of finishing work, and maintain areas free of dust and other contaminants during finishing operations.
- .7        Store volatile waste in covered metal containers, and remove from premises at end of each working day.
- .8        Provide adequate ventilation during use of volatile or noxious substances. Use of building ventilation systems is not permitted for this purpose.
- .9        Use only cleaning materials recommended by manufacturer of surface to be cleaned, and as recommended by cleaning material manufacturer.
- .10      Schedule cleaning operations so that resulting dust, debris and other contaminants will not fall on wet, newly painted surfaces nor contaminate building systems.

**1.2                FINAL CLEANING**

- .1        Perform final cleaning as referred to in GC3.12, “Cleanup of site”.
- .2        Prior to final review remove surplus products, tools, construction machinery and equipment.
- .3        Remove waste materials from site at regularly scheduled times or dispose of as directed by Owner’s Representative. Do not burn waste materials on site.
- .4        Make arrangements with and obtain permits from authorities having jurisdiction for disposal of waste and debris.
- .5        Remove stains, spots, marks and dirt from decorative work, electrical and mechanical fixtures, walls, and floors.
- .6        Inspect finishes, fitments and equipment and ensure specified workmanship and operation.
- .7        Remove dirt and other disfiguration from exterior surfaces.

**Part 2            Products**

**2.1                NOT USED**

.1                Not used.

**Part 3            Execution**

**3.1                NOT USED**

.1                Not used.

**END OF SECTION**

**Part 1            General**

**1.1                SUBMITTALS**

- .1        Submittals: in accordance with Section 01 33 00 – Submittal Procedures.
- .2        Prepare instructions and data using personnel experienced in maintenance and operation of described products.
- .3        Copy will be returned with Consultant's comments.
- .4        Revise content of documents as required prior to final submittal.
- .5        Two weeks prior to Substantial Performance of the Work, submit to the Consultant, three final copies of operating and maintenance manuals in English.
- .6        Ensure spare parts, maintenance materials and special tools provided are new, undamaged or defective, and of same quality and manufacture as products provided in Work.
- .7        Furnish evidence, if requested, for type, source and quality of products provided.

**1.2                FORMAT**

- .1        Organize data as instructional manual.
- .2        Binders: vinyl, hard covered, 3 'D' ring, loose leaf 219 x 279 mm with spine and face pockets.
- .3        When multiple binders are used correlate data into related consistent groupings. Identify contents of each binder on spine.
- .4        Cover: identify each binder with type or printed title 'Project Record Documents'; list title of project and identify subject matter of contents.
- .5        Arrange content by systems, under Section numbers and sequence of Table of Contents.
- .6        Provide tabbed fly leaf for each separate product and system, with typed description of product and major component parts of equipment.
- .7        Text: manufacturer's printed data.
- .8        Drawings: provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages.
- .9        Provide 3 copies of electronic O&M manuals each on a USB storage device, complete with site photos during demolition, construction, and as-built condition.

### **1.3 CONTENTS - EACH VOLUME**

- .1 Table of Contents: provide title of project; Date of submission; names.
  - .1 Addresses, and telephone numbers of Consultant and Contractor with name of responsible parties.
  - .2 Schedule of products and systems indexed to content of volume.
- .2 For each product or system:
  - .1 List names, addresses and telephone numbers of subcontractors and suppliers, including local source of supplies and replacement parts.
- .3 Product Data: mark each sheet to identify specific products and component parts, and data applicable to installation; delete inapplicable information.
- .4 Drawings: supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams.
- .5 Typewritten Text: as required to supplement product data. Provide logical sequence of instructions for each procedure.
- .6 Training: refer to Section 01 79 00 – Demonstration and Training.

### **1.4 AS-BUILTS AND SAMPLES**

- .1 Maintain, in addition to requirements in General Conditions, at site for Consultant one record copy of:
  - .1 Contract Drawings.
  - .2 Specifications.
  - .3 Addenda.
  - .4 Change Orders and other modifications to Contract.
  - .5 Reviewed shop drawings, product data, and samples. Field test records.
  - .6 Inspection certificates.
  - .7 Manufacturer's certificates.
  - .8 Copy of approved work Schedule.
  - .9 Health and Safety Plan and other related safety documents.
  - .10 Other documents as specified.
- .2 Store record documents and samples in field office apart from documents used for construction. Provide files, racks, and secure storage.
- .3 Label record documents and file in accordance with Section number listings in List of Contents of this Project Manual. Label each document "PROJECT RECORD" in neat, large, printed letters.
- .4 Maintain record documents in clean, dry and legible condition. Do not use record documents for construction purposes.
- .5 Keep record documents and samples available for inspection by Consultant.

## **1.5 RECORDING ACTUAL SITE CONDITIONS**

- .1 Record information on set of black line opaque drawings provided by Consultant.
- .2 Provide felt tip marking pens, maintaining separate colours for each major system, for recording information.
- .3 Record information concurrently with construction progress. Do not conceal Work until required information is recorded.
- .4 Contract Drawings and shop drawings: mark each item to record actual construction, including:
  - .1 Measured depths of elements of foundation in relation to finish first floor datum.
  - .2 Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - .3 Measured locations of internal utilities and appurtenances, referenced to visible and accessible features of construction.
  - .4 Field changes of dimension and detail.
  - .5 Changes made by change orders.
  - .6 Details not on original Contract Drawings.
  - .7 References to related shop drawings and modifications.
- .5 Specifications: mark each item to record actual construction, including:
  - .1 Manufacturer, trade name, and catalogue number of each product installed, particularly optional items and substitute items.
  - .2 Changes made by Addenda and change orders.
- .6 Other Documents: maintain manufacturer's certifications, inspection certifications, field test records, required by individual specifications sections.

## **1.6 EQUIPMENT AND SYSTEMS**

- .1 Each Item of Equipment and Each System: include description of unit or system, and component parts. Give function, normal operation characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.
- .2 Panel board circuit directories: provide electrical service characteristics, controls, and communications.
- .3 Include installed colour coded wiring diagrams.
- .4 Operating Procedures: include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shut-down, and emergency instructions. Include summer, winter, and any special operating instructions.
- .5 Maintenance Requirements: include routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.

- .6 Provide servicing and lubrication schedule, and list of lubricants required.
- .7 Include manufacturer's printed operation and maintenance instructions.
- .8 Include sequence of operation by controls manufacturer.
- .9 Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
- .10 Provide installed control diagrams by controls manufacturer.
- .11 Provide Contractor's co-ordination drawings, with installed colour coded piping diagrams.
- .12 Provide charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
- .13 Provide list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.
- .14 Additional requirements: as specified in individual specification sections.

## **1.7 MATERIALS AND FINISHES**

- .1 Building Products, Applied Materials, and Finishes: include product data, with catalogue number, size, composition, and colour and texture designations.
- .2 Instructions for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- .3 Moisture-Protection and Weather-Exposed Products: include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- .4 Additional Requirements: as specified in individual specifications sections.

## **1.8 MAINTENANCE MATERIALS**

- .1 Provide maintenance and extra materials, in quantities specified in individual specification sections.
- .2 Provide items of same manufacture and quality as items in Work.
- .3 Deliver to site; place and store.
- .4 Receive and catalogue items. Submit inventory listing to Consultant. Include approved listings in Maintenance Manual.
- .5 Obtain receipt for delivered products and submit prior to final payment.

**1.9 SPECIAL TOOLS**

- .1 Provide special tools, in quantities specified in individual specification section.
- .2 Provide items with tags identifying their associated function and equipment.
- .3 Deliver to site; place and store. Receive and catalogue items. Submit inventory listing to Consultant. Include approved listings in Maintenance Manual.

**1.10 STORAGE, HANDLING AND PROTECTION**

- .1 Refer to applicable General Conditions and clauses (GC) included in the ITT.
- .2 Store spare parts, maintenance materials, and special tools in manner to prevent damage or deterioration.
- .3 Store in original and undamaged condition with manufacturer's seal and labels intact.
- .4 Store components subject to damage from weather in weatherproof enclosures.
- .5 Store paints and freezable materials in a heated and ventilated room.
- .6 Remove and replace damaged products at own expense and to satisfaction of Consultant.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not Used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not Used.

**END OF SECTION**

**Part 1            General**

**1.1                ADMINISTRATIVE REQUIREMENTS**

- .1     Demonstrate scheduled operation and maintenance of any new equipment and systems to Owner's personnel, at least two weeks prior to date of Substantial Performance.
- .2     The Owner will provide list of personnel who will receive this information and attend any coordination meetings.
- .3     Preparation:
  - .1     Verify conditions for demonstration and instructions comply with requirements.
  - .2     Verify designated personnel are present.
  - .3     Ensure equipment has been inspected and put into operation.
- .4     Demonstration and Instructions:
  - .1     Demonstrate start-up, operation, control, adjustment, troubleshooting, times, at the agreed upon scheduled time and location.
  - .2     Instruct personnel in phases of operation and maintenance using operation and maintenance manuals as basis of instruction.
  - .3     Review contents of manual in detail to explain aspects of operation and maintenance.
  - .4     Prepare and insert additional data in operations and maintenance manuals when needed during instructions.
- .5     Time Allocated for Instructions: ensure amount of time required for instruction of each item of equipment or system as follows:

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1     Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.
- .2     Submit schedule of time and date for demonstration of each item of equipment and each system at least two weeks before the scheduled dates, to the Consultant.
- .3     Submit reports within one week after completion of demonstration, that demonstration and instructions have been satisfactorily completed.
- .4     Give time and date of each demonstration, with list of persons present.
- .5     Provide copies of completed operation and maintenance manuals for use in demonstrations and instructions.

**1.3                QUALITY ASSURANCE**

- .1     When specified in individual Sections requiring manufacturer to provide authorized representative to demonstrate operation of equipment and systems:
  - .1     Instruct Owner's personnel.
  - .2     Provide written report that demonstration and instructions have been completed.



**1.4 CONDITIONS FOR DEMONSTRATIONS**

- .1 All equipment/systems have been inspected by the appropriate authorities and Consultants, and fully operational as intended.

**1.5 PREPARATION**

- .1 Verify that conditions for demonstration and instructions comply with the above requirements.
- .2 Verify that the critical personnel to attend the demonstration are present.

**1.6 DEMONSTRATION AND INSTRUCTIONS**

- .1 During the demonstration, clearly explain the start-up, operation, control, adjustment, troubleshooting, servicing and maintenance of each piece of equipment/system and provide a proposed schedule of when critical maintenance items should be performed. Ensure that sufficient time is scheduled to properly explain these processes and confirm the Owner's personnel's understanding. More than one demonstration meeting may be required.
- .2 Instruct personnel in phases of operation and maintenance using the Project Operation and Maintenance manuals as a basis for instruction.
- .3 Review the contents of these manuals in detail and explain critical aspects of the operation and maintenance.
- .4 Prepare and insert additional data into the Project Operation and Maintenance manuals, as needed, before the final submission of these manuals to the Consultant.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not Used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not Used.

**END OF SECTION**

**Part 1 General**

**1.1 SUMMARY**

- .1 Acronyms:
  - .1 Cx - Commissioning.
  - .2 O&M - Operation and Maintenance.
  - .3 PI - Product Information.
  - .4 PV - Performance Verification.
  - .5 TAB - Testing, Adjusting and Balancing.

**1.2 COMMISSIONING PLAN**

- .1 Comprehensive commissioning plan shall be provided by Contractor for the review of Consultant minimum of two weeks prior to commissioning. The commissioning plan shall detail list of actions to be carried out on each day of commissioning period. The commissioning plan shall include a schedule that would indicate the dates of commissioning. It shall also include commissioning forms to be filled out by the contractor to record and document the results of commissioning procedures. (Commissioning forms are to be developed by Contractor with input from Consultant.)

**1.3 GENERAL**

- .1 Cx is a planned program of tests, procedures and checks carried out systematically on systems and integrated systems of the finished Project. Cx is performed after systems and integrated systems are completely installed, functional and Contractor's Performance Verification responsibilities have been completed and approved. Objectives:
  - .1 Verify installed equipment, systems and integrated systems operate in accordance with contract documents and design criteria and intent.
  - .2 Effectively train O&M staff.
- .2 Contractor assists in Cx process, operating equipment and systems, troubleshooting and adjusting as required.
  - .1 Systems to be operated at full capacity under various modes to determine if they function correctly and consistently at peak efficiency. Systems to be interactively with each other as intended in accordance with Contract Documents and design criteria.
  - .2 During these checks, adjustments to be made to enhance performance to meet environmental or user requirements.

**1.4 NON-CONFORMANCE TO PERFORMANCE VERIFICATION REQUIREMENTS**

- .1 Should equipment, system components, and associated controls be incorrectly installed or malfunction during Cx, correct deficiencies, re-verify equipment and components within the unfunctional system, including related systems as deemed required by Consultant, to ensure effective performance.

- .2 Costs for corrective work, additional tests, inspections, to determine acceptability and proper performance of such items to be borne by Contractor. Above costs to be in form of progress payment reductions or hold-back assessments.

## **1.5 PRE-CX REVIEW**

- .1 Before Construction:
  - .1 Review all Contract Documents, confirm by writing to Consultant.
    - .1 Adequacy of provisions for Cx.
    - .2 Aspects of design and installation pertinent to success of Cx.
  - .2 During Construction:
    - .1 Co-ordinate provision, location and installation of provisions for Cx.
    - .2 Perform pressure testing of piping in accordance with all applicable codes and standards.
  - .3 Before start of Cx:
    - .1 Have completed Cx Plan up-to-date.
    - .2 Ensure installation of related components, equipment, sub-systems, systems are complete.
    - .3 Fully understand Cx requirements and procedures.
    - .4 Have Cx documentation shelf ready.
    - .5 Understand completely design criteria and intent and special features.
    - .6 Submit complete start-up documentation to Consultant.
    - .7 Have Cx schedules up-to-date.
    - .8 Ensure systems have been cleaned thoroughly.
    - .9 Complete TAB procedures on systems, submit TAB reports to Consultant for review and approval.
    - .10 Ensure "As-Built" system schematics are available.
  - .4 Inform Consultant in writing of discrepancies and deficiencies on finished works.

## **1.6 SUBMITTALS**

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.

## **1.7 COMMISSIONING DOCUMENTATION**

- .1 Consultant to review and approve Cx documentation.
- .2 Provide completed and approved Cx documentation to Consultant.

## **1.8 STARTING AND TESTING**

- .1 Contractor assumes liabilities and costs for inspections. Including disassembly and re-assembly after approval, starting, testing and adjusting, including supply of testing equipment.

## **1.9 WITNESSING OF STARTING AND TESTING**

- .1 Provide 14 days notice prior to commencement.
- .2 Consultant representative to witness of start-up and testing.

## **1.10 MANUFACTURER'S INVOLVEMENT**

- .1 Factory testing: manufacturer to:
  - .1 Coordinate time and location of testing.
  - .2 Provide testing documentation for approval by Consultant.
  - .3 Obtain written approval of test results and documentation from Consultant before delivery to site.
- .2 Obtain manufacturers installation, start-up and operations instructions prior to start-up of components, equipment and systems and review with Consultant.
  - .1 Compare completed installation with manufacturer's published data, record discrepancies, and review with manufacturer.
  - .2 Modify procedures detrimental to equipment performance and review same with manufacturer before start-up.
- .3 Integrity of warranties:
  - .1 Use manufacturer's trained start-up personnel where specified elsewhere in other divisions or required to maintain integrity of warranty.
  - .2 Verify with manufacturer that testing as specified will not void warranties.
- .4 Qualifications of manufacturer's personnel:
  - .1 Experienced in design, installation and operation of equipment and systems.
  - .2 Ability to interpret test results accurately.
  - .3 To report results in clear, concise, logical manner.

## **1.11 PROCEDURES**

- .1 Verify that equipment and systems are complete, clean, and operating in normal and safe manner prior to conducting start-up, testing and Cx.
- .2 Conduct start-up and testing in following distinct phases:
  - .1 Included in delivery and installation:
    - .1 Verification of conformity to specification, approved shop drawings and completion of PI report forms.
    - .2 Visual inspection of quality of installation.
  - .2 Start-up: follow accepted start-up procedures.
  - .3 Operational testing: document equipment performance.
  - .4 System PV: include repetition of tests after correcting deficiencies.
  - .5 Post-substantial performance verification: to include fine-tuning.

- .3 Correct deficiencies and obtain approval from Consultant after distinct phases have been completed and before commencing next phase.
- .4 Document required tests on approved PV forms.

#### **1.12 START-UP DOCUMENTATION**

- .1 Assemble start-up documentation and submit to Consultant for approval before commencement of commissioning.
- .2 Start-up documentation to include:
  - .1 Factory and on-site test certificates for specified equipment.
  - .2 Pre-start-up inspection reports.
  - .3 Signed installation/start-up check lists.
  - .4 Start-up reports,
  - .5 Step-by-step description of complete start-up procedures, to permit Consultant to repeat start-up at any time.

#### **1.13 OPERATION AND MAINTENANCE OF EQUIPMENT AND SYSTEMS**

- .1 After start-up, operate and maintain equipment and systems as directed by equipment/system manufacturer.
- .2 With assistance of manufacturer develop written maintenance program and submit to Consultant for approval before implementation.
- .3 Operate and maintain systems for length of time required for commissioning to be completed.
- .4 After completion of commissioning, operate and maintain systems until issuance of certificate of interim acceptance.

#### **1.14 TEST RESULTS**

- .1 If start-up, testing and/or PV produce unacceptable results, repair, replace or repeat specified starting and/or PV procedures until acceptable results are achieved.
- .2 Provide manpower and materials, assume costs for re-commissioning.

#### **1.15 START OF COMMISSIONING**

- .1 Start Cx after elements of the facility affecting start-up and performance verification of systems have been completed.

#### **1.16 INSTRUMENTS / EQUIPMENT**

- .1 Provide the following equipment as required:
  - .1 2-way radios.

- .2 Equipment as required to complete work.

#### **1.17 COMMISSIONING PERFORMANCE VERIFICATION**

- .1 Carry out Cx:
  - .1 Under accepted simulated operating conditions, over entire operating range, in all modes.
  - .2 On independent systems and interacting systems.
- .2 Cx procedures to be repeatable and reported results are to be verifiable.
- .3 Follow equipment manufacturer's operating instructions.
- .4 EMCS trending to be available as supporting documentation for performance verification.

#### **1.18 WITNESSING COMMISSIONING**

- .1 Consultant representative to witness activities and verify results.

#### **1.19 AUTHORITIES HAVING JURISDICTION**

- .1 Where specified start-up, testing or commissioning procedures duplicate verification requirements of authority having jurisdiction, arrange for authority to witness procedures to avoid duplication of tests and to facilitate expedient acceptance of facility.
- .2 Obtain certificates of approval, acceptance and compliance with rules and regulation of authority having jurisdiction.
- .3 Provide copies to Consultant within 5 days of test and with Cx report.

#### **1.20 REPEAT VERIFICATIONS**

- .1 Assume costs incurred by Consultant for third and subsequent verifications where:
  - .1 Verification of reported results fail to receive Consultant's approval.
  - .2 Repetition of second verification again fails to receive approval.
  - .3 Consultant deems Contractor's request for second verification was premature.

#### **1.21 DEFICIENCIES, FAULTS, DEFECTS**

- .1 Correct deficiencies found during start-up and Cx to satisfaction of Consultant.
- .2 Report problems, faults or defects affecting Cx to Consultant in writing. Stop Cx until problems are rectified. Proceed with written approval from Consultant.

#### **1.22 COMPLETION OF COMMISSIONING**

- .1 Upon completion of Cx leave systems in normal operating mode.
- .2 Except for warranty and seasonal verification activities specified in Cx specifications, complete Cx prior to issuance of Interim Certificate of Completion.

- .3 Cx to be considered complete when contract Cx deliverables have been submitted and accepted by Consultant.

### **1.23 ACTIVITIES UPON COMPLETION OF COMMISSIONING**

- .1 When changes are made to baseline components or system settings established during Cx process, provide updated Cx form for affected item.

### **1.24 MAINTENANCE MATERIALS, SPARE PARTS, SPECIAL TOOLS**

- .1 Supply, deliver, and document maintenance materials, spare parts, and special tools as specified in contract.

### **1.25 OCCUPANCY**

- .1 Cooperate fully with Consultant during stages of acceptance and occupancy of facility.

### **1.26 INSTALLED INSTRUMENTATION**

- .1 Use instruments installed under Contract for TAB and PV if:
  - .1 Accuracy complies with these specifications.
  - .2 Calibration certificates have been deposited with Consultant.

### **1.27 PERFORMANCE VERIFICATION TOLERANCES**

- .1 Application tolerances:
  - .1 Specified range of acceptable deviations of measured values from specified values or specified design criteria. Except for special areas, to be within +/-10% of specified values.
- .2 Instrument accuracy tolerances:
  - .1 To be of higher order of magnitude than equipment or system being tested.
- .3 Measurement tolerances during verification:
  - .1 Unless otherwise specified actual values to be within +/- 2% of recorded values.

### **1.28 CONSULTANT'S PERFORMANCE TESTING**

- .1 Performance testing of equipment or system by Consultant will not relieve Contractor from compliance with specified start-up and testing procedures.

**Part 2            Products**

**2.1                NOT USED**

**Part 3            Execution**

**3.1                NOT USED**

**END OF SECTION**



**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1    Workplace Hazardous Materials Information System (WHMIS)
  - .1        Safety Data Sheets (SDS).
- .2    National Research Council Canada (NRC)
  - .1        National Building Code of Canada 2015 (NBC).
- .3    Underwriters Laboratories of Canada (ULC)
  - .1        ULC 115, Standard Method of Fire Tests of Firestop Systems.

**1.2                DEFINITIONS**

- .1    Fire Stop Material: device intended to close off opening or penetration during fire or materials that fill openings in wall or floor assembly where penetration is by cables, cable trays, conduits, ducts and pipes and poke-through termination devices, including electrical outlet boxes along with their means of support through wall or floor openings.
- .2    Single Component Fire Stop System: fire stop material that has Listed Systems Design and is used individually without use of high temperature insulation or other materials to create fire stop system.
- .3    Multiple Component Fire Stop System: exact group of fire stop materials that are identified within Listed Systems Design to create on site fire stop system.
- .4    Tightly Fitted; (ref: NBC Part 3.1.9.1(1) and 9.10.9.6(1)): penetrating items that are cast in place in buildings of non-combustible construction or have "0" annular space in buildings of combustible construction.
  - .1        Words "tightly fitted" should ensure that integrity of fire separation is such that it prevents passage of smoke and hot gases to unexposed side of fire separation.

**1.3                ACTION AND INFORMATIONAL SUBMITTALS**

- .1    Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.
- .2    Product Data:
  - .1        Submit manufacturer's printed product literature, specifications and datasheet and include product characteristics, performance criteria, physical size, finish and limitations.
- .3    Shop Drawings:
  - .1        Submit shop drawings to show location, proposed material, reinforcement, anchorage, fastenings and method of installation.
  - .2        Construction details should accurately reflect actual job conditions.

## **1.4 QUALITY ASSURANCE**

- .1 Qualifications:
  - .1 Installer: company specializing in fire stopping installations approved by manufacturer.
- .2 Pre-Installation Meetings: convene pre-installation meeting at least one week prior to beginning work of this Section:
  - .1 Verify project requirements.
  - .2 Review installation and substrate conditions.
  - .3 Co-ordination with other building subtrades.
  - .4 Review manufacturer's installation instructions and warranty requirements.

## **1.5 DELIVERY, STORAGE AND HANDLING**

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.
  - .2 Deliver materials to the site in undamaged condition and in original unopened containers, marked to indicate brand name, manufacturer and ULC markings.
- .2 Storage and Protection:
  - .1 Store materials indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
  - .2 Replace defective or damaged materials with new.

## **Part 2 Products**

### **2.1 MATERIALS**

- .1 Fire stopping and smoke seal systems: in accordance with ULC 115.
  - .1 Asbestos-free materials and systems capable of maintaining effective barrier against flame, smoke and gases in compliance with requirements of ULC 115 and not to exceed opening sizes for which they are intended.
- .2 Service penetration assemblies: systems tested to ULC 115.
- .3 Service penetration fire stop components: certified by test laboratory to ULC 115.
- .4 Fire-resistance rating of installed fire stopping assembly in accordance with NBC.
- .5 Fire stopping and smoke seals at openings intended for ease of re-entry such as cables: elastomeric seal.
- .6 Fire stopping and smoke seals at openings around penetrations for pipes, and other mechanical items requiring sound and vibration control: elastomeric seal.
- .7 Primers: to manufacturer's recommendation for specific material, substrate, and end use.

- .8 Water (if applicable): potable, clean and free from injurious amounts of deleterious substances.
- .9 Damming and backup materials, supports and anchoring devices: to manufacturer's recommendations, and in accordance with tested assembly being installed as acceptable to authorities having jurisdiction.
- .10 Sealants for vertical joints: non-sagging.

### **Part 3 Execution**

#### **3.1 MANUFACTURER'S INSTRUCTIONS**

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

#### **3.2 PREPARATION**

- .1 Examine sizes and conditions of voids to be filled to establish correct thicknesses and installation of materials.
  - .1 Ensure that substrates and surfaces are clean, dry and frost free.
- .2 Prepare surfaces in contact with fire stopping materials and smoke seals to manufacturer's instructions.
- .3 Maintain insulation around pipes and ducts penetrating fire separation without interruption to vapour barrier.
- .4 Mask where necessary to avoid spillage and over coating onto adjoining surfaces; remove stains on adjacent surfaces.

#### **3.3 INSTALLATION**

- .1 Install fire stopping and smoke seal material and components in accordance with manufacturer's certified tested system listing.
- .2 Seal holes or voids made by through penetrations, poke-through termination devices, and unpenetrated openings or joints to ensure continuity and integrity of fire separation are maintained.
- .3 Provide temporary forming as required and remove forming only after materials have gained sufficient strength and after initial curing.
- .4 Tool or trowel exposed surfaces to neat finish.
- .5 Remove excess compound promptly as work progresses and upon completion.

#### **3.4 SEQUENCES OF OPERATION**

- .1 Proceed with installation only when submittals have been reviewed by Consultant.
- .2 Install floor fire stopping before interior partition erections.

- .3 Metal deck bonding: fire stopping to precede spray applied fireproofing to ensure required bonding.
- .4 Mechanical pipe insulation: certified fire stop system component.
  - .1 Ensure pipe insulation installation precedes fire stopping.

### **3.5 CLEANING**

- .1 Proceed in accordance with Section 01 74 11 – Cleaning.
- .2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.
- .3 Remove temporary dams after initial set of fire stopping and smoke seal materials.

### **3.6 SCHEDULE**

- .1 Fire stop and smoke seal at:
  - .1 Penetrations through fire-resistance rated masonry, concrete, and gypsum board partitions and walls.
  - .2 Edge of floor slabs at curtain wall and precast concrete panels.
  - .3 Top of fire-resistance rated masonry and gypsum board partitions.
  - .4 Intersection of fire-resistance rated masonry and gypsum board partitions.
  - .5 Control and sway joints in fire-resistance rated masonry and gypsum board partitions and walls.
  - .6 Penetrations through fire-resistance rated floor slabs, ceilings and roofs.
  - .7 Openings and sleeves installed for future use through fire separations.
  - .8 Around mechanical and electrical assemblies penetrating fire separations.

**END OF SECTION**

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**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1    Workplace Hazardous Materials Information System (WHMIS)
  - .1        Safety Data Sheets (SDS).
- .2    The Master Painters Institute (MPI)
  - .1        Maintenance Repainting Manual.
- .3    National Research Council Canada (NRC)
  - .1        National Building Code of Canada (NBC).

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1    Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2    Product Data:
  - .1        Submit manufacturer's instructions, printed product literature and data sheets for paint and coating products and include product characteristics, performance criteria, physical size, finish and limitations.
  - .2        Submit copies of WHMIS SDS in accordance with Section 01 33 00 – Submittal Procedures.
- .3    Samples:
  - .1        Submit for review and acceptance of each unit.
  - .2        Samples will be returned for inclusion into work.
  - .3        Submit 200 x 300mm sample panels of each specified paint or coating in colours, gloss/sheen and textures required to MPI Painting Specification Manual standards.
- .4    Certificates: submit product certificates signed by manufacturer certifying materials comply with specified performance characteristics and criteria and physical requirements.

**1.3                DELIVERY, STORAGE AND HANDLING**

- .1    Deliver, store and handle materials in accordance with manufacturer's written instructions and 01 52 00 – Construction Facilities.
- .2    Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3    Storage and Handling Requirements:
  - .1        Provide and maintain dry, temperature controlled, secure storage.
  - .2        Store painting materials and supplies away from heat generating devices.
  - .3        Store materials and equipment in well ventilated area within temperature as recommended by manufacturer.
- .4    Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

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## 1.4 SITE CONDITIONS

- .1 Heating, Ventilation and Lighting:
  - .1 Co-ordinate use of existing ventilation system with Consultant and ensure its operation during and after application of paint as required.
  - .2 Provide minimum lighting level of 323 Lux on surfaces to be painted.
- .2 Temperature, Humidity and Substrate Moisture Content Levels:
  - .1 Apply paint finishes when ambient air and substrate temperatures at location of installation can be satisfactorily maintained during application and drying process, within MPI and paint manufacturer's prescribed limits.
  - .2 Test concrete, masonry and plaster surfaces for alkalinity as required.
  - .3 Apply paint to adequately prepared surfaces, when moisture content is below paint manufacturer's prescribed limits.
- .3 Additional application requirements:
  - .1 Apply paint finish in areas where dust is no longer being generated by related construction operations or when wind or ventilation conditions are such that airborne particles will not affect quality of finished surface.
  - .2 Apply paint in occupied facilities during silent hours only. Schedule operations to approval of Consultant such that painted surfaces will have dried and cured sufficiently before occupants are affected.

## Part 2 Products

### 2.1 MATERIALS

- .1 Supply paint materials for paint systems from single manufacturer.
- .2 Conform to latest MPI requirements for painting work including preparation and priming.
- .3 Materials in accordance with MPI - Maintenance Repainting Manual "Approved Product" listing.
  - .1 Use MPI listed materials where indoor air quality requirements exist.
  - .2 Primer: VOC limit 100 g/L maximum.
  - .3 Paint: VOC limit 100 g/L maximum.
- .4 Colours:
  - .1 Submit proposed Colour Schedule to Consultant for review.
- .5 Mixing and tinting:
  - .1 Perform colour tinting operations prior to delivery of paint to site, in accordance with manufacturer's written recommendations. Obtain written approval from Consultant for tinting of painting materials.
  - .2 Use and add thinner in accordance with paint manufacturer's recommendations.
    - .1 Do not use kerosene or similar organic solvents to thin water-based paints.

- .3 Thin paint for spraying in accordance with paint manufacturer's written recommendations.
- .4 Re-mix paint in containers prior to and during application to ensure break-up of lumps, complete dispersion of settled pigment, and colour and gloss uniformity.
- .6 Interior re-painting:
  - .1 Structural Steel and Metal Fabrications: columns, beams, joists and miscellaneous metal.
    - .1 To match existing.
  - .2 Galvanized Metal: high contact/high traffic areas (doors, frames, railings and handrails, etc.).
    - .1 To match existing.
  - .3 Plaster and Gypsum Board: gypsum wallboard, drywall, "sheet rock" type material, etc.
    - .1 To match existing.

### **Part 3 Execution**

#### **3.1 GENERAL**

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and data sheets.
- .2 Perform preparation and operations for interior painting in accordance with MPI - Maintenance Repainting Manual except where specified otherwise.

#### **3.2 EXAMINATION**

- .1 Investigate existing substrates for problems related to proper and complete preparation of surfaces to be painted. Report to Consultant damages, defects, unsatisfactory or unfavourable conditions before proceeding with work.
- .2 Conduct moisture testing of surfaces to be painted using properly calibrated electronic moisture meter, except test concrete floors for moisture using simple "cover patch test". Do not proceed with work until conditions fall within acceptable range as recommended by manufacturer.

#### **3.3 PREPARATION**

- .1 Protection of in-place conditions:
  - .1 Protect existing building surfaces and adjacent structures from paint spatters, markings and other damage by suitable non-staining covers or masking. If damaged, clean and restore surfaces as directed by Consultant.
  - .2 Protect items that are permanently attached such as Fire Labels on doors and frames.
  - .3 Protect factory finished products and equipment.

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.2 Surface Preparation:

- .1 Remove electrical cover plates, light fixtures, surface hardware on doors, bath accessories and other surface mounted equipment, fittings and fastenings prior to undertaking painting operations. Identify and store items in secure location and re-installed after painting is completed.
- .2 Move and cover furniture and portable equipment as necessary to carry out painting operations. Replace as painting operations progress.
- .3 Place "WET PAINT" signs in occupied areas as painting operations progress. Signs to approval of Consultant.
- .4 Clean and prepare surfaces in accordance with MPI - Maintenance Repainting Manual specific requirements and coating manufacturer's recommendations.
- .5 Prevent contamination of cleaned surfaces by salts, acids, alkalis, other corrosive chemicals, grease, oil and solvents before prime coat is applied and between applications of remaining coats. Apply primer, paint, or pre-treatment as soon as possible after cleaning and before deterioration occurs.
- .6 Sand and dust between coats as required to provide adequate adhesion for next coat and to remove defects visible from a distance up to 1000 mm.
- .7 Clean metal surfaces to be painted by removing rust, loose mill scale, welding slag, dirt, oil, grease and other foreign substances in accordance with MPI requirements.
- .8 Touch up of shop primers with primer as specified.

**3.4 APPLICATION**

- .1 Paint only after prepared surfaces have been accepted by Consultant.
- .2 Use method of application approved by Consultant.
  - .1 Conform to manufacturer's application recommendations.
- .3 Apply coats of paint in continuous film of uniform thickness.
  - .1 Repaint thin spots or bare areas before next coat of paint is applied.
- .4 Allow surfaces to dry and properly cure after cleaning and between subsequent coats for minimum time period as recommended by manufacturer.
- .5 Sand and dust between coats to remove visible defects.
- .6 Finish surfaces both above and below sight lines as specified for surrounding surfaces, including such surfaces as tops of interior cupboards and cabinets and projecting ledges.
- .7 Finish inside of cupboards and cabinets as specified for outside surfaces.
- .8 Finish closets and alcoves as specified for adjoining rooms.
- .9 Finish top, bottom, edges and cut-outs of doors after fitting as specified for door surfaces.
- .10 Mechanical/Electrical Equipment:
  - .1 Paint conduits, piping, hangers, ductwork and other mechanical and electrical equipment exposed in finished areas, to match adjacent surfaces, except as indicated.



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- .2 Do not paint over nameplates.
- .3 Keep sprinkler heads free of paint.

### **3.5 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.
- .2 Place products defined as hazardous or toxic waste, including tubes and containers, in containers or areas designated for hazardous waste.

**END OF SECTION**

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**Part 1            General**

**1.1                DEFINITIONS**

- .1    HVAC System: complete air duct system from outside air intake louvers to furthest air supply terminal unit and including:
  - .1    Rigid supply and return ductwork;
  - .2    Flexible ductwork;
  - .3    Mixing plenum boxes;
  - .4    Return air plenums including ceiling plenums;
  - .5    Cooling and heating coils and compartments;
  - .6    Condensate drain pans, eliminator blades and humidifiers;
  - .7    Fans, fan blades and fan housing;
  - .8    Filter housing and frames;
  - .9    Acoustically insulated duct linings;
  - .10   Diffusers, registers and terminal units;
  - .11   Dampers and controls.

**1.2                ADMINISTRATIVE REQUIREMENTS**

- .1    Site Evaluation: conduct site visit two weeks before start of work to establish specific co-ordinated video survey and cleaning plan to establish specific co-ordinated video survey and cleaning plan determining how areas of facility and HVAC systems will be protected during cleaning operations.
  - .1    Organize and lay out plan for video survey and identify camera and cleaning apparatus insertion points.
  - .2    Ensure plan identifies sequence and schedule of survey and cleaning operations for each individual HVAC system and for complete facility.
    - .1    Take account of elbows, bends, turning vanes, dampers, transitions, take-offs.
  - .3    Consultant to review video survey and cleaning plan one week minimum prior to start of work.
    - .1    Proceed with survey and cleaning work only after receiving written approval from Consultant.
- .2    Scheduling: Hours of Operation: complete work during business hours:
  - .1    Work may not be carried out during statutory holidays.
  - .2    Hours of operation are subject to change with 12 hours notice.
- .3    Project Co-ordination: assign Project Co-ordinator to oversee air duct cleaning processes.
  - .1    Provide Consultant with contact information of Project Co-ordinator including: name, telephone number, cell phone number, email address.
- .4    Damaged or broken equipment and components found during initial testing and inspection will be repaired or replaced.

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**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Submit video survey and cleaning plan developed during site evaluation.
  - .1 Ensure plan includes sequence of operation, identification of camera and cleaning apparatus insertion points and schedule for work.
- .3 Product Data:
  - .1 Submit manufacturer's printed product literature and data sheets for antimicrobial agents and include product characteristics, performance criteria and limitations.
  - .2 Provide copies of WHMIS SDS in accordance with Section 01 33 00 – Submittal Procedures, for antimicrobial agents or coatings.

**1.4 CLOSEOUT SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Post Cleaning Inspection Report: submit copies of Final Inspection Report, including data collected, observations and recommendations as well as following information:
  - .1 Name and address of facility;
  - .2 Name and address of HVAC cleaning contractor;
  - .3 Description of HVAC systems with drawings identifying systems cleaned;
  - .4 Identification scheme for location points in systems that were inspected with accompanying notes describing methods of inspection or tests used;
  - .5 Identification of points where samples were collected and type of analysis used for each collection;
  - .6 Identification of each sample collected;
  - .7 Comments complete with photographs of each sampling location and other observed system features;
  - .8 Identify systems tested, observations, actions taken and recommendations for future maintenance.
- .3 Record post cleaning video survey: submit copies of video survey on USB Drive media, and include on video survey following:
  - .1 Areas tested for particulate analysis or microbial growth evaluation;
  - .2 Areas of special interest and location;
  - .3 Special internal features;
  - .4 Problems such as broken or damaged controls or components;
  - .5 Ensure system tested, locations, observations, actions taken and recommendations are clearly identified in English on video using text or voice over.
- .4 Submit verification of delivery of hazardous or toxic waste materials to contaminated waste facility.

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## **1.5 EXTRA MATERIALS**

- .1 Extra Stock Materials:
  - .1 Supply four (4) extra filters for each HVAC System cleaned.
  - .2 Ensure filters are correct match, size, type and configuration of existing HVAC Systems.

## **Part 2 Products**

### **2.1 ACCESS DOORS AND PANELS**

- .1 Equipment Access Doors and Panels: construct from same materials as equipment panelling complete with sealing gasket and positive locking device.
  - .1 Size access doors and panels in equipment to allow for inspection and cleaning.
- .2 Ductwork Access Doors: construct access doors from 1.27mm minimum galvanized sheet steel with gasketed seal.
  - .1 Ensure access door is 25mm greater in every dimension than access opening.
  - .2 Access door size 200mm x 200mm minimum.
  - .3 Secure access doors with sheet metal screws on 75 mm centres minimum. Ensure 3 screws per side minimum.
- .3 Access Doors and Panels Acoustic Lining:
  - .1 Install acoustic lining to match existing.
  - .2 Self-adhesive glass fibre tape capable of adhering to both acoustic lining and metal access door or panel materials.
  - .3 Water-based duct sealer for repairing cut acoustic lining.

### **2.2 SYSTEM FILTERS**

- .1 Supply and install new filters for each HVAC System cleaned.

### **2.3 AIR DUCT CLEANING EQUIPMENT**

- .1 Manually propelled full contact brushes:
  - .1 Ensure brushes are specifically manufactured and shaped to fit individual ducts, equipment and components of HVAC system.
    - .1 Ensure brushes are sized to fit various duct sizes in HVAC system.
    - .2 Ensure brushes make scrubbing motion and full contact with HVAC system interior surfaces to be cleaned.
- .2 Brushes: manually propelled with integrally-mounted drive or motor and polypropylene or nylon or other non-metallic material bristles.
  - .1 Ensure drive or motor has capacity to continue to push brush after bristles are distorted.
  - .2 Replace worn and ineffective brushes when required.

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## **2.4 MULTI-FUNCTIONAL ROBOTIC CLEANING SYSTEM**

- .1 Self-propelled remote controlled, wheeled or track drive equipped with: camera, halogen lights, rotating or reciprocating brushes, vacuum, air supply nozzle and spraying system attachment.
  - .1 Ensure brushes are specifically manufactured and shaped to fit individual ducts and acoustic lined ducts, equipment and components of HVAC system.
  - .2 Ensure brushes make scrubbing motion and full contact with HVAC system interior surfaces.
  - .3 Replace worn and ineffective brushes when required.
- .2 Camera: fully rotational remote control focus and dustproof digital video with minimum 480 lines of resolution, capable of storing 4 hours of recorded media.
  - .1 Camera Light: 2 x 20 watt Halogen with dimmer

## **2.5 HEPA FILTER EVACUATION FAN**

- .1 Evacuation Fan: includes fan, HEPA filter, flexible hose and motor capable of maintaining debris and particulates airborne in airstream until they reach evacuation fan and maintaining system under negative pressure.
  - .1 Ensure HEPA filters are clean and maintain evacuation fan and HEPA filter to run efficiently.

## **2.6 HEPA VACUUM UNIT**

- .1 Vacuum Unit: includes vacuum fan, integral HEPA filter, suction hose and vacuum head, capable of maintaining HVAC System debris and particulates airborne in air stream until they reach vacuum unit and maintaining system under negative pressure.
  - .1 Ensure HEPA filters are clean and maintain vacuum unit and HEPA filter to run efficiently.

## **Part 3 Execution**

### **3.1 PREPARATION**

- .1 Close down HVAC system.
- .2 Locate and identify externally visible HVAC system features which may affect cleaning process including:
  - .1 Control devices;
  - .2 Fire and smoke control dampers;
  - .3 Balancing dampers: indicate and record positions for resetting;
  - .4 Air volume control boxes: indicate and record positions for resetting;
  - .5 Fire alarm devices;
  - .6 Monitoring devices and controls.
- .3 Cut openings in equipment panels and ductwork for access to system interior.

- .1 Square or rectangular opening sizes: 200mm minimum each side.
- .2 Circular opening sizes: 200mm minimum diameter.
- .4 Installation of Access Doors and Panels: install access doors and panels for equipment where required to facilitate system inspection and cleaning.
  - .1 Install access doors and panels for inspection and cleaning of equipment as follows:
    - .1 Heating and cooling coils;
    - .2 Fan units;
    - .3 Filters;
    - .4 Dampers;
    - .5 Sensors
  - .5 Installation of Access Doors in Ductwork: install access doors in ductwork where required to facilitate system inspection and cleaning.
    - .1 Access door installation is not permitted in flexible ductwork.
      - .1 Inspect flexible ductwork only by disconnecting from main duct and inspecting from open end.
  - .6 When acoustically lined duct is cut for access, repair cut edges of acoustic lining using self-adhesive fibre glass tape and water based duct sealer.
    - .1 Adhere new acoustic lining to match existing to inside of access panel or door to ensure continuity of acoustic properties of system.
  - .7 Remove and reinstall ceiling panels or tiles to gain access to HVAC system as required.
    - .1 Replace ceiling panels or tiles damaged or soiled by air duct cleaning procedures.

### **3.2 EXAMINATION / PRE-CLEANING INSPECTION**

- .1 Verification of Conditions:
  - .1 Make visual inspection of interior of HVAC system using remote controlled robotic camera.
  - .2 Insert camera at pre-established strategic locations to evaluate condition and cleanliness of HVAC systems and components.
- .2 Evaluation and Assessment:
  - .1 Identify location and type of internal components.
  - .2 Identify extent of potential problems.
  - .3 If toxic or hazardous materials or deposits are suspected after initial inspection immediately stop work and inform Consultant.
    - .1 Do not proceed further with inspection operations until written approval from Consultant.

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### 3.3 DUCT CLEANING

- .1 Isolate and clean sections in zones to ensure that dirt deposits and debris from zone being cleaned does not pass through other zones which have already been cleaned.
  - .1 Isolate zone of duct using closed-cell polyurethane foam or air inflated zone bag before cleaning.
- .2 Ensure vacuum units and evacuation fans are securely in place before starting cleaning operation of isolated section of HVAC air duct system.
- .3 Install HEPA filter evacuation fan at one end of zone section and insert full contact brushes at other end.
- .4 Clean HVAC supply air duct system and components where particulate sample collected from surfaces is greater than 75mg of particulate per 0.01 square metres.
- .5 Clean exhaust, return, transfer ductwork and plenums, equipment and components where particulate sample collected from surfaces is greater than 75mg of particulate per 0.01 square metres.
- .6 Energize brushes to travel from insertion point to HEPA filter evacuation fan.
  - .1 Pass brushes through sections as often as necessary to achieve required cleanliness.
  - .2 Change brush sizes as required to ensure positive contact with duct and component interiors.
  - .3 Clean corners and pockets where dirt and debris can accumulate.
- .7 Clean equipment, components and other features in isolated zone before moving to next zone of HVAC air duct system.
- .8 Clean diffusers, registers, louvers, and grilles.
- .9 Remove perforated supply diffusers from suspended tee-bar ceiling.
  - .1 Dismantle and clean perforated plates and supply diffuser duct collars.
  - .2 Re-assemble perforated plate diffusers and reconnect to HVAC system using supply diffuser duct collar after cleaning.
- .10 Advise Consultant 72 hours minimum before deactivation of fire alarm and smoke detectors duct cleaning operations.
  - .1 Pay for costs of deactivation of fire alarm and smoke detector system.

### 3.4 ACOUSTICALLY LINED DUCTWORK CLEANING

- .1 Clean glass fibre acoustically insulated ducts
  - .1 Use specifically designed robotic apparatus that has been demonstrated not to damage acoustic glass fibre lining.
  - .2 Monitor cleaning process progress by onboard camera.

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### **3.5 COMPONENTS AND EQUIPMENT CLEANING**

- .1 Brush and vacuum coils, humidifiers, air handling unit enclosures, and plenums.
- .2 When cleaning equipment and components by brushing and vacuuming is inappropriate or insufficient, dismantle and remove equipment or component and move to area designated by Consultant for cleaning.
  - .1 Pressure wash with water and cleaning solution until required cleanliness is achieved.
  - .2 Clean equipment and components in place only if there is no hazard to adjacent materials.
- .3 Proceed to next section in cleaning sequence only after written approval from Consultant.
- .4 Compressed air and manual cleaning is acceptable only for cleaning individual components and small areas as follows and only after written approval from Consultant:
  - .1 Fan blades;
  - .2 Dampers;
  - .3 Turning vanes;
  - .4 Controls;
  - .5 Sensor bulbs;
  - .6 Fire alarms;
  - .7 Smoke detectors.

### **3.6 SYSTEM STARTUP**

- .1 Install new system filters after cleaning operations are completed.
- .2 Cover each inspection opening with access door or panel and secure in place after inspection and cleaning are completed.
- .3 Restart each HVAC system.

### **3.7 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**



**PART 1        General**

**1.1            GENERAL**

- .1 All drawings and all sections of the specifications shall apply to and form an integral part of this section.
- .2 Provide fully tested and operational mechanical systems in complete accordance with applicable codes and bylaws.
- .3 Contract documents of this section are diagrammatic and approximately to scale. Do not scale from the drawings, exact dimensions to be taken from architectural drawings or from the site. The drawings and specifications establish scope for material and installation quality and are **not** detailed installation instructions. Follow Manufacturer's recommendations for installation supplemented by contract documents, unless otherwise specified by the Consultant. Any discrepancies must be brought to the Consultant's attention in writing prior to the close of tenders.

**1.2            SCOPE OF WORK**

- .1 Work to include labour, material and equipment required for supplying, installing, testing, adjusting, balancing, commissioning mechanical systems and provision of As-built drawings, O & M manuals and personnel training as detailed in this and other Sections of Division 23.
- .2 It is the responsibility of the General Mechanical Contractor to co-ordinate the work among the various sub-trades to ensure complete functioning systems.

**1.3            DEFINITIONS**

- .1 Whenever "drawings" and "specifications" are referred to, it means "the Contract Documents".

**1.4            WORK INCLUDED**

- .1 Sections of these mechanical specifications are not intended to delegate functions or to delegate work and supply to any specific trade. The work shall include all labour, materials, equipment, and tools required for a complete and working installation as described on the drawings and all Sections of Division 23.

**1.5            COMMISSIONING**

- .1 Systems commissioning will be conducted prior to substantial completion. The purpose of the Commissioning is to ensure all systems are functioning as designed prior to substantial completion.
- .2 Commissioning will require the presence of knowledgeable representatives of the necessary Mechanical Trades. Manufacturer representatives are required to be on site for commissioning. The Mechanical Contractor shall include all necessary costs for systems commissioning. The Consultant will participate to the extent deemed necessary.

- .3 All aspects of mechanical systems operations will be operated, checked and verified. If any portion of the work fails to meet design requirements, the Commissioning procedure will be halted and only resumed when all necessary repairs are completed. All extra costs including costs for the Consultant to revisit the site resulting from this postponement will be borne by this Contractor.
- .4 **The Contractor shall submit, to the Consultant, a commissioning report detailing the commissioning tests performed and the results of these tests. Format of report is to be one sheet for each piece of mechanical equipment and it shall include: Equipment tag, description, location and point form description of tests and results. Submit blank draft commissioning test forms for each equipment to consultant for review prior to testing.**
- .5 Contractor to provide seasonal commissioning as required. If heating or cooling systems can not be commissioned at the completion of the work due to outside weather conditions, the contractor is to return for the heating or cooling season to ensure the system is fully operational and functioning properly.

## 1.6 COMPLETION

- .1 After completing tests and adjustments remove temporary covers, and strainers, and obstructions to flow. Drain, flush and refill piping systems as often as required until all piping is clear of dirt and debris.
- .2 Leave Mechanical work in specified working order.
- .3 Provide spare components as specified in other Sections of Division 23.
- .4 Provide one set of all specialized tools required to service equipment as recommended by manufacturers.

## 1.7 CONFINED SPACE ENTRY

- .1 The Work, or portions of the Work, are required to be executed in a space that is classified as a confined space in accordance with the Manitoba Workplace Health and Safety Act and Regulations. The contractor is required to follow the requirements of the current edition of the Manitoba Workplace Health and Safety Act and Regulations during the execution of the Work.
- .2 The Contractor shall submit their confined entry plan, rescue plan, entry permit, and training certifications for review prior to executing the Work.

## 1.8 CONTRACT DRAWINGS AND SPECIFICATIONS

- .1 Drawings and specifications are complementary each to the other, what is called for by one shall be binding as if called for by both. Many items, such as valves, vents, thermometers, pressure gauges, etc. are shown only on schematics and are not shown on plan and elevation views. Provide and install all items shown in any or all of the drawings (or schematics).

- .2 Should any discrepancy appear between the drawings and specifications, which leave the Contractor in doubt as to the true intent and meaning of the plans, and specifications, the Contractor shall obtain a ruling from the Consultant in writing **before submitting a tender**. If this is not done it will be assumed that the most expensive alternative has been included in the tender price. For any ruling to become binding, the Consultant must issue the new direction in a published addendum.
- .3 Examine all contract documents, including all drawings, specifications and work of other trades to ensure that work is co-ordinated and satisfactorily carried out without changes to the building or contract value.
- .4 The drawings for mechanical work are performance drawings. They are generally diagrammatic and are not to scale unless detailed otherwise. They establish scope, material and installation quality and are not detailed installation instructions showing every offset, fitting, valve or every difficulty encountered during execution of work and should not be used as an excuse for deficiencies or omissions.
- .5 Follow the recommended installation details and procedures for equipment as found in Supplier technical data, supplemented by contract document details.
- .6 Install piping, ductwork, etc., generally in the locations and routes shown on the drawings, close to the building structure to minimize furring and interference with other services or free space. Remove piping, ductwork, etc. that is not properly installed and replace to the satisfaction of the Owner/Consultant at no additional cost.
- .7 Be completely responsible for the acceptable condition and operation of systems and equipment components forming part of the installation or associated with it. Promptly replace defective materials, parts and equipment and repair related damage.
- .8 The drawings are intended to convey the scope of work and indicate general arrangement and approximate location of apparatus and fixtures, and indicate the general location and route to be followed by pipes and ducts. Where required installations are not shown on plans or are only shown diagrammatically, install in such a way as to conserve headroom and interfere as little as possible with free use of space through which they pass, while allowing adequate space for service, maintenance, repair, or replacement for all equipment.
- .9 All serviceable items, such as valves, controls, bearings, filters and similar items, must be installed in such a manner as to be accessible for service, maintenance, repair and replacement without the removal of other material or equipment, and without the need for specialized equipment such as lifts, harnesses, or other safety items. Basically, work to be installed to allow easy equipment isolation and servicing functions while all surrounding systems continue to operate.
- .10 All individual pieces of equipment shall be provided with appropriate means of isolation and bypass so that systems may continue to operate during maintenance of individual components. It is understood that this may not be possible in all situations, but this is a requirement where isolation is possible.
- .11 Drawings and specifications to be considered as an integral part of contract documents and neither drawings nor specifications are to be used alone. Misinterpretation of requirements of plans or specifications shall not relieve Contractor of responsibility of properly completing work to approval of Consultant.

- .12 Obtain information involving accurate dimensions from dimensions shown by site measurement. Visit and inspect the site of the work to verify location and elevation of existing services which may affect the Tender and work of this Division (water, electrical, sanitary, ductwork etc.) before submission of tender and proceeding with work. Make all necessary changes or additions to runs to accommodate structural conditions (pipes or ducts around beams, columns etc.) without additional expense to the Owner. Locations of pipes, ducts and other equipment to be altered without charge to Owner, provided change is made before installation and does not necessitate additional materials and that all such changes are acceptable to the Consultant and are suitably recorded on Record Set of Drawings.
- .13 Confirm on the site the exact location and mounting elevation of outlets and fixtures as related to existing Mechanical & Electrical components.
- .14 As work progresses and before installing piping, ductwork, fixtures and equipment interfering with interior treatment and use of building, consult Consultant for appropriate action before proceeding. This applies to all levels and proper grading of piping. If Contractor fails to perform above checking and fails to inform Consultant of such interference, Contractor to bear all subsequent expense to make good the installation.
- .15 Alter, at no additional cost, the locations of materials and/or equipment as directed that do not necessitate additional material.

## **1.9 CUTTING AND PATCHING**

- .1 The cutting of openings not requiring lintels or other structural support will be the responsibility of the trade requiring the opening, the opening size will be the minimum required, and that patching will be the responsibility of the trade making the opening to the original or specified conditions.
- .2 Where openings require lintels or other structural support, or roofing work, such openings will be specified under other divisions of this specification.

## **1.10 PAINTING**

- .1 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.
- .2 Prime and paint marred finished paintwork to match original.
- .3 Restore to new condition finishes which have been damaged too extensively to be merely primed and touched up.
- .4 Painting of all new exposed ductwork and unexposed un-insulated piping in accordance with Section 09 91 99 – Painting for Minor Works.

## **1.11 DOCUMENTATION AND SYSTEMS ACCEPTANCE**

- .1 Provide the following on substantial performance of the work:
  - .1 As-Built drawings. As-built information is to be recorded as detailed elsewhere in this Section. Submit As-Built drawings to consultant for review prior to total completion.

- .2 Assemble the specified quantity of O&M manuals in D-ring binders with index tabs, each containing this Sub-Contractor's and suppliers names and telephone numbers, data sheets, valve charts, brochures, operating, maintenance, and lubricating instructions as well as number coded wiring diagrams and a complete set of reviewed shop drawings for all equipment provided by this Division. Present all copies to the Consultant for review.
- .3 Extended warranty certificates, where specified in other Sections of Division 23.
- .4 Air and Water balancing report. The work of Division 23 will not be considered totally performed until acceptance by the Consultant of the Air and Water Balancing Report.

#### **1.12 EQUIPMENT PROTECTION AND CLEANUP**

- .1 Protect equipment and materials in storage on site, during and after installation until final acceptance. Leave factory covers in place and take special precautions to prevent entry of foreign material into working parts of piping and duct systems.
- .2 Clean exposed surfaces of mechanical equipment, ductwork, piping, etc., and polish plated work.
- .3 Remove tools, surplus and waste material from the building site upon completion. Clean grease, dirt and excess material from walls, floors, ceilings and fixtures for which this Contractor was responsible, and leave the premises suitable for immediate use.

#### **1.13 EXAMINATION OF THE SITE AND DOCUMENTATION**

- .1 Prior to submitting tender, carefully examine site conditions, adjacent buildings and local conditions at the site, which could affect the work of this Division.
- .2 Examine all contract drawings to ensure work can be performed without changes to the building, or work, as shown on plans. No allowance will be made later for necessary changes, unless notification of interferences has been brought to Consultant's attention, in writing, prior to closing of tenders.
- .3 Verify that materials and equipment can be delivered to the place of the work and that sufficient space and access is available to permit installation thereof in locations shown on the drawings.

#### **1.14 GUARANTEES AND WARRANTIES**

- .1 Guarantee satisfactory operation of all work and apparatus installed under this contract. Replace, at no expense to the Owner, all items, which fail or prove defective within a period of time as define in Division 1, but in no circumstances shall the warranty period be less than one (1) year after final acceptance of complete contract by the Owner. Make good all damage incurred as a result of failure or repair of mechanical work.
- .2 No certification given, payment made, partial or entire use of equipment by the Owner, shall be construed as acceptance of defective work or acceptance of improper materials. Make good at once, without cost to the Owner, all such defective work or materials and consequence resulting, within the period of time defined in Division 1, but not less than one (1) year from time of final acceptance date.

- .3 This general guarantee shall not act as a waiver for any specified guarantee and/or warranty of greater length of time noted elsewhere in these documents.
- .4 Comply with requirements of Division 1. Where warranties specified in Division 1 are longer, or more stringent than in Division 23, Division 1 shall govern. Provide warranties on specified products, equipment and components as well as on the installation of these items. Include for all costs for cutting and patching, removals and restoration materials and work and repairs to other equipment affected in performance of warranty work.
- .5 Provide warranty certificates, wherever given or required, that are in excess of the normal warranty period showing the name of the firm giving the warranty, dated and acknowledged, on specific equipment and system.

#### **1.15 INSTRUCTIONS TO THE OWNER**

- .1 At the completion of the work, the Contractor shall instruct and demonstrate to the Owner's employee(s), or owner's representative, who will have charge of the equipment, the operation, maintenance care, and adjustment of all parts of the system to satisfaction of Consultant.
- .2 Demonstrate the specific starting, stopping, controlling and general maintenance requirements for each major piece of equipment and system.
- .3 Demonstrate all mechanical systems and provide a Contractor guided tour of the facility to point out all locations of equipment, dampers, control devices and the like.
- .4 Manufacturer's representative to provide training for operational staff, minimum of two separate 4hr training sessions.

#### **1.16 LIABILITIES**

- .1 Install concealed pipes and ducts neatly, close to building structure so furring is minimum size. Pipes, ducts and equipment installed improperly, to be removed and replaced without cost to Owner.
- .2 Co-ordinate work with other sections to avoid conflict and to ensure proper installation of all equipment. Review all contract drawings.

#### **1.17 MECHANICAL SUBTRADES**

- .1 Submit, with the tender, the names of all Sub-Trades to be used on this project as well as the extent of work to be performed by each.
- .2 Contractor to have minimum five years experience in field of mechanical contracting and to have successfully performed work of similar nature and approximate size to that indicated in specifications and on drawings.

#### **1.18 OPERATING AND MAINTENANCE MANUALS**

- .1 Provide O&M Manuals to the Consultant for review two (2) weeks prior to final inspection. Incorporate Consultant's review comments into final copies.

- .2 Provide three (3) sets of manuals in separate 3 “D” ring, loose leaf binders with spine and face pockets, with the project name clearly indicated on the spine and face. The final accepted copies shall be provided to the Owner.
- .3 General catalogue data for the Operations and Maintenance Manual is unacceptable. If manufacturer’s specification sheets are generalized in any way, they shall be clearly marked to show exactly which item has been supplied, and the project designation for that item (e.g., PRV-1) is to be noted on Manufacturer’s specification sheet which includes all details for this unit, including complete model number, serial number, and construction & performance data.
- .4 The outline for the Operating & Maintenance Manual shall be as follows:
  - Contractor and Subcontractor Contact Information
  - Purpose
  - General Description
  - Operating Instructions
  - Seasonal Operations
  - Normal Valve Positions and Control
  - Recommended Inspection and Preventative Maintenance
  - Maintenance Schedule
  - Description of Maintenance Procedures
  - Recommended Major Equipment Spare Parts List
  - Appendices
  - Equipment Shop Drawings
  - Equipment Supplier Schedule
  - Manufacturer Recommended O & M Information
  - Exploded Views and Parts Lists
  - As-Built Drawings (reduced)
  - Control Narrative
  - Control Drawings
- .5 Include the following information in the manuals, incorporated into the outline format above, as applicable:
  - .1 Mechanical Systems
    1. Maintenance Tasks - including daily, weekly, monthly, semi-annual and annual checks.
    2. Lubrication Information.
    3. List of Contractors and Equipment Suppliers including contact information
    4. Parts and Troubleshooting Information.
  - .2 Certification and Identification
    1. Inspection Certificates
    2. Balance Reports
  - .3 Component Information
    - .1 Section for each type of equipment to include shop drawings, installation and maintenance information.

- .4 Safety Information
- .5 Also provide the following information:
  - .1 Include control diagrams, (including Building Automation System diagrams), sequence of operations, and service instructions (calibration, trouble shooting, etc.).
  - .2 Provide Manufacturer’s preventive maintenance procedures (recommended lubrication materials and procedures, frequency, etc.).
  - .3 System and equipment troubleshooting guides.
  - .4 A copy of the final balancing reports.

**1.19 PERFORMANCE OF WORK**

- .1 Protect and maintain work until work has been completed and accepted. Protect work against damage during installation. Cover with tarpaulins if necessary. Repair all damage to floor and wall surfaces resulting from carrying out of work, without expense to the Owner.

**1.20 PERMITS, FEES, AND INSPECTIONS**

- .1 Apply for, obtain, and pay for all permits, licences, inspections, examinations, and fees required for work of Division 23.
- .2 Review drawings with authorities having jurisdiction to ensure compliance with all applicable codes and by-laws.
- .3 In case of conflict, codes and regulations take precedence over the contract documents. In no instance reduce the standard or scope of work or intent established by the drawings and specifications by applying any of the codes referred to herein. Any discrepancies must be brought to the Consultant’s attention in writing.
- .4 Before starting any work submit the required number of copies of drawings and specifications to the Authorities for their approval and comments. Comply with any changes requested as part of the contract but notify the Consultant immediately of such changes. Prepare and submit any additional drawings, details or information as may be required.

**1.21 RECORD DRAWINGS**

- .1 Obtain one set of drawings and specifications and, as the job progresses, mark these prints clearly in red pencil to accurately indicate installed work, as well as alterations to ductwork, piping, equipment and associated work changes and deviations from work shown on Contract Drawings, including all Addenda and Work Order Changes.
- .2 As-Built drawings to be maintained on a continuous basis to ensure they are up-to-date and accurate, and have current prints available for inspection at the site at all times.
- .3 Submit this set of record drawings to the Consultant for review on completion of the work. Should the record drawings be lacking information or details of changes made, they will be returned to the contractor. The contractor is to, without additional cost to the Owner or Consultant, make the required site inspections, etc. and update the record drawings to the satisfaction of the Consultant.



## **1.22 REGULATORY REQUIREMENTS**

- .1 Comply with the most stringent requirements of all Municipal, Provincial and Federal Bylaws and Ordinances, the requirements of Utilities such as Manitoba Hydro, and all sections of this specification.
- .2 Provide necessary notices, obtain permits and pay all fees, in order that work specified may be carried out.
- .3 Furnish certificates confirming work installed conforms to requirements of authorities having jurisdiction.

## **1.23 SHOP DRAWINGS**

- .1 Submit to the Consultant for review a maximum of four (4) sets of detailed shop drawings. Electronic (PDF format) shop drawings are acceptable.
- .2 Check shop drawings for conformity to plans and specifications prior to submission.
- .3 Submit shop drawings for all items specified in the sections of Division 23. For equipment, provide performance, physical and operating data as described in the Specifications and listed in equipment schedules. Provide performance curves for all pumps and fans.
- .4 Shop drawings shall include copies of applicable brochure or catalogue material clearly indicating manufacturer and model. Ambiguous shop drawings will not be reviewed.
- .5 Clearly mark submittal to indicate all differences from the specified material. The Consultant will require all options and material indicated on the shop drawing to be provided and installed. Specifically note on the submittal specified features such as tank linings, pump seal materials, painting finish, etc.
- .6 Include dimensional and technical data sufficient to determine if equipment meets requirements, including weights, loading points, electrical data and motor sizes.
- .7 Identify the equipment by system name and number, e.g. " S1, Second Floor, Air Supply Fan", "P1, Chilled Water Pump", etc.
- .8 Installed materials and equipment shall meet specified requirements regardless of whether or not the shop drawings were reviewed by the Consultant.
- .9 Each drawing to include name of project, equipment supplier and clause number equipment is specified under.
- .10 Clearly show division of responsibility. No item, equipment or description of work shall be indicated to be supplied or work to be done "By Others" or "By Purchaser". Any item, equipment or description of work shown on shop drawings shall form part of contract, unless specifically noted to contrary.
- .11 Take full responsibility for securing and verifying field dimensions. In cases where fabrication must proceed prior to field dimensions being available, check all shop drawings and approve for dimensions only. In this case guarantee that dimensions will be worked to and ensure that other sub-trades are aware of these dimensions and shall comply with them.

- .12 Review by Consultant shall be mutually understood to refer to general design only. If errors in detailed dimensions or interference with work are noticed, attention of Contractor will be called to such errors of interferences, but Consultant's review of drawings will not in any way relieve Contractor from responsibility for said errors or interferences, or from necessity of furnishing such work, and materials as may be required for completion of work as called for in contract documents.
- .13 This review by the Consultant is for the sole purpose of ascertaining conformance with the design concept.
- .14 Do not order equipment until the Consultant has reviewed and returned the reviewed shop drawings.
- .15 Keep one set of shop drawings on the site.
- .16 Bind one complete set of checked shop drawings in each operating and maintenance instruction manual.

#### **1.24 SITE REVIEW**

- .1 The Contractor's work will be reviewed periodically by the Owner, Consultant or their representatives, solely for the purpose of determining general quality of work. Guidance will be offered to Contractor in interpretation of plans and specifications as assistance to carry out work.
- .2 Reviews and directives given to Contractor, his agents, servants and employees does not relieve the Contractor, his agents, servants or employees of their responsibility to provide the work in all its parts in a safe and workmanlike manner, and in accordance with plans and specifications, nor impose on Owner, and/or Consultant or their representatives, any responsibility to supervise or oversee erection or installation of any work.

#### **1.25 SPECIAL TOOLS AND SPARE PARTS**

- .1 Furnish the Owner with spare parts as follows:
  - .1 Spare parts as detailed in individual Sections of Division 23.

#### **1.26 STANDARDS**

- .1 Conform to the best modern practices of workmanship and installation methods and employ only skilled tradesmen working under the direction of fully qualified personnel.

#### **1.27 STANDARD OF MATERIAL**

- .1 All materials and equipment installed under this contract shall be new unless otherwise noted.
- .2 Materials and equipment specified and acceptable manufacturers are named in this specification for the purpose of establishing the standard of materials and workmanship to which Contractor shall adhere. Tender price shall be based on the use of materials and equipment as specified.

- .3 Provide new material and equipment of first class quality, delivered, erected, connected and finished in every detail, and supplied with the acceptance of the Consultant. Assume responsibility of ensuring that provided equipment performs as specified.
- .4 In the preparation of the tender, if a Sub-Contractor neglects to name the manufacturer where accepted equals have been shown, it will be understood that the specified equipment will be provided.
- .5 Requests for approval of equals must be submitted not less than seven days prior to closing date of the tender, and submissions must bear proof of acceptance by the Owner or Consultant if used in the tender.
- .6 Assume full responsibility for ensuring that, when providing accepted equals, all space, weight, connections, power and wiring requirements, etc. are considered and adjusted costs are included in the tender. Alternative equipment requiring greater than specified energy requirements or unduly limiting service space requirements will not be accepted.
- .7 All additional costs for mechanical, electrical, structural and architectural revisions required to incorporate materials accepted as an equal and substituted by Contractor shall be responsibility of Contractor.
- .8 Equipment listed as “equal” in specifications or submitted as equal by the Contractor must meet all space requirements, specified capacities and must have equipment characteristics of specified equipment as interpreted by Consultant. Install equipment in strict accordance with Manufacturer’s published recommendations.

## **1.28 SUBSTANTIAL COMPLETION**

- .1 Prior to requesting any substantial completion inspection, complete all of the following items.
  - .1 All systems shall be operational with alarms, interlocks, and control functions.
  - .2 Obtain all certificates of approval from the authorities having jurisdiction.
  - .3 All manufacturer start-ups shall be complete.
  - .4 Complete valve tagging and identification of all new mechanical systems and components.
  - .5 Lubricate all equipment as per manufacturers’ instructions.
  - .6 Submit O&M Manuals and perform operator training.
  - .7 Provide all Manufacturers’ reports required by specifications.
  - .8 Complete System Commissioning
  - .9 Complete all previously identified deficiencies.
  - .10 Clean equipment both inside and out.
  - .11 Complete final air and water balancing and submit reports.
  - .12 Complete final calibration.
  - .13 Provide As-Built record drawings in accordance with the tender documents.

**1.29 SUPERINTENDENCE**

- .1 Maintain qualified job site personnel consisting of licensed tradesmen and registered apprentices with proven experience in erecting, supervising, testing, and adjusting projects of comparable nature and complexity.

**1.30 TEMPORARY USE OF EQUIPMENT**

- .1 Permanent systems and/or equipment not to be used during construction period, without the Owner's permission.
- .2 Temporary use of equipment shall in no way relieve Contractor of providing warranties, as described elsewhere in this Section and in Division 1, on all equipment and systems so used.
- .3 Operate systems under conditions that ensure no temporary or permanent damage. Operate systems with proper treatment. Operate fans at proper resistance with filters installed. Change filters at regular intervals and prior to final acceptance. Operate with proper safety devices and controls installed and fully operational.
- .4 Under no circumstances shall air handling units, heat recovery ventilators or other air systems be used to provide temporary heating, cooling or ventilation during construction. Air systems (air handling units and heat recovery ventilators) shall only be operated after all drywall sanding and carpet installation (or any other operation that creates considerable dust or fibres) is complete.

**1.31 WELDING REGULATIONS**

- .1 Welding shall be performed by welder holding current welder's certificate from Provincial Department of Labour.
- .2 Suitable fire extinguishers are to be present during welding operations and during fire watch period.
- .3 During welding or soldering ensure structure is protected against fire, shield with fire-rated sheets and galvanized iron sheets.
- .4 Proper ventilation shall be provided during welding operations. A fume extraction system shall be used for welding operations taking place indoors.
- .5 Maintain a fire watch for a minimum of 1 hour after welding operations are complete.

**1.31 WORKMANSHIP**

- .1 Only first-class workmanship will be accepted, not only as regards to safety, efficiency, and durability but also as regards to neatness of detail. Pipework must be installed parallel to, or at right angles to building planes. The entire work shall present a neat and clean appearance on completion.

**PART 2        Products**

**2.1            NOT USED.**

- .1        Not used.

**PART 3        Execution**

**3.1            PAINTING REPAIRS AND RESTORATION**

- .1        Do painting in accordance with Section 09 91 99 – Painting for Minor Works.
- .2        Prime and touch up marred finished paintwork to match original.
- .3        Restore to new condition, finishes which have been damaged.

**3.2            CLEANING**

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

**3.3            DEMONSTRATION**

- .1        Consultant will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2        Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, troubleshooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3        Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4        Contractor shall record these demonstrations on video tape for future reference.

**END OF SECTION**

## **Part 1           General**

### **1.1               REFERENCE STANDARDS**

- .1 American National Standards Institute (ANSI)
- .2 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.
- .3 Canadian Standards Association International (CSA)
  - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
- .4 Green Seal Environmental Standards (GSES)
  - .1 GS-11, Green Seal™ Standard for Paints, Coatings, Stains, and Sealers.
  - .2 GS-36, Green Seal™ Standard for Adhesives for Commercial Use.
- .5 National Research Council Canada (NRC)
  - .1 National Fire Code of Canada (NFC).
  - .2 National Plumbing Code of Canada (NPC).

### **1.2               ACTION AND INFORMATIONAL SUBMITTALS**

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

### **1.3               DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

## **Part 2           Products**

### **2.1               MATERIAL**

- .1 Paint: zinc-rich to CAN/CGSB 1.181.
  - .1 Primer: maximum VOC limit 250 g/L.
  - .2 Paints: maximum VOC limit 150 g/L.
- .2 Sealants: maximum VOC limit to GS-11.
- .3 Adhesives: maximum VOC limit to GS-36.

## **Part 3 Execution**

### **3.1 APPLICATION**

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

### **3.2 CONNECTIONS TO EQUIPMENT**

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

### **3.3 CLEARANCES**

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

### **3.4 DRAINS**

- .1 Install piping with grade in direction of flow except as indicated.
- .2 Install drain valve at low points in piping systems, at equipment and at section isolating valves.
- .3 Pipe each drain valve discharge separately to above floor drain.
  - .1 Discharge to be visible.
- .4 Drain valves: NPS 19 mm (3/4") gate or globe valves unless indicated otherwise, with hose end male thread, cap and chain.

### **3.5 AIR VENTS**

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

### **3.6 DIELECTRIC COUPLINGS**

- .1 General: compatible with system, to suit pressure rating of system.
- .2 Locations: where dissimilar metals are joined.
- .3 NPS 50 mm (2") and under: isolating unions or bronze valves.
- .4 Over NPS 50 mm (2"): isolating flanges.

### 3.7 PIPEWORK INSTALLATION

- .1 Install pipework to CSA B51.
- .2 Screwed fittings jointed with Teflon tape.
- .3 Protect openings against entry of foreign material.
- .4 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
- .5 Assemble piping using fittings manufactured to ANSI standards.
- .6 Saddle type branch fittings may be used on mains if branch line is no larger than half size of main.
  - .1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.
- .7 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
- .8 Install concealed pipework to minimize furring space, maximize headroom, conserve space.
- .9 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
- .10 Install, except where indicated, to permit separate thermal insulation of each pipe.
- .11 Group piping wherever possible and as indicated.
- .12 Ream pipes, remove scale and other foreign material before assembly.
- .13 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .14 Provide for thermal expansion as indicated.
- .15 Valves:
  - .1 Install in accessible locations.
  - .2 Remove interior parts before soldering.
  - .3 Install with stems above horizontal position unless indicated.
  - .4 Valves accessible for maintenance without removing adjacent piping.
  - .5 Install globe valves in bypass around control valves.
  - .6 Use ball valves at branch take-offs for isolating purposes except where specified.
  - .7 Install butterfly valves between weld neck flanges to ensure full compression of liner.
  - .8 Use chain operators on valves NPS 2½ and larger where installed more than 2400mm above floor in Mechanical Rooms.
- .16 Check Valves:
  - .1 Install silent check valves in vertical pipes with downward flow and as indicated.
  - .2 Install swing check valves in horizontal lines, on discharge of pumps and as indicated.



### **3.8 ESCUTCHEONS**

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

### **3.9 FLUSHING OUT OF PIPING SYSTEMS**

- .1 Flush system in accordance with Manitoba Plumbing Code requirements.
- .2 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

### **3.10 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK**

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

### **3.11 EXISTING SYSTEMS**

- .1 Connect into existing piping systems at times approved by Contract Administrator.
- .2 Request written approval by Contract Administrator 10 days minimum, prior to commencement of work.
- .3 Be responsible for damage to existing plant by this work.

### **3.1 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**3.2 PROTECTION**

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

**END OF SECTION**

**PART 1 General**

**1.1 SUMMARY**

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

**1.2 REFERENCE STANDARDS**

- .1 American Society Heating Refrigeration Air-Conditioning Engineers (ASHRAE)
  - .1 ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 Canadian Federal Legislation and Guidelines
  - .1 CEAA, Canadian Environmental Assessment Act.
  - .2 CEPA, Canadian Environmental Protection Act.
  - .3 TDGA, Transportation of Dangerous Goods Act.
- .3 Electrical Equipment Manufacturers Association Council (EEMAC)
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1 Safety Data Sheets (SDS).

**1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submittals: in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 – Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .3 Quality Control:
  - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
  - .2 Instructions: submit manufacturer's installation instructions.
- .4 Closeout Submittals:
  - .1 Provide maintenance data for motors, drives and guards for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

#### **1.4 QUALITY ASSURANCE**

- .1 Regulatory Requirements: work to be performed in compliance with CEAA, CEPA, TDGA, and applicable Provincial regulations.

#### **1.5 DELIVERY, STORAGE, AND HANDLING**

- .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 60 00 – Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

### **PART 2 Products**

#### **2.1 GENERAL**

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

#### **2.2 MOTORS**

- .1 Provide motors for mechanical equipment as specified.
- .2 Motors under 373 W (½ HP): speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120V, unless otherwise specified or indicated.
- .3 Motors 373 W (½ HP) and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 40 degrees C, 3 phase, 600V.
- .4 Electronically Commutated Motors:
  - .1 Motor enclosures: Open type
  - .2 Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications.
  - .3 Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
  - .4 Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.
  - .5 Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
  - .6 Motor shall be a minimum of 85% efficient at all speeds.

#### **2.3 TEMPORARY MOTORS**

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

## 2.4 BELT DRIVES

- .1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.
- .2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise indicated.
- .3 For motors under 7.46 kW (10 HP): standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified RPM.
- .4 For motors 7.46 kW (10 HP) and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.
- .5 Correct size of sheave determined during commissioning.
- .6 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
- .7 Motor slide rail adjustment plates to allow for centre line adjustment.
- .8 Supply one set of spare belts for each set installed in accordance with Section 01 78 00 – Closeout Submittals.

## 2.5 DRIVE GUARDS

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

**PART 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 INSTALLATION**

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

**3.3 FIELD QUALITY CONTROL**

- .1 Site Tests: conduct following tests and submit report as described in PART 1 - SUBMITTALS.
- .2 Manufacturer's Field Services:
  - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.
  - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
  - .3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

**3.4 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B31.1, Power Piping.
  - .2 ASME B31.9, Building Services Piping.
  - .3 ASME Boiler and Pressure Vessel Code:
    - .1 BPVC 2007 Section I: Power Boilers.
    - .2 BPVC 2007 Section V: Non-destructive Examination.
    - .3 BPVC 2007 Section IX: Welding and Brazing Qualifications.
- .2 American Water Works Association (AWWA)
  - .1 AWWA C206, Field Welding of Steel Water Pipe.
- .3 American Welding Society (AWS)
  - .1 AWS C1.1M/C1.1, Recommended Practices for Resistance Welding.
  - .2 AWS Z49.1, Safety in Welding, Cutting and Allied Process.
  - .3 AWS W1, Welding Inspection Handbook.
- .4 Canadian Standards Association (CSA International)
  - .1 CSA W47.2, Certification of Companies for Fusion Welding of Aluminum.
  - .2 CSA W48, Filler Metals and Allied Materials for Metal Arc Welding.
  - .3 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
  - .4 CSA-W117.2, Safety in Welding, Cutting and Allied Processes.
  - .5 CSA W178.1, Certification of Welding Inspection Organizations.
  - .6 CSA W178.2, Certification of Welding Inspectors.

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.

**1.3                QUALITY ASSURANCE**

- .1 Qualifications:
  - .1 Welders:
    - .1 Welding qualifications in accordance with CSA B51.
    - .2 Use qualified and licensed welders possessing certificate for each procedure performed from authority having jurisdiction.
    - .3 Submit welder's qualifications to Consultant.
    - .4 Each welder to possess identification symbol issued by authority having jurisdiction.
    - .5 Certification of companies for fusion welding of aluminum in accordance with CSA W47.2.

- .2 Inspectors:
  - .1 Inspectors qualified to CSA W178.2.
- .3 Certifications:
  - .1 Registration of welding procedures in accordance with CSA B51.
  - .2 Copy of welding procedures available for inspection.
  - .3 Safety in welding, cutting and allied processes in accordance with CSA W117.2.

#### **1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

### **Part 2 Products**

#### **2.1 ELECTRODES**

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

### **Part 3 Execution**

#### **3.1 APPLICATION**

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

#### **3.2 QUALITY OF WORK**

- .1 Welding:
  - .1 In accordance with applicable requirements of provincial authority having jurisdiction.
  - .2 Elsewhere: in accordance with ASME Boiler and Pressure Vessel Code, Sections I and IX and AWWA C206, using procedures conforming to AWS B3.0, AWS C1.1, and special procedures specified elsewhere in Division 23.

#### **3.3 INSTALLATION REQUIREMENTS**

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



.3 Not permitted on steam and condensate service.

.3 Fittings:

.1 NPS 50 mm (2") and smaller: install welding type sockets where indicated in applicable piping Sections.

.2 Branch connections: install welding tees or forged branch outlet fittings.

### **3.4 INSPECTION AND TESTS - GENERAL REQUIREMENTS**

.1 Review weld quality requirements and defect limits of applicable codes and standards with Consultant before work is started.

.2 Formulate "Inspection and Test Plan".

.3 Do not conceal welds until they have been inspected, tested and approved by inspector.

.4 Provide for inspector to visually inspect welds during early stages of welding procedures in accordance with Welding Inspection Handbook. Repair or replace defects as required by codes and as specified.

### **3.5 SPECIALIST EXAMINATIONS AND TESTS**

.1 General:

.1 In accordance with applicable Sections, as required, and as outlined below.

.2 Perform examinations and tests by specialist qualified to CSA W178.1 and CSA W178.2.

.3 To ASME Boiler and Pressure Vessels Code, Section V, CSA B51 and requirements of authority having jurisdiction.

.2 Hydrostatically test welds to ASME B31.1 or as otherwise indicated in applicable Sections.

.3 Visual examinations: include entire circumference of weld externally and wherever possible internally.

.4 Failure of visual examinations:

.1 Upon failure of welds by visual examination, perform additional testing as directed by Consultant.

### **3.6 DEFECTS CAUSING REJECTION**

.1 As described in ASME B31.1, ASME Boiler and Pressure Vessels Code or as otherwise indicated in applicable Sections.

### **3.7 REPAIR OF WELDS WHICH FAILED TESTS**

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

### **3.8 CLEANING**

.1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.

.1 Leave Work area clean at end of each day.

- .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1 American Society of Mechanical Engineers International (ASME)
  - .1 ASME B31.1, Power Piping.
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM A125, Standard Specification for Steel Springs, Helical, Heat-Treated.
  - .2 ASTM A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
  - .3 ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts.
- .3 Canadian Standards Association International (CSA)
  - .1 CSA A23.1, Concrete Materials and Methods of Concrete Construction / Test Methods and Standard Practices for Concrete.
- .4 Factory Mutual (FM)
- .5 Manufacturer's Standardization Society (MSS)
  - .1 MSS SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation.
- .6 Underwriters Laboratories of Canada (ULC)

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Provide manufacturer's printed product literature and data sheets for hangers and supports and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
  - .1 Submit shop drawings for:
    - .1 Bases, hangers and supports.
    - .2 Connections to equipment and structure.
    - .3 Structural assemblies.
- .4 Certificates:
  - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Manufacturers' Instructions:
  - .1 Provide manufacturer's installation instructions.

### **1.3 CLOSEOUT SUBMITTALS**

- .1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

### **1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

## **Part 2 Products**

### **2.1 SYSTEM DESCRIPTION**

- .1 Design Requirements:
  - .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
  - .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP-58.
  - .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
  - .4 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipe work or connected equipment.
  - .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP-58.

### **2.2 GENERAL**

- .1 Fabricate hangers, supports and sway braces in accordance with MSS SP-58 and ASME B31.1.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

### **2.3 PIPE HANGERS**

- .1 Finishes:
  - .1 Pipe hangers and supports: galvanized after manufacture.
  - .2 Use hot dipped galvanizing process.
  - .3 Ensure steel hangers in contact with copper piping are epoxy coated or copper plated.
- .2 Upper attachment structural: suspension from lower flange of I-Beam:

- .1 Cold piping NPS 50 mm (2") maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut carbon steel retaining clip.
  - .1 Rod: 9 mm UL listed or 13 mm FM approved.
- .2 Cold piping NPS 63 mm (2½") or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed to MSS SP-58 or FM approved.
- .3 Upper attachment structural: suspension from upper flange of I-Beam:
  - .1 Cold piping NPS 50 mm (2") maximum: ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed or FM approved to MSS SP-58.
  - .2 Cold piping NPS 63 mm (2½") or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed or FM approved.
- .4 Upper attachment to concrete:
  - .1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.
  - .2 Concrete inserts: wedge shaped body with knockout protector plate UL listed or FM approved to MSS SP-58.
- .5 Hanger rods: threaded rod material to MSS SP-58:
  - .1 Ensure that hanger rods are subject to tensile loading only.
  - .2 Provide linkages where lateral or axial movement of pipe work is anticipated.
  - .3 Do not use 22 mm or 28 mm rod.
- .6 Pipe attachments: material to MSS SP-58:
  - .1 Attachments for steel piping: carbon steel galvanized.
  - .2 Attachments for copper piping: copper plated black steel.
  - .3 Use insulation shields for hot pipe work.
  - .4 Oversize pipe hangers and supports.
- .7 Adjustable clevis: material to MSS SP-58 FM approved or UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
  - .1 Ensure "U" has hole in bottom for riveting to insulation shields.
- .8 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP-58.
- .9 U-bolts: carbon steel to MSS SP-58 with 2 nuts at each end to ASTM A563.
  - .1 Finishes for steel pipe work: galvanized.
  - .2 Finishes for copper, glass, brass or aluminum pipe work: epoxy coated or galvanized with formed portion plastic coated.
- .10 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP-58.

## **2.4 RISER CLAMPS**

- .1 Steel or cast iron pipe: galvanized carbon steel to MSS SP-58, type 42, UL listed or FM approved.
- .2 Copper pipe: carbon steel copper plated to MSS SP-58, type 42.
- .3 Bolts: to ASTM A307.
- .4 Nuts: to ASTM A563.

## **2.5 INSULATION PROTECTION SHIELDS**

- .1 Insulated cold piping:
  - .1 64 kg/m<sup>3</sup> density insulation plus insulation protection shield to: MSS SP-58, galvanized sheet carbon steel. Length designed for maximum 3 m span.
- .2 Insulated hot piping:
  - .1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP-58.

## **2.6 EQUIPMENT SUPPORTS**

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

## **2.7 EQUIPMENT ANCHOR BOLTS AND TEMPLATES**

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

## **2.8 HOUSE-KEEPING PADS**

- .1 Provide concrete housekeeping pads for base-mounted equipment as indicated.
- .2 The concrete shall have 35 MPa strength at 56 days and prepared to Exposure Category C-1 as defined in CSA A23.1, with Air Content Category 1.
- .3 Testing is required, providing minimum four cylinders: 7-day, 14-day, two 56-day tests.

## **2.9 OTHER EQUIPMENT SUPPORTS**

- .1 Fabricate equipment supports from structural grade steel.
- .2 Submit structural calculations with shop drawings.

## **Part 3 Execution**

### **3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 INSTALLATION**

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

**3.3 HANGER SPACING**

- .1 Copper piping: up to NPS ½: every 1.5 m.
- .2 Flexible joint roll groove pipe: in accordance with table below for steel, but not less than one hanger at joints. Table listings for straight runs without concentrated loads and where full linear movement is not required.

Maximum Pipe Size : NPS	Maximum Spacing Steel	Maximum Spacing Copper
up to 1¼	2.4 m	1.8 m
1½	3.0 m	2.4 m
2	3.0 m	2.4 m
2½	3.7 m	3.0 m
3	3.7 m	3.0 m
3½	3.7 m	3.3 m
4	3.7 m	3.6 m
5	4.3 m	
6	4.3 m	
8	4.3 m	
10	4.9 m	
12	4.9 m	

- .3 Within 300mm of each elbow.
- .4 Pipe work greater than NPS 12: to MSS SP-58.

**3.4 HANGER INSTALLATION**

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

- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

### **3.5 HORIZONTAL MOVEMENT**

- .1 Angularity of rod hanger resulting from horizontal movement of pipe work from cold to hot position not to exceed 4 degrees from vertical.
- .2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

### **3.6 FINAL ADJUSTMENT**

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

### **3.7 FIELD QUALITY CONTROL**

- .1 Manufacturer's Field Services:
  - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
  - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
  - .3 Schedule site visits, to review Work.

### **3.8 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**



**PART 1        General**

**1.1            SUMMARY**

- .1        Section Includes:
  - .1        Vibration isolation materials and components, and their installation.

**1.2            REFERENCE STANDARDS**

- .1        Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1        Safety Data Sheets (SDS).
- .2        National Fire Protection Association (NFPA)
  - .1        NFPA 13, Standard for the Installation of Sprinkler Systems.
- .3        National Research Council Canada (NRC)
  - .1        NBC, National Building Code of Canada.

**1.3            ACTION AND INFORMATIONAL SUBMITTALS**

- .1        Submittals: in accordance with Section 01 33 00 – Submittal Procedures.
  - .1        Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 – Submittal Procedures. Include product characteristics, performance criteria, and limitations.
  - .2        Submit shop drawings in accordance with Section 01 33 00 – Submittal Procedures.
    - .1        Provide separate shop drawings for each isolated system complete with performance and product data.
    - .2        Provide detailed drawings of seismic control measures for equipment and piping.
  - .3        Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
    - .1        Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
    - .2        Instructions: submit manufacturer's installation instructions.
    - .3        Manufacturer's Field Reports: manufacturer's field reports specified.

**1.4            DELIVERY, STORAGE, AND HANDLING**

- .1        Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 60 00 - Product Requirements.
- .2        Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3        Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

**PART 2        Products**

**2.1            GENERAL**

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

**2.2            ELASTOMERIC PADS**

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

**2.3            ELASTOMERIC MOUNTS**

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

**2.4            SPRINGS**

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

**2.5            SPRING MOUNT**

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

## **2.6 HANGERS**

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

## **2.7 ACOUSTIC BARRIERS FOR ANCHORS AND GUIDES**

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

## **2.8 HORIZONTAL THRUST RESTRAINT**

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

## **2.9 STRUCTURAL BASES**

- .1 Type B1 - Prefabricated steel base: integrally welded on sizes up to 2400mm on smallest dimension, split for field welding on sizes over 2400mm on smallest dimension and reinforced for alignment of drive and driven equipment; without supplementary hold down devices; complete with isolation element attached to base brackets arranged to minimize height; pre-drilled holes to receive equipment anchor bolts; and complete with adjustable built-in motor slide rail where indicated.
- .2 Type B2 - Steel rail base: structural steel, positioned for alignment of drive and driven equipment; without supplementary hold down devices; complete with isolation element attached to base brackets arranged to minimize height; and pre-drilled holes to receive equipment anchor bolts.
- .3 Bases to clear housekeeping pads by 25mm minimum.

## **2.10 INERTIA BASE**

- .1 Type B3 - Full depth perimeter structural or formed channels, frames: welded in place reinforcing rods running in both directions; spring mounted, carried by gusseted height-saving brackets welded to frame; and clear housekeeping pads by 50mm minimum.
- .2 Pump bases: "T" shaped, where applicable, to provide support for elbows.

**PART 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 INSTALLATION**

- .1 Seismic control measures to meet requirements of NBC.
- .2 Install vibration isolation equipment in accordance with manufacturer's instructions and adjust mountings to level equipment.
- .3 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping, conduit and ducting passage through walls and floors do not transmit vibrations.
- .4 Unless indicated otherwise, support piping connected to isolated equipment with spring mounts or spring hangers with 25mm minimum static deflection as follows:
  - .1 Up to NPS 4: first 3 points of support.
  - .2 NPS 5 to NPS 8: first 4 points of support.
  - .3 NPS 10 and over: first 6 points of support.
  - .4 First point of support: static deflection of twice deflection of isolated equipment, but not more than 50mm.
- .5 Where isolation is bolted to floor use vibration isolation rubber washers.
- .6 Block and shim level bases so that ductwork and piping connections can be made to rigid system at operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.

**3.3 FIELD QUALITY CONTROL**

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

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

#### **3.4 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1           General**

**1.1               REFERENCES**

- .1 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB 24.3, Identification of Piping Systems.
- .2 Canadian Standards Association International (CSA)
- .3 Workplace Hazardous Materials Information System (WHMIS)
  - .1 Safety Data Sheets (SDS).
- .4 Underwriters Laboratories of Canada (ULC)

**1.2               ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Product Data:
  - .1 Submittals: in accordance with Section 01 33 00 – Submittal Procedures.
  - .2 Product data to include paint colour chips, other products specified in this section.
- .2 Samples:
  - .1 Submit samples in accordance with Section 01 33 00 – Submittal Procedures.
  - .2 Samples to include nameplates, labels, tags, lists of proposed legends.

**1.3               QUALITY ASSURANCE**

- .1 Quality assurance submittals: submit following in accordance with Section 01 33 00 – Submittal Procedures.

**1.4               DELIVERY, STORAGE, AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

**Part 2           Products**

**2.1               MANUFACTURER'S EQUIPMENT NAMEPLATES**

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

## 2.2 SYSTEM NAMEPLATES

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

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20

- .2 Use maximum of 25 letters/numbers per line.
- .4 Locations:
  - .1 Terminal cabinets, control panels: use size #5.
  - .2 Equipment: use size #9.
  - .3 Isolation valves as indicated on drawings: use size #8

## 2.3 EXISTING IDENTIFICATION SYSTEMS

- .1 Apply existing identification system to new work. Paint all new piping to match existing color scheme.
- .2 Where existing identification system does not cover for new work, use identification system specified in this section.
- .3 Before starting work, obtain written approval of identification system from Consultant.

## 2.4 IDENTIFICATION OF PIPING SYSTEMS

- .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
- .2 Pictograms:
  - .1 Where required: WHMIS regulations.

- .3 Paint all new piping/piping jackets to match existing color scheme.
- .4 Arrows showing direction of flow:
  - .1 Outside diameter of pipe or insulation less than 75mm: 100mm long x 50mm high.
  - .2 Outside diameter of pipe or insulation 75mm and greater: 150mm long x 50mm high.
  - .3 Use double-headed arrows where flow is reversible.
- .5 Extent of background colour marking:
  - .1 To full circumference of pipe or insulation.
- .6 Materials for colour marking legend and arrows:
  - .1 Pipes and tubing 20mm and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.
  - .2 Other pipes: pressure sensitive vinyl or plastic-coated cloth with protective over-coating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C and intermittent temperature of 200°C.
- .7 Colours and Legends:
  - .1 Where not listed, obtain direction from Consultant.
  - .2 Colours for legends and arrows to following table:

<b>Background Colour:</b>	<b>Legend, arrows:</b>
Yellow	BLACK
Green	WHITE
Red	WHITE

- .3 Background colour marking and legends for piping systems to following table:

<b>Contents:</b>	<b>Background Colour Marking</b>	<b>Legend</b>
Domestic Cold Water	Dark Green*	DCW
Domestic Hot Water	Pale Green*	DHW
Domestic Hot Water Recirc.	Pale Green*	DHWR
Steam	Orange*	
Condensate	Brown*	

\*Confirm exact colour shade with Owner prior to painting piping.



## **2.5 VALVES, CONTROLLERS**

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

## **2.6 CONTROLS COMPONENTS IDENTIFICATION**

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

## **2.7 LANGUAGE**

- .1 Identification in English.

## **Part 3 Execution**

### **3.1 MANUFACTURER'S INSTRUCTIONS**

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

### **3.2 INSTALLATION**

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

### **3.3 NAMEPLATES**

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

### **3.4 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS**

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

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

### **3.5 VALVES, CONTROLLERS**

- .1 Valves and operating controllers, except where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.
- .2 Number valves in each system consecutively.

### **3.6 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1                SUMMARY**

- .1    TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.
- .2    TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this section.
- .3    This section includes the testing of all new fire dampers.
- .4    Complete water balancing on complete hydronic heating system including boilers, pumps, and all heating equipment.
- .5    Complete air balancing on total air flow through AHU-1. Balancing individual grilles not required.

**1.2                QUALIFICATIONS OF TAB PERSONNEL**

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

### **1.3 PURPOSE OF TAB**

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads
- .2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

### **1.4 EXCEPTIONS**

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

### **1.5 CO-ORDINATION**

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

### **1.6 PRE-TAB REVIEW**

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

### **1.7 START-UP**

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

### **1.8 OPERATION OF SYSTEMS DURING TAB**

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

### **1.9 START OF TAB**

- .1 Notify Contract Administrator 7 days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
- .3 Installation of ceilings, doors, windows, other construction affecting TAB.
- .4 Application of weatherstripping, sealing, and caulking.

- .5 Pressure, leakage, other tests specified elsewhere Division 23.
- .6 Provisions for TAB installed and operational.
- .7 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
  - .1 Proper thermal overload protection in place for electrical equipment.
  - .2 Air systems:
    - .1 Filters in place, clean.
    - .2 Duct systems clean.
    - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
    - .4 Correct fan rotation.
    - .5 Fire, smoke, volume control dampers installed and open.
    - .6 Coil fins combed, clean.
    - .7 Access doors, installed, closed.
    - .8 Outlets installed, volume control dampers open.
  - .3 Liquid systems:
    - .1 Flushed, filled, vented.
    - .2 Correct pump rotation.
    - .3 Strainers in place, baskets clean.
    - .4 Isolating and balancing valves installed, open.
    - .5 Calibrated balancing valves installed, at factory settings.
    - .6 Chemical treatment systems complete, operational.

#### **1.10 APPLICATION TOLERANCES**

- .1 Do TAB to following tolerances of design values:
  - .1 HVAC systems: plus 10%, minus 5%.
  - .2 Hydronic systems: plus or minus 5%.

#### **1.11 ACCURACY TOLERANCES**

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

#### **1.12 INSTRUMENTS**

- .1 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .2 Calibrate within 3 months of TAB.

#### **1.13 ACTION AND INFORMATIONAL SUBMITTALS**

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

**1.14 TAB REPORT**

- .1 Format in accordance with relevant standard.
- .2 TAB report to show results in SI units and to include:
  - .1 Project record drawings.
  - .2 System schematics.
- .3 Submit 1 copy of TAB Report to Contract Administrator for verification and approval, in English in D-ring binders, complete with index tabs.

**1.15 VERIFICATION**

- .1 Reported results subject to verification by Contract Administrator
- .2 Provide personnel and instrumentation to verify up to 30 % of reported results.
- .3 Pay costs to repeat TAB as required to satisfaction of Contract Administrator.

**1.16 SETTINGS**

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

**1.17 COMPLETION OF TAB**

- .1 TAB considered complete when final TAB Report received and approved by the Contract Administrator.

**1.18 AIR SYSTEMS**

- .1 Standard: TAB to most stringent of TAB standards of AABC or ASHRAE.
- .2 Do TAB of following systems, equipment, components, and controls:
  - .1 AHU-1
    - .1 Supply fan.
    - .2 All supply grilles.
    - .3 All balancing dampers.
- .3 Test all fire dampers.
- .4 Qualifications: personnel performing TAB to be current member in good standing of AABC or NEBB.
- .5 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dew point), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.
- .6 Locations of equipment measurements: to include, but not be limited to, following as appropriate:

- .1 Inlet and outlet of dampers, grille, filter, coil, humidifier, fan, other equipment causing changes in conditions.
- .2 At controllers, controlled device.
- .7 Locations of systems measurements to include, but not be limited to, following as appropriate: main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).

**1.19 OTHER TAB REQUIREMENTS**

- .1 General requirements applicable to work specified this paragraph:
  - .1 Qualifications of TAB personnel: as for air systems specified this section.
  - .2 Quality assurance: as for air systems specified this section.
- .2 Zone pressure differences:
  - .1 Adjust HVAC systems, equipment, controls to establish specified air pressure differentials, with systems in every possible combinations of normal operating modes.

**Part 2 Products**

**2.1 NOT USED**

- .1 Not used.

**Part 3 Execution**

**3.1 NOT USED**

- .1 Not used.

**END OF SECTION**

## **Part 1           General**

### **1.1               REFERENCES**

#### **.1               Definitions:**

##### **.1               For purposes of this section:**

- .1               "CONCEALED"** - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
- .2               "EXPOSED"** - means "not concealed" as previously defined.
- .3               Insulation systems** - insulation material, fasteners, jackets, and other accessories.

### **1.2               REFERENCE STANDARDS**

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

- .1               ASHRAE 90.1, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.**

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

- .1               ASTM B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.**
- .2               ASTM C335, Standard Test Method for Steady State Heat Transfer Properties of Pipe Insulation.**
- .3               ASTM C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.**
- .4               ASTM C449, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.**
- .5               ASTM C547, Standard Specification for Mineral Fiber Pipe Insulation.**
- .6               ASTM C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.**
- .7               ASTM C612, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.**
- .8               ASTM C795, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.**
- .9               ASTM C921, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.**

#### **.3               Canadian General Standards Board (CGSB)**

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

#### **.4               Thermal Insulation Association of Canada (TIAC)**

- .1               Mechanical Insulation Best Practices Guide.**



- .5 Underwriters Laboratories of Canada (ULC)
  - .1 ULC 102, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
  - .2 ULC 701, Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering.

### **1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Provide manufacturer's printed product literature and datasheets for duct insulation, and include product characteristics, performance criteria, physical size, finish and limitations.
    - .1 Description of equipment giving manufacturer's name, type, model, year and capacity.
    - .2 Details of operation, servicing and maintenance.
    - .3 Recommended spare parts list.
  - .3 Manufacturers' Instructions:
    - .1 Provide manufacture's written duct insulation jointing recommendations and special handling criteria, installation sequence, cleaning procedures.

### **1.4 QUALITY ASSURANCE**

- .1 Qualifications:
  - .1 Installer: specialist in performing Work of this section and have at least 3 years successful experience in this size and type of project.

### **1.5 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with manufacturers written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to Site in original factory packaging, labelled with manufacturer's name, address and ULC markings.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

## **Part 2 Products**

### **2.1 FIRE AND SMOKE RATING**

- .1 To ULC 102:
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

### **2.2 THERMAL INSULATION**

- .1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.

- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.
- .3 Code C-1: Rigid mineral fibre board to ASTM C612, without factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
- .4 Code C-2: Rigid mineral fibre board to ASTM C612, with factory applied all service vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
- .5 Code C-3: Mineral fibre blanket to ASTM C553 faced without factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
  - .1 Mineral fibre: to ASTM C553.
  - .2 Jacket: to CGSB 51-GP-52Ma.
  - .3 Maximum "k" factor: to ASTM C553
- .6 Code C-4: Mineral fibre blanket to ASTM C553 faced with factory applied all service vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
  - .1 Mineral fibre: to ASTM C553.
  - .2 Jacket: to CGSB 51-GP-52Ma.
  - .3 Maximum "k" factor: to ASTM C553.
- .7 Code C-5: Rigid moulded mineral fibre without factory applied vapour retarder jacket.
  - .1 Mineral fibre: to ULC 702.
  - .2 Maximum "k" factor: to ULC 702.
- .8 Code C-6: Rigid moulded mineral fibre with factory applied all service vapour retarder jacket.
  - .1 Mineral fibre: to ULC 702.
  - .2 Jacket: to CGSB 51-GP-52Ma.
  - .3 Maximum "k" factor: to ULC 702.
- .9 Code C-7: Foil-faced foam sheathing board consisting of a uniform closed-cell polyisocyanurate foam core with factory applied vapour barrier.
- .10 The use of duct liner as thermal insulation is not allowed. Duct liner may be considered for acoustical purposes only.

## 2.3 JACKETS

- .1 Canvas:
  - .1 170 gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
  - .2 Lagging adhesive: compatible with insulation.
  - .3 Painted to match adjacent finishes.
- .2 All-Service Jacket (ASJ):
  - .1 White, kraft paper, reinforced with glass fiber yarn and bonded to an aluminum foil.
  - .2 Self-sealing longitudinal closure laps (SSL) and butt strips.

- .3 Aluminum:
  - .1 To ASTM B209 without moisture barrier as scheduled in PART 3 of this section.
  - .2 Thickness: 0.50 mm sheet.
  - .3 Finish: Stucco embossed.
  - .4 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.
- .4 Polyvinyl Chloride (PVC):
  - .1 One-piece cut and curled type to CAN/CGSB 51.53 with pre-formed shapes for fittings as required.
  - .2 Colour: white
  - .3 Minimum service temperatures: -20°C.
  - .4 Maximum service temperature: 65°C.
  - .5 Moisture vapour transmission: 0.02 perm.
  - .6 Thickness: 20 mil.
  - .7 Fastenings:
    - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.

## 2.4 ACCESSORIES

- .1 Vapour retarder lap adhesive:
  - .1 Water based, fire retardant type, compatible with insulation.
- .1 Execution Tape: self-adhesive, aluminum, plain, 50 mm wide minimum.
- .2 Contact adhesive: quick-setting
- .3 Canvas adhesive: washable.
- .4 Banding: 19 mm wide, 0.5 mm thick stainless steel.
- .5 Fasteners: 2 mm diameter pins with 35 mm diameter clips, length to suit thickness of insulation.

## Part 3 Execution

### 3.1 APPLICATION

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

### 3.2 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure test ductwork systems complete, witness and certify.
- .2 Ensure surfaces are clean, dry, and free from foreign material.

### 3.3 INSTALLATION

- .1 Install in accordance with TIAC.
- .2 Apply materials in accordance with manufacturer's instructions and as indicated.
- .3 Use 2 layers with staggered joints when required nominal thickness exceeds 75 mm.

- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
  - .1 Ensure hangers, and supports are outside vapour retarder jacket.
- .5 Hangers and supports in accordance with Section 23 05 29 – Hangers and Supports for HVAC.
  - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .6 Fasteners: install at 300 mm on centre in horizontal and vertical directions, minimum 2 rows each side. Cover fasteners with foil-faced self-adhesive tape.

### 3.4 INSULATION THICKNESSES

- .1 Insulation types and thicknesses: conform to following table:

Duct System	Minimum Thermal Resistance (RSI)	Insulation Type	Location of Insulation	Unit Thermal Resistance (RSI/25mm)	Insulation Thickness (mm)	Total Thermal Resistance (RSI)
<b><u>Indoor Ductwork</u></b>						
<i>Temperature Difference = 5 to 22°C</i>						
Supply Air - Headers and Plenums – Rectangular	0.58	C-1/C-3	Exterior	0.67	25	0.67
Supply Air - Headers and Plenums – Round	0.58	C-3/C-5				
Supply Air – Runouts – Rectangular	0.58	C-1/C-3	Exterior	0.67	25	0.67
Supply Air – Runouts - Round	0.58	C-3/C-5	Exterior	0.67	25	0.67
Return Air - Headers and Plenums - Rectangular	0	N/A			-	
Return Air - Headers and Plenums - Rectangular	0	N/A			-	
Return Air – Runouts - Rectangular	0	N/A			-	
Return Air – Runouts - Round	0	N/A			-	
Outdoor/Combustion Air - Indoor Headers and Plenums - Rectangular	0.58	C-2/C-4	Exterior	0.67	25	0.67
Outdoor/Combustion Air - Indoor Headers and Plenums - Round	0.58	C-4/C-6	0.67	25	0.67	0.58
Exhaust/Relief Air - Indoor Headers and Plenums - Rectangular	0	N/A			-	
Exhaust/Relief Air - Indoor Headers and Plenums - Round	0	N/A			-	
<b>Temperature Difference = Over 22°C</b>						
Outdoor Air Intake - Rectangular	0.88	C-2/C-4	Exterior	0.67	50	1.34
Outdoor Air Intake - Round	0.88	C-4/C-6	Exterior	0.67	50	1.34
<b><u>Exterior Ductwork</u></b>						
Supply Air - Headers and Plenums	5.46	C-7	Exterior	0.99	125	5.2
Supply Air - Runouts	5.46	C-7	Exterior	0.99	125	5.2
Return Air - Headers and Plenums	5.46	C-7	Exterior	0.99	125	5.2
Return Air - Runouts	5.46	C-7	Exterior	0.99	125	5.2

**Notes:** 1) Ductwork carrying conditioned air and installed outdoors needs to be insulated to same level as building wall.

- 2) Runouts are ducts that do not exceed 3 meters in length and connects to terminal grilles or diffusers.
- 3) Insulate all exhaust/relief ducts 1800 mm back from outside wall.

### **3.5 INSULATION TYPE**

- .1 Rectangular Ductwork:
  - .1 Less than 750mm wide: Blanket insulation.
  - .2 Over 750mm wide: Rigid board insulation.
- .2 Round Ductwork:
  - .1 Less than 750mm diameter: Blanket insulation.
  - .2 Over 750mm diameter: Rigid, moulded insulation.

### **3.6 JACKET TYPE**

- .1 Location: Indoors Attic Space/Crawlspace:
  - .1 Exposed Rectangular Ductwork: Canvas.
  - .2 Exposed Round Ductwork: Canvas.
  - .3 Concealed Rectangular Ductwork: ASJ.
  - .4 Concealed Round Ductwork: ASJ.
- .2 Location: Outdoors:
  - .1 Rectangular Ductwork: Aluminum jacket.
  - .2 Round Ductwork: Aluminum jacket.

### **3.7 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1 American Society for Testing and Materials International (ASTM)
  - .1 ASTM C335, Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation.
  - .2 ASTM C449, Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
  - .3 ASTM C547, Standard Specification for Mineral Fiber Pipe Insulation.
  - .4 ASTM C921, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .2 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB 51.53, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts
- .3 Workplace Hazardous Materials Information System (WHMIS)
  - .1 Safety Data Sheets (SDS).
- .4 Thermal Insulation Association of Canada (TIAC)
  - .1 TIAC Mechanical Insulation Best Practices Guide.
- .5 Underwriters Laboratories of Canada (ULC)
  - .1 ULC 102, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
  - .2 ULC 702, Standard for Mineral Fibre Thermal Insulation for Buildings.

**1.2                DEFINITIONS**

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

**1.3                ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submittals: in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 – Submittal Procedures. Include product characteristics, performance criteria, and limitations.

- .1 Submit copies of WHMIS SDS in accordance with Section 01 33 00 – Submittal Procedures.
- .3 Shop Drawings:
  - .1 Submit shop drawings in accordance with Section 01 33 00 – Submittal Procedures.
- .4 Quality assurance submittals: submit following in accordance with Section 01 33 00 – Submittal Procedures.
  - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
  - .2 Instructions: submit manufacturer's installation instructions.

#### **1.4 QUALITY ASSURANCE**

- .1 Qualifications:
  - .1 Installer: specialist in performing work of this Section, and have at least 3 years successful experience in this size and type of project, qualified to standards of TIAC.

#### **1.5 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.
- .4 Dispose of unused adhesive material at official hazardous material collections site.

### **Part 2 Products**

#### **2.1 FIRE AND SMOKE RATING**

- .1 In accordance with ULC 102.
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

#### **2.2 INSULATION**

- .1 Mineral fibre specified includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.
- .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
  - .1 Mineral fibre: to ULC 702 and ASTM C547.
  - .2 Maximum "k" factor: to ULC 702.

### **2.3 INSULATION SECUREMENT**

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

### **2.4 CEMENT**

- .1 Thermal insulating and finishing cement:
  - .1 Hydraulic setting on mineral wool, to ASTM C449.

### **2.5 VAPOUR RETARDER LAP ADHESIVE**

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

### **2.6 INDOOR VAPOUR RETARDER FINISH**

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

### **2.7 OUTDOOR VAPOUR RETARDER FINISH**

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

### **2.8 JACKETS**

- .1 Canvas:
  - .1 220 gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
  - .2 Lagging adhesive: compatible with insulation.
  - .3 Painted to match adjacent finishes.
- .2 All-Service Jacket (ASJ):
  - .1 White, kraft paper, reinforced with glass fiber yarn and bonded to an aluminum foil.
  - .2 Self-sealing longitudinal closure laps (SSL) and butt strips.
- .3 Polyvinyl Chloride (PVC):
  - .1 One-piece moulded type to CAN/CGSB 51.53 with pre-formed shapes as required.
  - .2 Colours: white.
  - .3 Minimum service temperature: -20°C.
  - .4 Minimum service temperature: 65°C.
  - .5 Moisture vapour transmission: 0.02 perm.
  - .6 Thickness: 0.5mm.



- .7 Fastenings:
  - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
  - .2 Pressure sensitive vinyl tape of matching colour.

### **Part 3 Execution**

#### **3.1 MANUFACTURER'S INSTRUCTIONS**

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

#### **3.2 PRE-INSTALLATION REQUIREMENT**

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

#### **3.3 INSTALLATION**

- .1 Install in accordance with TIAC.
- .2 Apply materials in accordance with manufacturer's instructions and this specification.
- .3 Use two layers with staggered joints when required nominal wall thickness exceeds 75mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
  - .1 Install hangers, supports outside vapour retarder jacket.
- .5 Supports, Hangers:
  - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

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

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

#### **3.5 INSTALLATION OF ELASTOMERIC INSULATION**

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

### **3.6 PIPING INSULATION SCHEDULES**

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 TIAC Code: A-1.
  - .1 Insulation securements: Tape at 300mm on centre.
  - .2 Seals: lap seal adhesive, lagging adhesive.
  - .3 Installation: TIAC Code: 1501-H.
- .3 Finishes:
  - .1 Exposed in occupied spaces: PVC jacket.
  - .2 Exposed in mechanical rooms: Canvas jacket.
  - .3 Concealed, indoors: ASJ.
  - .4 Installation: to appropriate TIAC code CRF/1 through CPF/5.

### **3.7 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

### **3.8 PROTECTION**

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

**END OF SECTION**

## **Part 1 General**

### **1.1 SUMMARY**

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

### **1.2 REFERENCE STANDARDS**

- .1 American Society for Testing and Materials International (ASTM)
- .2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1 Material Safety Data Sheets (MSDS).

### **1.3 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Product Data:
  - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 – Submittal Procedures. Include product characteristics, performance criteria, and limitations.
  - .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 – Submittal Procedures.
    - .1 Instructions: submit manufacturer's installation instructions.
      - .1 Departmental Representative will make available 1 copy of systems supplier's installation instructions.

## **Part 2 Products**

### **2.1 CLEANING SOLUTIONS**

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

## **Part 3 Execution**

### **3.1 MANUFACTURER'S INSTRUCTIONS**

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

### **3.2 CLEANING HYDRONIC AND STEAM SYSTEMS**

- .1 Timing: systems operational, hydrostatically tested and with safety devices functional before cleaning is carried out.
- .2 Cleaning Agency:

- .1 Retain qualified water treatment specialist to perform system cleaning.
- .3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.
- .4 Cleaning procedures:
  - .1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report to include:
    - .1 Cleaning procedures, flow rates, elapsed time.
    - .2 Chemicals and concentrations used.
    - .3 Inhibitors and concentrations.
    - .4 Specific requirements for completion of work.
    - .5 Special precautions for protecting piping system materials and components.
    - .6 Complete analysis of water used to ensure water will not damage systems or equipment.
- .5 Conditions at time of cleaning of systems:
  - .1 Systems: free from construction debris, dirt and other foreign material.
  - .2 Control valves: operational, fully open to ensure that terminal units can be cleaned properly.
  - .3 Strainers: clean prior to initial fill.
  - .4 Install temporary filters on pumps not equipped with permanent filters.
  - .5 Install pressure gauges on strainers to detect plugging.
- .6 Report on Completion of Cleaning:
  - .1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.
- .7 Hydronic Systems:
  - .1 Fill system with water, ensure air is vented from system.
  - .2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 35 kPa (does not apply to diaphragm type expansion tanks).
  - .3 Use water metre to record volume of water in system to +/- 0.5%.
  - .4 Add chemicals under direct supervision of chemical treatment supplier.
  - .5 Closed loop systems: circulate system cleaner at 60 degrees C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
  - .6 Flush velocity in system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.
  - .7 Add chemical solution to system.
  - .8 Establish circulation, raise temperature slowly to maximum design. Circulate for 12 h, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 38 degrees C. Drain as quickly as possible. Refill with

clean water. Circulate for 6 hours at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).

### **3.3 START-UP OF HYDRONIC SYSTEMS**

- .1 After cleaning is completed and system is filled:
  - .1 Establish circulation and expansion tank level, set pressure controls.
  - .2 Ensure air is removed.
  - .3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.
  - .4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.
  - .5 Clean out strainers repeatedly until system is clean.
  - .6 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.
  - .7 Repeat with water at design temperature.
  - .8 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.
  - .9 Perform TAB as specified in Section 23 05 93 – Testing, Adjusting and Balancing for HVAC.
  - .10 Adjust pipe supports, hangers, springs as necessary.
  - .11 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.
  - .12 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.
  - .13 Check operation of drain valves.
  - .14 Adjust valve stem packings as systems settle down.
  - .15 Fully open balancing valves (except those that are factory-set).
  - .16 Check operation of over-temperature protection devices on circulating pumps.
  - .17 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

### **3.4 CLEANING**

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

**END OF SECTION**

**Part 1        General**

**1.1        GENERAL**

- .1 All drawings and all sections of the specifications shall apply to and form an integral part of this section. Refer to sections on specific equipment to obtain information on their own packaged controls.
- .2 Wherever words "shall be capable of" appear in specifications, interpret as meaning that; where feature or performance referred to is being applied, that feature or performance shall be provided. Where feature or performance is not applied now, but will be applied in future, system shall be provided with all necessary central hardware and software required to support that feature or performance, with only addition of field hardware being required at that future time.
- .3 Controls contractor shall have minimum 5 years experience in related Work.
- .4 Technical assessment of proposed system will be made as part of our selection criteria.
- .5 Controls contractor provides actuators for all motorized dampers in accordance with this section.

**1.2        REFERENCE STANDARDS**

- .1 American Society of Heating Refrigeration Air-Conditioning Engineers (ASHRAE)
  - .1 ASHRAE 135, BACnet – A Data Communication Protocol for Building Automation and Control Networks.
- .2 Canadian Standards Association International (CSA)
- .3 International Organization for Standardization (ISO)
  - .1 ISO 8802-3, Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specification.
- .4 Underwriters Laboratories (UL)

**1.3        SCOPE OF SERVICE**

- .1 The contractor is to have the expertise to install a new DDC system for the new equipment.
- .2 Provide a fully commissioned DDC system and documentation.
- .3 The contractor shall provide the necessary engineering, installation, supervision, equipment, commissioning and programming for a complete and fully operational system including but not limited to:
  - .1 Provide control shop drawings.

- .2 Provide a network of Direct Digital Control (DDC) panels (if required).
- .3 Provide all wells, sensors, interface devices, automatic control valves, VAV controllers, control dampers, transducers, relays, dampers, damper actuators, wiring, conduit raceways and piping (unless otherwise noted).
- .4 Provide graphics software, system software, and any third party software required to meet the intent of these specifications.
- .5 Provide labelling of the DDC controls system.
- .6 Provide laptop to contain the DDC system controls and graphics.
- .7 Provide labour and supervision for installation, calibration, checkouts and commissioning of systems.
- .8 Provide all application, database and graphic programming.
- .9 Provide shop drawings, training manuals and as-built drawings.
- .10 Provide operator training. 8 hrs of training required (or 2 x 4 hr sessions).
- .11 Provide a one-year warranty on all components.
- .12 Provide one year of maintenance.
- .13 Provide all the necessary software and interface devices for DDC based control of the points listed in the points list and the systems described in the sequences of operation.

#### **1.4 SCOPE OF WORK**

- .1 Includes the design, supply, installation, commissioning, and training for a complete DDC control system for control and/or monitoring of the equipment noted on the controls drawings.
- .2 All motorized dampers, actuators, control valves and devices required by this Section (unless noted otherwise).
- .3 The controls contractor shall be responsible for mounting and wiring all remote-mounted sensors and controls supplied with vendor-supplied equipment. All wiring inside conduit.
- .4 The DDC system shall be capable of remote access via internet in future. However this service is not required at this time.

#### **1.5 SUBMITTALS**

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

## **Part 2        Products**

### **2.1        MATERIALS**

- .1        All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by the Consultant in writing. Spare parts shall be available for at least five years after completion of this Contract.

### **2.2        THERMOSTATS AND TEMPERATURE SENSORS**

- .1        Provide wall-mounted thermostats and/or space temperature sensors suitable for specified operation. Provide vandal proof protective covers for all units.

### **2.3        COMMUNICATION**

- .1        All control products provided for this project shall comprise a BACnet network. Communication involving control components (i.e., all types of controllers and operator interfaces) shall conform to ASHRAE 135, BACnet.
- .2        Each BACnet device shall operate on the BACnet or Data Link/Physical layer protocol specified for that device as defined in this section.
- .3        The contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the network.
- .4        All controllers shall have a communication port for connections with the operator interfaces using the BACnet Data Link/Physical layer protocol.
- .5        Communication services over the network shall result in operator interface and value passing that is transparent to the network architecture as follows:
  - .1        Connection of an operator interface device to any one controller on the network will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the network.
  - .2        All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the network. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform network value passing.
  - .3        The time clocks in all controllers shall be automatically synchronized daily via the network. An operator change to the time clock in any controller shall be automatically broadcast to all controllers on the network.
  - .4        The network shall have the following minimum capacity for future expansion by 100%.



## 2.4 OPERATOR INTERFACE

- .1 Operator Interface. New DDC system shall be web-based. Provide access to DDC through office computers.
- .2 Workstation information access shall use the BACnet protocol. Communication shall use the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol.
- .3 System Software:
  - .1 System Graphics: Provide graphics for all systems noted under Section 1.5 of this specification.
- .4 System Applications: Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation:
  - .1 Automatic System Database Save and Restore: Each workstation shall store on the hard disk a copy of the current database of each Building Controller. This database shall be updated whenever a change is made in any system panel. The storage of these data shall be automatic and not require operator intervention. In the event of a database loss in a building management panel, the first workstation to detect the loss shall automatically restore the database for that panel. This capability may be disabled by the operator.
  - .2 Manual Database Save and Restore: A system operator with the proper password clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
  - .3 System Configuration: The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection.
  - .4 On-Line Help: Provide a context-sensitive, online help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
  - .5 Security: Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application, editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable. All system security data shall be stored in an encrypted format.
  - .6 System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

- .7 Alarm Processing: Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.
- .8 Alarm Messages: Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon acronyms or other mnemonics.
- .9 Alarm Reactions: The operator shall be able to determine (by object) what, if any, actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation, or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day.
- .10 Trend Logs: The operator shall be able to define a custom trend log for any data object in the system. This definition shall include interval, start time, and stop time. Trend data shall be sampled and stored on the building controller panel, be archivable on the hard disk, and be retrievable for use in spreadsheets and standard database programs.
- .11 Alarm and Event Log: The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.
- .12 Object and Property Status and Control: Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs.
- .13 Clock Synchronization: The system shall be able to automatically synchronize all system real-time clocks daily from any operator-designated device in the system. The system shall automatically adjust for daylight savings and standard time, if applicable.
- .14 Reports and Logs: Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archivable on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer and shall be set to be printed either on operator command or at a specific time each day.
- .15 Standard Reports: The following standard system reports shall be provided for this project. Provide ability for The Owner to readily customize these reports for this project.
  - .1 All Objects: All system (or subsystem) objects and their current values.
  - .2 Alarm Summary: All current alarms (except those in alarm lockout).
  - .3 Disabled Objects: All objects that are disabled.

- .4 Alarm Lockout Objects: All objects in alarm lockout (whether manual or automatic).
- .5 Alarm Lockout Objects in Alarm: All objects in alarm lockout that are currently in alarm.
- .6 Logs:
  - .1 Alarm History
  - .2 System Messages
  - .3 System Events
  - .4 Trends
- .16 Custom Reports: Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.
- .5 Workstation Applications Editors: Each PC workstation shall support editing of all system applications. Provide editors for each application at the PC workstation. The applications shall be downloaded and executed at one or more of the controller panels.
  - .1 Controller: Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
  - .2 Scheduling: An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and month. This shall consist of a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The start and stop times for each object shall be adjustable from this master schedule. Schedules shall be easy to copy to other objects and/or dates.
  - .3 Custom Application Programming: Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. The programming language shall have the following features:
    - .4 The language shall be English language oriented, be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and allow for free-form programming (i.e., not column-oriented or “fill in the blanks”). Alternatively, the programming language can be graphically based using function blocks as long as blocks are available that directly provide the functions listed below and that custom or compound function blocks can be created.
    - .5 A full-screen character editor/programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate word processing features such as cut/paste and find/replace.
    - .6 The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.

- .7 The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and observe any intermediate values and/or results. The debugger also shall provide error messages for syntax and execution errors.
- .8 The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
- .9 The programming language shall support floating-point arithmetic.
- .10 The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program. Values from all of the above variables shall be readable by the language so that they can be used in a program for such purposes as IF/THEN comparisons, calculations, etc.
- .11 The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.
- .12 The programming language shall have predefined variables representing the status and results of the System Software and shall be able to enable, disable, and change the set points of the System Software described below.

## **2.5 CONTROLLER SOFTWARE**

- .1 Furnish the following applications software for building and energy management. All software applications shall reside and operate in the system controllers. Editing of applications shall occur at the operator workstation.
- .2 System Security:
  - .1 User access shall be secured using individual security passwords and user names.
  - .2 Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
  - .3 User Log On/Log Off attempts shall be recorded.
  - .4 The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
- .3 Scheduling: Provide the capability to schedule each object or group of objects in the system. Each schedule shall consist of the following:
  - .1 Weekly Schedule: Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. Each schedule may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each member.
  - .2 Exception Schedules: Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in

- advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
- .3 Holiday Schedules: Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
  - .4 System Coordination: Provide a standard application for the proper coordination of equipment. This application shall provide the operator with a method of grouping together equipment based on function and location. This group may then be used for scheduling and other applications.
  - .5 Binary Alarms: Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
  - .6 Analog Alarms: Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
  - .7 Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate workstations based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.
  - .8 Remote Communication: The system shall have the ability to dial out in the event of an alarm using BACnet or PTP.
  - .9 Maintenance Management: The system shall monitor equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits.
  - .10 Sequencing: Provide application software based upon the sequences of operation specified to properly sequence chillers, boilers, and pumps.
  - .11 PID Control: A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and PID gains shall be user-selectable.
  - .12 Staggered Start: This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user-selectable.
  - .13 Anti-Short Cycling. All binary output objects shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.
  - .14 On/Off Control with Differential: Provide an algorithm that allows a binary output to be cycled based on a controlled variable and set point. The algorithm shall be direct-acting or reverse-acting and incorporate an adjustable differential.

- .15 Run-Time Totalization: Provide software to totalize run-times for all binary input objects. A high runtime alarm shall be assigned, if required, by the operator.

## 2.6 BUILDING CONTROLLERS

- .1 General: Provide an adequate number of building controllers to achieve the performance specified in the Part 1 Article on “System Performance.” Each of these panels shall meet the following requirements.
  - .1 The Building Automation System shall be composed of one or more independent, standalone, microprocessor-based building controllers to manage the global strategies described in the System Software section.
  - .2 The building controller shall have sufficient memory to support its operating system, database, and programming requirements.
  - .3 Data shall be shared between networked building controllers.
  - .4 The operating system of the building controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
  - .5 Controllers that perform scheduling shall have a real-time clock.
  - .6 The building controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall
    - .1 Assume a predetermined failure mode,
    - .2 Generate an alarm notification.
  - .7 The Building Controller shall communicate with other BACnet devices on the network using the Read (Execute and Initiate) and Write (Execute and Initiate) services as defined in ASHRAE 135 for BACnet.
- .2 Communication:
  - .1 Each building controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
  - .2 The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator’s terminal.
- .3 Environment: Controller hardware shall be suitable for the anticipated ambient conditions.
  - .1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).
  - .2 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- .4 Keypad: A local keypad and display shall be provided. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to

prevent unauthorized use of the keypad and display. If the manufacturer does not provide this keypad and display, provide a portable operator terminal.

- .5 Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
- .6 Memory: The building controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
- .7 Immunity to power and noise: Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

## 2.7 CUSTOM APPLICATION CONTROLLERS

- .1 General: Provide an adequate number of Custom Application Controllers to achieve the performance specified in the Part 1 Article on “System Performance.” Each of these panels shall meet the following requirements.
  - .1 The custom application controller shall have sufficient memory to support its operating system, database, and programming requirements.
  - .1 Data shall be shared between networked custom application controllers.
  - .2 The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms.
  - .3 Controllers that perform scheduling shall have a real-time clock.
  - .4 The custom application controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall
    - .1 Assume a predetermined failure mode and
    - .2 Generate an alarm notification.
  - .5 The custom application controller shall communicate with other BACnet devices on the network using the Read (Execute and Initiate) and Write (Execute and Initiate) services as defined in ASHRAE 135 for BACnet.
- .2 Communication:
  - .1 Each custom application controller shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
  - .2 The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator’s terminal.
- .3 Environment: Controller hardware shall be suitable for the anticipated ambient conditions.

- .1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).
- .2 Controllers used in conditioned space shall be mounted in dustproof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- .4 Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
- .5 Memory: The custom application controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
- .6 Immunity to power and noise: Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

## **2.8 APPLICATION SPECIFIC CONTROLLERS**

- .1 General: Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user-programmable but are customized for operation within the confines of the equipment they are designed to serve. Application specific controllers shall communicate with other BACnet devices on the network using the Read (Execute) service as defined in ASHRAE 135 for BACnet.
  - .1 Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
  - .2 Each ASC will contain sufficient I/O capacity to control the target system.
- .2 Communication:
  - .1 The controller shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol. Each network of controllers shall be connected to one building controller.
  - .2 Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port if required.
- .3 Environment: The hardware shall be suitable for the anticipated ambient conditions.
  - .1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).
  - .2 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).



- .4 Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
- .5 Memory: The application specific controller shall use non-volatile memory and maintain all BIOS and programming information in the event of a power loss.
- .6 Immunity to power and noise: Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- .7 Transformer: Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

## 2.9 INPUT/OUTPUT INTERFACE

- .1 Hardwired inputs and outputs may tie into the system through building, custom application, or application specific controllers.
- .2 All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
- .3 Universal type input/output points shall be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.
- .4 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.
- .5 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
- .6 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to—commonly available sensing devices.
- .7 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.
- .8 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually

adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

- .9 System Object Capacity: The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

## **2.10 POWER SUPPLIES AND LINE FILTERING**

- .1 Control transformers shall be CSA approved. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with CEC requirements. Limit connected loads to 80% of rated capacity.
- .2 Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

## **2.11 AUXILIARY CONTROL DEVICES**

- .1 Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:
  - .1 Control dampers shall be the parallel or opposed blade type as below or as scheduled on drawings.
    - .1 Outdoor and/or return air mixing dampers shall be parallel blade, arranged to direct airstreams toward each other.
    - .2 Other modulating dampers shall be the opposed blade type.
    - .3 Two-position shutoff dampers on exhaust and air intake applications shall have insulated blades and may be parallel or opposed blade type with blade and side seals. See control drawings for locations of these dampers and damper specifications for details.
  - .2 Damper frames shall be 13 gauge galvanized steel channel or 1/8 in. extruded aluminum with reinforced corner bracing.
  - .3 Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades are to be suitable for medium velocity performance (10 m/s [2000 fpm]). Blades shall be not less than 16 gauge.
  - .4 Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze or better.
  - .5 All blade edges and top and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel. The blade seals shall provide for a maximum leakage rate of 50 L/s·m<sup>2</sup> (10 cfm per ft<sup>2</sup>) at 1000 Pa (4 in. w.g.) differential pressure. Provide airfoil blades suitable for a wide-open face velocity of 7.5 m/s (1500 fpm).
  - .6 Individual damper sections shall not be larger than 125 cm × 150 cm (48 in. × 60 in.). Provide a minimum of one damper actuator per section.

- .7 Modulating dampers shall provide a linear flow characteristic where possible.
- .8 Motorized dampers shall be installed next to duct access doors for ease in maintenance.
- .2 Electric damper/valve actuators:
  - .1 The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.
  - .2 Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing.
  - .3 Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.
  - .4 All 24 VAC/VDC actuators shall operate on Class 2 wiring
  - .5 All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 Nm (60 in.-lb) torque capacity shall have a manual crank for this purpose.
- .3 Control valves:
  - .1 Control valves shall be two-way or three-way type for two-position or modulating service as shown.
  - .2 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
- .4 Binary Temperature Devices:
  - .1 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) set point range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
  - .2 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, CSA approved for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
  - .3 Low-limit thermostats: Low-limit air stream thermostats shall be CSA approved, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.
- .5 Temperature sensors:
  - .1 Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
  - .2 Duct sensors shall be single point or averaging. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m<sup>2</sup> (10 ft<sup>2</sup>) of duct cross section.

- .3 Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
- .4 Space sensors shall be equipped with set point adjustment, override switch, display, and/or communication port.
- .5 Provide matched temperature sensors for differential temperature measurement.
- .6 Flow switches:
  - .1 Flow-proving switches shall be either paddle or differential pressure type, as shown.
  - .2 Paddle type switches (water service only) shall be CSA approved, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.
  - .3 Differential pressure type switches (air or water service) shall be CSA approved, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.
- .7 Air flow sensors:
  - .1 Airflow transmitter shall provide measurements of air speed via PLC/outstation/EMS.
  - .2 Accuracy: +/- 5% of actual values.
  - .3 Output signal: 4 – 20mA, 0 – 10 VDC.
- .8 Relays:
  - .1 Control relays shall be CSA approved plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
  - .2 Time delay relays shall be CSA approved solid-state plug-in type with adjustable time delay. Delay shall be adjustable  $\pm 200\%$  (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.
  - .3 Override timers.
    - .1 Override timers shall be spring-wound line voltage, CSA approved, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.
- .9 Current switches:
  - .1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.
- .10 Pressure transducers:

- .1 Transducer shall have linear output signal. Zero and span shall be field adjustable.
  - .2 Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
  - .3 Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.
  - .4 Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Overrange limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.
- .11 Differential pressure type switches (air or water service) shall be CSA approved, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.
- .12 Pressure-Electric (PE) Switches:
- .1 Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale setpoint range of 14-125 kPa (2-18 psig) minimum, CSA approved.
  - .2 Provide one- or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
  - .3 Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
  - .4 Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.
- .13 Local control panels:
- .1 All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
  - .2 Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be CSA approved for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
  - .3 Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

## **2.12 WIRING AND RACEWAYS**

- .1 General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 26.

- .2 All insulated wire to be copper conductors, UL labelled for 90°C minimum service.

## **2.13 SPACE MOUNTED CO<sub>2</sub> SENSORS**

- .1 The Gas Monitor will be powered by an external power supply rated at 20-28 VAC/DC.
- .2 The unit will perform the detection of carbon dioxide. Carbon dioxide will be detected non-dispersive infrared diffusion sampling. The monitor will have resolution levels of 1 ppm with a minimum range of 0-2000 ppm (0-5% accuracy). Temperature and relative humidity variations will have no effect on the unit's accuracy. Infrared monitor life will be no less than 10 years.
- .3 The units will require very low levels of maintenance, including only one verification per year where required.
- .4 The unit must also be capable of providing a local display of the concentration of CO<sub>2</sub> and provide a 4 -20 ma output for connection to a DDC system.
- .5 The monitor will be capable of operating within relative humidity ranges of 0-95% and temperature ranges of 0°C to 50°C (32°F to 122°F).
- .6 The unit shall have a footprint of 119 mm (4.7") high X 84 mm (3.3 in) wide X 29 mm (1.15") deep. The unit must be designed for in space applications.
- .7 The unit must be manufactured within an ISO 9001-2000 production environment and shall be warranted by the manufacturer for a period of five years.

## **2.14 INSULATED MOTORIZED CONTROL DAMPERS**

- .1 Fail open.
- .2 Operators:
  - .1 On/Off spring return damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a shaft up to a 1/2" diameter and center a 1/2" shaft.
  - .2 The actuators must be designed so that they may be used for either clockwise or counter clockwise fail-safe operation.
  - .3 Actuators shall be protected from overload at all angles of rotation. If required, one SPDT auxiliary switch shall be provided having the capability of being adjustable.
  - .4 Actuators with auxiliary switch must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus listed, have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards.
- .3 Refer to specification in Section 23 33 15 Dampers – Operating, for product specification.

**Part 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 INSTALLATION**

- .1 General:
  - .1 The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Consultant for resolution before rough-in work is started.
  - .2 The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Consultant for resolution before rough-in work is started.
  - .3 The contractor shall examine the drawings and specifications for other parts of the Work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others the contractor shall report these discrepancies to the Consultant and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the Work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.
  - .4 All items shall be installed in accordance with manufacturer's instructions. All conduit shall be independently supported from the structure in an approved manner.
  - .5 The control equipment and connecting conduit and wire shall be installed in a neat and workmanlike manner by personnel skilled in this type of installation. All tubing, conduit and plenum rated cable shall be run in an approved manner; conduit shall be run parallel to or at right angles to the building structure. All conduit, tubing, and plenum cable shall be concealed in all finished spaces. Conduit containing wire or non-metallic tubing may be installed exposed in mechanical rooms or areas where other piping is run exposed.
  - .6 Non-metallic tubing and plenum cable may be used in concealed accessible spaces provided such installation is allowed by local codes.
  - .7 All electrical work shall be installed by experienced personnel and conform to CEC and all local codes. Where requirements of Division 26 differ from those contained herein, Division 26 section shall take precedence.

**3.3 GENERAL WORKMANSHIP**

- .1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

- .2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- .3 Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- .4 All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

### 3.4 WIRING

- .1 All control and interlock wiring shall comply with the CEC and local electrical codes and Electrical section of this specification. Where the requirements of this section differ from those in the Electrical section, the requirements of this section shall take precedence.
- .2 All CSA Class 1 (line voltage) wiring shall be CSA approved in approved raceway according to CSA and Division 26 requirements.
- .3 All low-voltage wiring shall meet CSA Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)
- .4 Where CSA Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are CSA approved for the intended application. For example, cables used in ceiling plenums shall be CSA approved specifically for that purpose.
- .5 All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage shall be installed in raceway at levels below 3 m (10 ft).
- .6 Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- .7 Do not install wiring in raceway containing tubing.
- .8 Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and *neatly* tied at 3 m (10 ft) intervals.
- .9 Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
- .10 All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
- .11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- .12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.



- .13 All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
- .14 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
- .15 Size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and CSA requirements, except as noted elsewhere.
- .16 Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- .17 Use coded conductors throughout with conductors of different colors.
- .18 Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- .19 Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment.
- .20 Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
- .21 Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.
- .22 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
- .23 The contractor shall terminate all control and/or interlock wiring and shall maintain updated (asbuilt) wiring diagrams with terminations identified at the job site.
- .24 Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
- .25 Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

### **3.5 COMMUNICATION WIRING**

- .1 The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

- .2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- .3 Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- .4 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- .5 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
- .6 When a cable enters or exits a building, a lightning arrester must be installed between the lines and ground. The lightning arrester shall be installed according to the manufacturer's instructions.
- .7 All runs of communication wiring shall be un-spliced length when that length is commercially available.
- .8 All communication wiring shall be labelled to indicate origination and destination data.

### **3.6 INSTALLATION OF SENSORS**

- .1 Install sensors in accordance with the manufacturer's recommendations.
- .2 Mount sensors rigidly and adequately for the environment within which the sensor operates.
- .3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- .4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
- .5 Sensors used in mixing plenums shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- .6 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m<sup>2</sup> (1 ft of sensing element for each 1 ft<sup>2</sup>) of coil area.
- .7 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
- .8 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
- .9 Differential air static pressure:

- .1 Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
- .2 Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
- .3 Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
- .4 The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
- .5 All pressure transducers, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
- .6 All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

### **3.7 FLOW SWITCH INSTALLATION**

- .1 Use correct paddle for pipe diameter.
- .2 Adjust flow switch in accordance with manufacturer's instructions.

### **3.8 ACTUATORS**

- .1 Mount and link control damper actuators according to manufacturer's instructions.
  - .1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
  - .2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
  - .3 Provide all mounting hardware and linkages for actuator installation.
- .2 Electric/Electronic:
  - .1 Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
  - .2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

### 3.9 WARNING LABELS

- .1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
  - .1 Labels shall use white lettering (12-point type or larger) on a red background.
  - .2 Warning labels shall read as follows:

**C A U T I O N**

This equipment is operating under automatic control  
and may start or stop at any time without warning.

Switch disconnect to “Off” position before servicing.

- .2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
  - .1 Labels shall use white lettering (12-point type or larger) on a red background.
  - .2 Warning labels shall read as follows:

**C A U T I O N**

This equipment is fed from more than one  
power source with separate disconnects.

Disconnect all power sources before servicing.

### 3.10 IDENTIFICATION OF HARDWARE AND WIRING

- .1 All wiring and cabling, including that within factory fabricated panels, shall be labelled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- .2 All pneumatic tubing shall be labelled at each end within 5 cm (2 in.) of termination with a descriptive identifier.
- .3 Permanently label or code each point of field terminal strips to show the instrument or item served.
- .4 Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- .5 Identify all other control components with permanent labels. All plug-in components shall be labelled such that removal of the component does not remove the label.
- .6 Identify room sensors relating to terminal box or valves with nameplates.
- .7 Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
- .8 Identifiers shall match record documents.

### **3.11 CONTROLLERS**

- .1 Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- .2 Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.
- .3 Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional controller boards or point modules shall be required to implement use of these spare points.

### **3.12 PROGRAMMING**

- .1 Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.
- .2 Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.
- .3 Software Programming:
  - .1 Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation.
- .4 Operator Interface:
  - .1 Standard graphics: Provide graphics for all mechanical systems identified. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.
  - .2 Show terminal equipment information on a “graphic” summary table. Provide dynamic information for each point shown.
  - .3 The contractor shall provide all the labour necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.

### **3.13 CONTROL SYSTEM CHECKOUT AND TESTING**

- .1 Start-up Testing: All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Consultant is notified of the system demonstration.
  - .1 The contractor shall furnish all labour and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
  - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
  - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
  - .4 Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
  - .5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
  - .6 Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.
  - .7 Alarms and Interlocks:
    - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
- .2 Testing and balancing shall also be performed in accordance with Section 23 05 93 – Testing, Adjusting and Balancing for HVAC Systems.

### **3.14 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE**

- .1 Refer to Section 23 05 01 – Common Work Results for Mechanical, for commissioning details and requirements.

### **3.15 CLEANING**

- .1 The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

- .2 At the completion of Work in any area, the contractor shall clean all Work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- .3 At the completion of Work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

### **3.16 TRAINING**

- .1 Provide training sessions for building personnel.
- .2 Train the designated staff of the building to enable them to do the following:
  - .1 Day-to-day Operators:
    - .1 Proficiently operate the system
    - .2 Understand system operation, including DDC system control and optimizing routines (algorithms)
    - .3 Operate the workstation and peripherals
    - .4 Log on and off the system
    - .5 Access graphics, point reports, and logs
    - .6 Adjust and change system set points, time schedules, and holiday schedules
    - .7 Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
    - .8 Understand system drawings and Operation and Maintenance manual
    - .9 Understand the job layout and location of control components
    - .10 Access data from DDC controllers and ASCs
  - .3 Provide course outline and materials. The instructor(s) shall provide one copy of training material per student.
  - .4 The instructor(s) shall be factory-trained instructors experienced in presenting this material.
  - .5 One 8 hour training session or 2 x 4 hour training sessions are required.
  - .6 **Provide a follow up training sessions 6 months after the first training session as described above.**

### **3.17 DDC CONTROLS SEQUENCES OF OPERATION**

- .1 General:
  - .1 Controls contractor shall enter/confirm the base schedule of the buildings occupied times into the DDC control system and shall train designated building personnel with the new system controls.
  - .2 DDC software to have capability for trained personnel to change scheduled occupancy times as required and to schedule special events mode into the DDC control system.

- .3 Controls contractor shall meet with mechanical engineer and go over the sequence of operations prior to submitting shop drawings. Make changes to sequences where required as directed by the engineer.
  - .1 Refer to drawings for control sequences of operation.

**3.18 PREDICTIVE MAINTENANCE & AUTOMATED ENERGY OPTIMIZATION**

- .1 Provide predictive maintenance and automated energy optimization algorithms within the control system software to achieve performance enhancements.

**END OF SECTION**



## **PART 1        General**

### **1.1            REFERENCE STANDARDS**

- .1 American Society of Mechanical Engineers International (ASME)
  - .1 ASME BPVC, Boiler and Pressure Vessel Code.
  - .2 ASME BPVC Section VII, Recommended Guidelines for the Care of Power Boilers.
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM A47, Standard Specification for Ferritic Malleable Iron Castings.
  - .2 ASTM A278, Standard Specification for Grey Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (350°C).
  - .3 ASTM A516, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower - Temperature Service.
  - .4 ASTM A536, Standard Specification for Ductile Iron Castings.
  - .5 ASTM B62, Standard Specification for Composition Bronze or Ounce Metal Castings.

### **1.2            ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for expansion tanks, air vents, separators, valves, and strainers and include product characteristics, performance criteria, physical size, finish and limitations.

### **1.3            CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic specialties for incorporation into manual.

### **1.4            DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 60 00 – Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

## **PART 2        Products**

### **2.1            AUTOMATIC AIR VENT**

- .1 Standard float vent: brass body and NPS 3.18 mm (1/8”) connection and rated at 690 kPa working pressure.

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

## **2.2 PIPE LINE STRAINER**

- .1 NPS 12.7 mm (1/2") to 50 mm (2"): bronze body to ASTM B62, screwed connections, Y pattern.
- .2 NPS 63 mm (2 1/2") to 300 mm (12"): flanged, cast iron body to ASTM A278/A278M, Class 30 connections.
- .3 Blowdown connection: NPS 25 mm (1").
- .4 Screen: stainless steel with 1.19mm perforations.
- .5 Working pressure: 860 kPa.

## **PART 3 Execution**

### **3.1 EXAMINATION**

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

### **3.2 APPLICATION**

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

### **3.3 GENERAL**

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

### **3.4 STRAINERS**

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

**3.5 AIR VENTS**

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

**3.6 EXPANSION TANKS**

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

**3.7 PRESSURE SAFETY RELIEF VALVES**

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

**3.8 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**

**PART 1 General**

**1.1 REFERENCE STANDARDS**

- .1 American Society Heating Refrigeration Air-Conditioning Engineers (ASHRAE)
  - .1 ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 Electrical Equipment Manufacturers Association of Canada (EEMAC)
- .3 National Electrical Manufacturers' Association (NEMA)
  - .1 NEMA MG 1, Motors and Generators.
- .4 CSA Group
  - .1 CSA B214, Installation Code for Hydronic Heating System

**1.2 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for pump, circulator, and equipment and include product characteristics, performance criteria, physical size, finish and limitations indicate point of operation, and final location in field assembly.
- .3 Shop Drawings:
  - .1 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.

**1.3 CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic pumps for incorporation into manual.

**1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 60 00 – Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

**PART 2      Products**

**2.1            EQUIPMENT**

- .1      Size and select components to: CSA B214.

**2.2            INLINE CLOSE-COUPLED CIRCULATOR (P-1 & P-2)**

- .1      General:
  - .1      Flange mounted, horizontal, system lubricated type.
  - .2      The pumps shall be close-coupled, inline for vertical or horizontal installation, in cast iron bronze fitted (or all bronze) construction specifically designed for quiet operation. Suitable standard operations at 120 C (250°F) and 1207 kPa (175 PSIG) working pressure. The pump internals shall be capable of being serviced without disturbing piping connections.
  - .3      As an option, an EPR/Graphite loaded Silicon-Carbide/Graphite loaded Silicon-Carbide or FKM/Carbon/Silicon-Carbide seal (108C (225°F) maximum operating temperature) should be used in lieu of the standard EPR/Carbon/Silicon-Carbide seal (122C (250°F) maximum operating temperature).
  - .4      The pumps shall have a solid stainless steel shaft that is integral to the motor.
  - .5      The motor bearings shall support the shaft via heavy-duty permanently lubricated ball bearings.
  - .6      Pump shall be equipped with an internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Seal assembly shall be the unitized type with stainless steel drive tabs, EPR bellows and seat gasket, stainless steel spring, and be of a carbon silicon-carbide design with the carbon face rotating against a stationary silicon-carbide face.
  - .7      Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, threaded onto the motor shaft.
  - .8      Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
  - .9      Pump volute shall be of a cast iron design for heating systems or cast brass for domestic water systems. The connection style on the cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.
  - .10     Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have permanently lubricated ball bearings sized to offset the additional bearing loads associated with the closed-coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
  - .11     Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.
  - .12     Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.
  - .13     Pump manufacturer shall be ISO-9001 certified.
  - .14     Each pump shall be factory tested and name-plated before shipment.

**2.3 AHU-1 CIRCULATOR PUMP (P-4)**

- .1 General:
  - .1 Capacity: as Scheduled
  - .2 The pump shall be of the horizontal, system lubricated type specifically designed and guaranteed for quiet operation.
  - .3 Pumps to be suitable for 107°C (225°F) operation at 10.3 Bar (150 psig) working pressure.
  - .4 The pump shall have a ceramic shaft supported by carbon bearings. Bearings are to be lubricated by the circulating fluid.
  - .5 Motor stator to be isolated from circulating fluid through use of stainless steel can. Rotor to be sheathed in stainless steel.
  - .6 Motors shall be non-overloading at any point on the pump curve. NRF-25 motors to have built-in impedance protection.
  - .7 NRF-25 is available with 3-speed, thermally protected motor covering a wide range of hydraulic capabilities.
  - .8 The pump manufacturer shall be ISO-9001 certified.

**PART 3 Execution**

**3.1 EXAMINATION**

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

**3.2 APPLICATION**

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

**3.3 INSTALLATION**

- .1 Install hydronic pumps to: CSA B214.
- .2 In line circulators: install as indicated by flow arrows.
  - .1 Support at inlet and outlet flanges or unions.
  - .2 Install with bearing lubrication points accessible.
- .3 Ensure that pump body does not support piping or equipment.
  - .1 Provide stanchions or hangers for this purpose.
  - .2 Refer to manufacturer's installation instructions for details.

- .4 Pipe drain tapping to floor drain.
- .5 Install volute venting pet cock in accessible location.
- .6 Check rotation prior to start-up.
- .7 Install pressure gauge test cocks.
- .8 Install with:
  - .1 Isolation valves on inlet and outlet.
  - .2 Strainer on inlet.
  - .3 Balancing valve on outlet.

### 3.4 **START-UP**

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

### **3.5 PERFORMANCE VERIFICATION (PV)**

- .1 General:
  - .1 Verify performance in accordance with Section 01 91 13 – General Commissioning Requirements.
  - .2 Verify that manufacturer's performance curves are accurate.
  - .3 Ensure valves on pump suction and discharge provide tight shut-off.
  - .4 Net Positive Suction Head (NPSH):
    - .1 Application: measure NPSH for pumps which operate on open systems and with water at elevated temperatures.
    - .2 Measure using procedures prescribed in Section 01 91 13 – General Commissioning Requirements.
    - .3 Where procedures do not exist, discontinue PV, report to Consultant and await instructions.
  - .5 Multiple Pump Installations - Series and Parallel:
    - .1 Repeat PV procedures specified above for pump performance and pump BHP for combinations of pump operations.
  - .6 Mark points of design and actual performance at design conditions as finally set upon completion of TAB.
  - .7 Commissioning Reports: in accordance with Section 01 91 13 – General Commissioning Requirements. Reports to include:
    - .1 Record of points of actual performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.
    - .2 Use Report Forms specified in Section 01 91 13 – General Commissioning Requirements.
    - .3 Pump performance curves (family of curves).

### **3.6 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**



**Part 1            General**

**1.1                REFERENCES**

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM A480, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
  - .2 ASTM A635, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
  - .3 ASTM A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- .3 Green Seal Environmental Standards (GS)
  - .1 GS-36-11, Standard for Adhesives for Commercial Use.
- .4 National Fire Protection Association (NFPA)
  - .1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
  - .2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .5 Sheet Metal Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2005.
  - .2 SMACNA HVAC Air Duct Leakage Test Manual, 2012.
  - .3 SMACNA IAQ Guideline for Occupied Buildings Under Construction, 2007.

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for metal ducts and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Test and Evaluation Reports:
  - .1 Certification of Ratings:
    - .1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

**1.3                DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 60 00 – Product Requirements.

- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

## **Part 2 Products**

### **2.1 DUCTWORK**

- .1 Construction: round.
  - .1 Ducts: factory fabricated, spiral wound, with matching fittings and specials to SMACNA.
  - .2 Transverse joints up to 900 mm: slip type with tape and sealants.
  - .3 Transverse joints over 900 mm: Vanstone.
  - .4 Fittings:
    - .1 Elbows: smooth radius. Centreline radius: 2.5 x diameter.
    - .2 Branches: conical transition with conical branch at 45 degrees and 45 degrees elbow.
- .2 Fire stopping:
  - .1 50 x 50 x 3 mm retaining angles around duct, on both sides of fire separation.
  - .2 Fire stopping material must not distort duct.

### **2.2 SEAL CLASSIFICATION**

- .1 Classification as follows:

Maximum Pressure (Pa)	SMACNA Seal Class
500	C
250	C
125	C
125	Unsealed

- .2 Seal classification:
  - .1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.
  - .2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant or tape or combination thereof.
  - .3 Class C: transverse joints and connections made air tight with gaskets or sealant or tape or combination thereof. Longitudinal seams unsealed.
  - .4 Unsealed seams and joints.

### **2.3 SEALANT**

- .1 Sealant: oil resistant, water borne, polymer type flame resistant duct sealant. Temperature range of minus -30°C to plus 93°C.

## **2.4 TAPE**

- .1 Tape: polyvinyl treated, open weave fibre glass, 50mm wide.

## **2.5 DUCT LEAKAGE**

- .1 In accordance with SMACNA HVAC Air Duct Leakage Test Manual.

## **2.6 FITTINGS**

- .1 Fabrication: to SMACNA.
- .2 Radiused elbows:
  - .1 Rectangular: centreline radius 1.5 times width of duct.
  - .2 Round: centreline radius 1.5 times diameter.
- .3 Mitred elbows, rectangular:
  - .1 To 400mm: with single thickness turning vanes.
  - .2 Over 400mm: with double thickness turning vanes.
- .4 Branches:
  - .1 Rectangular main and branch: with 45 degrees entry on branch.
  - .2 Round main and branch: enter main duct at 45 degrees with conical connection.
  - .3 Provide volume control damper in branch duct near connection to main duct.
  - .4 Main duct branches: with splitter damper.
- .5 Transitions:
  - .1 Diverging: 20 degrees maximum included angle.
  - .2 Converging: 30 degrees maximum included angle.
- .6 Offsets:
  - .1 Full radiused elbows.
- .7 Obstruction deflectors: maintain full cross-sectional area.
  - .1 Maximum included angles: as for transitions.

## **2.7 FIRE STOPPING**

- .1 Retaining angles around duct, on both sides of fire separation in accordance with Section 07 84 00 – Fire Stopping.
- .2 Fire stopping material and installation must not distort duct.

## **2.8 GALVANIZED STEEL**

- .1 Lock forming quality: to ASTM A653, Z90 zinc coating.
- .2 Thickness, fabrication and reinforcement: to SMACNA.
- .3 Joints: to SMACNA.

## 2.9 ALUMINUM

- .1 To SMACNA.
- .2 Aluminum type: 3003-H-14.
- .3 Thickness, fabrication and reinforcement: to SMACNA.
- .4 Fittings: smooth radius.
- .5 Joints: to SMACNA.

## 2.10 HANGERS AND SUPPORTS

- .1 Hangers and Supports: in accordance with Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment.
  - .1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
    - .1 Maximum size duct supported by strap hanger: 500mm.
  - .2 Hanger configuration: to SMACNA. Hangers: galvanized steel angle with galvanized steel rods to SMACNA following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10
  - .3 Upper hanger attachments:
    - .1 For concrete: manufactured concrete inserts.
    - .2 For steel joist: manufactured joist clamp or steel plate washer.
    - .3 For steel beams: manufactured beam clamps

## Part 3 Execution

### 3.1 EXAMINATION

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

### 3.2 GENERAL

- .1 Do work in accordance SMACNA.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.

- .1 Insulate strap hangers 100mm beyond insulated duct.
- .2 Ensure diffuser is fully seated.
- .3 Support risers in accordance with SMACNA.
- .4 Install breakaway joints in ductwork on sides of fire separation.
- .5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.
- .6 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

### 3.3 HANGERS

- .1 Strap hangers: install in accordance with SMACNA.
- .2 Angle hangers: complete with locking nuts and washers.
- .3 Hanger spacing: in accordance with SMACNA as follows:

Duct Size (mm)	Spacing (mm)
to 1500	3000
1501 and over	2500

### 3.4 SEALING AND TAPING

- .1 Apply sealant in accordance with SMACNA.
- .2 Bed tape in sealant and recoat with minimum of one coat of sealant to manufacturer's recommendations.

### 3.5 WATERTIGHT DUCT

- .1 Provide watertight duct for:
  - .1 Fresh air intake.
  - .2 As indicated.
- .2 Form bottom of horizontal duct without longitudinal seams.
  - .1 Weld or solder joints of bottom and side sheets.
  - .2 Seal other joints with duct sealer.
- .3 Slope horizontal branch ductwork down towards fume hoods served.
  - .1 Slope header ducts down toward risers.
- .4 Fit base of riser with 150mm deep drain sump and 32mm drain connected, with deep seal trap, valve, trap primer and discharging to open funnel drain.

### 3.6 SEALING AND TAPING

- .1 Apply sealant following manufacturer's installation requirements and SMACNA recommendations.

- .2 Apply sealant at temperatures with acceptable range as indicated in the manufacturer's installation details.
- .3 Concealed ducts and ducts not exposed to view: apply as recommended by manufacturer.
- .4 Where duct work is to be exposed within space and as directed by Consultant, apply sealant in neat and tidy manner as follows:
  - .1 Sealant to be applied such that neat, straight lines are formed on either side of joint. Mask areas with tape or other means to provide overrun and untidy application of sealant.
  - .2 Apply sealant in uniform thickness with even and straight brush strokes.
  - .3 Alternatively, sealant may be applied to the internal mating surfaces of fittings prior to connection such that exposed sealant is minimized. Obtain approval from Consultant prior to using this application technique.

### **3.7 LEAKAGE TESTS**

- .1 In accordance with SMACNA HVAC Duct Leakage Test Manual.
- .2 Perform leakage tests in sections.
- .3 Perform trial leakage tests, as instructed to demonstrate quality of work.
- .4 Do not install additional ductwork until trial tests have been achieved.
- .5 Test section minimum of 30 m long with not less than 3 branch takeoffs and two 90 degrees elbows.
- .6 Complete tests before performing insulation or concealment Work.

### **3.8 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCES**

- .1    Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
  - .1        SMACNA HVAC Duct Construction Standards - Metal and Flexible.

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1    Submittals in accordance with Section 01 33 00 – Submittal Procedures.
- .2    Product Data:
  - .1        Submit manufacturer's printed product literature, specifications and data sheet. Indicate the following:
    - .1           Flexible connections.
    - .2           Duct access doors.
    - .3           Turning vanes.
    - .4           Instrument test ports.
- .3    Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
  - .1        Certification of ratings: catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- .4    Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5    Instructions: submit manufacturer's installation instructions.
- .6    Manufacturer's Field Reports: manufacturer's field reports specified.
- .7    Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

**1.3                DELIVERY, STORAGE AND HANDLING**

- .1    Deliver, store and handle materials in accordance with manufacturer's written instructions
- .2    Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3    Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

**Part 2            Products**

**2.1                GENERAL**

- .1    Manufacture in accordance with SMACNA.

## **2.2 FLEXIBLE CONNECTIONS**

- .1 Frame: galvanized sheet metal frame with fabric clenched by means of double locked seams.
- .2 Material:
  - .1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40°C to plus 90°C, density of 1.3 kg/m<sup>2</sup>.

## **2.3 ACCESS DOORS IN DUCTS**

- .1 Non-Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.
- .2 Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25mm thick rigid glass fibre insulation.
- .3 Gaskets: neoprene.
- .4 Hardware:
  - .1 Up to 300 x 300mm: two sash locks.
  - .2 301 to 450mm: four sash locks.
  - .3 451 to 1000mm: piano hinge and minimum two sash locks.
  - .4 Hold open devices.

## **2.4 TURNING VANES**

- .1 Factory or shop fabricated double thickness with trailing edge, to recommendations of SMACNA and as indicated.

## **2.5 INSTRUMENT TEST**

- .1 1.6mm thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28mm minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.

## **2.6 SPIN-IN COLLARS**

- .1 Conical galvanized sheet metal spin-in collars with lockable butterfly damper.
- .2 Sheet metal thickness to co-responding round duct standards.

## **Part 3 Execution**

### **3.1 MANUFACTURER'S INSTRUCTIONS**

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



### 3.2 INSTALLATION

- .1 Flexible Connections:
  - .1 Install in following locations:
    - .1 Inlets and outlets to supply air units and fans.
    - .2 Inlets and outlets of exhaust and return air fans.
    - .3 As indicated.
  - .2 Length of connection: 100mm.
  - .3 Minimum distance between metal parts when system in operation: 75 mm.
  - .4 Install in accordance with recommendations of SMACNA.
  - .5 When fan is running:
    - .1 Ducting on sides of flexible connection to be in alignment.
    - .2 Ensure slack material in flexible connection.
- .2 Access Doors and Viewing Panels:
  - .1 Size:
    - .1 As indicated.
  - .2 Locations:
    - .1 Fire and smoke dampers.
    - .2 Control dampers.
    - .3 Devices requiring maintenance.
    - .4 Required by code.
    - .5 Elsewhere as indicated.
- .3 Instrument Test Ports:
  - .1 General:
    - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
  - .2 Locate to permit easy manipulation of instruments.
  - .3 Install insulation port extensions as required.
  - .4 Locations:
    - .1 For traverse readings:
      - .1 Ducted inlets to roof and wall exhausters.
      - .2 Inlets and outlets of other fan systems.
      - .3 Main and sub-main ducts.
      - .4 And as indicated.
    - .2 For temperature readings:
      - .1 At outside air intakes.
      - .2 At inlet and outlet of coils.
      - .3 And as indicated.
- .4 Turning vanes:

- .1 Install in accordance with recommendations of SMACNA and as indicated.

### **3.3 CLEANING**

- .1 Perform cleaning operations in accordance with manufacturer's recommendations.
- .2 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

**END OF SECTION**

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**Part 1            General**

**1.1                REFERENCES**

- .1 American Movement and Control Association International (AMCA)
- .2 Sheet Metal and Air Conditioning National Association (SMACNA)
  - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for dampers and include product characteristics, performance criteria, physical size, finish and limitations.

**1.3                CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for dampers for incorporation into manual.

**1.4                DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

**Part 2            Products**

**2.1                GENERAL**

- .1 Manufacture to SMACNA standards.

**2.2                BACK DRAFT DAMPERS**

- .1 Automatic gravity operated, multi leaf, aluminum construction with nylon bearings, as indicated.

**2.3                INSULATED MOTORIZED DAMPERS**

- .1 Dampers shall be parallel blade action.
- .2 Operator: in accordance with Section 23 09 33 – Electric and Electronic Control System for HVAC.

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- .3 Extruded aluminum (6063-T5) damper frame shall not be less than 2mm in thickness. Damper frame shall be 200mm deep x 25mm, with duct mounting flanges on both sides of frame. Damper frame shall have a 50mm mounting flange on the rear of the damper, when installed as Extended Rear Flange install type. Frame to be assembled using zinc-plated steel mounting fasteners.
- .4 Blades shall be maximum 160mm deep extruded aluminum (6063-T5) air-foil profiles with a minimum wall thickness of 1.5mm. Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
- .5 Blade seals shall be extruded EPDM, secured in an integral slot within the aluminum blade extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals will not be approved.
- .6 Frame seals shall be extruded silicone, secured in an integral slot within the aluminum frame extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Metallic compression type jamb seals will not be approved.
- .7 Bearings shall be a dual bearing system composed of a Celcon inner bearing (fixed around a 11mm aluminum hexagon blade pivot pin), rotating within a polycarbonate outer bearing inserted in the frame. Single axle bearing, rotating in an extruded or punched hole shall not be acceptable.
- .8 Hexagonal control shaft shall be 11mm. It shall have an adjustable length and shall be an integral part of the blade axle. A field-applied control shaft shall not be acceptable. All parts shall be zinc-plated steel.
- .9 Linkage hardware shall be aluminum and corrosion-resistant zinc-plated steel, installed in the frame side, out of the airstream, and accessible after installation. Linkage hardware shall be complete with cup-point trunnion screws to prevent linkage slippage. Linkage that consists of metal rubbing metal will not be approved.
- .10 Dampers shall be designed for operation in temperatures ranging from -40°C to 100°C.
- .11 Dampers shall be AMCA rated for Leakage Class 1A at 250 Pa static pressure differential. Standard air leakage data to be certified under the AMCA Certified Ratings Program.
- .12 Dampers shall be custom made to required size, with blade stops not exceeding 31.75mm in height.
- .13 Dampers mounting type: Flanged to Duct.
- .14 Installation of dampers must be in accordance with manufacturers current installation guidelines, provided with each damper shipment.
- .15 Intermediate or tubular steel structural support is required to resist applied pressure loads for dampers that consist of two or more sections in both height and width.

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**Part 3 Execution**

**3.1 EXAMINATION**

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

**3.2 MANUFACTURER'S INSTRUCTIONS**

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

**3.3 INSTALLATION**

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .3 Seal multiple damper modules with silicone sealant.
- .4 Install access door adjacent to each damper. Refer to Section 23 33 00 – Air Duct Accessories.
- .5 Dampers: install vibration free.
- .6 Operators: install outside of air stream.
- .7 Ensure damper operators are observable and accessible.

**3.4 CLEANING**

- .1 Clean in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**

**PART 1      General**

**1.1          REFERENCE STANDARDS**

- .1      Air Movement and Control Association (AMCA)
  - .1          AMCA 99, Standards Handbook.
  - .2          AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
  - .3          AMCA 300, Reverberant Room Method for Sound Testing of Fans.
  - .4          AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .2      The Master Painters Institute (MPI)
  - .1          Architectural Painting Specification Manual - current edition.
    - .1              MPI #18, Primer, Zinc Rich, Organic.

**1.2          ACTION AND INFORMATIONAL SUBMITTALS**

- .1      Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2      Product Data:
  - .1          Submit manufacturer's instructions, printed product literature and data sheets for HVAC fans and include product characteristics, performance criteria, physical size, finish and limitations.
- .3      Shop Drawings:
  - .1          Provide:
    - .1              Fan performance curves showing point of operation, bhp and efficiency.
    - .2              Sound rating data at point of operation.
  - .2          Indicate:
    - .1              Motors, sheaves, bearings, shaft details.
    - .2              Minimum performance achievable with variable speed controllers.

**1.3          MAINTENANCE MATERIAL SUBMITTALS**

- .1      Extra Materials:
  - .1          Submit in accordance with Section 01 78 00 – Closeout Submittals.
    - .1              Provide:
      - .1                  Matched sets of belts for belt driven fans.
      - .2                  Furnish list of individual manufacturer's recommended spare parts for equipment, include:
        - .1                      Bearings and seals.
        - .2                      Addresses of suppliers.
        - .3                      List of specialized tools necessary for adjusting, repairing or replacing.

#### **1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 60 00 – Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

### **PART 2 Products**

#### **2.1 SYSTEM DESCRIPTION**

- .1 Performance Requirements:
  - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.
  - .2 Capacity: flow rate, total static pressure, bhp, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
  - .3 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.
  - .4 Sound ratings: comply with AMCA 301, tested to AMCA 300. Supply unit with AMCA certified sound rating seal.
  - .5 Performance ratings: based on tests performed in accordance with AMCA 210. Supply unit with AMCA certified rating seal, except for propeller fans smaller than 300mm diameter.

#### **2.2 FANS GENERAL**

- .1 Motors:
  - .1 In accordance with Section 23 05 13 – Common Motors Requirements for HVAC Equipment supplemented as specified herein.
  - .2 For use with variable speed controllers.
  - .3 Sizes as indicated.
- .2 Accessories and hardware: matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards, fan inlet and outlet safety screens as indicated and as specified in Section 23 05 13 – Common Motor Requirements for HVAC Equipment, inlet and outlet dampers and vanes and as indicated.
- .3 Factory primed before assembly in colour standard to manufacturer.
- .4 Scroll casing drains: as indicated.
- .5 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.
- .6 Vibration isolation: to Section 23 05 48 – Vibration and Seismic Controls for HVAC.

- .7 Flexible connections: to Section 23 33 00 – Air Duct Accessories.

### **2.3 CABINET FANS - GENERAL PURPOSE**

- .1 Fan characteristics and construction: as centrifugal fans.
- .2 Cabinet hung, single or multiple wheel with DWDI centrifugal fans in factory fabricated casing complete with vibration isolators and seismic control measures, variable speed motor, direct drive.
- .3 Fabricate casing of zinc coated or phosphate treated steel of 1.2 mm thickness, reinforced and braced for rigidity. Provide removable panels for access to interior. Paint uncoated, steel parts with corrosion resistant paint to MPI #18. Internally line cabinet with 50 kg/m<sup>3</sup> density insulation.
- .4 With aluminum grille with non-yellowing white finish.

### **2.4 INLINE CABINET FAN**

- .1 Fan characteristics and construction: as centrifugal fans.
- .2 Cabinet hung, single fans in factory fabricated casing complete with vibration isolators and seismic control measures, motor, variable speed, direct drive. Fan wheel mounted perpendicular to direction of airflow. Cabinet design shall incorporate square inlet and outlet connections of the same size.
- .3 Fabricate casing of zinc coated or phosphate treated steel of 1.2 mm thickness, reinforced and braced for rigidity. Provide removable panels for access to interior. Paint uncoated, steel parts with corrosion resistant paint to MPI #18. Internally line cabinet with 50 kg/m<sup>3</sup> density insulation.

## **PART 3 Execution**

### **3.1 EXAMINATION**

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

### **3.2 FAN INSTALLATION**

- .1 Install fans as indicated, complete with resilient mountings specified in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment, flexible electrical leads and flexible connections in accordance with Section 23 33 00 – Air Duct Accessories.
- .2 Provide sheaves and belts required for final air balance.
- .3 Bearings and extension tubes to be easily accessible.



- .4 Access doors and access panels to be easily accessible.

### **3.3 ANCHOR BOLTS AND TEMPLATES**

- .1 Size anchor bolts to withstand seismic acceleration and velocity forces as specified.

### **3.4 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCES**

- .1        American Boiler Manufacturers Association (ABMA)
- .2        ASME
  - .1        ASME Boiler and Pressure Vessel Code (BPVC), Section VII.
- .3        CSA Group
  - .1        CAN1-3.1, Industrial and Commercial Gas-Fired Package Boilers.
  - .2        CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
  - .3        CSA B149.1, Natural Gas and Propane Installation Code.
  - .4        ANSI Z21.13/CSA 4.9, Gas-Fired Low-Pressure Steam and Hot Water Boilers.
- .4        Electrical and Electronic Manufacturers Association of Canada (EEMAC)

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1        Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2        Product Data:
  - .1        Submit manufacturer's instructions, printed product literature and data sheets for heating boilers and include product characteristics, performance criteria, physical size, finish and limitations.
- .3        Shop Drawings:
  - .1        Indicate on drawings:
    - .1        General arrangement showing terminal points, instrumentation test connections.
    - .2        Clearances for operation, maintenance, servicing, tube cleaning, tube replacement.
    - .3        Foundations with loadings, anchor bolt arrangements.
    - .4        Piping hook-ups.
    - .5        Equipment electrical drawings.
    - .6        Burners and controls.
    - .7        All miscellaneous equipment.
    - .8        Flame safety control system.
    - .9        Breeching and stack configuration.
  - .2        Engineering data to include:
    - .1        Boiler efficiency at 25%, 50%, 75%, and 100% of design capacity.
    - .2        Radiant heat loss at 100% design capacity.
- .4        Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

### **1.3 CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for heating boilers for incorporation into manual.

### **1.4 QUALITY ASSURANCE**

- .1 Regulatory Requirements: Work to be performed in compliance with provincial regulations.
- .2 Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- .3 ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- .4 "ASHRAE/IESNA 90.1 Compliance" Paragraph may be required to comply with Project requirements or authorities having jurisdiction.
- .5 ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- .6 Delete first paragraph below if boiler rating exceeds 300,000 Btu/h (87.9 kW).
- .7 AHRI Compliance: Boilers shall be AHRI listed and must meet the minimum efficiency specified under AHRI BTS-2000 as defined by Department of Energy in 10 CFR Part 431.
- .8 ANSI Compliance: Boilers shall be compliant with ANSI Z21.13 test standards for US and Canada.
- .9 CSA Compliant: Boilers shall be compliant with CSA certification.

### **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- .1 Extra materials:
  - .1 Submit maintenance materials in accordance with Section 01 78 00 – Closeout Submittals.
    - .1 Special tools for burners, access opening, handholes and Operation and Maintenance.
    - .2 Spare parts for 1 year of operation.
    - .3 Spare gaskets.
    - .4 Spare gauge glass inserts.
    - .5 Probes and sealants for electronic indication.
    - .6 Spare burner tips.
    - .7 Spare burner gun.
    - .8 Safety valve test gauge.

## **1.6 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with Section 01 60 00 – Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
  - .1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
  - .2 Store and protect boiler and equipment from damages.
  - .3 Replace defective or damaged materials with new.

## **Part 2 Products**

### **2.1 SPACE HEATING BOILERS, B-1 & B-2:**

- .1 Description: Boiler shall be natural gas fired, fully condensing, and fire tube design. The boiler shall be factory-fabricated, factory-assembled, and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
- .2 Heat Exchanger: The heater exchanger shall bear the ASME “H” stamp for 1104 kPa (160 psi) working pressure and shall be National Board listed. The heat exchanger shall be constructed of a fully welded 316L stainless steel and of fire tube design. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. Cast iron, aluminum, or condensing copper tube boilers will not be accepted.
- .3 Efficiency: Boilers shall have an AHRI certified minimum thermal efficiency of 97 percent.
- .4 Condensate Collection Basin: Fully welded 316L stainless steel and shall include a stainless steel combustion analyzer test port.
- .5 Pressure Vessel: The pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The pressure vessel shall be designed for a single-pass water flow to limit the water side pressure drop.
- .6 Burner: Natural gas, forced draft single burner premix design. The burner shall be high temperature stainless steel with a woven FeCrAlloy outer covering to provide modulating firing rates. The burner shall be capable of the stated gas train turndown without loss of combustion efficiency.
- .7 Blower: Boiler shall be equipped with a pulse width modulating blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The burner firing sequence of operation shall include pre-purge, firing, modulation, and post-purge operation.
- .8 Motor characteristics such as NEMA designation, temperature rating, service factor, enclosure type, and efficiency are specified in Division 23 Section

"Common Motor Requirements for HVAC Equipment." If different characteristics are required, add subparagraphs below to suit Project.

- .9 Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
- .10 High Altitude: Boiler shall operate at altitudes up to 1372 meters (4,500 feet) above sea level without additional parts or adjustments. High altitude operation shall be certified at a minimum of 1372 meters (4,500 feet) above sea level by a third party organization. High altitude boilers shall be certified to 915 meters (3,000 ft) to 3660 meters (12,000 feet) above sea level. The boilers shall carry a CSA certification for high altitude operation up to 3660 meters (12,000 feet).
- .11 Casing:
  - .1 Jacket: Heavy gauge primed and painted steel jacket with snap-in closures.
  - .2 Control Compartment Enclosures: NEMA 250, Type 1A.
  - .3 Insulation: Minimum 12.7 mm (½ inch) thick, mineral fiber insulation surrounding the heat exchanger.
  - .4 Combustion-Air Connections: Inlet and vent duct collars.
- .12 Characteristics and Capacities:
  - .1 Heating Medium: Hot water.
  - .2 Design Water Pressure Rating: 1100 kPa (160 psi) working pressure.
  - .3 Safety Relief Valve Setting: 345 kPa (50 psig)
- .13 TRIM
  - .1 Safety Relief Valve:
    - .1 Size and Capacity: 345 kPa (50 psig).
    - .2 Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
  - .2 Pressure Gage: Minimum 89 mm (3-1/2 inch) diameter. Gage shall have normal operating pressure about 50 percent of full range.
  - .3 Drain Valves: Minimum NPS 19 mm (3/4") or nozzle size with hose-end connection.
  - .4 Condensate Neutralization Kit: Factory supplied condensate trap with condensate trip sensor, high capacity condensate receiver prefilled with appropriate medium.
- .14 CONTROLS
  - .1 Boiler controls shall feature a standard, factory installed multi-color graphic LCD screen display with navigation dial and includes the following standard features:
    - .1 Con-X-U's capable: Boiler shall have the ability to communicate remotely using the optional Con-X-U's software via a wireless or Ethernet connection.
    - .2 Variable Speed Boiler Pump Control: Boiler may be programmed to send a 0-10V DC output signal to an ECM or VFD boiler pump to maintain a designed temperature rise across

- the heat exchanger. The boiler shall be able to operate in this mode with a minimum temperature rise of 11.1 C (20 degrees F) and a maximum temperature rise of 33.4 C (60 degrees F).
- .3 Password Security: Boiler shall have a different password security code for the User and the Installer to access adjustable parameters.
  - .4 Outdoor air reset: Boiler shall calculate the set point using a field installed, factory supplied outdoor sensor and an adjustable reset curve.
  - .5 Pump exercise: Boiler shall energize any pump it controls for an adjustable time if the associated pump has been off for a time period of 24 hours.
  - .6 Four pump control: Boiler shall have the ability to control the boiler pump, a system pump, a domestic hot water pump, and a domestic hot water recirculation pump.
  - .7 Ramp delay: Boiler may be programmed to limit the firing rate based on six limits steps and six time intervals.
  - .8 Boost function: Boiler may be programmed to automatically increase the set point a fixed number of degrees (adjustable by installer) if the setpoint has been continuously active for a set period of time (time adjustable by installer). This process will continue until the space heating demand ends.
  - .9 Domestic hot water priority: Boiler shall make the domestic hot water call for heat a priority over any space heating call and adjust the boiler setpoint to the domestic hot water boiler setpoint.
  - .10 Domestic hot water modulation limiting: Boiler may be programmed to limit the maximum domestic hot water firing rate to match the input rating of the indirect tank coil.
  - .11 Domestic hot water night setback: Boiler may be programmed to reduce the domestic hot water tank set point during a certain time of the day.
  - .12 PC port connection: Boiler shall have a PC port allowing the connection of PC boiler software.
  - .13 Time clock: Boiler shall have an internal time clock with the ability to time and date stamp lock-out codes and maintain records of runtime.
  - .14 Maintenance reminder: Boiler shall have the ability to display a yellow colored, customizable maintenance notification screen. All notifications are adjustable by the installer based upon months of installation, hours of operation, and number of boiler cycles.
  - .15 English Error codes: Boiler shall have a user interface that displays a red error screen with fault codes that are displayed in English and include a date and time stamp for ease of servicing.

- .16 Anti-cycling control: Boiler shall have the ability to set a time delay after a heating demand is satisfied allowing the boiler to block a new call for heat. The boiler will display an anti-cycling blocking on the screen until the time has elapsed or the water temperature drops below the anti-cycling differential parameter. The anti-cycling control parameter is adjustable by the installer.
- .17 Space Heating Night setback: Boiler may be programmed to reduce the space heating temperature set point during a certain time of the day.
- .18 Freeze protection: When the boiler water temperature falls below 2.8 C (37 degrees F) the boiler will automatically turn on. Boiler and pumps will turn off when the boiler water temperature rises above 6C (43 degrees F).
- .19 Isolation valve control: Boiler shall have the ability to control a 2-way motorized control valve. Boiler shall also be able to force a fixed number of valves to always be energized regardless of the number of boilers that are firing.
- .20 BMS integration with 0-10V DC input: The Control shall allow an option to Enable and control set point temperature or control firing rate by sending the boiler a 0-10V input signal.
- .21 Data logging: Boiler shall have non-volatile data logging memory including last 10 lockouts, space heat run hours, domestic hot water run hours and ignition attempts. All data should be visible on the boiler screen.
- .2 The boiler shall have a built in Cascade controller to sequence and rotate lead boiler to ensure equal runtime while maintaining modulation of up to 8 boilers of different inputs without utilization of an external controller. The factory installed, internal cascade controller shall include:
  - .1 Lead lag: The Control module shall allow only one boiler to fire at the beginning of a call for heat. Once the lead boiler is in full fire and the control calculates that additional heat is required it will call on an additional boiler as needed.
  - .2 Efficiency optimization: The Control module shall allow multiple boilers to simultaneously fire at minimum firing rate in lieu of Lead/Lag.
  - .3 Front end loading: The Control module shall allow the cascading and functional control of several non condensing Lochinvar products alongside the Knight FTXL.
  - .4 Rotation of lead boiler: The Control module shall change the lead boiler every hour for the first 24 hours after initializing the Cascade. Following that, the leader will be changed once every 24 hours.
- .3 Boiler operating controls shall include the following devices and features:

- .1 Set-Point Adjust: Set points shall be fully adjustable by the installer.
  - .2 Retain two subparagraphs below for steam boilers.
  - .3 Retain one of three subparagraphs below for operating control sequences. Retain one of first two subparagraphs for hot-water boilers; or third, for steam boilers.
  - .4 Sequence of Operation: Factory installed controller to modulate burner firing rate to maintain system water temperature in response to call for heat.
  - .5 Sequence of Operation: Boiler shall come standard with outdoor reset control which will control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At -12C (10 deg F) outside-air temperature, set supply-water temperature at 83C (180 deg F); at 16C (60 deg F) outside-air temperature, set supply-water temperature at 60C (140 deg F).
- .4 Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation and include:
- .1 High Temperature Limit: Automatic and manual reset stops burner if operating conditions rise above maximum boiler design temperature. Limit switch to be manually reset on the control interface.
  - .2 In first subparagraph below, retain first option for hot-water boilers and second option for steam boilers.
  - .3 Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manually reset on the control interface.
  - .4 Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
  - .5 High and Low Gas Pressure Switches: Pressure switches shall prevent burner operation on low or high gas pressure. Pressure switches to be manually reset on the control interface.
  - .6 Blocked Drain Switch: Blocked drain switch shall prevent burner operation when tripped. Switch to be manually reset on the control interface.
  - .7 Low air pressure switch: Pressure switches shall prevent burner operation on low air pressure. Switch to be manually reset on the control interface.
  - .8 Optional Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for any lockout conditions.
- .5 Building Automation System Interface:
- .1 Boiler shall have the ability to receive a 0-10V system from a building management system and control by the following:
    - .1 0-10V DC input to control Modulation or Setpoint



- .2 0-10V DC input from Variable speed Boiler pump
  - .3 0-10V DC output signal to a Variable speed system pump
  - .4 0-10V DC input Enable/Disable signal
- .2 Factory installed Modbus gateway interface to enable building automation system to monitor, control, and display boiler status and alarms.

.15 VENTING

- .1 Exhaust flue must be Category IV approved PVC, CPVC, PP or stainless steel sealed vent material from one of the approved manufacturers listed in the Installation and Operation manual. Boilers exhaust vent length must be able to extend to 100 equivalent feet.
- .2 Intake piping must be of approved material as listed in the Installation and Operations manual. Boilers intake pipe length must be able to extend to 30.5 equivalent meters (100 equivalent feet).
- .3 Boiler venting and intake piping configuration shall be installed per one of the approved venting methods shown in the Installation and Operation manual.
- .4 Boilers using common venting must only include like models and the optional common vent damper. Contact the factory for common vent sizing.
- .5 Boiler shall come standard with a flue sensor to monitor and display flue gas temperature on factory provided LCD display.
- .6 Refer to manufacturer's Installation and Operations manual for detailed venting instructions and approved manufacturers.

.16 SOURCE QUALITY CONTROL

- .1 Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- .2 Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

.17 ACCESSORIES (SHIPPED LOOSE)

- .1 Bolt Pack
- .2 100mm plate
- .3 Shutoff valve with tap
- .4 Temperature & Pressure Gauge
- .5 Outdoor Sensor
- .6 Relief Valve
- .7 13 mm PVC Tee
- .8 50x50x19 mm tee
- .9 100mm Termination base

- .10 100mm Termination Cap
- .11 100mm CPVC Flue Pipe
- .12 Additional Components: sensor & bulb well kit (Sensor kit tied to piping)

### **Part 3 Execution**

#### **3.1 EXAMINATION**

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for heating boiler installation in accordance with manufacturer's written instructions.
  - .1 Visually inspect substrate in presence of Contract Administrator.
  - .2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.
  - .3 Proceed with installation only after unacceptable conditions have been remedied.

#### **3.2 MANUFACTURER'S INSTRUCTIONS**

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

#### **3.3 INSTALLATION**

- .1 Install in accordance with ASME Boiler and Pressure Vessels Code, regulations of Province having jurisdiction, and manufacturer's recommendations.
- .2 Make required piping connections to inlets and outlets recommended by boiler manufacturer.
- .3 Maintain clearances as indicated or if not indicated, as recommended by manufacturer for operation, servicing and maintenance without disruption of operation of any other equipment/system.
- .4 Mount unit level.
- .5 Pipe hot water relief valves full size to nearest drain (or to makeup tank for glycol systems).
- .6 Natural gas fired installations: in accordance with CSA B149.1.

#### **3.4 MOUNTINGS AND ACCESSORIES**

- .1 Safety valves and relief valves:
  - .1 Run separate discharge from each valve.
  - .2 Terminate discharge pipe as indicated.
  - .3 Run drain pipe from each valve outlet and drip pan elbow to above nearest drain (or to makeup tank for glycol systems).

### **3.5 FIELD QUALITY CONTROL**

- .1 Commissioning:
  - .1 Manufacturer to:
    - .1 Certify installation.
    - .2 Start up and commission installation.
    - .3 Carry out on-site performance verification tests.
    - .4 Demonstrate operation and maintenance.
  - .2 Provide Contract Administrator at least 24 hours notice prior to inspections, tests, and demonstrations. Submit written report of inspections and test results.

### **3.6 CLEANING**

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 – Cleaning.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCES**

- .1 American Architectural Manufacturers Association (AAMA)
  - .1 AAMA 1503.1, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.
- .2 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE)
  - .1 ASHRAE 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
  - .2 ASHRAE 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
  - .3 ASHRAE 135, BACnet – A Data Communication Protocol for Building Automation and Control Networks.
- .3 Air-Conditioning, Heating and Refrigeration Institute (AHRI)
  - .1 AHRI 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
  - .2 AHRI 270, Sound Rating of Outdoor Unitary Equipment.
- .4 Air Movement and Control Association International (AMCA)
  - .1 AMCA 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
- .5 American Society for Testing and Materials International (ASTM)
  - .1 ASTM C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
  - .2 ASTM D570, Standard Test Method for Water Absorption of Plastics.
  - .3 ASTM D638, Standard Test Method for Tensile Properties of Plastics.
  - .4 ASTM D751, Standard Test Methods for Coated Fabrics.
  - .5 ASTM D1004, Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.
  - .6 ASTM D1204, Standard Test Method for Linear Dimensional Changes of Non-Rigid Thermoplastic Sheeting or Film at Elevated Temperature.
  - .7 ASTM D2135, Standard
  - .8 ASTM D2565, Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications.
  - .9 ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
  - .10 ASTM E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
  - .11 ASTM E108, Standard Test Methods for Fire Tests of Roof Coverings.
- .6 Canadian Standards Association International (CSA)
  - .1 CSA B52, Mechanical Refrigeration Code.
  - .2 CSA C22.1, Canadian Electrical Code, Part 1 (22nd Edition), Safety Standard for Electrical Installations.

- .3 CSA C746, Energy Performance Rating for Large and Single Packaged Vertical Air Conditioners and Heat Pumps.
- .7 Factory Mutual (FM)
- .8 National Fire Protection Association (NFPA)
  - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .9 Underwriters Laboratories of Canada (ULC)
  - .1 ULC 102, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

## **1.2 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data: submit manufacturer's instructions, printed product literature and data sheets for outdoor HVAC equipment and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop drawings to indicate project layout and dimensions; indicate:
  - .1 Equipment, piping, and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
  - .2 Piping, valves, fitting shipped loose showing final location in assembly.
  - .3 Control equipment.
  - .4 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
  - .5 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, controllers.
  - .6 Fan performance curves.
  - .7 Details of vibration isolation.
  - .8 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.
  - .9 Type of refrigerant used.

## **1.3 CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for outdoor HVAC equipment for incorporation into manual.
  - .1 Indicate: brief description of unit, indexed, with details of function, operation, control, and service for components.
  - .2 Provide for units, manufacturer's name, type, year, number of units, and capacity.

#### **1.4 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 52 00 – Construction Facilities.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

### **Part 2 Products**

#### **2.1 GENERAL (AHU-1)**

- .1 Certify ratings: to ANSI/AHRI 430 with AHRI seal.
- .2 Horizontal type, as indicated, having air tight modular components, consisting of casing, fan section with motor and drive, filter section, heating coil, direct expansion coil, mixing box.

#### **2.2 UNIT CONSTRUCTION**

- .1 Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.
- .2 Panels and access doors shall be constructed as a 50 mm (2 inch) nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.
  - .1 The inner liner shall be constructed of G90 galvanized steel.
  - .2 The outer panel shall be constructed of G90 galvanized steel.
  - .3 The floor plate shall be constructed as specified for the inner liner.
  - .4 Unit will be furnished with solid inner liners.
- .3 Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 125 mm (5 inches) of positive or 150 mm (6 inches) of negative static pressure. Deflection shall be measured at the panel midpoint.
- .4 The casing leakage rate shall not exceed 0.24 L/s (0.50 cfm) per square foot of casing surface area at design static pressure up to a maximum of +1.25 kPa (+5" w.c.) in positive pressure sections and -1.5 kPa (-6" w.c.) in negative pressure sections (.0025 m<sup>3</sup>/s per square meter of cabinet area at 1.24 kPa static pressure)
- .5 Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.
- .6 Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.
- .7 The unit base shall be provided by others.
- .8 Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection

centerline shall be a minimum of 75 mm (3'') above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 50 mm (2'') thickness of insulation under drain pan.

### **2.3 FAN ASSEMBLIES**

- .1 Acceptable fan assembly shall be a double width, double inlet, class I, belt-drive type housed forward curved fan dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes and at all bearing supports. Copper lubrication lines shall be provided and extend from the bearings and attached with grease fittings to the fan base assembly near access door. If not supplied at the factory, contractor shall mount copper lube lines in the field. Fan and motor shall be mounted internally on a steel base. Provide access to motor, drive, and bearings through hinged access door.
- .2 Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on rubber-in-shear vibration type isolators inside cabinetry.

### **2.4 BEARINGS, SHAFTS AND DRIVES**

- .1 Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be designed for service with an L-50 life of 200,000 hours and shall be a heavy duty pillow block, self-aligning, grease-lubricated ball or spherical roller bearing type.
- .2 Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.
- .3 V-Belt drives shall be cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Fixed sheaves, matched belts, and drive rated based on motor horsepower. Minimum of 2 belts shall be provided on all fans with 10 HP motors and above.

### **2.5 COOLING AND HEATING COILS**

- .1 Certification: Acceptable water cooling, water heating, steam, and refrigerant coils shall be certified in accordance with AHRI Standard 410 and bear the AHRI label. Coils exceeding the scope of the manufacturer's certification and/or the range of AHRI's standard rating conditions will be considered provided the manufacturer is a current member of the AHRI Forced Circulation Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with AHRI Standard 410. Manufacturer must be ISO 9002 certified.
- .2 Water heating coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 125 mm (5'') beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

- .1 Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
  - .2 Fins shall have a minimum thickness of 0.2 mm (0.0075 inch) aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
  - .3 Coil tubes shall be 15.8 mm (5/8 inch) OD seamless copper, 0.5 mm (0.020 inch) nominal tube wall thickness, expanded into fins, brazed at joints.
  - .4 Coil connections shall be carbon steel, threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
  - .5 Coil shall be furnished as an uncased galvanized steel to allow for thermal movement and slide into a pitched track for fluid drainage.
- .3 Direct expansion refrigerant cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 75 mm (3") beyond unit casing for ease of installation. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
- .1 Sweat type copper suction headers shall be provided.
  - .2 Fins shall have a minimum thickness of 0.2 mm (0.0075 inch) aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
  - .3 Coil tubes shall be 15.8 mm (5/8 inch) OD seamless copper, 0.5 mm (0.020 inch) nominal tube wall thickness, expanded into fins on 1 1/2-inch centers, brazed at joints.
  - .4 Sweat type copper suction connections located at the bottom of the suction headers for gravity oil drainage. Coils shall be uniformly circuited in a counterflow manner for either single circuit, row, face, interlaced, or interlaced face split capacity reduction as shown on unit schedule. Pressure type liquid distributors used. Coils shall be tested with 315 pounds air pressure under warm water, and suitable for 1724 kPa (250 psig) working pressure.
  - .5 Coil casing shall be a formed channel frame of galvanized steel.

## 2.6 VIBRATION ISOLATION

- .1 Flexible connections at inlet and outlet of fan



## **2.7 FILTER BOX**

- .1 Material to match casing.
  - .1 Provide access to filter through hinged door with suitable hardware.
- .2 Provide blank-off plates and gaskets to prevent air bypass.
- .3 Filters:
  - .1 Furnish flat panel filter section with 50 mm (2-inch) pleated MERV 8 filter. Provide side loading and removal of filters.
  - .2 Filter media shall be UL 900 listed, Class I or Class II.
  - .3 Filter Magnehelic gauge(s) shall be furnished and mounted by equipment manufacturer.

## **2.8 MIXING BOX**

- .1 Mixing box section shall be provided with top outside air opening and end return air opening with or without parallel low leak airfoil damper blades. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Linkage and ABS plastic end caps shall be provided when return and outside air dampers sized for full airflow. Return and outside air dampers of different sizes must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 500 Pa (2 inches) static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.

## **2.9 ELECTRICAL**

- .1 Fan motors shall be manufacturer provided and installed, Open Drip Proof, premium efficiency (meets or exceeds EPA requirements), 1750 RPM, single speed, 200V / 60HZ / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.
- .2 The air handler(s) shall be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.
- .3 Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.
- .4 Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.
- .5 Installing contractor shall provide GFI receptacle within 7.62 m (25 feet) of unit to satisfy National Electrical Code requirements.
- .6 All electrical connection components shall be field provided and mounted as shown on project schedule.

## **2.10 CONDENSING UNITS (CU-1)**

- .1 GENERAL
  - .1 Air-Cooled condensing unit shall include compressors, air-cooled condenser coils, condenser fans, filter driers, and suction and liquid connection valves.

- .2 Unit shall be factory assembled and tested including leak testing of the coil and run testing of the completed unit. Run test report shall be supplied with the unit in the control compartment.
- .3 Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
- .4 Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
- .5 Installation, Operation and Maintenance manual shall be supplied within the unit.
- .6 Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
- .7 Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.

.2 CONSTRUCTION

- .1 Unit shall be completely factory assembled, piped, and wired and shipped in one section.
- .2 All cabinet walls, access doors, and roof shall be fabricated of G90 galvanized steel panels.
- .3 Unit shall be specifically designed for outdoor application.
- .4 Access to compressors and control components shall be through hinged access doors with quarter turn, lockable handles.
- .5 Access to condenser coils and fans is through removable access panels.
- .6 Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
- .7 Unit shall include lifting lugs.
- .8 Unit shall include forklift slots.

.3 ELECTRICAL

- .1 Unit shall be provided with standard power block for connecting power to the unit.
- .2 Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage provided to the unit.
- .3 Unit shall have a 5kAIC SCCR.

.4 REFRIGERATION SYSTEM

- .1 Unit shall be provided with two independently circuited R-410A scroll compressors with thermal overload protection. Lead compressor shall be a variable capacity scroll capable of modulation from 10-100% of its capacity.
- .2 Each compressor shall be furnished with a crankcase heater.
- .3 Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged access doors shall provide access to the compressors.
- .4 Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators and mounted on an elevated compressor deck, to reduce any transmission of noise from the compressors into the building area.
- .5 Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and service valves for liquid and suction connections. Liquid line filter driers shall be factory provided and installed. Field installed refrigerant circuits shall include the low side cooling components, refrigerant, thermal expansion valve, liquid line and insulated suction line.
- .6 Unit shall include a factory holding charge of R-410A refrigerant and oil. Adjusting the charge of the system will be required during installation.
- .7 Each capacity stage shall be equipped with a 5 minute off delay timer to prevent compressor short cycling. Each additional capacity stage shall be equipped with an adjustable, 20 second delay timer to prevent multiple capacity stages from starting simultaneously.

.5 FANS

- .1 Condenser fan shall be vertical discharge, axial flow, direct drive fans.
- .2 Fan motor shall be weather protected, single phase, direct drive, and semi-enclosed air over with thermal overload protection.

.6 COILS

- .1 Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
- .2 Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- .3 Coils shall be hydrogen leak tested.

.7 CONTROLS

- .1 Unit shall be provided with a terminal block for field installation of controls. Option shall include factory installed isolation relays.

**Part 3 Execution**

**3.1 EXAMINATION**

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for outdoor HVAC equipment installation in accordance with manufacturer's written instructions.
  - .1 Visually inspect substrate in presence of Contractor Administrator.
  - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
  - .3 Proceed with installation only after unacceptable conditions have been remedied.

**3.2 INSTALLATION**

- .1 Manufacturer to certify installation, supervise start-up and commission unit.

**3.3 FIELD QUALITY CONTROL**

- .1 Manufacturer's Field Services:
  - .1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its products, and submit written reports, in acceptable format, to verify compliance of work with Contract.
  - .2 Provide manufacturer's field services, consisting of product use recommendations and periodic site visits for inspection of product installation, in accordance with manufacturer's instructions.
- .2 Performance Verification:
  - .1 General:
    - .1 In accordance with Section 01 91 13 – General Commissioning Requirements, supplemented as specified herein.
  - .2 Packaged Air Handling Units:
    - .1 Set zone mixing dampers for full cooling, except that where diversity factor forms part of design set that percentage of zone dampers to full heating.
    - .2 Set outside air and return air dampers for minimum outside air.
    - .3 Set face and bypass dampers so face dampers are fully open and bypass dampers are fully closed.
    - .4 Check for smooth, vibration less correct rotation of supply fan impeller.
    - .5 Measure supply fan capacity.
    - .6 Adjust impeller speed as necessary and repeat measurement of fan capacity.
    - .7 Measure pressure drop each component of air handling unit.
    - .8 Set outside air and return air dampers for the percentage of outside air required by design and repeat measurements of fan capacity.
    - .9 Reduce differences between fan capacity at minimum and maximum outside air less than 5%.
    - .10 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than 5%.

- .11 Measure DBT, WBT of SA, RA, EA.
  - .12 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
  - .13 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
  - .14 Use smoke test to verify no short-circuiting of relief air to outside air intake or to condenser intake.
  - .15 Simulate maximum heating load and:
    - .1 Verify temperature rise across heat exchanger.
    - .2 Simulate minimum heating load and repeat measurements.
  - .16 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
  - .17 Verify operating control strategies, including:
    - .1 Early morning warm-up cycle.
    - .2 Freeze protection.
    - .3 Alarms.
    - .4 Voltage drop across thermostat wiring.
    - .5 Operation of remote panel including pilot lights, failure modes.
  - .18 Set zone mixing dampers for full heating and repeat measurements.
  - .19 Measure leakage past zone mixing dampers by taking temperature measurements. Reduce leakage to less than 5%.
  - .20 Check capacity of heating unit.
  - .21 Refer to other sections of these specifications for PV procedures for other components.
- .3 Start-Up:
- .1 General: in accordance with Section 01 91 13 – General Commissioning Requirements.
  - .4 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, sensors, electrical disconnects.
  - .5 Verify accessibility, clean ability, drainage of drain pans for coils.

### **3.4 DEMONSTRATION**

- .1 Training: in accordance with Section 01 79 00 – Demonstration and Training, supplemented as specified.

### **3.5 CLEANING**

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.
- .2 Perform cleaning operations in accordance with manufacturer's recommendations.

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCES**

- .1        Institute of Boiler and Radiator Manufacturers (IBR)

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1        Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2        Product Data:
  - .1        Submit manufacturer's instructions, printed product literature and data sheets for finned tube radiation heaters and include product characteristics, performance criteria, physical size, finish and limitations.
- .3        Shop Drawings:
  - .1        Indicate on drawings:
    - .1        Equipment, capacity, piping, and connections.
    - .2        Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, sizes and location of mounting bolt holes.
    - .3        Special enclosures.

**1.3                CLOSEOUT SUBMITTALS**

- .1        Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2        Operation and Maintenance Data: submit operation and maintenance data for finned tube radiation heaters for incorporation into manual.

**1.4                DELIVERY, STORAGE AND HANDLING**

- .1        Deliver, store and handle materials in accordance with Section 01 60 00 – Product Requirements and with manufacturer's written instructions.
- .2        Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3        Storage and Handling Requirements:
  - .1        Store materials off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
  - .2        Store and protect metal ducts from nicks, scratches, and blemishes.
  - .3        Replace defective or damaged materials with new.

**Part 2            Products**

**2.1                DAMPERS**

- .1        Factory built, internal damper, at enclosure air outlet grille for each convection type heating unit not thermostatically controlled. Refer to schedules on drawings.

## **2.2 FINNED TUBE RADIATION**

- .1 Heating elements: NPS 19 mm (3/4”) seamless copper tubing, 1.2 mm minimum wall thickness, mechanically expanded into flanged collars of evenly spaced aluminum fins, 102 x 102 mm nominal, 164 fins per metre suitable for sweat fittings.
- .2 Element hangers: Heavy gauge hangers shall be provided for mounting on the enclosure bracket and shall consist of rigid galvanized steel with peg board style mounting hook and nylon roller bearing to allow for free expansion. Element hanger shall swing from mounting hole for free expansion of element. Centre on minimum 1.2 m.
- .3 Standard enclosures: 1.5 mm thick 16 satin coat steel with electrostatically applied powder coat prime finish. Unless otherwise indicated, cabinets will be supported at the top by a 25 mm joggle strip mounted to the wall and at the bottom by support brackets on not more than 1.2 m centres. Enclosures to have factory gusset plates to maintain shape during shipment and installation. Enclosure cabinets shall have pencil proof louvres. Enclosure shall have self-aligning butt joint connections of a male end and a female end to insure a smooth joint between adjacent enclosure pieces.
- .4 Special enclosures: as indicated.
- .5 Dimensions for enclosures: measure site conditions. Do not scale from drawing.
- .6 Provide for noiseless expansion of components.

## **Part 3 Execution**

### **3.1 EXAMINATION**

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for finned tube radiation convector heater installation in accordance with manufacturer's written instructions.
  - .1 Visually inspect substrate in presence of Consultant.
  - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
  - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

### **3.2 INSTALLATION**

- .1 Install in accordance with manufacturer's instructions.
- .2 Install in accordance with piping layout and approved shop drawings.
- .3 Provide for pipe movement during normal operation.
- .4 Maintain sufficient clearance to permit performance of service maintenance.
- .5 Check final location with Consultant if different from that indicated prior to installation. Should deviations beyond allowable clearances arise, request and follow Consultant's directive.
- .6 Valves:
  - .1 Install valves with stems upright or horizontal unless approved otherwise.

- .2 Install isolating gate valves on inlet and lockshield globe balancing valves on outlet of each unit.
- .7 Venting:
  - .1 Install screwdriver vent on cabinet convector, terminating flush with surface of cabinet.
  - .2 Install automatic air vent on continuous finned tube radiation.
- .8 Clean finned tubes and comb straight.
- .9 Install flexible expansion compensators as indicated.

### **3.3 CLEANING**

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 – Cleaning.

**END OF SECTION**



**PART 1      General**

**1.1            REFERENCE STANDARDS**

- .1 American Society for Testing and Materials International (ASTM)
  - .1 ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
  - .2 ASTM C916, Standard Specification for Adhesives for Duct Thermal Insulation.
  - .3 ASTM C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- .2 National Fire Protection Association (NFPA)
  - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
  - .2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- .3 Underwriters Laboratories (UL)
  - .1 UL 2021, Fixed and Location-Dedicated Electric Room Heaters.

**1.2            ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for unit heaters and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Manufacturer's Instructions: provide to indicate special handling criteria, installation sequence, and cleaning procedures.
- .4 Shop Drawings:
  - .1 Indicate on drawings:
    - .1 Equipment, capacity and piping connections.
    - .2 Dimensions, internal and external construction details, recommended method of installation with proposed support, sizes and location of mounting bolt holes.

**1.3            CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for unit heaters for incorporation into manual.

**1.4            DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions and Section 01 60 00 – Product Requirements.

- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Dispose of waste materials in accordance with Section 01 74 11 – Cleaning.

## **PART 2 Products**

### **2.1 CABINET UNIT HEATERS/ FORCE FLOWS (FF-1 TO FF-5)**

- .1 Cabinet Unit Heaters: to UL 2021 and CSA approved with CSA label
- .2 Cabinet: surface type as indicated, 1.5 mm thick 16 gauge satin coat steel with electrostatically applied powder coat prime finish, removable front panels, and hinged access door to electrical junction box. Recessed units shall be furnished with a recessing frame.
- .3 Finish with factory applied primer coat.
- .4 Hydronic coils:
  - .1 Hot water coil: 13mm copper tube, with rippled aluminum fins and sweat connections. Coils to be factory tested with air at 2070 kPa and 104 degrees C maximum entering-water temperature. Include manual air vent and drain.
- .5 Fans: forward curve centrifugal, double width, double inlet wheels, statically and dynamically balanced for quiet vibration free operation.
- .6 Motor: 3 speed permanent split capacitor, open type, resiliently mounted, incorporating sleeve bearings and internal automatic re-set overload protection.
- .7 Filters: removable 25 mm thick permanent washable type.
- .8 Capacity: as indicated.
- .9 Provide factory installed:
  - .1 3 speed plus off fan switch
  - .2 Cleanable wire frame filter
  - .3 Internal insulation
  - .4 Line voltage thermostat
  - .5 Control thermostat: room low voltage, rating to suit cabinet unit heater, set point locking device, concealed adjustment, plastic cover and guard.

### **2.2 HORIZONTAL UNIT HEATERS (UH-1 & UH-2)**

- .1 Horizontal Unit Heaters: to UL 2021.
- .2 Casing: 18 gauge 1.2 mm satin coat steel with electrostatically applied powder coat prime finish and shall have two integral 3/8" (10 mm) threaded hanger connections. Provide four way adjustable louvre diffuser, factory mounted on each unit.
- .3 Coils:

- .1 Hot water coil: 13mm copper tube, mechanically bonded rippled aluminum fins. Headers include steel MPT pipe connections located at back of unit. Coils to be factory tested with air at 300 psig (2070 kPa).
- .4 Fan: aluminum blade type, dynamically balanced and direct connected to motor shaft
- .5 Motor: speed as indicated continuous duty, built-in overload protection, and resilient motor explosion proof supports.
- .6 Air outlet: four-way adjustable louvres.
- .7 Capacity: as indicated
- .8 Control room thermostat: line voltage set point locking device, concealed adjustment, plastic cover and guard.

### **PART 3 Execution**

#### **3.1 EXAMINATION**

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

#### **3.2 INSTALLATION**

- .1 Install in accordance with manufacturer's instructions.
- .2 Check final location with Consultant if different from that indicated prior to installation.
  - .1 Should deviations beyond allowable clearances arise, request and follow Consultant's directive.
- .3 Provide supplementary suspension steel as required.
- .4 Install thermostats in locations indicated.
- .5 Before acceptance, set discharge patterns and fan speeds to suit requirements.

#### **3.3 CLEANING**

- .1 Proceed with cleaning in accordance with Section 01 74 11 – Cleaning.
  - .1 Leave Work area clean at end of each day.
  - .2 Upon completion remove surplus materials, rubbish, tools and equipment.

#### **3.4 PROTECTION**

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

Canadian Coast Guard Base – Selkirk, MB  
HVAC Refurbishment  
DFO Central and Arctic Region  
September 23, 2020

Section 23 82 39  
UNIT HEATERS  
Page 4 of 4

**END OF SECTION**

**Part 1            General**

**1.1                REFERENCE STANDARDS**

- .1 American National Standards Institute (ANSI)/CSA Group
  - .1 ANSI Z83.19a/CSA 2.35a-2011, Gas-Fired High-Intensity Infrared Heaters.
- .2 CSA Group
  - .1 CSA B149.1, Natural Gas and Propane Installation Code.
  - .2 CSA C22.1, Canadian Electrical Code, Part 1 (22nd Edition), Safety Standard for Electrical Installations.

**1.2                ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for radiant heating unit and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
  - .1 Submit drawings stamped and signed by professional engineer.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
  - .1 Recycled Content:
    - .1 Submit listing of recycled content products used, including details of required percentages or recycled content materials and products, showing their costs and percentages of post-consumer content, and total cost of materials for project.

**1.3                CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 01 78 00 – Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for radiant heating units for incorporation into manual.

**1.4                DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store and handle materials in accordance with Section 01 60 00 – Product Requirements with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
  - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
  - .2 Store and protect radiant heating units from nicks, scratches, and blemishes.

- .3 Replace defective or damaged materials with new.

## **Part 2 Products**

### **2.1 GENERAL**

- .1 A Radiant Heater Unit System shall be provided that is;
  - .1 CSA approved.
  - .2 Fitted for Natural Gas.
  - .3 Complete with hangers, thermostats, vent terminals, and/or other accessories as noted on the plan.
- .2 A manufacturer's published warranty covering all components for a period of 36 months and covering the heat exchanger for a period of at least 60 months shall be supplied.
- .3 Clearance to combustibles shall be as specified.
- .4 Flexible gas connectors of approved type shall be provided.
- .5 The Heater Unit shall operate at a minimum inlet gas pressure of 1.25 kPa (5 in. W.C.) for Natural Gas and 2.74 kPa (11 in. W.C.) for Propane and draw no more than 1A @120VAC, 60Hz.

### **2.2 EQUIPMENT COMPONENTS**

- .1 Ignition shall be direct spark with ignition taking place within the burner cup for reliability.
- .2 Ignition control shall:
  - .1 Make 3 ignition attempts before lockout.
  - .2 Shall recycle again in one hour with 3 ignition attempts.
  - .3 Shall have a lighted diagnostic display capability.
  - .4 Shall have openly accessible sense current measurement contacts within the housing.
  - .5 Shall have a blower post purge function.
  - .6 Shall accept 24V thermostat wiring.
- .3 Air blower motor shall be totally enclosed, requiring no oiling and shall be equipped with a thermal overload switch.
- .4 Gas and electric controls shall be separated from the combustion air stream.
- .5 The burner shall be serviceable from either side while in operation.
- .6 Gas valve shall be of the slow opening type.
- .7 Air pressure proving switch shall be an integral part of burner safety control system.
- .8 Burner housing shall be constructed of 18ga corrosion resistant steel and coated with powder epoxy paint.
- .9 Outside air adapters and flue connectors shall be provided as standard equipment.

- .10 Burner box surface temperature shall not exceed 27 C (80 F) at any point during operation.
- .11 Burner shall be equipped with a flame sight port safely useable while the unit is running during service.
- .12 Reflectors shall be mill-finished aluminum, ASTM 1100, with 10 reflective surfaces.
- .13 Reflector material shall be at least 0.61 MM (0.024 inches) thick (per CGA code).
- .14 Reflector end caps shall be provided as standard and shall be fitted to the end of each reflector run to reduce convective heat loss.
- .15 Reflectors shall extend below the bottom surface of the radiant tube.
- .16 Directing of radiant pattern shall be accomplished through use of side shields or bottom shields only.
- .17 Couplings shall be of aluminized steel, be twelve inches in length with two draw bands of 50 MM (2 inch) wide by 0.0625 (16ga) aluminized steel.
- .18 Radiant heat exchanger tubing shall be seamless welded 16ga thick either hot rolled steel or heat-treated aluminized steel.

### **2.3 CAPACITY**

- .1 Output: 23.45 kW & 36.64 kW
- .2 Input:
  - .1 1.2 kPa (5" W.C.) natural gas.
- .3 Electrical characteristics: 120V/1

### **2.4 TYPE**

- .1 Single Stage Infrared Heater. vented. Low Intensity. Design compatible with natural gas fuel.

### **2.5 BURNERS**

- .1 Burners to include following features:
  - .1 Manufactured to ANSI Z83.19/CSA 2.35 vented infrared heater standards.
  - .2 CGA CSA certified for use with natural gas.
  - .3 Air-fuel mixture controlled combustion system designed for compatibility with remote-generated and controlled vacuum.
  - .4 Fail-safe design to shut off supply of fuel in following situations:
    - .1 Power failure.
    - .2 Inadequate pilot flame.
    - .3 Inadequate vacuum in combustion chamber.
    - .4 Failure of main fuel valve in open position.
  - .5 Combustion air terminal compatible with connect of outside air duct.
  - .6 Electrical control system isolated from combustion air system.

- .7 Combustion process operational status indicator lights.
- .8 Pre-wired burner control system with electric ignition.
- .9 Suitable for operation with 115 V AC, single phase, 60 Hz electrical service.
- .10 Enamel-finished steel enclosure complete with removable access panels.
- .11 Heating output capacity compatible with associated downstream radiant tube.
- .2 Burners to include following features:
  - .1 Manufactured to ANSI Z83.19/CSA 2.35 vented infrared heater standards.
  - .2 CGA CSA certified for use with natural gas.
  - .3 Air-fuel mixture controlled combustion system designed for compatibility with combustion supply air blower.
  - .4 Fail-safe design to shut off supply of fuel in following situations:
    - .1 Blower motor failure.
    - .2 Main flame failure.
    - .3 Inadequate inlet air.
    - .4 Excessive flue back pressure.
  - .5 Combustion air terminal suitable for connection of outside air duct.
  - .6 Electrical control system isolated from combustion air system.
  - .7 Combustion process operational status indicator lights.
  - .8 Pre-wired burner control system with electric ignition.
  - .9 Suitable for operation with 120 V AC, single phase, 60 Hz electrical service.
  - .10 Enamel-finished steel enclosure complete with removable access panels.
  - .11 Heating output capacity compatible with associated downstream radiant tube.
  - .12 Centrifugal, direct-drive blower with adequate air flow capacity to accommodate ducted inlet and exhaust air requirements.

## **2.6 VACUUM GENERATORS**

- .1 Vacuum generators to include following features:
  - .1 Corrosion-resistant construction with capacity to accommodate total upstream output of burners.
  - .2 Direct-drive via 115/230 V, 60 Hz, totally-enclosed, thermally protected, ball-bearing motor.
  - .3 Dynamically-balanced impeller.
  - .4 Flexible inlet connection.
  - .5 Temperature and pressure rated for maximum conditions which could be encountered.
  - .6 Common support bracket for vacuum generator and motor.
  - .7 Exhaust duct terminal complete with exhaust duct and exterior terminal with bird screen.
  - .8 Removable acoustic enclosure.
  - .9 Condensate terminal complete with trap and drain line connection.



## **2.7 HEAT EXCHANGER**

- .1 Heat exchanger to consist of radiant piping with following features:
  - .1 Removable, heat and corrosion-resistant joint connections designed to accommodate system expansion/contraction.
  - .2 Length compatible with upstream burner output capacity.

## **2.8 REFLECTORS**

- .1 Reflectors to include following features:
  - .1 Polished aluminum construction complete with corrugations and configuration to maximize radiant heat directed toward floor.
  - .2 Standard lengths to facilitate installation complete with overlaps at joints to accommodate expansion and contraction.
  - .3 Hangers/supports at spacing recommended by system manufacturer to maintain maximum reflector efficiency.
  - .4 Side extension reflector complete with supports, retainers, and brackets, to prevent radiant heat from striking adjacent surfaces.
  - .5 Barrier reflector shield complete with supports, retainers, and brackets, to prevent radiant heat from striking objects beneath radiant piping.
  - .6 Factory fabricated corners, joints, tees, end caps, and related accessories.
  - .7 Egg-crate style aluminum grille beneath reflectors complete with supports, shields, as required, to improve aesthetics of radiant heating system and complement reflector design efficiency.

## **2.9 OUTSIDE AIR SUPPLY**

- .1 Outside air supply to include following features:
  - .1 Ducted outside air supply to each burner to provide sealed-combustion system.
  - .2 Insulation and vapour retarder on duct to prevent condensation.
  - .3 Duct size to ensure adequate air supply to each burner.
  - .4 Exterior air inlet terminal complete with bird screen and weatherproof hood.
  - .5 Flexible duct connector adjacent to burner complete with removable joint clamp at burner.

## **2.10 CONTROLS**

- .1 System controls to include following features:
  - .1 Pre-wired control panel complete with transformers, relays, terminal blocks, wiring, circuits, hinged door, visible door-mounted system status lights, steel cabinet complete with baked enamel finish and keyed access.
  - .2 24 V heating thermostat control of burners complete with radiant heat shields where shown.
  - .3 Integral pre purge and post purge cycles for combustion chambers and heat exchanger pipes.
  - .4 Thermostat radiant heat reflector shields, if exposed to radiant heat.

- .5 Vacuum switch interlock with vacuum generator.

### **Part 3 Execution**

#### **3.1 EXAMINATION**

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for radiant heating unit installation in accordance with manufacturer's written instructions.
  - .1 Visually inspect substrate in presence of Departmental Representative.
  - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
  - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

#### **3.2 INSTALLATION**

- .1 Installation must comply with manufacturer supplied Instruction Manual, all applicable local codes and/or gas utility requirements. In the absence of any of the former, reference should be made to ANSI Z223.1 (NFPA 54) and CAN 1-B149.1 and B149.2 Installation Codes.
- .2 Heater units must be wired in accordance with ANSI/NFPA 70 and CSA C22.1 and local ordinances.
- .3 Heater Units shall be suspended in accordance with manufacturer's instruction with chain and turnbuckles exceeding 68 kg (150lb) pull test. (3/8 – 4 inch turnbuckles and 2/0 chain).
- .4 Install infrared radiant system in accordance with CSA B149.1, as recommended by manufacturer and as indicated.
- .5 Provide grading of radiant pipe as required.
- .6 Make provision for pipe movement caused by normal operation and expansion.
- .7 Maintain required clearances from combustibles.
- .8 Follow manufacturer's detailed installation, testing, operation and maintenance instructions.
- .9 Install thermostats where indicated. Supply heat shields where recommended by manufacturer.
- .10 Test radiant system as recommended by manufacturer and required by authorities having jurisdiction. Air test piping for leaks. Check burner safety controls.
- .11 Arrange equipment, including burners, to facilitate removal without dismantling pipe, reflectors, or associated apparatus.

#### **3.3 CLEANING**

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 – Cleaning.

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

**END OF SECTION**

**Part 1            General**

**1.1                GENERAL**

- .1        All drawings and all sections of the specifications shall apply to and form an integral part of this section.

**1.2                CODES AND STANDARDS**

- .1        Do complete installation in accordance with CSA C22.1-18 except where specified otherwise.
- .2        While not identified and specified by number in these Divisions, comply with CSA Electrical Bulletins in force at time of tender submission. Comply with the requirements of all provincial and local laws, rules, ordinances and codes.
- .3        Electrical installation shall be in accordance with current edition of the Canadian Electrical Code, Provincial and other codes, rules and regulations. It is not the intention of the drawings and specifications to reiterate the Code. It is expected that the Contractor will be responsible for, but not limited to access panels, ground fault receptacles, wire sizes and methods, conduit sizes, fire rating of cables, coordination of circuit protection components, fire alarm ancillary devices, exit and emergency lighting requirements, specialty ratings for cable for elevators etc. Notify the Consultant of any detected code deficiencies prior to submission of tender. In the absence of such notifications, it will be assumed that the Contractor has accepted responsibility for a complete code-compliant installation, and no additional compensation will be provided for code-related items.
- .4        Supply materials and labour required to meet requirements of codes, rules and regulations, whether or not such work is indicated on the drawings or in specifications.
- .5        Electrical installation shall be in accordance with the requirements of the electrical supply authority and local inspections authority.
- .6        Emergency systems to be in accordance with CSAC282-09.
- .7        All underground systems will be installed in accordance with CSA C22.3 except where specified otherwise.

**1.3                CARE, OPERATION AND START-UP**

- .1        Instruct operating personnel in the operation, care and maintenance of systems, system equipment and components. Arrange care and instructional sessions to be provided at a time convenient to the Owner.
- .2        Arrange and pay for services of manufacturer's factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.
- .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 all aspects of its care and operation.

#### 1.4 VOLTAGE RATINGS

- .1 Operating voltages: to CAN3-C235.
- .2 Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard. Equipment to operate in extreme operating conditions established in above standard without damage to equipment.

#### 1.5 CONFINED SPACE ENTRY

- .1 The Work, or portions of the Work, are required to be executed in a space that is classified as a confined space in accordance with the Manitoba Workplace Health and Safety Act and Regulations. The contractor is required to follow the requirements of the current edition of the Manitoba Workplace Health and Safety Act and Regulations during the execution of the Work.
- .2 The Contractor shall submit their confined entry plan, rescue plan, entry permit, and training certifications for review prior to executing the Work.

#### 1.6 PERMITS, FEES AND INSPECTION

- .1 Submit to Electrical Inspection Department and Supply Authority necessary number of drawings and specifications for examination and approval prior to commencement of work.
- .2 Pay all fees for permits and inspections as required for the electrical installation.
- .3 Notify Consultant of changes required by Electrical Inspection Department prior to making changes.
- .4 Furnish Certificates of Acceptance from Electrical Inspection Department on completion of work to Consultant. Include copies of certificate in maintenance manuals.

#### 1.7 DEFINITIONS

- .1 The following are definitions of terms and expressions used in the Specification:
  - .1 **Consultant** means Electrical Engineering Consultant: KGS.
  - .2 **Inspection Authority** means agent of any authority having jurisdiction over construction standards associated with any part of the electrical work on site.
  - .3 **Supply Authority** means electrical power utility company responsible for delivery of electrical power to project.
  - .4 **Electrical Code** means Canadian Electrical Code or Local Code in force at Project location.
  - .5 **Indicated** means as shown on contract drawings or noted in contract documents.
  - .6 **Type Tested** means that each piece of equipment produced by manufacturer is not fully tested. An original piece with similar arrangement has been fully tested and results of that test are available.

- .7 **Provide** means to supply, install and leave in working order all materials and necessary wiring, supports, access panels, etc., as necessary for equipment.
- .8 **Owner** means “Department of Fisheries and Oceans”.
- .9 **Concealed** means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions;
- .10 **Exposed** means work normally visible, including work in equipment rooms, tunnels, and similar spaces;
- .11 **Finished** means when in description of any area or part of an area or a product which receives a finish such as paint, or in case of a product may be factory finished;
- .12 **Install** (and tenses of "install") – means secure in position, connect complete, test, adjust and verify;
- .13 **Supply** means to procure, arrange for delivery to site, distribute to floors, inspect, accept delivery and administer supply of manufacturer’s products and/or systems, and includes manufacturer’s supply of any special cables, standard on site testing, initial start-up, programming, basic commissioning, warranties and assistance to Contractor;
- .14 **Delete or Remove** (and tenses of "delete" or “remove”) – means to disconnect, make safe, remove including any back box and exposed conduits, patch and repair/finish surfaces to match adjoining similar construction, include for associated re-programming of systems and/or change of documentation identifications to suit deletions, and properly dispose of deleted products off site unless otherwise instructed by Consultant. All items to be deleted are to be disconnected and completely removed in its entirety, any branch circuit wiring, outlet, etc. for any system no longer required to remain in use is to be removed or if this is not possible rendered permanently inaccessible and completely disconnected from panel.
- .15 **BAS** means building automation system; "BMS" – means building management system, "FMS" – means facility management system; and “DDC” means direct digital controls; references to "BAS", "BMS", "FMS" and “DDC” generally mean same;
- .16 **Electrical Divisions** refers to Divisions 26 and other Divisions as specifically noted, and which work as defined in Specifications and /or on drawings is responsibility of Electrical Contractor, unless otherwise noted;
- .17 **Mechanical Divisions** refers to Divisions 23 and other Divisions as specifically noted, and which work as defined in Specifications and /or on drawings is responsibility of Mechanical Contractor, unless otherwise noted;

## 1.8 OPERATION AND MAINTENANCE DATA

- .1 Provide operation and maintenance data for incorporation into operation and maintenance manuals. Operation and maintenance manuals shall be submitted to Owner in time to be used in the commissioning of the project.
- .2 Include detail of design elements, construction features, components function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of any portion or feature of installation.

- .3 Include technical data, product data; supplement by bulletins, component illustration, exploded views, technical description of items, and parts lists. Advertising or sales literature will not be accepted.
- .4 Include wiring, schematic diagrams and performance curves.
- .5 Include driver data sheets, wiring device types, data sheets for each lamp type including emergency lighting system, final panel board directories, survey at motor data sheets.
- .6 Include name and addresses of local suppliers for items included in maintenance manuals.
- .7 Maintenance manuals shall be submitted to Consultant for review. Manuals that are incomplete shall be returned to electrical subcontractor for completion. Completed manuals must be submitted, to the satisfaction of the Consultant, before final payment may be considered to be due.

## **1.9 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES**

- .1 Submit shop drawings, product data and samples for review by Consultant. Manufacture of equipment must not commence until shop drawings have been reviewed.
- .2 Indicate detail construction, dimension, capacities, weights and electrical performance characteristics of equipment or material.
- .3 Where applicable, include wiring, single line and schematic diagrams.
- .4 Include wiring drawings or diagrams showing interconnection with work of other sections.
- .5 Submit samples in accordance with General Conditions. Deliver samples to Consultant's office. Pay all transportation costs to ship samples to Consultant's office including return costs. Approved samples will be retained until after tender closing, then all samples will be returned except for the samples submitted by successful Contractor in tender documents. This sample will be used for comparison with the actual production run of successful manufacturer.
- .6 Each drawing submission to bare following signed stamp, and include name of project, equipment supplier and clause number equipment is specified under.

### **CONTRACTORS CERTIFICATION**

This drawing has been reviewed by

(firm name)

All dimensions have been checked and found compatible with the contract drawings and all capacities, quantities, sizes and other data contained in the contract documents have been listed by the supplier on this drawing and have been checked by the undersigned and found correct.

Date

Per

- .7 Clearly show division of responsibility. No item, equipment or description of work shall be indicated to be supplied or work to be done 'By Others' or 'By Purchaser'. Any item, equipment or description of work shown on shop drawings shall form part of the contract, unless specifically noted to the contrary.
- .8 Provide field dimensions required by electrical supplier and sub-subcontractors. In cases where fabrication is required prior to field dimensions being available, check all related drawings and obtain clarification from Consultant if necessary.
- .9 Division 26 shall check all shop drawings and make necessary changes, prior to submission to the Consultant. They will be reviewed by the Consultant and, if re-submission is required, Division 26 shall ensure that the supplier's drawings have been changed to comply before returning them to the Consultant for another review. If the drawings still do not comply, and require additional review by the Consultant, the Consultant shall be reimbursed by Division 26 for the time required for such additional reviews.
- .10 Review of the shop drawings by the Consultant shall not relieve the Contractor from responsibility for errors and omissions therein.
- .11 Shop drawings reflecting additional design or change in design shall be reviewed by the Consultant and Owner.
- .12 Provide shop drawings for all electrical components, including but not limited to wiring devices, lamps, starters, luminaires, etc.

#### **1.10 EQUIVALENT MATERIALS AND EQUIPMENT**

- .1 Bidder shall submit a tender based on the specified materials and equipment only.
- .2 Bidders may submit a tender based on equivalent material and equipment, only if such items have been approved as equal by the Consultant.
- .3 Request for equal submissions shall include a photocopy of all applicable specification sections showing a complete compliance/non-compliance listing in the left hand margin. Every clause of the applicable specification section must be individually marked indicating details of how compliance is met or, how the non-compliance items should be considered equal.
- .4 All requests for equals shall be submitted to the consultant forty (40) business hours prior to tender closing.
- .5 The approval of equivalent products will be granted on the basis of general design only. Such approvals will not relieve the electrical trade from providing all necessary components and functions required in the specifications or on the drawings.
- .6 Clearly show division of responsibility. No item, equipment or description of work shall be indicated to be supplied or work to be done 'By Others' or 'By Purchaser'. Any item,



equipment or description of work shown on shop drawings shall form part of the contract, unless specifically noted to the contrary.

#### **1.11 FIELD QUALITY CONTROL**

- .1 All electrical work to be carried out by qualified licensed electricians or apprentices as per conditions of the Provincial Act respecting manpower vocational training and qualifications. Employees registered in a provincial apprentices program shall be permitted, under the direct supervision of a qualified licensed electrician, to perform specific tasks - the activities permitted shall be determined based on the level of training attained and the demonstration of ability to perform specific duties.
- .2 The work of this Division to be carried out by a Contractor who holds a valid Master Electrical Contractor license as issued by the Province that the work is being constructed.
- .3 Conduct and pay for all tests as indicated in Section 26 08 01 – Electrical Testing Requirements.

#### **1.12 CO-ORDINATION WITH OTHER TRADES**

- .1 Refer to structural and mechanical design drawings and specification for electrical work in connection with other divisions. The most stringent or restrictive requirement of specifications or drawings from any Division shall apply and be included in the tender price. This will be applicable even after the work was installed with the lesser requirement. Provide all required work to the full satisfaction of the Consultant.
- .2 Co-ordinate electrical work with work of other trades to avoid conflict with pipes, air ducts and other equipment. Provide additional supports, wiring, etc. to all relocated equipment as required where relocation is necessary to avoid interferences.

#### **1.13 EXAMINATION OF SITE**

- .1 Prior to submitting a tender, examine site and local conditions, which may affect work. Claims for extra payment resulting from conditions, which may have been foreseen during examination of the site, will not be recognized.
- .2 Ensure that all equipment designated as “existing to remain” or “existing to be relocated” is suitable for its intended re-use, including panelboards and circuits. Report any discrepancies to the Consultant before tender close.

#### **1.14 RECORD DOCUMENTS**

- .1 Submit project documents in accordance with Division 01.
- .2 Submit three (3) copies of the maintenance manuals to the owner, in 3-ring binders. Include a copy of all inspection and testing certificates, shop drawings, name/address/phone # of each supplier, contractor and engineer, table of contents, and a copy of project "as-built" drawings in an envelope at the back of the binder and electronic files on a USB stick. Include all costs in contract. CAD files can be obtained from consultant.

- .3 The Contractor shall keep a set of white prints on the job site at all times on which he shall record all additions or deviations from the contract documents including all changes covered by addenda, change orders, field changes, job conditions, etc. A set of drawings shall be utilized for each system and the contractor shall obtain prints as required. Drawings to include locations of all junction and pull boxes, routing of feeders and conduits, and changes to circuit numbers.
- .4 All principle below grade or inaccessible conduits, systems, etc. shall be dimensioned at each change in direction. All conduit routes not shown by the Consultant on original drawing shall be shown including circuit wiring, junction boxes, zoned conduit runs, etc.
- .5 The Contractor shall provide one set of clean marked-up drawings for approval and a final set with changes as may be requested by the Consultant.
- .6 If corrections are required after the second Consultant review, due to missing information, the Electrical Subcontractor shall be responsible for the Consultant's time to indicate the required corrective measures and all courier and printing costs.
- .7 The Contractor is responsible for the total cost of mylars, and white prints taken from mylars, and electronic files.
- .8 Corrected, revised "Mylars", white prints, electronic files, etc. will be forwarded to the Owner by the Consultant. Final payment on the contract will not be made until correct mylars, and files are prepared and submitted to the Owner.

## **Part 2 Products**

### **2.1 MATERIALS AND EQUIPMENT**

- .1 Electrical equipment shall be new and of the type and quality specified.
- .2 Equipment and material to be CSA certified. Where there is no alternative to supplying equipment which is not CSA certified, obtain special approval from Electrical Inspection Department.
- .3 Provide labour, materials, transportation, equipment and facilities, etc. required for the complete electrical installation as indicated or can be reasonably implied from the drawings and specifications.
- .4 Provide factory assembled control panels and component assemblies.
- .5 Equipment shall not be located near pipe shafts or fluid piping.
- .6 Equipment, conduits and cables shall not restrict or interfere with necessary access space required to safely service mechanical equipment (ventilation fans, filters, etc.) which are existing and/or to be installed under this contract.

## **2.2 FINISHES**

- .1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
  - .1 Paint switchgear and distribution enclosures light grey to EEMAC 2Y-1-1958.
- .2 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .3 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

## **2.3 WIRING TERMINATIONS**

- .1 Lugs, terminals, screws used for termination of wiring to be suitable for either copper or aluminium conductors.

## **2.4 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS**

- .1 Control wiring and conduit is specified in Division 26 except for conduit, wiring and connections below 50 volts, related to control systems, are specified.
- .2 All electrical connections, terminations, power requirements related to electrical work shown on mechanical drawings to be included by this Division.

## **2.5 MANUFACTURERS AND CSA LABELS**

- .1 Visible and legible, after equipment is installed.

## **2.6 WARNING SIGNS**

- .1 Provide warning signs on equipment, as required, to meet the requirements of the Inspection Authorities and Consultant.

## **2.7 FIRE STOPPING**

- .1 Provide approved fire stopping systems and smoke seals for all electrical penetrations at all fire rated walls and floors to maintain the integrity of wall/floor fire rating being penetrated.

## **Part 3 Execution**

### **3.1 PROCEDURE SCHEDULE**

- .1 All electrical work shall be coordinated with Owner and sub-trades involved. Manner and areas of work shall be pre-arranged prior to proceeding.
- .2 Procedure schedule will be prepared by the Contractor in conjunction with the Owner and Electrical Consultant to ensure continuity of work can be maintained with minimal

interruption to occupant routine within the existing facilities. Electrical sub-contractor to coordinate his/her proposed schedule with the GC in a manner satisfactory to all parties involved.

### **3.2 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver all materials to the site in an orderly fashion.
- .2 Store all materials in a clean and dry place, secure from vandalism or theft. All materials to be left in shipping containers until required for use.
- .3 Provide additional protection such as tarps, padding, wood skids, etc., where such is required to ensure protection of equipment and as directed by the Architect.

### **3.3 WORKMANSHIP**

- .1 Install equipment, conduits and cables in a workmanlike manner to present a neat appearance to the satisfaction of the Consultant. Install conduit and cable runs parallel and perpendicular to building lines, in chases, behind furring or above ceilings, where such concealment is possible. In areas where systems are to be exposed, install neatly and group in a tidy appearance.
- .2 Install equipment and apparatus requiring maintenance, adjustment or eventual replacement, with adequate clearance and accessibility for same.
- .3 Include in the work all requirements shown on the shop drawings or manufacturer's installation instructions.
- .4 Replace work unsatisfactory to the Consultant without extra cost.

### **3.4 SUPERVISION**

- .1 Supervise the work at all times through a responsible and competent supervisor.
- .2 Employ the same supervisor on the project from the start to the finish to ensure continuity of the work.
- .3 Employ experienced, qualified journeymen and apprentices.

### **3.5 CUTTING AND PATCHING**

- .1 Pay the costs of all cutting and patching required for the installation of electrical work. Payment for cutting and patching shall be made through the GC.
- .2 Cutting and patching required for the installation of electrical work shall be done by the particular trade whose work is involved.
- .3 Obtain the approval of the Engineer and/or Owner before arranging for any cutting. Patching shall restore the affected area to the original condition; material used for patching shall be compatible with existing condition.

- .4 Cutting or patching shall be carried out by the tradesmen of the subcontractor who normally works with materials involved, with the cost being the responsibility of Division 26 Sub-Contractors.

### 3.6 CONDUIT, SLEEVES AND HOLES

- .1 Make necessary arrangement for cutting of chases, drilling of holes and other structural work required to install electrical conduits, cables, pull boxes and outlet boxes. **In existing facilities - Do Not core without Owner's permission or without x-ray or scanning of floors.**
- .2 Install conduit and sleeves prior to pouring of concrete. Sleeves through concrete to be sized for free passage of conduit.
- .3 Flash and weatherproof any penetrations or holes through exterior walls and roof.
- .4 Install cables, conduits, and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to a minimum.
- .5 All sleeves and access conduits shall protrude through the floor min. 25mm (1") above finished floor surface.
- .6 Fire-stop all floor and wall penetrations.

### 3.7 LOCATION OF OUTLETS

- .1 Locate outlets as indicated.
- .2 Do not install outlets back-to-back in wall; allow minimum 150 mm (6") horizontal clearance between boxes.
- .3 Change location of outlets at no extra cost or credit, providing distance does not exceed 3000 mm (10'-0"), and information is provided before installation.
- .4 Drawings are schematic only, co-ordinate mounting height and location of all equipment with mechanical and structural drawings prior to installation.
- .5 Vertically align outlets of different systems when shown in close proximity to each other and occur at different mounting heights.

### 3.8 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
- .3 Install electrical equipment at following heights listed below unless indicated on electrical drawings, architectural elevations, or instructed otherwise.
  - .1 Local switches: 1200 mm (48") to top.

- .2 Wall receptacles:
  - .1 General: 450 mm (18”).
  - .2 Above top of continuous baseboard heater: 200 mm (8”).
  - .3 Above top of counters: 150 mm (6”).
  - .4 Above top of counter splash backs: 100 mm (4”).
  - .5 In mechanical rooms: 1200 mm (48”).
- .3 Panelboards: 2000 mm (78”) to top.
- .4 Voice, data and cable TV outlets: 450 mm (18”).
- .5 Wall mounted telephone outlets: 1200 mm (48”).
- .6 Fire alarm manual pull stations: 1200 mm (48”).
- .7 Fire alarm strobe/speakers: 2300 mm (90”).
- .8 Wall mounted emergency lights: 2286 mm (90”).

### **3.9 CO-ORDINATION OF PROTECTIVE DEVICES**

- .1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings.

### **3.10 PROTECTION**

- .1 Protect exposed live equipment during construction for personnel safety.
- .2 Shield and mark live parts "LIVE 120 VOLTS", or with appropriate voltage in English.
- .3 Arrange for installation of temporary doors for rooms containing electrical distribution equipment. Keep these doors locked except when under direct supervision of electrician.

### **3.11 LOAD BALANCE**

- .1 Measure phase current to panelboards with normal loads operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
- .2 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
- .3 Submit, at completion of work, report listing phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load. Record hour and date on which each load was measured, including voltage at time of test.

### **3.12 CONDUIT AND CABLE INSTALLATION**

- .1 Install conduit and sleeves prior to pouring of concrete. Sleeves through concrete: schedule 40 steel pipe sized for free passage of conduit, and protruding 50 mm (2”).
- .2 If plastic sleeves are used in fire rated walls or floors, remove before conduit installation.

- .3 Install cables, conduits and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to minimum.

### **3.13 CLEANUP**

- .1 The electrical trade and his/her sub-trades shall at all times during construction, keep the site free of all debris, boxes, packing, etc., resulting from work of this trade.
- .2 At the completion of the work, the electrical installation shall be left in a clean, finished condition to the satisfaction of the building owner.

### **3.14 GUARANTEE/WARRANTY**

- .1 Satisfactory operation of all work and equipment installed under this contract shall be guaranteed for a period of one (1) year from the date of final acceptance of this work except where otherwise noted.
- .2 All unsatisfactory work and any equipment that does not perform satisfactorily within the guarantee period shall immediately be repaired or replaced at no cost to the Owner, providing such failure is not due to improper usage by the Owner. The warranty on any replacement equipment or components shall be one year from the date of their installation.
- .3 Any equipment that has been placed in use for any reason prior to the beginning of the guarantee period, such as for heating during construction, shall be cleaned and provided with whatever maintenance and repair is required so that its condition is equal to that of new equipment, or it shall be replaced, at no cost to the Owner.
- .4 Equipment that fails as a result of its use prior to the beginning of its one-year guarantee period shall be repaired or replaced at no cost to the Owner, even after the normal one-year guarantee period has expired.
- .5 All details of warranty repairs shall be documented in letters to the Owner, with a copy sent to the Consultant.
- .6 No certificate given, payment made, or the use of the equipment by the Owner, shall be construed as acceptance of defective work or of improper materials.
- .7 This guarantee shall not act as a waiver for products that are warranted by the manufacturer for longer than one year.

### **3.15 PRICING OF CHANGES AFTER TENDER**

- .1 Within a week of contract award, the Electrical Contractor shall submit an itemized cost breakdown for labour, including an hourly rate for foreman (or journeyman) for all work to be performed on changes of the Contract (PCNs). Refer to General Conditions for further requirements under this section.
- .2 The Electrical Consultant reserves the right to review costing using acceptable pricing standards based on Means “normal” pricing guide.

**3.16 FINAL ELECTRICAL ACCEPTANCE**

- .1 As the Consultants are required to give professional assurance that all electrical systems have been installed, tested, commissioned and verified in accordance with the current edition of the Manitoba Building Code and the Canadian Electrical Code, the following items are required from the Contractor prior to substantial performance acceptance and issuance of "Assurance of Field Review and Compliance."
  - .1 "Certificate of Final Electrical Inspection" certificate signed by the Electrical Inspector for the project (a declaration form signed by the Electrical Contractor is not acceptable);
  - .2 Submit all testing reports and certifications as specified in Section 26 08 01 – Electrical Testing Requirements.

**3.17 EVALUATION OF “PROGRESS CLAIMS”**

- .1 Contractor shall submit to the Consultant for review and approval a detailed breakdown of material and labor.
- .2 The Progress Claim form(s) shall be submitted to the Consultant prior to the initiation of the Contractor’s first claim for payment for review and acceptance. Failure to submit the Progress Claim form(s), and to subsequently submit all Progress Claims based on the same format, will delay the processing of the Contractor’s Progress Claim.

**END OF SECTION**



**Part 1            General**

**1.1                RELATED WORK**

- .1            Refer to all sections of the specification for related work.

**1.2                COORDINATION**

- .1            Contractor shall allow for off-hours work as required.
- .2            Where existing services or systems, such as electrical power, telephone system, data systems, equipment alarm system, fire alarm system, etc. are required to be disrupted and/or shut-down, coordinate the shut-downs with the Owner and carry out the work at a time and in a manner acceptable to them. Carefully schedule all disruptions and/or shutdowns and ensure the duration of same is kept to the absolute minimum. Submit for approval, a written concise schedule of each disruption at least 120 hours in advance of performing work and obtain written consent prior to implementing. Allow for after-hours work.
- .3            Should any temporary connections be required to maintain services or systems during work in the existing building, supply and install all necessary material and equipment and provide all labour at no extra cost. Should any existing equipment or system be damaged, make full repairs without extra cost, and to the satisfaction of the Owner and Consultant.
- .4            Refer to General Requirements for phasing and staging of work and adhere to that schedule. Comply with instructions regarding working hours necessary to maintain the building in operation.
- .5            The drawings indicate major items of equipment to be deleted or relocated but may not indicate every item of equipment or conduit to be deleted or relocated. Contractor shall be responsible for determining which existing equipment is to be deleted or relocated by examining all site conditions and all construction documents.
- .6            No drilling in concrete floors shall take place unless the floor has been scanned (or x-rayed) to confirm exactly what is in the floor. The Contractor shall notify the Owner's Construction Officer before drilling. The Contractor assumes complete responsibility for any and all damages or work stoppages occurring from unforeseen problems. The Owner does not want any facility disruptions.

**1.3                EXISTING DEVICES IN NEW CONSTRUCTION**

- .1            Disconnect and remove existing electrical equipment made obsolete due to renovations. Remove associated wiring and conduits back to source panel.
- .2            Where existing devices (receptacles, switches, etc.) are presently mounted on a wall which will be covered with a new finish, provide an extension ring, coverplate, etc., as required, to mount device to new wall finish.
- .3            All existing electrical equipment to remain, which is located in or on portions of existing walls being demolished, shall be relocated to nearest wall. This equipment shall include cabinets, panels, switches, receptacles, etc.

- .4 Where existing conduits, which are in use, pass vertically through a wall being demolished, relocate those conduits and conceal in a new wall or surface mount in a service area. Extend conduit, wiring, etc. as required.
- .5 Where new ceilings are to be installed, relocate all existing ceiling mounted devices down to new ceiling. This equipment shall include but not be limited to smoke detectors, heat detectors, speakers, luminaires, etc. Extend existing conduit and wiring as required.
- .6 All existing junction boxes in walls and ceiling spaces required to maintain existing circuits shall remain accessible.
- .7 Include all costs to x-ray existing floors to be drilled or sleeved to ensure no existing services are severed or damaged. Damages could be very serious. Any damages resulting from failure to x-ray (or scan) is the Contractor's responsibility.
- .8 Redundant existing circuit breakers will not be connected to any wiring and are to be labelled as spares.

#### **1.4 REMEDIAL WORK**

- .1 It is the Electrical Contractor's responsibility to ensure that any coring of holes through decks or floor slabs, will not penetrate existing conduits, cables or mechanical equipment in walls, ceilings or floor slabs. The Contractor, at his cost, is responsible to take all actions required and as may be deemed necessary by the Owner to correct any damage. No coring shall be undertaken unless permission is given by the building the Owner's Construction Officer.

#### **1.5 RELOCATE EXISTING CABLING IN NEW CONSTRUCTION**

- .1 Include allowance to relocate existing cabling that may exist in ceiling spaces. Allowance includes replacing entire lengths of cables, testing and commissioning.

### **Part 2 Products**

#### **2.1 MATERIALS**

- .1 Provide all materials required for the complete interface and reconnection installation.
- .2 New wiring required to interconnect new devices to existing systems shall be provided to suit the manufacturer's requirements and instructions.
- .3 Add new grounding materials as required to make existing grounding systems good in renovated areas only. Confirm existing on site.
- .4 Add modules, switches, etc., in existing control panels, as required, to extend existing systems to the new or renovated areas only. Confirm existing on site.
- .5 New system devices, speakers, starters, panelboards, breakers, etc. that are required to be tied into existing systems, quality of new materials to match or exceed existing. Confirm existing on site.

- .6 Add modules, switches, etc. in existing control panels, as required, to extend existing systems to new or renovated areas.
- .7 It is the intent of these specifications to not re-use any existing wiring.

**Part 3 Execution**

**3.1 INSTALLATION**

- .1 Install boxes, conduit and wiring through existing areas as required for the new installation.
- .2 Patch and repair walls and ceilings in existing building that have been damaged or cut open due to the new electrical installation.
- .3 Patch and make good existing walls which are to remain where existing electrical devices have been removed.
- .4 Where new cables or conduits have been installed through existing fire rated walls, seal opening around cables and conduit to maintain fire rating.
- .5 Test and confirm all existing grounding systems are effective and in good condition. Include work and materials required to change wiring and make good existing.
- .6 Electrical Contractor shall confirm the exact position and mounting height of each outlet prior to commencement of work. Special efforts are required to coordinate outlets, conduit routes, etc. with architectural, mechanical and other related work.

**END OF SECTION**

**Part 1           General**

**1.1               RELATED WORK**

- .1       Refer to all sections of the specifications for related work.

**1.2               REFERENCES**

- .1       CSA C22.2 No. 65 Wire Connectors.
- .2       CSA C22.2 No. 0.3 Test Methods for Electrical Wires and Cables.
- .3       CSA C22.2 No. 131 Type Teck 90 Cable.

**Part 2           Products**

**2.1               WIRE CONNECTORS**

- .1       Copper long barrel compression connectors sized for conductors. Use two-hole long barrel compression connectors for feeder conductors.
- .2       Solderless, self-insulated connectors for hand twist wire joints for lighting, small power, and associated control devices, with nylon insulator. Standard of acceptance: Thomas & Betts Marette Type II Winged or Ideal Cantwist.
- .3       Solderless, self-insulated connectors for hand twist wire joints for solid to stranded connections (e.g. heater thermostats), nylon insulator. Standard of acceptance: Thomas & Betts Marette ACS.
- .4       Terminate conductors #8 AWG and larger with Thomas & Betts Color-Keyed compression connectors 54000 Series, or on lugs provided with equipment. Use Thomas & Betts "KOPR-SHIELD" compound Series CP8-TB on all terminations for compression connectors.

**2.2               CABLE CONNECTORS**

- .1       Provide rain-tight connector fittings, complete with O-rings for use on all enclosures. Side entrances to enclosures are preferred.

**2.3               RAIN-TITE COUPLINGS**

- .1       Rain-tight couplings shall be used for all conduits.

**Part 3           Execution**

**3.1               CABLE INSTALLATION**

- .1       Install cables for feeders or branch circuits in raceways, cable trays, wireways or trenches.

- .2 Prevent over-heating by induction in accordance with rule 12-3022(6) and 12-3022(7) and Appendix B Canadian Electric Code, Part 1 where single conductor cables connect to boxes and cabinets.
- .3 Provide mechanical protection for cables where cables are turned up above the floor through sleeves or slots. Provide channels, angle sills or rigid conduit sleeves which protrude at least 150 mm (6”) above the finished floor.
- .4 Support on channels where cables are grouped and not run in tray.
- .5 Run cables parallel to the lines of the building.
- .6 Bends to be concentric.
- .7 Seal cables which penetrate air barrier and vapour boxes to barrier and boxes.

**END OF SECTION**

**Part 1            General**

**1.1                RELATED WORK**

- .1        Refer to all Sections of the specification for related work.

**1.2                REFERENCES**

- .1        CSA C22.2 No. 0.3 Test Methods for Electrical Wires and Cables.
- .2        CAN/CSA-C22.2 No. 131.

**1.3                PRODUCT DATA**

- .1        Submit product data in accordance with Section 26 05 00 – Common Work Results - Electrical.

**Part 2            Products**

**2.1                CABLE IDENTIFICATION**

- .1        Cables to be identified with wire markers.
- .2        Machine printed self laminating label type.
- .3        Thermal transfer type with printable area and translucent vinyl film.

**2.2                BUILDING WIRES**

- .1        Conductors in conduit:
  - .1        Type: RW90, RWU90
  - .2        Conductors for panel and branch circuits:
    - .1        Solid copper #10 AWG and smaller
    - .2        Stranded copper #8 AWG and larger.
    - .3        Sized as required (minimum #12 AWG).
  - .3        Insulation:
    - .1        Cross link polyethylene (XLPE), 90°C.
  - .4        Configuration:
    - .1        Single conductor.
  - .5        Voltage Rating: 600V.
  - .6        Certification:
    - .1        CSA C22.22 No. 38 or latest revision.

**2.3                ARMOURED CABLE**

- .1        Type: AC90 (BX).

- .2 Conductors:
  - .1 Solid copper #10 AWG and smaller.
  - .2 Stranded copper #8 AWG and larger.
  - .3 Sized as required (minimum #12 AWG).
- .3 Insulation:
  - .1 Cross link polyethylene (XLPE), 90°C.
- .4 Configuration:
  - .1 Multi-conductor, as required, complete with a separate bare CU ground wire.
- .5 Voltage Rating: 600V.
- .6 Armour: Bare inter-locked aluminum.
- .7 Certification:
  - .1 CSA C22.22 No. 51 or latest revision.

## **2.4 ARMOURED CABLE (TECK)**

- .1 Type: Teck 90
- .2 Conductors for panel and branch circuits:
  - .1 Solid copper #10 AWG and smaller.
  - .2 Stranded copper #8 AWG and larger.
  - .3 Sized as required (minimum #12 AWG).
- .3 Insulation:
  - .1 Cross link polyethylene (XLPE), 90°C.
- .4 Configuration:
  - .1 Single or multi-conductor, as required.
- .5 Colour Code:
  - .1 Black, red, blue and white in 4/C cable. Cables of more than 4/C to be number coded.
- .6 Voltage Rating: 600V.
- .7 Inner Jacket:
  - .1 Black polyvinyl chloride (PVC).
  - .2 Low flame spread (LFS).
  - .3 Low gas emission (LGE).
- .8 Armour:
  - .1 Inter-locked aluminum.

- .9 Outer Jacket:
  - .1 Black polyvinyl chloride (PVC), -40°C.
  - .2 Low flame spread (LFS).
  - .3 Low gas emission (LGE).
- .10 Fire Rating: FT4, AG14.
- .11 Certification:
  - .1 CSA C22.22 No. 131 or latest revision.

## **2.5 LOW VOLTAGE CONTROL CABLES**

- .1 Type: LVT.
- .2 Conductors:
  - .1 Solid copper #18 AWG.
- .3 Insulation:
  - .1 Thermoplastic, colour coded.
- .4 Configuration:
  - .1 Single, two conductors – parallel.
  - .2 Three or more conductors – twisted.
- .5 Voltage Rating: 30V.
- .6 Outer Jacket:
  - .1 Thermoplastic.
- .7 Certification:
  - .1 CSA C22.22 No. 35.

## **2.6 INSTRUMENTATION CABLES**

- .1 Type: Instrumentation cable.
- .2 Conductors:
  - .1 7-wire, concentric lay, Class B tinned copper, #18 or #14 AWG as required.
- .3 Voltage Rating: 300V or 600V as required.
- .4 Insulation:
  - .1 Fire retardant - cross link polyethylene (XLPE), 90°C.
- .5 Configuration:
  - .1 Single or multi pairs or triads, as required.
- .6 Shielding:



- .1 Aluminum/mylar shield with drain wire for each pair triad.
- .2 Overall aluminum/mylar shield with drain wire.
  
- .7 Drain Wires:
  - .1 7-wire, concentric lay, Class B tinned copper.
  - .2 Individual shields to be one size smaller than conductor size.
  - .3 Overall shields to be the same as conductor size.
  
- .8 Colour Codes:
  - .1 300V Pairs:
    - .1 black, white and number code.
  - .2 300V Triads:
    - .1 black, white and number code.
  - .3 600V Pairs:
    - .1 black, red and number code.
  - .4 600V Triads:
    - .1 black, red, yellow and number code.
  
- .9 Armour:
  - .1 Inter-locked aluminum.
  
- .10 Outer Jacket:
  - .1 Grey polyvinyl chloride (PVC).
  - .2 Low flame spread (LFS).
  - .3 Low gas emission (LGE).
  
- .11 Fire Rating: FT4.
  
- .12 Certification:
  - .1 CSA C21.1 or latest revision.
  - .2 CSA C22.2 No. 174 or latest revision.

## **2.7 CONNECTORS**

- .1 Pressure type connectors, fixture type splicing connectors, cable clamps and lugs, as required.
- .2 Refer to Section 26 05 20 – Wire and Box Connectors and 26 05 22 – Connectors and Terminations.

**Part 3 Execution**

**3.1 CABLE INSTALLATION & WORKMANSHIP**

- .1 Install cables for feeders or branch circuits in raceways, cable trays, wireways or trenches as required.
- .2 Prevent over-heating by induction in accordance with rule 12-3022(6) and 12-3022(7) and Appendix B Canadian Electric Code, Part 1 where single conductor cables connect to boxes and cabinets.
- .3 Install sleeves where cables pass through poured concrete or masonry.
- .4 Provide mechanical protection for cables where cables are turned up above the floor through sleeves or slots. Provide channels, angle sills or rigid conduit sleeves which protrude at least 150 mm (6”) above the finished floor.
- .5 Where cables are grouped and not run in tray, support on channels.
- .6 Run cables parallel to the lines of the building.
- .7 Bends to be concentric.
- .8 Seal cables which penetrate air barrier and vapour boxes to barrier and boxes.

**3.2 PHASE BALANCING**

- .1 Connect single phase equipment to minimize imbalance on feeders. Adjust branch circuiting for optimum balancing.
- .2 Record all changes on “as-built” drawings.
- .3 Phase rotation to match existing

**3.3 MINIMUM CABLE SIZE**

- .1 Minimum wire size to be #12 gauge throughout except where indicated otherwise.
- .2 Be responsible for providing the minimum wire size to meet the code where the wire size shown on the drawing is inadequate to serve the load.
- .3 Minimum size of panelboard and motor feeders is to be in accordance with CEC.

**3.4 VOLTAGE DROP**

- .1 Size wiring for branch circuits to achieve a maximum 3% voltage drop.
- .2 Base on distance from overcurrent device to furthest wiring device/load.
- .3 Provide cable size for entire length of circuit.

- .4 Submit voltage drop calculations when requested.

### **3.5 NEUTRAL CONDUCTORS**

- .1 Reduced neutrals not permitted.
- .2 Provide separate neutrals for all dimmers, laser printers or as otherwise indicated.
- .3 Provide 200% Neutral connections where shown on single line drawings and on K-rated and harmonic mitigating transformers.

### **3.6 GROUND CONDUCTORS**

- .1 Provide a green insulated ground conductor equal in size to current carrying conductors within all raceways.

### **3.7 FIRE SEPARATIONS**

- .1 Submit drawings showing proposed method of sealing fire separations.

### **3.8 INSTALLATION OF BUILDING WIRES**

- .1 Install wiring in conduit system in accordance with Section 26 05 34 – Conduits, Conduit Fastenings and Conduit Fittings.
- .2 Ensure conduits are dry and free of debris before pulling cables.
- .3 Provide colour coding and identification as per this Section.
- .4 Wires in outlet, junction and switch boxes, not having a connection within the box shall not be spliced, but shall continue unbroken through the box.

### **3.9 INSTALLATION OF ARMOURED CABLES (BX)**

- .1 Group cables wherever possible.
- .2 Terminate cables in accordance with Section 26 05 22 – Connectors and Terminations.
- .3 Type AC90 armoured cable (Bx) with screw type connectors shall be used for connections from conduit systems to luminaires in accessible ceilings only.
- .4 Type Bx cable shall not be used for any other application.
- .5 Maximum length of AC90 armoured cable for connections to luminaires mounted in stud partitions shall be 1.5 metres. Cable drops for luminaires in accessible ceilings shall be of sufficient length to allow the luminaire to be relocated to any location within a 3m radius.
- .6 Cable shall be clamped before entering the lighting fixture and shall be clipped before entering the conduit system junction box.

### **3.10 INSTALLATION OF ARMOURED CABLES (TECK)**

- .1 Group cables wherever possible on channels, spaced one (1) cable diameter apart.
- .2 Do not splice cables.
- .3 Terminate cables in accordance with Section 26 05 22 – Connectors and Terminations. Terminate cables using non-magnetic connectors. Cable armour shall be grounded via an aluminum plate at the supply end and isolated via an insulating plate at the load end of the cable.
- .4 Cable bending radius shall be at least twelve (12) times the overall cable diameter and bend shall not damage or distort the outer sheath.
- .5 Do not install PVC jacketed cables in circulating air plenums.

### **3.11 INSTALLATION OF ALUMINUM SHEATHED CABLES**

- .1 Group cables wherever possible.
- .2 Terminate cables in accordance with Section 26 05 22 – Connectors and Terminations.
- .3 Do not use aluminum sheathed cable in cast concrete or masonry construction.

### **3.12 INSTALLATION OF LOW VOLTAGE CONTROL CABLES**

- .1 Install low voltage control cables in conduit.
- .2 Ground control cable shield.

### **3.13 INSTALLATION OF INSTRUMENTATION CABLES**

- .1 Install instrumentation cables in conduit.
- .2 Ground cable shield.

### **3.14 INSTALLATION IN EQUIPMENT**

- .1 Group and lace-in neatly, wire and cable installed in switchboards, panel boards, cabinets, wireways and other such enclosures.

### **3.15 TERMINATIONS**

- .1 Terminate wires and cables with appropriate connectors in an approved manner.

### **3.16 MOTOR CONNECTIONS**

- .1 Flexible connections to motors shall not exceed 2m unless authorized in writing by Consultant.

### 3.17 IDENTIFICATION

- .1 Provide cable identification on all cables.
- .2 Wire in conduit #2 AWG and smaller shall have solid coloured insulation, colour coded as listed below.
- .3 Wire in conduit #1/0 AWG and larger and single conductor cables shall be identified at each outlet box and termination with a 150mm (6”) band of coloured vinyl tape of the appropriate colour. Neutral and ground conductors shall be identified. Paint or other means of colouring the insulation shall not be used.
- .4 Colour code wire in conduit and single conductor cables as follows unless otherwise shown on the drawings:

<b>Three Phase Systems:</b>	<b>Single Phase Systems:</b>
Phase A - red	Phase A - red
Phase B - black	Phase B - black
Phase C - blue	Neutral - white
Neutral - white	Ground - green
Ground - green	
- .5 Maintain phase sequence and colour coding throughout project.
- .6 Use colour-coded wires in communication cables, matched throughout the system.
- .7 Identify control conductors in motor control equipment, contactors, fire alarm panels, etc. with mylar/cloth wire markers.
- .8 Identification text to include panel name, wire number and wire type (A, B, C, N or G). Identification to be independent of circuit numbers to allow phase balancing.
- .9 Provide identification on cables at:
  - .1 Inside distributions/panelboards.
  - .2 Inside device boxes or at terminations.
  - .3 Wide junction boxes where joints are made.
- .10 Distribution feeders to be identified as follows:
  - .1 Color code of feeder phase shall appear on every cable in two locations at any distribution; once inside the distribution enclosure near the cable termination and once outside the distribution enclosure, in a visible location near the enclosure.
- .11 Color code all feeders at all terminations, at all points where taps are made, and at all panelboards, switchboards, motor control centres, etc., by means of colored insulation or markers. Use markers of a type not subject to aging or deterioration through heating, drying or easy erasure. Color code in accordance with Rule 4-036 of the CEC. Phasing to be ABC, left, centre, right respectively.

- .12 Demonstrate to the Consultant that each wire has been clearly identified with wire markers where requested.

**END OF SECTION**

**Part 1           General**

**1.1               RELATED WORK**

- .1       Refer to all sections of the specification for related work.

**1.2               PRODUCT DATA**

- .1       Submit product data in accordance with Section 26 05 00 – Common Work Results - Electrical.

**Part 2           Products**

**2.1               CONNECTORS AND TERMINATIONS**

- .1       Copper, long barrel or short barrel compression connectors as required, sized for conductors.
- .2       Provide compression lugs for feeder cables. Set screw connectors not allowed.

**Part 3           Execution**

**3.1               INSTALLATION**

- .1       Install terminations and splices in accordance with manufacturer's instructions.
- .2       Bond and ground as required.

**END OF SECTION**

**Part 1            General**

**1.1                RELATED WORK**

- .1            Refer to all Sections of the specification for related work.

**1.2                SECTION INCLUDES**

- .1            Provision of low voltage and extra low voltage grounding/bonding system for the facility.
- .2            Includes but is not limited to grounding/bonding for:
  - .1            Equipment.

**1.3                REFERENCES**

- .1            Canadian Standards Association:
  - .1            CAN/CSA C22.2 No. 41 Grounding and Bonding Equipment.

**Part 2            Products**

**2.1                MANUFACTURERS**

- .1            Acceptable manufacturers:
  - .1            FCI Burnay Limited.
  - .2            Erico Eritech.

**2.2                EQUIPMENT**

- .1            Ground equipment: to CAN/CSA C22.2 No. 41
- .2            Grounding conductor system, circuit and equipment, grounding to be bare standard copper, sized in accordance with the Canadian Electrical Code.
- .3            Compression fittings to ground conductors to existing electrical system grounding.
- .4            Insulated grounding conductors: green, insulated.

**2.3                ACCESSORIES**

- .1            Non-corroding, necessary for complete grounding system, type, size, material as required, including:
  - .1            Grounding and bonding bushings
  - .2            Protective type clamps
  - .3            Bolted type conductor connectors
  - .4            Thermit welded type conductor connectors
  - .5            Bonding jumpers, straps
  - .6            Pressure wire connectors



- .2 Copper alloy castings with silicon bronze bolts, nuts and washers for connecting pipe, tube, cable, flat bar and special bus shapes.
- .3 Wire connectors and terminations: to Section 26 05 22 – Connectors and Terminations.

### **Part 3 Execution**

#### **3.1 INSTALLATION GENERAL**

- .1 Ensure that all components make good contact at connections to form a continuous metallic ground through the system. Torque bolts in accordance with manufacturer's recommendations.
- .2 Ensure that contact surfaces are free of grease, oil, paint, primer and similar surface coverings. Clean all conductor contact surfaces thoroughly before installation by scratch brushing until bright and shiny.
- .3 Install complete permanent, continuous system and circuit grounding systems including electrodes, conductors, connectors and accessories to conform to requirements of local authority having jurisdiction over installation. Where EMT is used, run ground wire in conduit.
- .4 Install connectors in accordance with manufacturer's instructions.
- .5 For welding type connections, follow manufacturer's instructions.
- .6 Protect exposed grounding conductors from mechanical injury.
- .7 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .8 Soldered joints not permitted.
- .9 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .10 Install flexible ground straps for bus duct enclosure joints, where such bonding is not inherently provided with equipment.
- .11 Make grounding connections in radial configuration only, with connections terminating at single grounding point. Avoid loop connections.
- .12 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end as necessary and run separate ground conductor.

#### **3.2 EQUIPMENT GROUNDING**

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to following list. Service equipment, transformers, switchboard, duct systems, frames of motors, starters, control panels, building steel work, generators, distribution panels, outdoor lighting.

**3.3 FIELD QUALITY CONTROL**

- .1 Perform tests in accordance with Section 26 05 00 – Common Work Results – Electrical and Section 26 08 01 – Electrical Testing Requirements.
- .2 Perform tests before energizing electrical system.

**END OF SECTION**

**Part 1           General**

**1.1               RELATED WORK**

- .1       Refer to all Sections of the specification for related work.

**Part 2           Products**

**2.1               SUPPORT CHANNELS**

- .1       U shape, galvanized steel, size 41 mm (1.6”) x 41 mm (1.6”), 2.5 mm (0.1”) thick, surface mounted, suspended or set in poured concrete walls and ceilings as required.
- .2       Acceptable manufacturers: Burndy, Electrovert, Unistrut, Pilgrim, Pursley.
- .3       Support equipment to be of type and size required to withstand the fire rating where used (rack hangers, rods, anchors).

**Part 3           Execution**

**3.1               INSTALLATION**

- .1       Secure equipment to solid masonry, tile and plaster surfaces with lead anchors or nylon shields.
- .2       Secure equipment to poured concrete with cast in or expandable inserts.
- .3       Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- .4       Secure surface mounted equipment with twist clip fasteners to inverted T bar ceilings. Ensure that T bars are adequately supported to carry weight of equipment specified before installation. Provide additional support where required.
- .5       Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- .6       Fasten exposed conduit or cables to building construction or support system using straps.
  - .1       One-hole steel straps to secure surface conduits and cables 32mm (1-1/4”) and smaller.
  - .2       Two-hole steel straps for conduits and cables larger than 32mm (1-1/4”).
  - .3       Beam clamps to secure conduit to exposed steel work.
- .7       Suspended support systems.
  - .1       Support individual cable or conduit runs with 6mm (1/4”) diameter threaded rods and spring clips.
  - .2       Support two or more cables or conduits on channels supported by 10mm (0.4”) diameter threaded rod hangers where direct fastening to building construction is impractical.

- .8 For surface mounting of two or more conduits use U-channels at 1500mm (60”) on centre spacing.
- .9 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.
- .10 Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
- .11 Do not use wire lashing or perforated strap to support or secure raceways or cables.
- .12 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of Consultant.
- .13 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.
- .14 Provide a separate fire rated system of supports where required (e.g. mineral insulated cables).
- .15 Install continuous vertical channel supports for conduits in utility service rooms and mechanical room.
- .16 Where conduit and cable runs are installed on support systems, they shall run so as to be as inconspicuous as possible. Coordinate support system with equipment of other trades to ensure proper installation of equipment. Run support system paths perpendicular or parallel to building lines.

**END OF SECTION**

**Part 1            General**

**1.1                RELATED WORK**

- .1            Refer to all Sections of the specification for related work.

**1.2                REFERENCES**

- .1            CAN/CSA C22.2 No. 40 Cutout, Junction and Pull Boxes.
- .2            CAN/CSA C22.2 No. 75 Splitters.

**1.3                SHOP DRAWINGS AND PRODUCT DATA**

- .1            Submit shop drawings and product data for splitters and cabinets in accordance with Section 26 05 00 – Common Work Results - Electrical.

**Part 2            Products**

**2.1                JUNCTION BOXES, PULL BOXES AND CABINETS - GENERAL**

- .1            ANSI 61 grey polyester powder coat finish inside and out over phosphatized steel.
- .2            Gasketed and waterproof for wet and damp locations.
- .3            Locate splitters, junction and pull boxes as needed for each system.

**2.2                JUNCTION AND PULL BOXES**

- .1            Code gauge sheet steel, welded construction.
- .2            Screw-on hinged flat covers.
- .3            For flush mounting, covers to overlap box by 25mm (1”) minimum all round with flush head cover retaining screws.

**2.3                CABINETS**

- .1            Cabinets: code gauge sheet steel, welded construction, suitable for field painting with handle lock and catch.
- .2            Locks: to match panelboards, complete with two keys.
- .3            Backboards: 21mm (3/4”) GIS fir painted plywood, one piece per cabinet, covering entire cabinet interior.
  - .1            Type E: with hinged door and return flange overlapping sides, for surface mounting, size as indicated or to suit.
  - .2            Type T: surface, or flush with trim, and hinged door.

**Part 3 Execution**

**3.1 JUNCTION, PULL BOXES AND CABINETS INSTALLATION**

- .1 Supply all pull boxes and junction boxes shown on the drawings and as required for the installation.
- .2 Install in inconspicuous but accessible locations, above removable ceiling or in electrical rooms, utility rooms, or storage areas. Advise Consultant of locations prior to installation.
- .3 Size in accordance with Rule 12-3038, Canadian Electrical Code, as a minimum. Sizes shown on the drawings may be adjusted to suit available space. Review with Consultant where necessary.
- .4 Mount cabinets with top not greater than 2000mm (78”) above finished floor, coordinated with masonry, panelboards, fire hose cabinets and similar items. Securely fasten backboards to cabinet interiors.
- .5 Install terminal block as Type T cabinets.
- .6 Where junction and pull boxes are not indicated, install pull boxes so as not to exceed 30m of conduit run between pull boxes.
- .7 Install junction and pull boxes clear of all mechanical duct work and piping.

**3.2 IDENTIFICATION**

- .1 Provide equipment identification in accordance with Section 26 05 53 – Identification for Electrical Systems.
- .2 Install size 2 identification labels indicating system name and system voltage (where voltage is applicable).

**END OF SECTION**

**Part 1            General**

**1.1                RELATED SECTIONS**

- .1            Refer to all Sections of the specification for related work.

**1.2                REFERENCES**

- .1            CAN/CSA C22.2 No. 18.1 Metallic Outlet Boxes.
- .2            UL 514C Non-Metallic Outlet Boxes, Flush Device Boxes and Covers.
- .3            Latest issue of CSA C22.1 Canadian Electrical Code, Part 1.

**Part 2            Products**

**2.1                OUTLET AND CONDUIT BOXES - GENERAL**

- .1            Minimum size of boxes to be in accordance with Canadian Electrical Code, Section 12.
- .2            Boxes to be hot dip galvanized to ASTM A924 (M), designation zinc coating Z180 (G60).
- .3            102mm (4") square or larger outlet boxes as required for special devices.
- .4            Provide multi-gang boxes where wiring devices are grouped.
- .5            Provide blank cover plates for boxes without wiring devices.
- .6            Provide barriers where outlets for more than one system are grouped.
- .7            All electrical equipment to be sprinkler-proof.

**2.2                CONDUIT BOXES**

- .1            Cast ferrous boxes, 64mm (2½") deep, with factory-threaded hubs and mounting feet for surface mounting of wiring devices and for use in electrical or mechanical rooms and service spaces/corridors.
  - .1            Provide 43mm (1 11/16") deep boxes only when installation does not allow 64mm (2½") boxes to be used.
  - .2            Not approved for telecommunications use.

**2.3                FITTINGS - GENERAL**

- .1            Bushing and connectors with nylon insulated throats.
- .2            Knock-out fillers to prevent entry of debris.
- .3            Conduit outlet bodies for conduit up to 32 mm (1-1/4") and pull boxes for larger conduits.

- .4 Double locknuts and insulated bushings on sheet metal boxes.

### **Part 3 Execution**

#### **3.1 INSTALLATION**

- .1 Install all outlets flush, plumb and square with building lines.
- .2 Surface mount above suspended ceilings and in mechanical and electrical rooms.
- .3 Adjust position of outlets in finished masonry walls to suit course lines. Coordinate cutting of masonry wall to achieve net openings for all boxes.
- .4 Where a two gang box is required for single gang device, provide special plate with device opening in one gang and blank second gang.
- .5 Do not distort boxes during installation. If boxes are distorted, replace with new boxes.
- .6 Installation to be in accordance with Rules 12-3000 to 12-3036, Canadian Electrical Code, “Installation of Boxes, Cabinets, Outlets and Terminal Fittings”. Minimum box size to be in accordance with Rule 12-3036 and Table 23, Canadian Electrical Code, “Number of Conductors in Boxes”. Use more than one outlet box where the number of joints exceeds the requirements for the boxes specified.
- .7 Support boxes independently of connecting conduits.
- .8 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.
- .9 For flush installations mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm (1/4”) of opening.
- .10 Provide correct size of openings in boxes for conduit and cable connections. Reducing washers are not allowed.
- .11 Align outlets that are installed in the same general location so that they are centered.
- .12 Boxes installed in walls with air barriers require vapour boxes. Apply acoustical sealant around conduits and cables which penetrate vapour boxes. Maximum VOC Content: 250 g/L for acoustic sealant.

**END OF SECTION**



**Part 1            General**

**1.1                RELATED WORK**

- .1            Refer to all Sections of the specification for related work.

**1.2                REFERENCES**

- .1            Canadian Standards Association (CSA)
  - .1            CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, and Fittings and Associated Hardware.
  - .2            CAN/CSA C22.2 No. 45, Rigid Metal Conduit.
  - .3            CAN/CSA C22.2 No. 83, Electrical Metallic Tubing.

**1.3                PRODUCT DATA**

- .1            Submit product data for non-metallic raceways in accordance with Section 26 05 00 – Common Work Results - Electrical.

**1.4                LOCATION OF CONDUIT**

- .1            Drawings do not indicate all conduit runs. Those indicated are in diagrammatic form only.
- .2            Electrical contractor shall produce layout sketches of conduit runs through mechanical and electrical service areas to avoid any conflict with other construction elements and to determine the most efficient route to run conduit. Submit sketches prior to roughing-in of conduits.

**1.5                FIRE RATING**

- .1            Fire rating of combustible conduits shown are minimum required. Provide conduit of fire rating as required by authority having jurisdiction.

**Part 2            Products**

**2.1                CONDUIT FASTENINGS**

- .1            One hole steel straps to secure surface conduits 32mm (1-1/4”) and smaller. Two hole steel straps for conduits larger than 32mm (1-1/4”).
- .2            Beam clamps to secure conduits to exposed steel work.
- .3            U-channel type supports for two or more conduits at no more than 2m (78”) o.c. spaced as per code and manufacturer’s recommendations, whichever is closer.
- .4            Threaded rods, 6mm (1/4”) diameter, to support suspended channels.
- .5            Perforated metal and field fabricated hangers and supports not acceptable.

## **2.2 CONDUIT FITTINGS**

- .1 Fittings: manufactured for use with conduit specified. Coating: same as conduit.
- .2 Factory "ells" where 90° bends are required for 27mm (1") and larger conduits.
- .3 Steel set screw connectors and couplings are not permitted.
- .4 Rain-tight connector fittings and couplings complete with O-rings for use on all enclosures and conduit installations, etc.

## **2.3 EXPANSION FITTINGS FOR RIGID METAL**

- .1 Weatherproof expansion fittings suitable for 200mm (8") linear expansion.
- .2 Watertight expansion fittings suitable for linear expansion and 19mm (3/4") deflection in all directions.
- .3 Weatherproof expansion fittings for linear expansion at entry to exterior enclosures/panels.
- .4 With internal bonding assembly for metallic conduits.

## **2.4 FISH CORD**

- .1 Polypropylene, minimum 200 kg strength, UV resistant.

## **2.5 CONDUIT - GENERAL**

- .1 Minimum conduit size shall be 21mm (3/4") unless otherwise indicated.

## **2.6 ELECTRICAL METALLIC TUBING (EMT)**

- .1 Conduit: electrical metallic tubing with wall thickness less than rigid conduit, hot dipped galvanized with corrosion resistant and friction reducing coating on inside, to CAN/CSA C22.2 No. 83.
- .2 Connectors and fittings to be rain-tight type.

## **2.7 RIGID METAL CONDUIT**

- .1 Conduit: rigid galvanized steel, heavy wall, with threaded joints and connections to CAN/CSA C22.2 No. 45.
- .2 Connectors: liquid and dust tight with insulated throat.
- .3 Rigid conduit fittings: outlet boxes, junction boxes, LB's and other fittings cast metal with factory applied epoxy paint.
- .4 Expansion joints: rigid conduit type with external bonding jumper.
- .5 Ground bushing: threaded type with insulated throat.

**Part 3 Execution**

**3.1 CONDUIT INSTALLATION**

- .1 Provide a separate raceway for each electrical system.
- .2 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
- .3 Conceal conduits except in mechanical and electrical service rooms and in unfinished areas.
- .4 Do not surface mount conduits in other areas unless specifically indicated.
- .5 Wiring homeruns to panel boards and main branch circuit wiring runs in ceiling space to be run using TECK or in conduit.
- .6 Armour of TECK cable shall be grounded via an aluminum plate at the supply end and isolated via an insulating plate at the load end of the cable.
- .7 Use electrical metallic tubing (EMT) above 2.4m (0.1”) and in areas where it will not be subjected to physical damage.
- .8 Rigid galvanized steel conduit shall be used where exposed to damage, in wet or hazardous locations or under floor slabs and where shown on the drawings.
- .9 Use flexible metal conduit in dry locations for connection to motors movable partitions not served by a solid (wire mold type) raceway, fluorescent fixtures recessed in T-bar ceilings, suspended fixtures, transformers and equipment subject to movement or vibration. Motor connections and connections to transformers in damp locations to be liquid-tight.
- .10 The length of any conduit run shall not exceed 30m (200’) and no conduit run shall have more than four 90° bends before a pull box is required. Pull boxes to be installed in accessible ceiling space. Conduits shall be supported within 300mm (12”) of entering any junction box, pull box, cabinet or panel board.
- .11 Conduit to be sized as per Canadian Electrical Code. Note that the sizes of branch circuit conductors scheduled and/or specified on the drawings are minimum sizes and must be increased as required to suit length of run and voltage drop in accordance with Canadian Electrical Code. Where conductor sizes are increased to suit voltage drop requirements, increase the conduit size to suit at no extra cost.
- .12 Seal around all conduit penetrations through floors to ensure penetrations are watertight.
- .13 Use explosion proof flexible connection for connection to explosion proof motors.
- .14 Install conduit sealing fittings in hazardous areas. Fill with compound.
- .15 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter. Radius of bend shall be not less than 600mm (24”).

- .16 Mechanically bend steel conduit over 21mm (3/4”) diameter.
- .17 Install fish cord in empty conduits.
- .18 Install expansion joints where conduits cross building expansion joints or for outdoor installations.
- .19 Ream conduit ends to remove all burrs.
- .20 Seal to air barriers conduits which penetrate barrier.
- .21 Remove and replace blocked conduit sections. Do not use liquids to clean out conduits.
- .22 Dry conduits out before installing wire.

### **3.2 SURFACE CONDUITS**

- .1 Run parallel or perpendicular to building lines.
- .2 Locate conduits behind infrared or gas fired heaters with 1.5 m (59”) clearance.
- .3 Run conduits in flanged portion of structural steel.
- .4 Group conduits wherever possible on suspended or surface channels.
- .5 Do not pass conduits through structural members except as indicated.
- .6 Do not locate conduits within 300mm (12”) of flues, steam or hot water lines.
- .7 When a conduit can be run surface, it shall be primed and painted with two coats to match the wall.

### **3.3 GROUNDING**

- .1 Where current carrying conductors are installed in raceway, provide ground wire of equal size.
- .2 Ensure raceways are large enough to accommodate additional (ground) wire.

### **3.4 INSTALLATION OF EMT CONDUIT**

- .1 Use EMT strictly in accordance with Rules 12-1400 to 12-1414 inclusive of CEC.

### **3.5 INSTALLATION OF RIGID METAL CONDUIT**

- .1 Touch up damage to epoxy finish on rigid conduit fittings with touch-up paint supplied by manufacturer. Paint exposed threads on rigid conduit with epoxy paint.

### **3.6 CONDUIT AND CABLE IDENTIFICATION**

- .1 Refer to Section 26 05 53 – Identification for Electrical Systems for scope of work.

**3.7 WORKMANSHIP**

- .1 Install all conduit and wiring concealed, except where specifically noted otherwise. Install conduit in furred spaces or recessed in block or masonry walls. Do not recess conduits in columns or concrete walls, except as noted, without permission. Where conduit is necessary to be run exposed, run parallel to building lines.
- .2 Where metal conduit is placed in concrete, screw up joints tight and paint joints with sealant paint. Before concrete is poured, tightly pack outlet boxes with paper and cap open ends of conduit to prevent concrete intrusion. At junction between exposed conduit and concrete, paint conduit before concrete is poured.
- .3 Take extreme care and ream the ends of all conduits to ensure a smooth interior finish that will not damage the insulation of the wires. Ensure electrical continuity in all conduit systems.

**END OF SECTION**

**Part 1 General**

**1.1 GENERAL**

- .1 Suitably identify with nameplates all pieces of electrical equipment such as lighting, power and distribution panels, power conditioner unit, panelboards, motor control centre, telephone panels, transformers, disconnect switches, contactors, motor starters, control devices, pull boxes, exit lights, splitters, system panels, receptacle coverplates and all equipment connected direct to the power supply.
- .2 Revise and update all existing electrical identification plates (lamacoids) and panel directories affected by changes made in this project.

**1.2 NAMEPLATES AND PANEL DIRECTORIES**

- .1 Laminated phenolic nameplates with engraved white letters on:
  - .1 Black for normal power.
  - .2 Red for emergency power.
- .2 Unless specifically indicated otherwise lettering size to be as follows:
  - .1 Lamacoid nameplates: 3mm (1/8") thick plastic engraving sheet, black or red faced, white core, mechanically attached with shelf-tapping screws or split rivets, unless otherwise specified. Sizes as follows:

**NAMEPLATE SIZES**

Size 1	10 (0.4") x 50 mm (2")	1 line	3 mm (1/8") high letters
Size 2	12 (0.5") x 70 mm (2-3/4")	1 line	5 mm (0.2") high letters
Size 3	12 (0.5") x 70 mm (2-3/4")	2 lines	3 mm (1/8") high letters
Size 4	20 (3/4") x 90 mm (3.5")	1 line	8 mm (0.3") high letters
Size 5	20 (3/4") x 90 mm (3.5")	2 lines	5 mm (0.2") high letters
Size 6	25 (1") x 100 mm (4")	1 line	12 mm (0.5") high letters
Size 7	25 (1") x 100 mm (4")	2 lines	6 mm (1/4") high letters

- .2 Label receptacle and other outlet box coverplates: 5 mm (0.2") minimum height (.76 mm inscription width).
- .3 Motor control centre identification lamacoid (top one), large sub-distribution panel identification lamacoid (top one), all main distribution identification lamacoids: 100 mm (4") minimum height (1.52 mm inscription width).
- .4 Breakers:
  - .1 Sub-distribution panels: 7 mm (1/4") minimum height. May be reduced to 5 mm (0.2") if there are space restrictions.
  - .2 Panelboards: 5 mm (0.2") minimum height. May be reduced to 3 mm (1/8") if there are space restrictions.
- .5 Others: 7 mm (1/4") minimum height (1.02 mm inscription width) when less than 2500 mm (100") above floor; 10 mm (0.4") minimum height (1.52 mm inscription width) when more than 2500 mm (100") above floor.

- .3 Prior to nameplate fabrication, submit to the Consultant/Owner for approval a copy of all panel directories with a list stating exact wording and fabrication details for all nameplates.
  - .1 Submit one complete package, including details for all equipment and devices connected to or part of the electrical distribution.
  - .2 Submission to be received by Consultant a minimum of 7 weeks prior to schedule completion of the work.
- .4 Submit panel directories in electronic format to accommodate future revisions.
  - .1 Submit copies of all ‘as-built’ panel directories for all new and existing panelboards worked on.
  - .2 Do not destroy old directories. For existing panels, insert old directory behind the new one where possible, otherwise turn them over to Owner’s representative on site.
- .5 Use Owner’s building and location codes to provide permanent equipment identification. Architectural room numbers on drawings are not acceptable. Confirm permanent building and location codes with Consultant and Owner prior to making name plates and directories.
- .6 In each maintenance/operating manual, include a copy of all panel directories and nameplate listings which were reviewed by Consultant, including any changes or corrections prior to lamacoid fabrication. Nameplate listing schedule shall have exact description of what appears on installed lamacoid, for all lamacoids (excluding receptacle lamacoids) installed by Division 26.
- .7 Co-ordinate names of equipment and systems with mechanical to ensure consistency.
- .8 All nameplates and panel directories to be installed and 100% complete prior to commissioning.

### **1.3 PANELBOARD AND DISTRIBUTION CENTRE IDENTIFICATION**

- .1 Provide nameplates to identify the following:
  - .1 Panelboard or distribution centre title and code number and voltage characteristics.
  - .2 Supply feeder panelboard or distribution centre title and code number, slot number and location (Owner’s building and location code).
  - .3 Slots on distribution centres stating either “spare” or location (Owner’s building and location code) of panelboard being fed, and panelboard title and code number.
- .2 Rivet nameplate to top, exterior on cabinet door.
- .3 Provide a typewritten data card enclosed in a clear plastic pouch attached inside the door of each panelboard or distribution centre. Information listed on the data card shall include the following:
  - .1 Panelboard or distribution centre title and code number.

- .2 Supply feeder panelboard or distribution centre title and code number, slot number and location (Owner’s building and location code).
- .3 The following information for each circuit:
  - .1 Circuit # and location(s) (Owner’s building and location code).
  - .2 Circuit function i.e. lighting, receptacles, equipment (state equipment name), spare, etc.
- .4 When a lighting and/or receptacle panelboard sub-feeds other lighting and/or receptacle panelboards, supply and install a lamacoid on supply feeder panelboard door (inside) below directory. Information on lamacoid shall identify the following:
  - .1 Circuit # and location(s) (Owner’s building and location code).
  - .2 Panelboard identification of panel being sub-fed. This lamacoid identification and directory shall be identical. Rivet or screw lamacoid to panelboard door. Letter size shall be minimum 5 mm (0.2”) high.
- .5 Insert a copy of each data card into each maintenance/operating manual.
- .6 All existing panelboards or distribution centres affected by this project shall have their directories neatly updated. A copy of updated directories shall be included in each maintenance/operating manual.
- .7 Panel and circuit identification (examples provided):
  - .1 Panel directory identification:
    - .1 Near the top of the directory, provide the following information:  
 PANEL: A (panel identification code no.) 120/208V/3PH/4W (panel voltage, # of phases and wires) FED FROM SD-2A IN B-005 (origin of feeder).
    - .2 If panel is connected to emergency power, indicate: EMERG. POWER: EA.
  - .2 Receptacle colour and circuiting:
    - .1 Refer to wiring devices section for color
  - .3 Sample panel directory:

Panel: A  
 120/208V/3PH/4W  
 Fed from SD-2A in B-01

Circuit	Three Phase	Circuit
Receptacles, Rm 100	1A 22A	Receptacles, Rm 101
Receptacles, Rm 100	2B 23B	Receptacles, Rm 101
Receptacles, Rm 102	3C 24C	Crane
Receptacles, Rm 103	4A 25A	10 Ton Crane
Receptacles, Rm 103	5B 26B	10 Ton Crane
Receptacles, Rm 104	6C 27C	10 Ton Crane
Receptacles, Rm 104	7A 28A	Receptacles, Rm 105
Receptacles, Rm 104	8B 29B	Receptacles, Rm 106
Receptacles, Corr.	9C 30C	B/B Heater BB-1
Receptacles, Corr.	10A 31A	B/B Heater BB-1



Receptacles, Print Rm	11B	32B	UnitHeater UH-1
Receptacles, Reception	12C	33C	UnitHeater UH-1
Lights, Rm 100	13A	34A	UnitHeater UH-2
Lights, Rm 101	14B	35B	UnitHeater UH-2
Lights, Rm 101	16A	37A	Spare
Lights, 102/103	17B	38B	Spare
Lights, Rm 104	18C	39C	Spare
Fan, F-1	19A	40A	Space
Fan, F-2	20B	41B	Space
Fan, F-3	21C	42C	Space

The contractor is to supply a sample of the proposed panel designations to the Owner for approval, prior to all labeling.

#### 1.4 OTHER EQUIPMENT IDENTIFIED BY NAMEPLATE

- .1 Panels and terminal cabinets for low voltage systems: Indicate panel designation, system, and load, system or load location and area served. Provide directories to identify equipment and locations of equipment connected to each circuit. Insert a copy of directory in clear plastic pouch attached inside panel door and in maintenance operating manuals.
- .2 Splitters and pullboxes: Indicate their function and characteristics (equipment description and location where fed from and what it feeds).
- .3 Miscellaneous equipment and exit lights: All equipment, including equipment supplied by others, wired directly to the power source such as exit lights, electromagnetic door hold-open devices, magnetic door holders, drinking fountains, line voltage thermostats, control panels, alarm panels, power supplies, fans, heaters and other equipment, shall have lamacoid mechanically fastened onto the piece of equipment, in a conspicuous location, stating: e.g. POWER FROM PANEL A/22 IN 100. Letter size on lamacoids shall be 5 mm high.
  - .1 Dyno markers maybe used for labeling small devices and use of the dyno markers must be pre-approved by the Owner.
  - .2 Division 26 to site check space available on equipment to determine lamacoid dimensions. Lamacoid shall be flush mounted and shall not project over equipment edges nor conceal other information or elements on surface of equipment. The installation shall have a neat appearance.
- .4 Computer equipment lamacoids are not to be mechanically fastened. . Discuss method of labeling with Owner prior to labeling of equipment.
- .5 Panel Breakers:
  - .1 Sub-distribution panels: All breakers to have lamacoid identification with 7 mm (1/4") high letters. Examples are:
    - .1 For mechanical equipment:
 

CONDENSING UNIT CU-1	(equipment description)
ON Roof	(equipment location)
    - .2 For electrical distribution equipment:

FEEDS TR-1 (equipment description)  
IN Room 100 (equipment location)

- .2 Panelboards: Provide lamacoid identification with 5 mm (0.2”) high lettering for breakers which control sub-fed panels. If there is insufficient space available adjacent to breakers, lamacoids to be mechanically fastened to the interior of panel door, either above or below the directory. If lamacoids are fastened adjacent to individual breakers, circuit numbers may be omitted from lamacoids.

EXAMPLE: CCT. #14, 15, 16

PANEL: A IN Rm 100

- .6 By-Pass Switches:
- .1 Indicate designation, characteristics, normal supply feeder and panel, generator supply feeder and panel. Identify each breaker and each position of the interlocking. See drawings as well.
- .7 Battery Powered Emergency Lighting: Provide lamacoid with 7 mm (1/4”) high white lettering as indicated, AC power to battery bank determines lamacoid colour, black for normal power, red for emergency power.
- .1 At each battery bank which serves remote fixtures: BATTERY BANK # FOR EMERG. LIGHTING IN Rm 100 (state room numbers) AC power fed from distribution SD-A in Rm B-001.
- .2 At each remote light fixture: BATTERY POWERED FROM BANK # IN Rm 100 (state room number).
- .3 Lamacoid identification described in this clause is not required if battery bank does not serve remote fixtures. However, on battery bank provide a lamacoid indication: AC power fed from distribution A in Rm. 100.
- .4 Exit lighting powered by both AC and DC:
- .1 AC power fed from panel A in Rm. 100.
- .2 DC battery powered from bank # in Room 101.

## 1.5 CONDUIT AND CABLE IDENTIFICATION

- .1 Colour code of feeder phase (Refer to Section 26 05 34 – Conduits, Conduit Fastenings and Conduit Fittings for colour coding.) shall appear on every cable in two locations at any distribution; once inside distribution enclosure near cable termination and once outside distribution enclosure, in visible location near enclosure.
- .2 Junction boxes with power wiring, all circuits inside the box shall be identified on the inside of the cover plate with permanent marker.
- .3 Provide Thomas and Betts stick-on conduit markers for the following systems. Markers to be:
- .1 Style B 28.6 mm (1-1/8”) x 114.3 mm (4.5”) for 25 mm (1”) conduit and larger.
- .2 Style C 12.7 mm (0.5”) x 57.2 mm (2-1/4”) for conduit under 25 mm (1”).

- .4 Space markers 10 metres (33') on centres maximum for exposed conduits and conduits in accessible ceiling spaces and, in addition, attach markers before and after all barriers, where conduits pass through closets, cupboards, stairwells, etc., and adjacent to all panels, cabinets, pullboxes and access fittings. Markers to be laminated mylar with orange background and black letters. Identify systems as follows:

NORMAL POWER	VOICE/DATA
EMERGENCY POWER	UPS POWER
DATA PROCESSING	AMPLE ORGANICS DATA PROCESSING
INTERCOM	FIRE ALARM
TELEVISION	CCVS
MONITORING SYSTEM	INTRUSION ALARM
ACCESS CONTROL	CONTROL WIRING
A.T.S. CONTROLS	DC EMERG. LIGHTING
GROUND CONDUCTOR	

Others: Check with Consultant. All conduit systems shall be identified.

- .5 All stick-on conduit markers must be installed during installation of related conduit systems, not after installation of complete conduit systems.
- .6 Do not apply stick-on conduit markers onto exposed wiremold raceways.

**Part 2 Products**

- .1 Not used.

**Part 3 Execution**

- .1 Not used.

**END OF SECTION**

**Part 1            General**

**1.1                RELATED WORK**

- .1     Refer to all Sections of the specification for related work.
- .2     Mechanical Divisions.

**1.2                REQUIREMENTS**

- .1     Provide a complete system of power wiring to motors and controls.
- .2     Unless specifically noted otherwise, wire and leave in operation all electrically operated equipment supplied under this Contract. Examine the drawings and shop drawings of all Divisions for the extent of electrically operated equipment supplied by other Divisions.
- .3     Where control wiring diagrams are shown illustrate typical control circuits applicable to the equipment. Control circuits may vary with different manufacturers of equipment. Verify all control circuits with the suppliers of the equipment and make any corrections that may be required.
- .4     Unless specifically noted otherwise, supply all pushbuttons, relays, starters, etc. necessary for the operation of equipment. Check all starters, relay coils and thermal elements to ensure that they provide the necessary protection for motors.
- .5     Do not operate motors and controls until approval is obtained from the trade providing equipment.
- .6     Examine drawings and shop drawings of other Divisions to obtain exact location of motors and equipment shown on other Division drawings and specifications. Where necessary, obtain conduit locations from other trades' drawings & shop drawings. The complete list of motors may not be shown on the electrical drawings.
- .7     Assist in placing in operation all mechanical equipment having electrical connections.
- .8     Provide three phase starters with primary and secondary fused 120 volt control transformers and overload relays.
- .9     In general, wiring for freezestats, firestats, EP switches P.E. switches, dampers, temperature controllers, flow switches, solenoid valves, etc., for heating, ventilating and air conditioning equipment will be by Mechanical Contractor, from control panels supplied and installed by Mechanical Contractor. Provide terminations in starters and MCC's for control wiring, so that starter control circuits may be extended by Mechanical Contractor. Where 120 volt power is required for mechanical equipment, i.e.: for roll type filters, refrigerated aftercoolers, control cabinets, etc., wiring to the equipment terminals is the work of the Electrical Contractor. Electrical Contractor to wire all 120V AHU internal lighting and receptacles, condensers and rooftops weatherproof outdoor receptacles.

**Part 2 Products**

**2.1 3Ø MOTOR DISCONNECT SWITCHES**

- .1 Industrial Type "A" having quick-make, quick-break visible blade mechanism, cover interlocks and padlocking switch in the closed or open position. Use EEMAC-4 enclosures outdoors, EEMAC-1 indoors and drip proof shield watertight for areas exposed to sprinklers. Switches to be kW rated, Square "D" Type A heavy duty.

**2.2 120V 1Ø DISCONNECT SWITCHES**

- .1 Manual starter without overload relay.

**2.3 208V 1Ø MOTOR DISCONNECT SWITCHES**

- .1 Manual starter without overload relay.

**Part 3 Execution**

**3.1 GENERAL**

- .1 For all motors, provide disconnect switches adjacent to the motors.
- .2 Wall mount disconnects adjacent to equipment or floor mount at motor locations. Wall mounted disconnects to be 1400 mm (55") above floor.

**3.2 CONTROL CABINETS & CONTROLS**

- .1 Verify the location of all control cabinets, and provide power wiring to each cabinet from the nearest electrical panel where not specifically shown from a particular panel.
- .2 Power wiring for mechanical equipment is the responsibility of the Electrical Contractor. Provide circuits and wiring to suit the controls contractor requirements. All control power wiring requirements may not be specifically shown on the drawings.
- .3 All control wiring shall be run in conduit. Coordinate with controls subcontractor.

**3.3 COMMISSIONING**

- .1 Do not start motors until the supplier of the equipment has verified that the electrical connection has been made in accordance with the nameplate information.
- .2 Extreme caution must be taken in connection of motors with nameplates having multiple connection diagrams i.e.: WYE-DELTA Start, MULTISPEED.
- .3 Be responsible for replacement of motors or other equipment damaged by starting-up prior to being checked by equipment supplier.

**END OF SECTION**

**Part 1            General**

**1.1                INCLUDED SYSTEMS AND EQUIPMENT**

- .1    The following is a partial list of equipment and system test requirements included in this section:
  - .1    Distribution systems including phasing, voltage, grounding, load balancing and/or megger testing.
  - .2    Grounding systems.
  - .3    Motors and associated control equipment including sequenced operation of systems where applicable.
  - .4    Receptacles.
  - .5    Connections to mechanical equipment.

**1.2                DESCRIPTION**

- .1    This section specifies the functional testing and commissioning requirements for electrical systems and equipment as performed by the electrical contractor. The test requirements for each piece of equipment or system shall contain the following:
  - .1    A list of the integral components being tested.
  - .2    Pre-functional checklists associated with the components.
  - .3    Functions and modes to be tested.
  - .4    Required conditions of the test for each mode.
  - .5    Special procedures.
  - .6    Required methods of testing.
  - .7    Required monitoring.
  - .8    Acceptance criteria.
- .2    Include the cost of testing in the contract price.
- .3    In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
- .4    Provide a copy of the O&M manual submittals of tested equipment, through normal channels, to the Consultant for review and approval.
- .5    Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure technicians are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests and adjustments. Provide suitable notice to the owners and allow them to be present during testing if they deem necessary
- .6    Prepare O&M manuals according to the Contract Documents. Include clarifying and updating the original sequences of operation to as-built conditions.
- .7    Provide training of the Owner’s operating personnel. Provide a DVD of all training as approved by the Owner.

- .8 Immediately prior to building occupancy, test the entire electrical system by performing a loss and return of utility power test as approved by the Owner.

### **1.3 TEST EQUIPMENT**

- .1 Electrical Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

### **Part 2 Products**

- .1 Not used

### **Part 3 Execution**

#### **3.1 GENERAL**

- .1 Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.
- .2 Carry out tests in presence of the Consultant's and Owners representative.
- .3 Give advance notice of proposed time of tests so that the Consultant and owner can be represented at the tests.
- .4 Submit test results for review by the Consultant. Complete deficiencies within construction schedule.
- .5 Include copy of test results in maintenance manuals.
- .6 Testing methods and test results: in accordance with CSA, CEC and regulations of the supply authority, other authorities having jurisdiction and manufactures recommendations.
- .7 Conduct dielectric tests, megger tests, insulation resistance tests and ground continuity tests as required by the nature of the various systems and equipment.

#### **3.2 EQUIPMENT TESTING**

- .1 With the systems completely connected and lamped, conduct the following tests on the power system:
  - .1 Control and Switching: test all circuits for the correct operation of devices, switches and controls.
  - .2 Polarity Tests: test all circuits for correct operation of devices, switches and controls.
  - .3 Voltage Tests: make a voltage test at the last outlet of each circuit. Maximum drop in potential permitted will be 3% on 120V, and 208V branch circuits. 3% on 208V feeder circuits, and 3% on 600V feeder circuits. Correct any deficiency in this respect.

- .4 Phase Balance: measure the load on each phase at each switchboard, distribution panelboard and lighting and power panelboards. Report results in writing to the Consultant. Re-arrange phase connections as necessary to balance the load on each phase as instructed by the Consultant with the re-arrangement being restricted to the exchanging of connections at the distribution points mentioned in this paragraph. After marking any such changes, make available to the Consultant, drawings or marked prints showing the modified connections.
- .5 Supply Voltage: measure the line voltage of each phase at the load terminals of the main breakers and report the results in writing to the Consultant. Perform this test with the majority of electrical equipment in use.
- .6 Motor Loading: measure the line current of each phase of each motor with the motor operating under load and report the results in writing to the Consultant. Upon indications of any imbalance or overload, thoroughly examine the electrical connections and rectify any defective parts or wiring. If electrical connections are correct, overloads due to defects in the driven machines shall be reported in writing to the Consultant. Verify motor full load amps and overload relays are properly sized and adjusted accordingly.
- .7 General Operations: energize and put into operation each and every electrical circuit and item. Make repairs, alterations, replacements, tests and adjustments necessary for a complete and satisfactory operating electrical system.
- .2 When tests are performed, the Consultant may require that equipment be opened and removed from their housings to examine interior of equipment, terminations and connections. Provide all required labour and tools.
- .3 Coordinate the testing of motors with the trades providing the equipment driven by the motors so that they are carried out at the time the driven equipment is put on test. In addition to the motor loading tests, provide labour and instruments to take and record all motor load readings required to supplement the tests on the driven equipment through various load sequences, as required by the trades involved.
- .4 General Component Starting and Testing:
  - .1 Prior to energizing:
    - .1 Confirm components nameplate data with characteristics of power supply.
    - .2 Verify supply voltage and phase rotation.
    - .3 Ensure all testing as specified has been completed and deficiencies have been corrected.
    - .4 Close and open all devices to ensure proper mechanical operation.
    - .5 Megger all feeders and record results on approved verification forms.
- .5 Insulation Resistance Testing:
  - .1 After installing cable and terminating reform insulation resistance test with megger on each phase conductor.
  - .2 Megger all circuits, feeders and components up to 350 V with a 500 V instrument.



- .3 Megger all 350-600 V circuits, feeders and components with a 1000 V instrument.
  - .4 Check insulation resistance to ground before energizing.
  - .5 Megger cables for one minute, graph results at 10 second intervals. Submit graphs to Consultant and include graphs in O & M manuals.
  - .6 Minimum insulation resistance to earth or between phases: 100.
  - .7 Instrument to have minimum of 100 Megaohm resolution in the 0 to 500 Megaohm range.
  - .8 Check insulation resistance after each termination to ensure that cable system is ready for acceptance testing.
- .6 Disconnect Switches - Fused/Unfused:
- .1 Visual and mechanical inspection:
    - .1 Check physical, electrical and mechanical condition. Inspect for cracks or other defects.
    - .2 Compare equipment nameplate data with latest contractual documents/requirements. Operate switch to ensure smooth operation.
    - .3 Check tightness of connections using calibrated torque wrench.
    - .4 Check blade alignment.
    - .5 Check each fuse holder for adequate mechanical support of each fuse.
    - .6 Check all electrical and mechanical interlocks.
    - .7 Check proper phase barrier materials and installation.
    - .8 Inspect all indicating devices for proper operation.
    - .9 Clean entire switch using approved methods and materials.
    - .10 Lubricate to manufacturer's recommendations.
    - .11 Exercise all active components.
  - .2 Electrical Tests:
    - .1 Perform a contact resistance test across each switch blade and fuse holder.
- .7 Wiring and Cables:
- .1 Test all conductors, including those at distribution centres and panelboards for insulation resistance to ground (megger test).
  - .2 Test service grounding conductors for ground resistance.
  - .3 Provide list of test results on approved verification form showing location at which each test was made, circuit tested and results of each test.
  - .4 Remove and replace entire length of cable if cable fails to meet any of the test criteria.
- .8 Grounding:
- .1 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of Consultant and local authority having jurisdiction over installation.
  - .2 Perform tests before energizing electrical distribution.

- .3 Provide test report documenting successful test results.
- .9 Motor Starters:
  - .1 Operate switches, contactors to verify correct functioning.
  - .2 Perform starting and stopping sequences of contactors and relays.
  - .3 Check that sequence controls, interlocking with other separate related starters, components and control devices operate as per component verification form.
  - .4 Record all observations, data and test results
- .10 Motors:
  - .1 Prior to starting motors:
    - .1 Confirm motor nameplate data with motor starter heater overloads, setting of MCP's and sizing of fuses.
    - .2 Verify rotation. Ensure disconnects are installed.
    - .3 Confirm labeling of motors, disconnects and starters.

**END OF SECTION**

**Part 1            General**

**1.1                RELATED WORK**

- .1            Refer to all Sections of the specification for related work.

**1.2                SECTION INCLUDES**

- .1            Receptacles, cover plates, special wiring devices and their installation.

**1.3                REFERENCES**

- .1            Canadian Standards Association (CSA International)
  - .1            CSA-C22.2 No.42, General Use Receptacles, Attachment Plugs and Similar Devices.
  - .2            CSA-C22.2 No.42.1, Cover Plates for Flush-Mounted Wiring Devices.
  - .3            CSA-C22.2 No.55, Special Use Switches.
  - .4            CSA-C22.2 No.111, General-Use Snap Switches (Bi-national standard, with UL 20).

**1.4                SHOP DRAWINGS AND PRODUCT DATA**

- .1            Submit shop drawings and product data in accordance with Section 26 05 00 – Common Work Results - Electrical.

**Part 2            Products**

**2.1                RECEPTACLES**

- .1            Duplex receptacles, NEMA No. 5-20 R, 125 VAC, 20 A, parallel slot, U ground, with the following features:
  - .1            Industrial grade.
  - .2            Suitable for #10 AWG back and side wiring.
  - .3            Break-off links for use as split receptacles.
  - .4            Double wipe contacts and non-riveted grounding contacts.
  - .5            Aluminum yokes, blades or terminals or with CU/AL rating will not be accepted.
  - .6            Acceptable manufacturer: Cooper, Hubbell, Leviton.
  - .7            GFCI as indicated:
    - .1            Testing and reset buttons.
    - .2            Indicator light to show status of GFCI protection operation.
    - .3            Malfunction protection. Device cannot be reset if GFCI is non-operational or unit is wired incorrectly.
    - .4            5mA trip level.
- .2            Single receptacles NEMA No. 5-20R, 125V AC, 20A, U-ground, suitable for #10 back and side wiring.

- .3 Other receptacles with ampacity and voltage as required.
- .4 Receptacles of one manufacturer throughout project.
- .5 Colour of receptacles shall be as follows:
  - .1 White for general use normal power.
  - .2 Red for emergency power.

## **2.2 COVERPLATES**

- .1 Provide cover plates for all wiring devices.
- .2 Cover plates from one manufacturer throughout project.
- .3 Coverplates for surface mounted receptacles and switches on exposed conduit systems shall be stainless steel 12mm (0.5") raised type.
- .4 Stainless steel coverplates, thickness 1mm for wiring devices mounted in flush-mounted outlet box.
- .5 For all exterior weatherproof receptacle provide "while-in-use" wet listed metal die cast cover box c/w grey powder coat finish, NEMA 3R rating, lockable and c/w gasket, mounting hardware, GFCI receptacle cover. Construction to be all die cast metal heavy duty construction.
- .6 Acceptable manufacturer: Cooper, Hubbell, Leviton.

## **Part 3 Execution**

### **3.1 INSTALLATION**

- .1 Location of outlets:
  - .1 Do not install outlets back-to-back in wall, allow minimum 400 mm (16") clearance between boxes.
  - .2 Change location of outlets at no extra cost providing distance does not exceed 3 m (10'-0") in radius and information is provided before installation.
  - .3 Drawings are schematic only, coordinate mounting height and location of all equipment with architectural, mechanical and structural drawings prior to installation.
  - .4 Vertically align outlets of different systems when shown in close proximity to each other and occur at different mounting heights.
- .2 Receptacles:
  - .1 Install receptacles in gang type outlet box when more than one receptacle is required in one location.
  - .2 Mount receptacles at height in accordance with Section 26 05 00 – Common Work Results – Electrical.

- .3 Where split receptacle has one portion switched, mount vertically and switch upper portion.
- .4 Install vertical receptacles ground up on walls and ground down under counters. Horizontal receptacles neutral up on walls and neutral down under counters.
- .3 Cover plates:
  - .1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.
  - .2 Install suitable common cover plates where wiring devices are grouped.
  - .3 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.

### **3.2 RECEPTACLE WIRING VERIFICATION**

- .1 Verify all receptacles have been wired correctly using an outlet circuit tester. Provide written test results. See Section 26 08 01 – Electrical Testing Requirements.

**END OF SECTION**

**Part 1           General**

**1.1               RELATED WORK**

- .1       Refer to all sections of the specification for related work.

**1.2               SHOP DRAWINGS AND PRODUCT DATA**

- .1       Submit shop drawings and product data in accordance with Section 26 05 00 – Common Work Results - Electrical

**Part 2           Products**

**2.1               BREAKERS – GENERAL**

- .1       Common-trip breakers: with single handle for multi-pole applications.
- .2       Bolt-on moulded case circuit breakers, quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40°C (104°F) ambient.
- .3       Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting. Trip settings on breakers with adjustable trips to range from 3-10 times current rating.
- .4       To be of same manufacturer as switchboards, CDP's and panelboards.

**2.2               THERMAL MAGNETIC BREAKERS**

- .1       Moulded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping and instantaneous tripping for short circuit protection.

**2.3               MANUFACTURERS**

- .1       Acceptable manufacturers: GE, Eaton (Cutler Hammer) or Schneider (Square D).

**Part 3           Execution**

**3.1               INSTALLATION**

- .1       Install circuit breakers according to manufacturer's recommendations.

**END OF SECTION**

**Part 1           General**

**1.1               RELATED WORK**

- .1       Refer to all sections of the specification for related work.

**1.2               SHOP DRAWINGS AND PRODUCT DATA**

- .1       Submit shop drawings and product data in accordance with Section 26 05 00 – Common Work Results - Electrical.

**Part 2           Products**

**2.1               DISCONNECT SWITCHES**

- .1       Fusible and non-fusible disconnect switch in EEMAC '4' enclosure.
- .2       Provision for padlocking in on-off positions.
- .3       Mechanically interlocked door to prevent opening when handle in ON position.
- .4       Fuses: size as required.
- .5       Fuseholders: suitable without adaptors, for type and size of fuse indicated.
- .6       Quick-make, quick-break action.
- .7       ON-OFF switch position indication on switch enclosure cover.
- .8       Cover viewing window to allow visual verification of “On-Off” status.

**2.2               EQUIPMENT IDENTIFICATION**

- .1       Provide equipment identification in accordance with Section 26 05 00 – Common Work Results - Electrical.
- .2       Indicate name of load controlled on size 4 nameplates.

**2.3               APPROVED MANUFACTURERS**

- .1       Approved manufacturers: GE, Eaton (Cutler Hammer) or Schneider (Square D).

**Part 3            Execution**

**3.1                INSTALLATION**

- .1            Install disconnect switches complete with fuses only where specifically indicated.
- .2            Install circuit disconnect switches where indicated or where required by the inspection authorities and/or for equipment supplied by other trades.

**END OF SECTION**