

PROJECT TITLE      LABORATORY BUILDING ROOFTOP UNIT REPLACEMENT  
PUBLIC HEALTH AGENCY OF CANADA  
110 STONE RD. WEST  
GUELPH, ONTARIO

PROJECT NUMBER      R.090980.001

PROJECT DATE      2018-05-01

Consultant for Building Code Review:



Building Code Designation Number (BCDN):

END OF SECTION

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END OF SECTION

## **PART 1 - GENERAL**

### **1.1 MINIMUM STANDARDS**

- .1 Materials shall be new and work shall conform to the minimum applicable standards of the Canadian General Standards Board, the Canadian Standards Association, the National Building Code of Canada 2015 (NBCC) and all applicable Provincial and Municipal codes. In the case of conflict or discrepancy the most stringent requirement shall apply.

### **1.2 TAXES**

- .1 Pay all taxes properly levied by law (including Federal, Provincial and Municipal).

### **1.3 FEES, PERMITS, AND CERTIFICATES**

- .1 Pay all fees and obtain all permits. Provide authorities with plans and information for acceptance certificates. Provide inspection certificates as evidence that work conforms to requirements of Authority having jurisdiction.

### **1.4 FIRE SAFETY REQUIREMENTS**

- .1 Comply with the National Building Code of Canada 2015 (NBCC) for fire safety in construction and the National Fire Code of Canada 2015 (NFCC) for fire prevention, fire fighting and life safety in building in use.
- .2 Comply with PSPC Standard on Construction Occupational Health and Safety, Fire Commissioner of Canada (FCC) standards:
  - .1 No. 301: Standard for Construction Operations
  - .2 No. 302: Standard for Welding and Cutting
  - .3 No. 374: Fire Protection Standard for General Storage (Indoor and Outdoor)
  - .4 available from Fire Protection Engineering Services, Labour Program, HRSDC or following internet site: es, Labour Program, HRSDC or following internet
  - .5 Retain all fire safety documents and standards on site.

### **1.5 FIELD QUALITY CONTROL**

- .1 Carry out Work using qualified licenced workers or apprentices in accordance with Provincial Act respecting manpower vocational training and qualification.
- .2 Permit employees registered in Provincial apprenticeship program to perform specific tasks only if under direct supervision of qualified licenced workers.
- .3 Determine permitted activities and tasks by apprentices, based on level of training attended and demonstration of ability to perform specific duties.

#### 1.6 HAZARDOUS MATERIALS

- .1 Comply with the requirements of the Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage, and disposal of hazardous materials; and regarding labelling and the provision of Material Safety Data Sheets (MSDS) acceptable to Human Resources Development Canada, Labour Program.

#### 1.7 REMOVED MATERIALS

- .1 Unless otherwise specified, materials for removal become the Contractor's property and shall be taken from site.

#### 1.8 PROTECTION

- .1 Protect finished work against damage until take-over.
- .2 Protect adjacent work against the spread of dust and dirt
- .3 Protect operatives and other users of site from all hazards.

#### 1.9 USE OF SITE AND FACILITIES

- .1 Execute work with least possible interference or disturbance to the normal use of premises. Make arrangements with Departmental Representative to facilitate work as stated.
- .2 Maintain existing services to building and provide for personnel and vehicle access.
- .3 Where security is reduced by work provide temporary means to maintain security.
- .4 Where elevators, dumbwaiters, conveyors or escalators exist Contractor may use these at Departmental Representative's discretion. Protect from damage, safety hazards and overloading of existing equipment.
- .5 Sanitary facilities will be assigned for Contractor's personnel. Others shall not be used. Keep facilities clean.
- .6 Closures: Protect work temporarily until permanent enclosures completed.

#### 1.10 SITE STORAGE

- .1 Do not unreasonably encumber site with materials or equipment.
- .2 Move stored products or equipment which interfere with operations of Departmental Representative or other contractors.
- .3 Obtain and pay for use of additional storage as space for equipment storage on site is minimal.

#### 1.11 CUT, PATCH AND MAKE GOOD

- .1 Cut existing surfaces as required to accommodate new work.

- .2 Remove all items so shown or specified.
- .3 Patch and make good surfaces cut, damaged or disturbed, to Departmental Representative's approval. Match existing material, colour, finish and texture.
- .4 Install firestops and smoke seals in accordance with ULC-S115-11, around pipe, ductwork, cables, and other objects penetrating fire separations to provide fire resistance not less than the fire resistance rating of surrounding floor, ceiling, and wall assembly.

#### 1.12 SLEEVES, HANGERS AND INSERTS

- .1 Co-ordinate setting and packing of sleeves and supply and installation of hangers and inserts. Obtain Departmental Representative's approval before cutting into structure.

#### 1.13 EXAMINATION

- .1 Examine site and conditions likely to affect work and be familiar and conversant with existing conditions

#### 1.14 SIGNS

- .1 Provide common-use signs related to traffic control, information, instruction, use of equipment, public safety devices, etc., in both official languages or by the use of commonly-understood graphic symbols to the Departmental Representative's approval.
- .2 No advertising will be permitted on this project.

#### 1.15 WASTE MANAGEMENT

- .1 Comply with the Environmental Protection Act, Ontario Regulations O.Reg. 102/94 and O. Reg. 103/94 for waste management program on construction and demolition projects.
- .2 Conduct "waste audit" to determine waste generated during demolition or construction operations, prepare written "waste reduction work plan" and implement procedures to reduce, reuse and recycle materials to the extent possible.
- .3 Provide a "source separation program" to disassemble and collect in an orderly fashion the following "materials designated for alternative disposal" from the "general waste" stream.
  - .1 Cardboard (corrugated).
  - .2 Steel.
  - .3 Wood (not including treated or laminated wood).
- .4 Submit complete records of all removals from site for both "materials designated for alternative disposal" and "general waste" including:
  - .1 Time and date of removal.
  - .2 Description of material and quantities.
  - .3 Proof that materials have been received at an Approved Waste Processing .
  - .4 Site or certified Waste Disposal Site as required.

1.16 GUARANTEES AND WARRANTIES

- .1 Before completion of work collect all manufacturer's guarantees and warranties and deposit with Departmental Representative.

1.17 SECURITY ESCORT

- .1 Personnel will be checked daily at start of work shift and given a pass which must be worn at all times. Pass must be returned at end of work shift and personnel checked out.
- .2 All personnel must attend a mandatory 2 hour site specific safety training session. Provide minimum 72 hours notice to Departmental Representative requesting site training.

1.18 BUILDING SMOKING ENVIRONMENT

- .1 Smoking is not permitted in the Building. Obey smoking restrictions on building property.

1.19 DUST CONTROL

- .1 Provide dust tight screens or partitions to localize dust generating activities, and for protection of workers, finished areas of work and public.
- .2 Maintain and relocate protection until such work is complete.

1.20 TESTING LABORATORY SERVICES

- .1 Departmental Representative will appoint and pay for costs of inspection and testing services, unless indicated otherwise.
- .2 Provide safe working areas and assist with testing procedures, including provisions for materials or services and co-ordination, as required by testing agency and as authorized by Departmental Representative.
- .3 Where tests indicate non-compliance with specifications, contractor to pay for initial test and all subsequent testing of work to verify acceptability of corrected work.

1.21 SCHEDULING

- .1 On award of contract submit bar chart construction schedule for work, indicating anticipated progress stages within time of completion. When schedule has been reviewed by the Departmental Representative, take necessary measures to complete work within scheduled time. Do not change schedule without notifying Departmental Representative.
- .2 Carry out work during "normal working hours" Monday to Friday 06:00 to 18:00 and on Saturdays, Sundays and statutory holidays.
- .3 Give the Departmental Representative 48 hours notice for work to be carried out during "off hours".

1.22 COST BREAKDOWN

- .1 Before submitting first progress claim submit breakdown of Contract Amount in detail as directed by Departmental Representative and aggregating the Contract Amount. After approval by Departmental Representative cost breakdown will be used as the basis of progress payments.

1.23 PRECEDENCE

- .1 Division 01 Sections take precedence over technical specification sections in other Divisions of this Project Manual.

1.24 WORK PERMIT

- .1 Obtain applicable work and hot work permit forms from building operator.

1.25 STAGING PLAN

- .1 Submit to Departmental Representative for review and approval, a Staging Plan that outlines work stages in compliance with specified implementation restrictions and in accordance with submitted schedule. Once approved by the Departmental Representative, do not make changes to specified stages without prior written approval of Departmental Representative. Any changes to the Phasing Plan will require a minimum of 7 days advanced notice. Do not work in staging areas outside of indicated times.

**PART 2 - PRODUCTS**

2.1 NOT USED

- .1 Not Used.

**PART 3 - EXECUTION**

3.1 NOT USED

- .1 Not Used.

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END OF SECTION



## **PART 1 - GENERAL**

### **1.1 ADMINISTRATIVE**

- .1 Submit to Departmental Representative 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 is not produced in SI Metric units converted values are acceptable.
- .5 Review submittals prior to submission to Departmental Representative. 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.
- .6 Notify Departmental Representative, in writing at time of submission, identifying deviations from requirements of Contract Documents stating reasons for deviations.
- .7 Verify field measurements and affected adjacent Work are co-ordinated.
- .8 Contractor's responsibility for errors and omissions in submission is not relieved by Departmental Representative's review of submittals.
- .9 Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved by Departmental Representative review.
- .10 Keep one reviewed copy of each submission on site.

### **1.2 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submissions include:
  - .1 Date and revision dates.
  - .2 Project title and number.
  - .3 Name and address of:
    - .1 Subcontractor.
    - .2 Supplier.
    - .3 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:
    - .1 Fabrication.
    - .2 Layout, showing dimensions, including identified field dimensions, and clearances.
    - .3 Setting or erection details.
    - .4 Capacities.
    - .5 Performance characteristics.
    - .6 Standards.
    - .7 Operating weight.

- .8 Wiring diagrams.
- .9 Single line and schematic diagrams.
- .10 Relationship to adjacent work.
- .2 After Departmental Representative's review, distribute copies.
- .3 Submit electronic copy of shop drawings for each requirement requested in specification Sections and as Departmental Representative may reasonably request.
- .4 Submit electronic copies of Operation and Maintenance Data for requirements requested in specification Sections and as requested by Departmental Representative.
- .5 Delete information not applicable to project.
- .6 Supplement standard information to provide details applicable to project.
- .7 If upon review by Departmental Representative, 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.
- .8 The review of shop drawings is for sole purpose of ascertaining conformance with general concept.
  - .1 This review shall not mean that Departmental Representative approves detail design inherent in shop drawings, responsibility for which shall remain with Contractor submitting same, and such review shall not relieve Contractor of responsibility for errors or omissions in shop drawings or of responsibility for meeting requirements of construction and Contract Documents.
  - .2 Without restricting generality of foregoing, Contractor is responsible for dimensions to be confirmed and correlated at job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for co-ordination of Work of sub-trades.

## **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 Canada Labour Code, Part 2, Canada Occupational Safety and Health Regulations
- .2 Province of Ontario
  - .1 Occupational Health and Safety Act and Regulations for Construction Projects, R.S.O. 1990, c.0.1, as amended and O. Reg. 213/91 as amended - Updated 2005.

### **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 days after date of Notice to Proceed and prior to commencement of Work. Health and Safety Plan must include:
  - .1 Results of site specific safety hazard assessment.
  - .2 Results of safety and health risk or hazard analysis for site tasks and operation found in work plan.
- .3 Submit one (1) copy of Contractor's authorized representative's work site health and safety inspection reports to Departmental Representative weekly.
- .4 Submit copies of reports or directions issued by Federal and Provincial health and safety inspectors.
- .5 Submit copies of incident and accident reports.
- .6 Submit WHMIS MSDS - Material Safety Data Sheets.
- .7 Departmental Representative will review Contractor's site-specific Health and Safety Plan and provide comments to Contractor within 2 days after receipt of plan. Revise plan as appropriate and resubmit plan to Departmental Representative within 2 days after receipt of comments from Departmental Representative.
- .8 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.
- .9 Medical Surveillance: where prescribed by legislation, regulation or safety program, submit certification of medical surveillance for site personnel prior to commencement of Work, and submit additional certifications for any new site personnel to Departmental Representative.
- .10 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.
- .2 Contractor shall agree to install proper site separation and identification in order to maintain time and space at all times throughout life of project.

#### 1.4 SAFETY ASSESSMENT

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

#### 1.5 MEETINGS

- .1 Schedule and administer Health and Safety meeting with Departmental Representative prior to commencement of Work.

#### 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.

#### 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 Contractor will be responsible and assume the role Constructor as described in the Ontario Occupational Health and Safety Act and Regulations for Construction Projects.
- .3 Comply with and enforce compliance by employees with safety requirements of Contract Documents, applicable federal, provincial, territorial and local statutes, regulations, and ordinances, and with site-specific Health and Safety Plan.

#### 1.8 COMPLIANCE REQUIREMENTS

- .1 Comply with Ontario Occupational Health and Safety Act, R.S.O. 1990, c. 0.1, Ontario Regulations for Construction Projects, O. Reg. 213/91 and PSPC Standard on Construction Occupational Health and Safety.

#### 1.9 UNFORSEEN HAZARDS

- .1 When unforeseen or peculiar safety-related factor, hazard, or condition occur during performance of Work, follow procedures in place for Employee's Right to Refuse Work in accordance with Acts and Regulations of Province having jurisdiction and advise Departmental Representative verbally and in writing.

#### 1.10 POSTING OF DOCUMENTS

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

1.11 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.

1.12 POWDER ACTUATED DEVICES

- .1 Use powder actuated devices only after receipt of written permission from Departmental Representative.

1.13 WORK STOPPAGE

- .1 Give precedence to safety and health of public and site personnel and protection of environment over cost and schedule considerations for Work.

**PART 2 - PRODUCTS**

2.1 NOT USED

- .1 Not used.

**PART 3 - EXECUTION**

3.1 NOT USED

- .1 Not used.

## **PART 1 - GENERAL**

### **1.1 REFERENCES**

- .1 Within text of each specifications section, reference may be made to reference standards.
- .2 Conform to these reference standards, in whole or in part as specifically requested in specifications.
- .3 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.
- .4 Cost for such testing will be born by Departmental Representative in event of conformance with Contract Documents or by Contractor in event of non-conformance.

### **1.2 QUALITY**

- .1 Products, materials, equipment and articles incorporated in Work shall be new, not damaged or defective, and of best quality for purpose intended. If requested, furnish evidence as to type, source and quality of products provided.
- .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 STORAGE, HANDLING AND PROTECTION**

- .1 Handle and store products in manner to prevent damage, adulteration, deterioration and soiling and in accordance with manufacturer's instructions when applicable.
- .2 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.
- .3 Store products subject to damage from weather in weatherproof enclosures.
- .4 Remove and replace damaged products at own expense and to satisfaction of Departmental Representative.

#### 1.4 TRANSPORTATION

- .1 Pay costs of transportation of products required in performance of Work.

#### 1.5 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.
- .2 Notify Departmental Representative in writing, of conflicts between specifications and manufacturer's instructions, so that Departmental Representative will establish course of action.
- .3 Improper installation or erection of products, due to failure in complying with these requirements, authorizes Departmental Representative to require removal and re-installation at no increase in Contract Price or Contract Time.

#### 1.6 QUALITY OF WORK

- .1 Ensure Quality of Work is of highest standard, executed by workers experienced and skilled in respective duties for which they are employed. Immediately notify Departmental Representative if required Work is such as to make it impractical to produce required results.
- .2 Decisions as to standard or fitness of Quality of Work in cases of dispute rest solely with Departmental Representative, whose decision is final.

#### 1.7 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.

#### 1.8 CONCEALMENT

- .1 In finished areas conceal pipes, ducts and wiring in floors, walls and ceilings, except where indicated otherwise.
- .2 Before installation inform Departmental Representative if there is interference. Install as directed by Departmental Representative.

#### 1.9 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.

**1.10 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 and pedestrian and vehicular traffic.
- .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**

**2.2 NOT USED**

- .1 Not Used.

END OF SECTION



## **PART 1 - GENERAL**

### **1.1 PROJECT CLEANLINESS**

- .1 Maintain Work in tidy condition, free from accumulation of waste products and debris, other than that caused by Owner or other Contractors.
- .2 Remove waste materials from site at daily regularly scheduled times or dispose of as directed by Departmental Representative. Do not burn waste materials on site, unless approved by Departmental Representative.
- .3 Make arrangements with and obtain permits from authorities having jurisdiction for disposal of waste and debris.
- .4 Provide on-site containers for collection of waste materials and debris.
- .5 Provide and use marked separate bins for recycling.
- .6 Provide adequate ventilation during use of volatile or noxious substances. Use of building ventilation systems is not permitted for this purpose.
- .7 Use only cleaning materials recommended by manufacturer of surface to be cleaned, and as recommended by cleaning material manufacturer.
- .8 Schedule cleaning operations so that resulting dust, debris and other contaminants will not contaminate building systems.

### **1.2 WASTE MANAGEMENT AND DISPOSAL**

- .1 Separate waste materials for reuse and recycling.

## **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 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Two weeks prior to Substantial Performance of the Work, submit to the Departmental Representative, electronic final copy of operating and maintenance manuals in English.
- .3 Provide spare parts, maintenance materials and special tools of same quality and manufacture as products provided in Work.
- .4 Provide evidence, if requested, for type, source and quality of products supplied.

### **1.2 FORMAT**

- .1 Organize data as instructional manual.

### **1.3 CONTENTS - PROJECT RECORD DOCUMENTS**

- .1 Table of Contents for Each Volume: provide title of project:
  - .1 Date of submission; names.
  - .2 Addresses, and telephone numbers of Consultant and Contractor with name of responsible parties.
  - .3 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.

### **1.4 AS -BUILT DOCUMENTS AND SAMPLES**

- .1 Maintain, at site for Departmental Representative 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.
  - .6 Field test records.
  - .7 Inspection certificates.
  - .8 Manufacturer's certificates.
- .2 Store record documents and samples in field office apart from documents used for construction.
  - .1 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.
  - .1 Label each document "PROJECT RECORD" in neat, large, printed letters.
- .4 Maintain record documents in clean, dry and legible condition.
  - .1 Do not use record documents for construction purposes.
- .5 Keep record documents and samples available for inspection by Departmental Representative.

#### 1.5 RECORDING INFORMATION ON PROJECT RECORD DOCUMENTS

- .1 Record information on set of drawings, provided by Departmental Representative.
- .2 Use felt tip marking pens, maintaining separate colours for each major system, for recording information.
- .3 Record information concurrently with construction progress.
  - .1 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 actually installed, particularly optional items and substitute items.
  - .2 Changes made by Addenda and change orders.

#### 1.6 EQUIPMENT AND SYSTEMS

- .1 For each item of equipment and each system include description of unit or system, and component parts.
  - .1 Give function, normal operation characteristics and limiting conditions.
  - .2 Include performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.
- .2 Include installed colour coded wiring diagrams.
- .3 Maintenance Requirements: include routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
- .4 Provide servicing and lubrication schedule, and list of lubricants required.
- .5 Include manufacturer's printed operation and maintenance instructions.
- .6 Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.

- .7 Provide Contractor's co-ordination drawings, with installed colour coded piping diagrams.
- .8 Provide charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
- .9 Additional requirements: as specified in individual specification sections.

#### 1.7 DELIVERY, STORAGE AND HANDLING

- .1 Store spare parts, maintenance materials, and special tools in manner to prevent damage or deterioration.
- .2 Store in original and undamaged condition with manufacturer's seal and labels intact.
- .3 Store components subject to damage from weather in weatherproof enclosures.
- .4 Store paints and freezable materials in a heated and ventilated room.
- .5 Remove and replace damaged products at own expense and for review by Departmental Representative.

#### 1.8 WARRANTIES AND BONDS

- .1 Develop warranty management plan to contain information relevant to Warranties.
- .2 Submit warranty management plan, 30 days before planned pre-warranty conference, to Departmental Representative approval.
- .3 Warranty management plan to include required actions and documents to assure that Departmental Representative receives warranties to which it is entitled.
- .4 Provide plan in narrative form and contain sufficient detail to make it suitable for use by future maintenance and repair personnel.
- .5 Submit, warranty information made available during construction phase, to Departmental Representative for approval prior to each monthly pay estimate.
- .6 Respond in timely manner to oral or written notification of required construction warranty repair work.

### **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 AFD - Alternate Forms of Delivery, service provider.
  - .2 BMM - Building Management Manual.
  - .3 Cx - Commissioning.
  - .4 EMCS - Energy Monitoring and Control Systems.
  - .5 O&M - Operation and Maintenance.
  - .6 PI - Product Information.
  - .7 PV - Performance Verification.
  - .8 TAB - Testing, Adjusting and Balancing.

### **1.2 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 Ensure appropriate documentation is compiled into the BMM.
  - .3 Effectively train O&M staff.
- .2 Contractor assists in Cx process, operating equipment and systems, troubleshooting and making adjustments 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.
- .3 Design Criteria: as per client's requirements or determined by designer. To meet Project functional and operational requirements.

### **1.3 COMMISSIONING OVERVIEW**

- .1 Section 01 91 31 - Commissioning (Cx) Plan.
- .2 For Cx responsibilities refer to Section 01 91 31 - Commissioning (Cx) Plan.
- .3 Cx to be a line item of Contractor's cost breakdown.
- .4 Cx activities supplement field quality and testing procedures described in relevant technical sections.
- .5 Cx is conducted in concert with activities performed during stage of project delivery. Cx identifies issues in Planning and Design stages which are addressed during Construction and Cx stages to ensure the built systems are constructed and proven to operate satisfactorily under weather, environmental and occupancy conditions to meet functional and operational requirements. Cx activities includes transfer of critical knowledge to facility operational personnel.

- .6 Departmental Representative will issue Interim Acceptance Certificate when:
  - .1 Completed Cx documentation has been received, reviewed for suitability and approved by Departmental Representative.
  - .2 Equipment, components and systems have been commissioned.
  - .3 O&M training has been completed.

#### 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 Departmental Representative, 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 Contract Documents, confirm by writing to Departmental Representative.
  - .2 Adequacy of provisions for Cx.
  - .3 Aspects of design and installation pertinent to success of Cx.
- .2 During Construction:
  - .1 Co-ordinate provision, location and installation of provisions for Cx.
- .3 Before start of Cx:
  - .1 Have completed Cx Plan up-to-date.
  - .2 Ensure installation of related components, equipment, sub-systems, systems is 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 Departmental Representative.
  - .7 Have Cx schedules up-to-date.
  - .8 Ensure systems have been cleaned thoroughly.
  - .9 Complete TAB procedures on systems, submit TAB reports to Departmental Representative for review and approval.
  - .10 Ensure "As-Built" system schematics are available.
- .4 Inform Departmental Representative in writing of discrepancies and deficiencies on finished works.

#### 1.6 CONFLICTS

- .1 Report conflicts between requirements of this section and other sections to Departmental Representative before start-up and obtain clarification.
- .2 Failure to report conflict and obtain clarification will result in application of most stringent requirement.

## 1.7 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
  - .1 Submit no later than 4 weeks after award of Contract:
  - .2 Name of Contractor's Cx agent.
  - .3 Draft Cx documentation.
  - .4 Preliminary Cx schedule.
- .2 Request in writing to Departmental Representative for changes to submittals and obtain written approval at least 8 weeks prior to start of Cx.
- .3 Submit proposed Cx procedures to Departmental Representative where not specified and obtain written approval at least 8 weeks prior to start of Cx.
- .4 Provide additional documentation relating to Cx process required by Departmental Representative.

## 1.8 COMMISSIONING DOCUMENTATION

- .1 Refer to Section 01 91 33 - Commissioning (Cx) Forms: Installation Check Lists and Product Information (PI) /Performance Verification (PV) Forms for requirements and instructions for use.
- .2 Departmental Representative to review and approve Cx documentation.
- .3 Provide completed and approved Cx documentation to Departmental Representative.

## 1.9 COMMISSIONING SCHEDULE

- .1 Provide detailed Cx schedule as part of construction schedule.
- .2 Provide adequate time for Cx activities prescribed in technical sections and commissioning sections including:
  - .1 Approval of Cx reports.
  - .2 Verification of reported results.
- .3 Repairs, retesting, re-commissioning, re-verification.
- .4 Training.

## 1.10 COMMISSIONING MEETINGS

- .1 Convene Cx meetings following project meetings.
- .2 Purpose: to resolve issues, monitor progress, identify deficiencies, relating to Cx.
- .3 Continue Cx meetings on regular basis until commissioning deliverables have been addressed.
- .4 At 60% construction completion stage. Departmental Representative to call a separate Cx scope meeting to review progress, discuss schedule of equipment start-up activities and prepare for Cx. Issues at meeting to include:
  - .1 Review duties and responsibilities of Contractor and subcontractors, addressing delays and potential problems.

- .2 Determine the degree of involvement of trades and manufacturer's representatives in the commissioning process.
- .5 Thereafter Cx meetings to be held until project completion and as required during equipment start-up and functional testing period.
- .6 Meeting will be chaired by Departmental Representative, who will record and distribute minutes.
- .7 Ensure subcontractors and relevant manufacturer representatives are present at 60% and subsequent Cx meetings and as required.

#### 1.11 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.

#### 1.12 WITNESSING OF STARTING AND TESTING

- .1 Provide 14 days notice prior to commencement.
- .2 Departmental Representative to witness of start-up and testing.
- .3 Contractor's Cx Agent to be present at tests performed and documented by sub-trades, suppliers and equipment manufacturers.

#### 1.13 MANUFACTURER'S INVOLVEMENT

- .1 Obtain manufacturers installation, start-up and operations instructions prior to start-up of components, equipment and systems and review with Departmental Representative.
  - .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.
- .2 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.
  - .3 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.

#### 1.14 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 Departmental Representative after distinct phases have been completed and before commencing next phase.
- .4 Document require tests on approved PV forms.
- .5 Failure to follow accepted start-up procedures will result in re-evaluation of equipment by an independent testing agency selected by Departmental Representative. If results reveal that equipment start-up was not in accordance with requirements, and resulted in damage to equipment, implement following:
  - .1 Minor equipment/systems: implement corrective measures approved by Departmental Representative.
  - .2 Major equipment/systems: if evaluation report concludes that damage is minor, implement corrective measures approved by Departmental Representative.
  - .3 If evaluation report concludes that major damage has occurred, Departmental Representative shall reject equipment.
    - .1 Rejected equipment to be remove from site and replace with new.
    - .2 Subject new equipment/systems to specified start-up procedures.

#### 1.15 START-UP DOCUMENTATION

- .1 Assemble start-up documentation and submit to Departmental Representative 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 Departmental Representative to repeat start-up at any time.

#### 1.16 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 Departmental Representative 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.

#### 1.17 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.

#### 1.18 START OF COMMISSIONING

- .1 Notify Departmental Representative at least 21 days prior to start of Cx.
- .2 Start Cx after elements of building affecting start-up and performance verification of systems have been completed.

#### 1.19 INSTRUMENTS / EQUIPMENT

- .1 Submit to Departmental Representative for review and approval:
  - .1 Complete list of instruments proposed to be used.
  - .2 Listed data including, serial number, current calibration certificate, calibration date, calibration expiry date and calibration accuracy.
- .2 Provide the following equipment as required:
  - .1 2-way radios.
  - .2 Ladders.
- .3 Equipment as required to complete work.

#### 1.20 COMMISSIONING PERFORMANCE VERIFICATION

- .1 Carry out Cx:
  - .1 Under actual 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.

#### 1.21 WITNESSING COMMISSIONING

- .1 Departmental Representative to witness activities and verify results.

#### 1.22 EXTENT OF VERIFICATION

- .1 Provide manpower and instrumentation to verify up to 50% of reported results.
- .2 Number and location to be at discretion of Departmental Representative.
- .3 Conduct tests repeated during verification under same conditions as original tests, using same test equipment, instrumentation.
- .4 Review and repeat commissioning of systems if inconsistencies found in more than 20% of reported results.
- .5 Perform additional commissioning until results are acceptable to Departmental Representative.

#### 1.23 REPEAT VERIFICATIONS

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

#### 1.24 SUNDRY CHECKS AND ADJUSTMENTS

- .1 Make adjustments and changes which become apparent as Cx proceeds.
- .2 Perform static and operational checks as applicable and as required.

#### 1.25 DEFICIENCIES, FAULTS, DEFECTS

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

#### 1.26 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 Departmental Representative.

#### 1.27 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.

1.28 TRAINING

- .1 In accordance with Section 01 91 41 - Commissioning (Cx) - Training.

1.29 OCCUPANCY

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

1.30 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 Departmental Representative.
- .2 Calibrated EMCS sensors may be used to obtain performance data provided that sensor calibration has been completed and accepted.

1.31 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.

1.32 OWNER'S PERFORMANCE TESTING

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

**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 Public Works and Government Services Canada (PSPC)
  - .1 PSPC - Commissioning Guidelines CP.4 -3rd edition-03.

### **1.2 GENERAL**

- .1 Provide fully functional systems:
  - .1 Systems, equipment and components meet user's functional requirements before date of acceptance, and operate consistently at peak efficiencies and within specified energy budgets under normal loads.
  - .2 Facility personnel have been fully trained in aspects of installed systems.
  - .3 Complete documentation relating to installed equipment and systems.
- .2 Term "Cx" in this section means "Commissioning".
- .3 Use this Cx Plan as master planning document for Cx:
  - .1 Outlines organization, scheduling, allocation of resources, documentation, pertaining to implementation of Cx.
  - .2 Communicates responsibilities of team members involved in Cx Scheduling, documentation requirements, and verification procedures.
  - .3 Sets out deliverables relating to O&M, process and administration of Cx.
- .4 Describes process of verification of how built works meet design requirements.
- .5 Produces a complete functional system prior to issuance of Certificate of Occupancy.
- .6 Management tool that sets out scope, standards, roles and responsibilities, expectations, deliverables, and provides:
  - .1 Overview of Cx.
  - .2 General description of elements that make-up Cx Plan.
  - .3 Process and methodology for successful Cx.
  - .4 Acronyms:
    - .1 Cx - Commissioning.
    - .2 BMM - Building Management Manual.
    - .3 EMCS - Energy Monitoring and Control Systems.
    - .4 MSDS - Material Safety Data Sheets.
    - .5 PI - Product Information.
    - .6 PV - Performance Verification.
    - .7 TAB - Testing, Adjusting and Balancing.
    - .8 WHMIS - Workplace Hazardous Materials Information System.
  - .5 Commissioning terms used in this Section:
    - .1 Bumping: short term start-up to prove ability to start and prove correct rotation.
    - .2 Deferred Cx - Cx activities delayed for reasons beyond Contractor's control due to lack of occupancy, weather conditions, need for heating/cooling loads.

### **1.3 DEVELOPMENT OF CX PLAN**

- .1 Cx Plan to be updated by Departmental Representative during construction to take into account:
  - .1 Approved shop drawings and product data.

- .2 Approved changes to contract.
- .3 Contractor's project schedule.
- .4 Cx schedule.
- .5 Contractor's, sub-contractor's, suppliers' requirements.
- .6 Project construction team's and Cx team's requirements.

#### 1.4 REFINEMENT OF CX PLAN

- .1 During construction phase, Cx Plan will be updated by Departmental Representative to include:
  - .1 Changes resulting from Client program modifications.
- .2 Approved design and construction changes.

#### 1.5 COMPOSITION, ROLES AND RESPONSIBILITIES OF CX TEAM

- .1 Departmental Representative to maintain overall responsibility for project and is sole point of contact between members of commissioning team.
- .2 Project Manager will select Cx Team consisting of following members:
  - .1 PSPC Design Quality Review Team: during construction, will conduct periodic site reviews to observe general progress.
  - .2 PSPC Quality Assurance Commissioning Manager: ensures Cx activities are carried out to ensure delivery of a fully operational project including:
    - .3 Review of Cx documentation from operational perspective.
    - .4 Review for performance, reliability, durability of operation, accessibility, maintainability, operational efficiency under conditions of operation.
    - .5 Protection of health, safety and comfort of occupants and O&M personnel.
    - .6 Monitoring of Cx activities, training, development of Cx documentation.
    - .7 Work closely with members of Cx Team.
- .3 Departmental Representative is responsible for:
  - .1 Organizing Cx.
  - .2 Monitoring operations Cx activities.
  - .3 Witnessing, certifying accuracy of reported results.
  - .4 Witnessing and certifying TAB and other tests.
  - .5 Developing BMM.
  - .6 Ensuring implementation of final Cx Plan.
  - .7 Performing verification of performance of installed systems and equipment.
  - .8 Implementation of Training Plan.
- .4 Construction Team: contractor, sub-contractors, suppliers and support disciplines, is responsible for construction/installation in accordance with Contract Documents, including:
  - .1 Updating Cx Plan.
  - .2 Testing.
  - .3 TAB.
  - .4 Performance of Cx activities.
  - .5 Delivery of training and Cx documentation.

- .6 Assigning one person as point of contact with Consultant and PSPC Cx Manager for administrative and coordination purposes.
- .5 Contractor's Cx agent implements specified Cx activities including:
  - .1 Demonstrations.
  - .2 Training.
  - .3 Testing.
  - .4 Preparation, submission of test reports.
- .6 Property Manager: represents lead role in Operation Phase and onwards and is responsible for:
  - .1 Receiving facility.
  - .2 Day-To-Day operation and maintenance of facility.

#### 1.6 CX PARTICIPANTS

- .1 Employ the following Cx participants to verify performance of equipment and systems:
  - .1 Installation contractor/subcontractor:
    - .1 Equipment and systems except as noted.
  - .2 Equipment manufacturer: equipment specified to be installed and started by manufacturer.
    - .1 To include performance verification.
  - .3 Specialist subcontractor: equipment and systems supplied and installed by specialist subcontractor.
  - .4 Specialist Cx agency:
    - .1 Possessing specialist qualifications and installations providing environments essential to client's program but are outside scope or expertise of Cx specialists on this project.
  - .5 Client: responsible for intrusion and access security systems.
  - .6 Ensure that Cx participant:
    - .1 Could complete work within scheduled time frame.
  - .7 Provide names of participants to Departmental Representative and details of instruments and procedures to be followed for Cx 3 weeks prior to starting date of Cx for review and approval.

#### 1.7 EXTENT OF CX

- .1 Commission mechanical systems and associated equipment:
  - .1 HVAC and humidification systems:
    - .1 Air handling unit.
    - .2 VAV boxes.
    - .3 Humidifier.
    - .4 Controls.
  - .2 Commission electrical systems and equipment:
    - .1 Low voltage below 750 V:
      - .1 Low voltage equipment.
    - .2 Low voltage distribution systems.
    - .3 Electronic data and communications information systems.

#### 1.8 DELIVERABLES RELATING TO O&M PERSPECTIVES

- .1 General requirements:
  - .1 Compile English documentation.
  - .2 Documentation to be computer-compatible format ready for inputting for data management.

- .2 Provide deliverables:
  - .1 Warranties.
  - .2 Project record documentation.
- .3 Inventory of spare parts, special tools and maintenance materials.
- .4 Maintenance Management System (MMS) identification system used.
- .5 WHMIS information.
- .6 MSDS data sheets.
- .7 Electrical Panel inventory containing detailed inventory of electrical circuitry for each panel board. Duplicate of inventory inside each panel.

#### 1.9 DELIVERABLES RELATING TO THE CX PROCESS

- .1 General:
  - .1 Start-up, testing and Cx requirements, conditions for acceptance and specifications form part of relevant technical sections of these specifications.
  - .2 Definitions:
    - .1 Cx as used in this section includes:
      - .1 Cx of components, equipment, systems, subsystems, and integrated systems.
    - .2 Factory inspections and performance verification tests.
    - .3 Deliverables: provide:
      - .1 Start-up, pre-Cx activities and documentation for systems, and equipment.
      - .2 Completed installation checklists (ICL).
      - .3 Completed product information (PI) report forms.
      - .4 Completed performance verification (PV) report forms.
      - .5 Results of Performance Verification Tests and Inspections.
      - .6 Description of Cx activities and documentation.
      - .7 Description of Cx of integrated systems and documentation.
      - .8 Training Plans.
      - .9 Cx Reports.
      - .10 Prescribed activities during warranty period.
    - .4 Departmental Representative to witness and certify tests and reports of results provided to Departmental Representative.
    - .5 Departmental Representative to participate.

#### 1.10 PRE-CX ACTIVITIES AND RELATED DOCUMENTATION

- .1 Items listed in this Cx Plan include the following:
  - .1 Pre-Start-Up inspections: by Departmental Representative prior to permission to start-up and rectification of deficiencies to Departmental Representative's satisfaction.
  - .2 Departmental Representative to use approved check lists.
- .2 Pre-Cx activities - MECHANICAL:
  - .1 HVAC equipment and systems:
    - .1 At this time, complete pre-start-up checks and complete relevant documentation.
    - .2 After equipment has been started, test related systems in conjunction with control systems on a system-by-system basis.
    - .3 Perform TAB on systems. TAB reports to be approved by Departmental Representative.



- .2 EMCS:
  - .1 EMCS trending to be available as supporting documentation for performance verification.
  - .2 Perform point-by-point testing in parallel with start-up.
- .3 Carry out point-by-point verification.
- .4 Demonstrate performance of systems, to be witnessed by Departmental Representative prior to start of 30 day Final Acceptance Test period.
- .5 Perform final Cx and operational tests during demonstration period and 30 day test period.
- .6 Only additional testing after foregoing have been successfully completed to be "Off-Season Tests".

#### 1.11 START-UP

- .1 Start-up components, equipment and systems.
- .2 Equipment manufacturer, supplier, installing specialist sub-contractor, as appropriate, to start-up, under Contractor's direction, following equipment, systems:
  - .1 Sash Retrofit Kit
  - .2 Controls.
  - .3 Departmental Representative to monitor some of these start-up activities.
    - .1 Rectify start-up deficiencies to satisfaction of Departmental Representative.
  - .4 Performance Verification (PV):
    - .1 Approved Cx Agent to perform.
      - .1 Repeat when necessary until results are acceptable to Departmental Representative.
    - .2 Use procedures modified generic procedures to suit project requirements.
    - .3 Departmental Representative to witness and certify reported results using approved PI and PV forms.
    - .4 Departmental Representative to approve completed PV reports and provide to Departmental Representative.
    - .5 Failure of randomly selected item shall result in rejection of PV report or report of system start-up and testing.

#### 1.12 CX ACTIVITIES AND RELATED DOCUMENTATION

- .1 Perform Cx by specified Cx agency using procedures developed by Departmental Representative and approved by Departmental Representative.
- .2 Departmental Representative to monitor Cx activities.
- .3 Upon satisfactory completion, Cx agency performing tests to prepare Cx Report using approved PV forms.
- .4 Departmental Representative to witness, certify reported results of, Cx activities and forward to Departmental Representative.
- .5 Departmental Representative reserves right to verify a percentage of reported results at no cost to contract.

#### 1.13 INSTALLATION CHECK LISTS (ICL)

- .1 Refer to Section 01 91 33 - Commissioning (Cx) Forms: Installation Check Lists and Product Information (PI)/Performance Verification (PV) Forms.

#### 1.14 PRODUCT INFORMATION (PI) REPORT FORMS

- .1 Refer to Section 01 91 33 - Commissioning (Cx) Forms: Installation Check Lists and Product Information (PI)/Performance Verification (PV) Forms.

#### 1.15 PERFORMANCE VERIFICATION (PV) REPORT

- .1 Refer to Section 01 91 33 - Commissioning (Cx) Forms: Installation Check Lists and Product Information (PI)/Performance Verification (PV) Forms.

#### 1.16 CX SCHEDULES

- .1 Prepare detailed Cx Schedule and submit to Departmental Representative for review and approval same time as project Construction Schedule. Include:
  - .1 Milestones, testing, documentation, training and Cx activities of components, equipment, subsystems, systems and integrated systems, including:
    - .1 Design criteria, design intents.
    - .2 Pre-TAB review: before construction starts.
    - .3 Cx agents' credentials: 30 days before start of Cx.
    - .4 Cx procedures: 3 weeks after award of contract.
    - .5 Cx Report format: 3 weeks after contract award.
    - .6 Submission of list of instrumentation with relevant certificates: 7 days before start of Cx.
  - .2 Notification of intention to start TAB: 7 days before start of TAB.
  - .3 TAB: after successful start-up, correction of deficiencies and verification of normal and safe operation.
  - .4 Notification of intention to start Cx: 14 days before start of Cx.
  - .5 Notification of intention to start Cx of integrated systems: after Cx of related systems is completed 14 days before start of integrated system Cx.
  - .6 Identification of deferred Cx.
  - .7 Implementation of training plans.
  - .8 Cx reports: immediately upon successful completion of Cx.
  - .9 Detailed training schedule to demonstrate no conflicts with testing, completion of project and hand-over to Property Manager.
  - .10 After approval, incorporate Cx Schedule into Construction Schedule.
  - .11 Consultant, Contractor, Contractor's Cx agent, and Departmental Representative will monitor progress of Cx against this schedule.

#### 1.17 CX REPORTS

- .1 Submit reports of tests, witnessed and certified by Departmental Representative to Departmental Representative who will verify reported results.

- .2 Include completed and certified PV reports in properly formatted Cx Reports.
- .3 Before reports are accepted, reported results to be subject to verification by Departmental Representative.

#### 1.18 ACTIVITIES DURING WARRANTY PERIOD

- .1 Cx activities must be completed before issuance of Interim Certificate, it is anticipated that certain Cx activities may be necessary during Warranty Period, including:
  - .1 Fine tuning of HVAC systems.

#### 1.19 TRAINING PLANS

- .1 Refer to Section 01 91 41 - Commissioning (Cx) - Training.

#### 1.20 FINAL SETTINGS

- .1 Upon completion of Cx to satisfaction of Departmental Representative lock control devices in their final positions, indelibly mark settings marked and include in Cx Reports.

### **PART 2 - PRODUCTS**

#### 2.1 NOT USED

- .1 Not Used.

### **PART 3 - EXECUTION**

#### 3.1 NOT USED

- .1 Not Used.

## **PART 1 - GENERAL**

### **1.1 INSTALLATION/START-UP CHECK LISTS**

- .1 Include the following data:
  - .1 Product manufacturer's installation instructions and recommended checks.
  - .2 Special procedures as specified in relevant technical sections.
  - .3 Items considered good installation and engineering industry practices deemed appropriate for proper and efficient operation.
- .2 Equipment manufacturer's installation/start-up check lists are acceptable for use. As deemed necessary by Departmental Representative supplemental additional data lists will be required for specific project conditions.
- .3 Use check lists for equipment installation. Document check list verifying checks have been made, indicate deficiencies and corrective action taken.
- .4 Installer to sign check lists upon completion, certifying stated checks and inspections have been performed. Return completed check lists to Departmental Representative. Check lists will be required during Commissioning and will be included in Building Maintenance Manual (BMM) at completion of project.
- .5 Use of check lists will not be considered part of commissioning process but will be stringently used for equipment pre-start and start-up procedures.

### **1.2 PRODUCT INFORMATION (PI) REPORT FORMS**

- .1 Product Information (PI) forms compiles gathered data on items of equipment produced by equipment manufacturer, includes nameplate information, parts list, operating instructions, maintenance guidelines and pertinent technical data and recommended checks that is necessary to prepare for start-up and functional testing and used during operation and maintenance of equipment. This documentation is included in the BMM at completion of work.
- .2 Prior to Performance Verification (PV) of systems complete items on PI forms related to systems and obtain Departmental Representative's approval.

### **1.3 PERFORMANCE VERIFICATION (PV) FORMS**

- .1 PV forms to be used for checks, running dynamic tests and adjustments carried out on equipment and systems to ensure correct operation, efficiently and function independently and interactively with other systems as intended with project requirements.
- .2 PV report forms include those developed by Contractor records measured data and readings taken during functional testing and Performance Verification procedures.
- .3 Prior to PV of integrated system, complete PV forms of related systems and obtain Departmental Representative's approval.

### **1.4 SAMPLES OF COMMISSIONING FORMS**

- .1 Departmental Representative will develop and provide to Contractor required project-specific Commissioning forms in electronic format complete with specification data (see attached for sample forms).

- .2 Revise items on Commissioning forms to suit project requirements.

#### 1.5 CHANGES AND DEVELOPMENT OF NEW REPORT FORMS

- .1 When additional forms are required, but are not available from Departmental Representative, develop appropriate verification forms and submit to Departmental Representative for approval prior to use.
  - .1 Additional commissioning forms to be in same format as provided by Departmental Representative.

#### 1.6 COMMISSIONING FORMS

- .1 Use Commissioning forms to verify installation and record performance when starting equipment and systems.
- .2 Strategy for Use:
  - .1 Departmental Representative provides Contractor project-specific Commissioning forms with Specification data included.
  - .2 Contractor will provide required shop drawings information and verify correct installation and operation of items indicated on these forms.
- .3 Confirm operation as per design criteria and intent.
- .4 Identify variances between design and operation and reasons for variances.
- .5 Verify operation in specified normal and emergency modes and under specified load conditions.
- .6 Record analytical and substantiating data.
- .7 Verify reported results.
- .8 Form to bear signatures of recording technician and reviewed and signed off by Departmental Representative.
- .9 Submit immediately after tests are performed.
- .10 Reported results in true measured SI unit values.
- .11 Provide Departmental Representative with originals of completed forms.
- .12 Maintain copy on site during start-up, testing and commissioning period.
- .13 Forms to be both hard copy and electronic format with typed written results in Building Management Manual in accordance with Section 01 91 51 - Building Management Manual (BMM).

#### 1.7 LANGUAGE

- .1 English.

**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        TRAINEES**

- .1     Trainees: personnel selected for operating and maintaining this facility. Includes Facility Manager, building operators, maintenance staff, security staff, and technical specialists as required.
- .2     Trainees will be available for training during later stages of construction for purposes of familiarization with systems.

### **1.2        INSTRUCTORS**

- .1     Departmental Representative will provide:
  - .1       Descriptions of systems.
  - .2       Instruction on design philosophy, design criteria, and design intent.
- .2     Contractor and certified factory-trained manufacturers' personnel: to provide instruction on the following:
  - .1       Start-Up, operation, shut-down of equipment, components and systems.
  - .2       Control features, reasons for, results of, implications on associated systems of, adjustment of set points of control and safety devices.
  - .3       Instructions on servicing, maintenance and adjustment of systems, equipment and components.
- .3     Contractor and equipment manufacturer to provide instruction on:
  - .1       Start-up, operation, maintenance and shut-down of equipment they have certified installation, started up and carried out PV tests.

### **1.3        TRAINING OBJECTIVES**

- .1     Training to be detailed and duration to ensure:
  - .1       Safe, reliable, cost-effective, energy-efficient operation of systems in normal and emergency modes under all conditions.
- .2     Effective on-going inspection, measurements of system performance.
- .3     Proper preventive maintenance, diagnosis and trouble-shooting.
- .4     Ability to update documentation.
- .5     Ability to operate equipment and systems under emergency conditions until appropriate qualified assistance arrives.

### **1.4        TRAINING MATERIALS**

- .1     Instructors to be responsible for content and quality.
- .2     Training materials to include:
  - .1       "As-Built" Contract Documents.
  - .2       Operating Manual.
  - .3       Maintenance Manual.
  - .4       Management Manual.

- .5 TAB and PV Reports.
- .3 Project Manager, Commissioning Manager and Facility Manager will review training manuals.
- .4 Training materials to be in a format that permits future training procedures to same degree of detail.
- .5 Supplement training materials:
  - .1 Transparencies for overhead projectors.
  - .2 Multimedia presentations.
  - .3 Manufacturer's training videos.
  - .4 Equipment models.

#### 1.5 SCHEDULING

- .1 Include in Commissioning Schedule time for training.
- .2 Deliver training during regular working hours, training sessions to be 3 hours in length.
- .3 Training to be completed prior to acceptance of project.

#### 1.6 RESPONSIBILITIES

- .1 Be responsible for:
  - .1 Implementation of training activities,
  - .2 Coordination among instructors,
  - .3 Quality of training, training materials,
- .2 Departmental Representative will evaluate training and materials.
- .3 Upon completion of training, provide written report, signed by Instructors, witnessed by Departmental Representative.

#### 1.7 TRAINING CONTENT

- .1 Training to include demonstrations by Instructors using the installed equipment and systems.
- .2 Content includes:
  - .1 Review of facility and occupancy profile.
  - .2 Functional requirements.
  - .3 System philosophy, limitations of systems and emergency procedures.
  - .4 Review of system layout, equipment, components and controls.
  - .5 Equipment and system start-up, operation, monitoring, servicing, maintenance and shut-down procedures.
  - .6 System operating sequences, including step-by-step directions for starting up, shut-down, operation of valves, dampers, switches, adjustment of control settings and emergency procedures.
  - .7 Maintenance and servicing.
  - .8 Trouble-shooting diagnosis.
  - .9 Inter-Action among systems during integrated operation.
  - .10 Review of O&M documentation.
- .3 Provide specialized training as specified in relevant Technical Sections of the construction specifications.



**1.8 VIDEO-BASED TRAINING**

- .1 Manufacturer's video to be used as training tool with Departmental Representative's review and written approval 3 months prior to commencement of scheduled training.
- .2 On-Site training videos:
  - .1 Video training sessions for use during future training.
  - .2 To be performed after systems are fully commissioned.
  - .3 Organize into several short modules to permit incorporation of changes.
- .3 Production methods to be professional quality.

**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 Section Includes:
  - .1 This section is limited to portions of the Building Management Manual (BMM) provided to Departmental Representative by Contractor.
  - .2 Acronyms:
    - .1 BMM - Building Management Manual.
    - .2 Cx - Commissioning.
  - .3 HVAC - Heating, Ventilation and Air Conditioning.
  - .4 PI - Product Information.
  - .5 PV - Performance Verification.
  - .6 TAB - Testing, Adjusting and Balancing.
  - .7 WHMIS - Workplace Hazardous Materials Information System.

### **1.2 GENERAL REQUIREMENTS**

- .1 Standard letter size paper 216 mm x 279 mm.
- .2 Methodology used to facilitate updating.
- .3 Drawings, diagrams and schematics to be professionally developed.
- .4 Electronic copy of data to be in a format accepted and approved by Departmental Representative.

### **1.3 APPROVALS**

- .1 Prior to commencement, co-ordinate requirements for preparation, submission and approval with Departmental Representative.

### **1.4 GENERAL INFORMATION**

- .1 Provide Departmental Representative the following for insertion into appropriate Part and Section of BMM:
  - .1 Complete list of names, addresses and, telephone numbers of contractor, sub-contractors that participated in delivery of project - as indicated in Section 1.2 of BMM.
- .2 Summary of mechanical and electrical systems installed and commissioned - as indicated in Section 1.4 of BMM.
  - .1 Including sequence of operation as finalized after commissioning is complete as indicated in Section 2.0 of BMM.
- .3 Description of building operation under conditions of heightened security and emergencies as indicated in Section 2.0 of BMM.
- .4 System, equipment and components Maintenance Management System (MMS) identification - Section 2.1 of BMM..
- .5 Information on operation and maintenance of mechanical systems and equipment installed and commissioned - Section 2.0 of BMM.

- .6 Operating and maintenance manual - Section 3.2 of BMM.
- .7 Final commissioning plan as actually implemented.
- .8 Completed commissioning checklists.
- .9 Commissioning test procedures employed.
- .10 Completed Product Information (PI) and Performance Verification (PV) report forms, approved and accepted by Departmental Representative.
- .11 Commissioning reports.

#### 1.5 CONTENTS OF OPERATING AND MAINTENANCE MANUAL

- .1 For detailed requirements refer to Section 01 78 00 - Closeout Submittals.
- .2 Departmental Representative to review and approve format and organization within 12 weeks of award of contract.
- .3 Include original manufactures brochures and written information on products and equipment installed on this project.
- .4 Record and organize for easy access and retrieval of information contained in BMM.
- .5 Include completed PI report forms, data and information from other sources as required.
- .6 Inventory directory relating to information on installed systems, equipment and components.
- .7 Approved project shop-drawings, product and maintenance data.
- .8 Manufacturer's data and recommendations relating: manufacturing process, installation, commissioning, start-up, O&M, shutdown and training materials.
- .9 Inventory and location of spare parts, special tools and maintenance materials.
- .10 Warranty information.
- .11 Inspection certificates with expiration dates, which require on-going re-certification inspections.
- .12 Maintenance program supporting information including:
  - .1 Recommended maintenance procedures and schedule.
  - .2 Information to removal and replacement of equipment including, required equipment, points of lift and means of entry and egress.

#### 1.6 SUPPORTING DOCUMENTATION FOR INSERTION INTO SUPPORTING APPENDICES

- .1 Provide Departmental Representative supporting documentation relating to installed equipment and system, including:
  - .1 General:
    - .1 Finalized commissioning plan.
    - .2 WHMIS information manual.

- .3 Approved "as-built" drawings and specifications.
  - .4 Procedures used during commissioning.
  - .5 Cross-Reference to specification sections.
- .2 Mechanical:
  - .1 Installation permits, inspection certificates.
  - .2 Ducting leakage test reports.
  - .3 TAB and PV reports.
- .2 Copies of posted instructions.
- .3 Electrical:
  - .4 Installation permits, inspection certificates.
  - .5 TAB and PV reports.
  - .6 Electrical work log book.
  - .7 Charts and schedules.
- .8 Assist Departmental Representative with preparation of BMM.

#### 1.7 LANGUAGE

- .1 English.

#### 1.8 USE OF CURRENT TECHNOLOGY

- .1 Use current technology for production of documentation. Emphasis on ease of accessibility at all times, maintain in up-to-date state, compatibility with user's requirements.
- .2 Obtain Departmental Representative's approval before starting Work.

### **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 RELATED REQUIREMENTS**

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

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

- .1 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .2 Shop Drawings:
  - .1 Indicate on drawings:
    - .1 Mounting arrangements.
    - .2 Operating and maintenance clearances.
  - .2 Shop drawings and product data accompanied by:
    - .1 Detailed drawings of bases, supports, and anchor bolts.
    - .2 Acoustical sound power data, where applicable.
    - .3 Points of operation on performance curves.
    - .4 Manufacturer to certify current model production.
    - .5 Certification of compliance to applicable codes.
  - .3 Use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.

### **1.3 CLOSEOUT SUBMITTALS**

- .1 Operation and Maintenance Data: submit operation and maintenance data.
  - .1 Operation and maintenance manual approved by, and final copies deposited with, Departmental Representative before final inspection.
  - .2 Operation data to include:
    - .1 Control schematics for systems including environmental controls.
    - .2 Description of systems and their controls.
    - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
    - .4 Operation instruction for systems and component.
    - .5 Description of actions to be taken in event of equipment failure.
    - .6 Valves schedule and flow diagram.
    - .7 Colour coding chart.
  - .3 Maintenance data to include:
    - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
    - .2 Data to include schedules of tasks, frequency, tools required and task time.
  - .4 Performance data to include:
    - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
    - .2 Equipment performance verification test results.
    - .3 Special performance data as specified.
    - .4 Testing, adjusting and balancing reports as specified in Section 23 05 93.
  - .5 Approvals:
    - .1 Submit 2 copies of draft Operation and Maintenance Manual to Departmental Representative for approval. Submission of individual data will not be accepted unless directed by Departmental Representative.

- .2 Make changes as required and re-submit as directed by Departmental Representative.
- .6 Additional data:
  - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .7 Site records:
  - .1 Departmental Representative will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.
  - .2 Transfer information to reproducibles, revising reproducibles to show work as actually installed.
  - .3 Use different colour waterproof ink for each service.
  - .4 Make available for reference purposes and inspection.
- .8 As-built drawings:
  - .1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.
  - .2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: - "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).
  - .3 Submit to Departmental Representative for approval and make corrections as directed.
  - .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
  - .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.

#### 1.4 MAINTENANCE MATERIAL SUBMITTALS

- .1 Furnish spare parts as follows:
  - .1 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.
- .2 Provide one set of special tools required to service equipment as recommended by manufacturers.

#### 1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance 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.

### **PART 2 - PRODUCTS**

#### 2.1 NOT USED

- .1 Not used.

### **PART 3 - EXECUTION**

#### **3.1 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.

#### **3.2 DEMONSTRATION**

- .1 Departmental Representative 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, trouble-shooting 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.

#### **3.3 PROTECTION**

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

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.

### **1.2 QUALIFICATIONS OF TAB PERSONNEL**

- .1 Submit names of personnel to perform TAB to Departmental Representative within 30 days of award of contract.
- .2 Provide documentation confirming qualifications, successful experience.
- .3 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- .4 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .5 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- .6 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .7 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
  - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by 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.

## 1.6 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.

## 1.7 OPERATION OF SYSTEMS DURING TAB

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

## 1.8 START OF TAB

- .1 Notify Departmental Representative 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 Correct fan rotation.
    - .4 Fire, smoke, volume control dampers installed and open.
    - .5 Coil fins combed, clean.
    - .6 Access doors, installed, closed.
    - .7 Outlets installed, volume control dampers open.

## 1.9 APPLICATION TOLERANCES

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

#### 1.10 ACCURACY TOLERANCES

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

#### 1.11 INSTRUMENTS

- .1 Prior to TAB, submit to Departmental Representative list of instruments used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .3 Calibrate within 3 months of TAB. Provide certificate of calibration to Departmental Representative.

#### 1.12 TAB REPORT

- .1 Format in accordance with referenced standard.
- .2 TAB report to show results in SI units and to include:
  - .1 Project record drawings.
  - .2 System schematics.
- .3 Submit electronic pdf copy of TAB Report to Departmental Representative for verification and approval, in English , complete with index tabs.

#### 1.13 VERIFICATION

- .1 Reported results subject to verification by Departmental Representative.
- .2 Provide personnel and instrumentation to verify up to 30% of reported results.
- .3 Number and location of verified results as directed by Departmental Representative.
- .4 Pay costs to repeat TAB as required to satisfaction of Departmental Representative.

#### 1.14 SETTINGS

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

#### 1.15 COMPLETION OF TAB

- .1 TAB considered complete when final TAB Report received and approved by Departmental Representative.

## 1.16 AIR SYSTEMS

- .1 Standard: TAB to most stringent of this section or TAB standards of AABC, NEBB, SMACNA or ASHRAE.
- .2 Do TAB of systems, equipment, components, controls specified Division 23.
- .3 Qualifications: personnel performing TAB current member in good standing of AABC or NEBB qualified to standards of AABC or NEBB.
- .4 Quality assurance: perform TAB under direction of supervisor qualified by to standards of AABC or NEBB.
- .5 Measurements: to include as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.
- .6 Locations of equipment measurements: to include as appropriate:
  - .1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
  - .2 At controllers, controlled device.
- .7 Locations of systems measurements to include as appropriate: main ducts.

## **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 RELATED REQUIREMENTS**

- .1 Section 23 05 00 - Common Work Results for HVAC.

### **1.2 REFERENCE STANDARDS**

- .1 ASTM International (ASTM)
  - .1 ASTM C335/C335M-17, Standard Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
  - .2 ASTM C449-07(2013), Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
  - .3 ASTM C612-14, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
  - .4 ASTM C921-10(2015), Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .2 Canadian General Standards Board (CGSB)
  - .1 CGSB 51-GP-52Ma-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .3 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (2005).
- .4 Underwriters Laboratories of Canada (ULC)
  - .1 CAN/ULC-S102-10, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

### **1.3 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.
- .2 TIAC Codes:
  - .1 CRD: Code Round Ductwork,
  - .2 CRF: Code Rectangular Finish.

### **1.4 ACTION AND INFORMATIONAL SUBMITTALS**

- .1 Provide submittals in accordance with Section 23 05 00.

## **PART 2 - PRODUCTS**

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

- .1 To CAN/ULC-S102:
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

### **2.2 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 degrees C mean temperature when tested in accordance with ASTM C335/C335M.
- .3 TIAC Code C-1: Rigid mineral fibre board to ASTM C612, with without factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).

### **2.3 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.

### **2.4 ACCESSORIES**

- .1 Vapour retarder lap adhesive:
  - .1 Water based, fire retardant type, compatible with insulation.
- .2 Indoor Vapour Retarder Finish:
  - .1 Vinyl emulsion type acrylic, compatible with insulation.
- .3 Insulating Cement: hydraulic setting on mineral wool, to ASTM C449.
- .4 Tape: self-adhesive, aluminum, reinforced, 75 mm wide minimum.
- .5 Contact adhesive: quick-setting
- .6 Canvas adhesive: washable.
- .7 Tie wire: 1.5 mm stainless steel.
- .8 Banding: 19 mm wide, 0.5 mm thick stainless steel.
- .9 Facing: 25 mm galvanized steel hexagonal wire mesh stitched on one face of insulation.
- .10 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, free from foreign material.

#### **3.3 INSTALLATION**

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturers instructions and as indicated.
- .3 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
  - .1 Ensure hangers, and supports are outside vapour retarder jacket.
- .4 Fasteners: install at 300 mm on centre in horizontal and vertical directions, minimum 2 rows each side.

#### **3.4 DUCTWORK INSULATION SCHEDULE**

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

	TIAC Code	Vapour Retarder	Thickness
Rectangular code and dual temperature supply and return air ducts	C-1	yes	50

- .2 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:
  - .1 Use TIAC code C-1 insulation, scored to suit diameter of duct.
    - .1 Finishes: conform to following table:

## **PART 1 - GENERAL**

### **1.1 RELATED REQUIREMENTS**

- .1 Section 23 05 00 - Common Work Results for HVAC.

### **1.2 REFERENCE STANDARDS**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B16.5-2017 Pipe Flanges and Flanged Fittings.
  - .2 ASME B16.18-2012, Cast Copper Alloy Solder Joint Pressure Fittings.
  - .3 ASME B16.22-2013, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
  - .4 ASME B18.2.1-2012, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
- .2 ASTM International (ASTM)
  - .1 ASTM A47/A47M-99(2014), Standard Specification for Ferritic Malleable Iron Castings.
  - .2 ASTM A53/A53M-12, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
  - .3 ASTM B837-10, Standard Specification for Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.
- .3 CSA Group (CSA)
  - .1 CSA W47.1-09 (R2014), Certification of Companies for Fusion Welding of Steel.
- .4 Canadian Standards Association (CSA)
  - .1 CSA B149.1-15, Natural Gas and Propane Installation Code.

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

- .1 Submittals in accordance with Section 23 05 00.

## **PART 2 - PRODUCTS**

### **2.1 PIPE**

- .1 Steel pipe: to ASTM A53/A53M, Schedule 40, seamless as follows:
  - .1 NPS ½ to 2, screwed.
  - .2 NPS 2½ and over, plain end.
- .2 Copper tube: to ASTM B837.

### **2.2 JOINTING MATERIAL**

- .1 Screwed fittings: pulverized lead paste.
- .2 Welded fittings: to CSA W47.1.

.3 Flange gaskets: nonmetallic flat.

.4 Brazing: to ASTM B837 .

## 2.3 FITTINGS

- .1 Steel pipe fittings, screwed, flanged or welded:
  - .1 Malleable iron: screwed, banded, Class 150.
  - .2 Steel pipe flanges and flanged fittings: to ASME B16.5.
  - .3 Welding: butt-welding fittings.
  - .4 Unions: malleable iron, brass to iron, ground seat, to ASTM A47/A47M.
  - .5 Bolts and nuts: to ASME B18.2.1.
  - .6 Nipples: schedule 40, to ASTM A53/A53M.
- .2 Copper pipe fittings, screwed, flanged or soldered:
  - .1 Cast copper fittings: to ASME B16.18.
  - .2 Wrought copper fittings: to ASME B16.22.

## 2.4 VALVES

- .1 Provincial Code approved, ball type.

# **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 PIPING

- .1 Install in accordance with applicable Provincial/Territorial Codes, and CSA B149.1, supplemented as specified.
- .2 Install drip points:
  - .1 At low points in piping system.
  - .2 At connections to equipment.

## 3.3 FIELD QUALITY CONTROL

- .1 Site Tests/Inspection:
  - .1 Test system in accordance with CSA B149.1 and requirements of authorities having jurisdiction.

## 3.4 ADJUSTING

- .1 Purging: purge after pressure test in accordance with CSA B149.1.



- .2 Pre-Start-Up Inspections:
  - .1 Check vents from regulators, control valves, terminate outside building in approved location, protected against blockage, damage.
  - .2 Check gas trains, entire installation is approved by authority having jurisdiction.

END OF SECTION

## **PART 1 - GENERAL**

### **1.1 REFERENCE STANDARDS**

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- .2 ASTM International (ASTM)
  - .1 ASTM A653/A653M-17, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- .3 National Fire Protection Association (NFPA)
  - .1 NFPA (Fire) 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, 2018 Edition.
  - .2 NFPA (Fire) 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 2018 Edition.
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA 008-2008, IAQ Guideline for Occupied Buildings Under Construction, 2nd Edition.
  - .2 SMACNA 016-2012, HVAC Air Duct Leakage Test Manual, 2012, 2nd Edition.
  - .3 SMACNA 1966-2005, HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition

## **PART 2 - PRODUCTS**

### **2.1 SEAL CLASSIFICATION**

- .1 Classification as follows:

Maximum Pressure Pa	SMACNA Seal Class
500	A
250	A
125	A
- .2 Seal classification:
  - .1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.

### **2.2 SEALANT**

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

### **2.3 TAPE**

- .1 Tape: polyvinyl treated, open weave fibreglass tape, 50 mm wide.

### **2.4 DUCT LEAKAGE**

- .1 In accordance with SMACNA 016.

## 2.5 FITTINGS

- .1 Fabrication: to SMACNA.
- .2 Radiused elbows:
  - .1 Rectangular: standard radius or short radius with single thickness turning vanes.
  - .2 Round: smooth radius, centreline radius: 1.5 times diameter.
- .3 Mitred elbows, rectangular:
  - .1 To 400 mm: with single thickness turning vanes.
  - .2 Over 400 mm: with double thickness turning vanes.
- .4 Branches:
  - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct or 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.

## 2.6 GALVANIZED STEEL

- .1 Lock forming quality: to ASTM A653/A653M, Z90 zinc coating.
- .2 Thickness, fabrication and reinforcement: to ASHRAE or SMACNA.
- .3 Joints: to ASHRAE, SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint to be considered to be a class A seal.

## 2.7 HANGERS AND SUPPORTS

- .1 Hangers and Supports:
  - .1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
    - .1 Maximum size duct supported by strap hanger: 500.
  - .2 Hanger configuration: to ASHRAE and SMACNA.

- .3 Hangers: galvanized steel angle with galvanized steel rods to 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 3	10
2401 and over	50 x 50 x 6	10

- .4 Upper hanger attachments:

- .1 For concrete: manufactured concrete inserts.
- .2 For steel joist: manufactured joist clamp.
- .3 For steel beams: manufactured beam clamps:

### **PART 3 - EXECUTION**

#### **3.1 GENERAL**

- .1 Do work in accordance with NFPA (Fire) 90A, NFPA (Fire) 90B, ASHRAE & SMACNA as indicated.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.
  - .1 Insulate strap hangers 100 mm beyond insulated duct.
- .3 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.
- .4 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

#### **3.2 HANGERS**

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

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

#### **3.3 SEALING AND TAPING**

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

### 3.4 LEAKAGE TESTS

- .1 In accordance with SMACNA 016.
- .2 Make trial leakage tests as instructed to demonstrate workmanship.
- .3 Do not install additional ductwork until trial test has been passed.
- .4 Complete test before performance insulation or concealment Work.

END OF SECTION

## **PART 1 - GENERAL**

### **1.1 RELATED REQUIREMENTS**

- .1 Section 23 05 00 - Common Work Results for HVAC.

### **1.2 REFERENCE STANDARDS**

- .1 ASTM International (ASTM)
  - .1 ASTM C177-13, Standard Test Method for Steady-State Heat Flux and Thermal Measurements Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
  - .2 ASTM C423-17, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
  - .3 ASTM C916-14, Standard Specification for Adhesives for Duct Thermal Insulation.
  - .4 ASTM C1071-16, Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
  - .5 ASTM C1338-14, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
  - .6 ASTM G21-15, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .2 National Fire Protection Association (NFPA)
  - .1 NFPA (Fire) 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, 2018 Edition.
  - .2 NFPA (Fire) 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 2018 Edition.
- .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA 016-2012, HVAC Air Duct Leakage Test Manual, 2012, 2nd Edition.
  - .2 SMACNA 1966-2005, HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition
- .4 Underwriter's Laboratories of Canada (ULC)
  - .1 CAN/ULC-S102-10, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

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

- .1 Submit in accordance with Section 23 05 00.

## **PART 2 - PRODUCTS**

### **2.1 DUCT LINER**

- .1 General:
  - .1 Mineral Fibre duct liner: air surface coated mat facing.
  - .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50 when tested in accordance with CAN/ULC-S102, NFPA (Fire) 90A and NFPA (Fire) 90B.
  - .3 Fungi resistance: to ASTM C1338 and ASTM G21.

- .2 Rigid:
  - .1 Use on flat surfaces where indicated.
  - .2 25 mm thick, to ASTM C1071 Type 2, fibrous glass rigid board duct liner.
  - .3 Density: 48 kg/m<sup>3</sup> minimum.
  - .4 Thermal resistance to be minimum 1.53 (m<sup>2</sup>.degrees C)/W for 50 mm thickness when tested in accordance with ASTM C177, at 24 degrees C mean temperature.
  - .5 Maximum velocity on faced air side: 20.3 m/s.
  - .6 Minimum NRC of 0.70 at 25 mm thickness based on Type A mounting to ASTM C423.
  - .7 Thickness: 50 mm.

## 2.2 ADHESIVE

- .1 Adhesive: to NFPA (Fire) 90A, NFPA (Fire) 90B and ASTM C916.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 29 degrees C to plus 93 degrees C.
- .3 Water-based fire retardant type.

## 2.3 FASTENERS

- .1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm square.

## 2.4 JOINT TAPE

- .1 Poly-Vinyl treated open weave fibreglass membrane 50 mm wide.

## 2.5 SEALER

- .1 Meet requirements of NFPA (Fire) 90A and NFPA (Fire) 90B.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 68 degrees C to plus 93 degrees C.

# **PART 3 - EXECUTION**

## 3.1 GENERAL

- .1 Do work in accordance with SMACNA 1966.
- .2 Line inside of ducts where indicated.
- .3 Duct dimensions, as indicated, are clear inside duct lining.

### 3.2 DUCT LINER

- .1 Install in accordance with manufacturer's recommendations, and as follows:
  - .1 Fasten to interior sheet metal surface with 100% coverage of adhesive to ASTM C916.
    - .1 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
  - .2 In addition to adhesive, install weld pins not less than 2 rows per surface and not more than 425 mm on centres to compress duct liner sufficiently to hold it firmly in place.
    - .1 Spacing of mechanical fasteners in accordance with SMACNA 1966.
- .2 In systems, where air velocities exceeds 20.3 m/s, install galvanized sheet metal nosing to leading edges of duct liner.

### 3.3 JOINTS

- .1 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations, and as follows:
  - .1 Bed tape in sealer.
  - .2 Apply 2 coats of sealer over tape.
- .2 Replace damaged areas of liner at discretion of Departmental Representative.
- .3 Protect leading and trailing edges of duct sections with sheet metal nosing having 15 mm overlap and fastened to duct.

END OF SECTION



## **PART 1 - GENERAL**

### **1.1 RELATED REQUIREMENTS**

- .1 Section 23 05 00 - Common Work Results for HVAC.

### **1.2 REFERENCE STANDARDS**

- .1 Air Moving and Conditioning Association (AMCA)
  - .1 AMCA 300-14, Reverberant Room Method for Sound Testing of Fans.
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM B152/B152M-13, Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar.
  - .2 ASTM B209-14, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate.
  - .3 ASTM B224-16, Standard Classification of Coppers.
  - .4 ASTM E527-16, Standard Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS).
- .3 Canadian Standards Association (CSA)
  - .1 CSA C22.1-18, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations (24th Edition).
- .4 National Electrical Manufacturers Association (NEMA).
- .5 Underwriters Laboratories (UL).

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

- .1 Submit in accordance with Section 23 05 00.

### **1.4 CLOSEOUT SUBMITTALS**

- .1 Submit in accordance with Section 23 05 00.

### **1.5 WARRANTY**

- .1 For Work of this section, 12 months warranty period is extended to 60 months.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- .1 Indirect fired self-contained air handling unit with packaged cooling in accordance with the following specifications. The unit shall be ETL and CETL certified.

## 2.2 CASING

- .1 The unit exterior casing shall be heavy gauge Z275 rated bonderized steel. Unit roof shall feature standing seam construction. The entire unit casing shall be insulated with (50 mm thick 0.7 kg) fibreglass insulation with hard neoprene backing in a sandwich wall fashion 0.64 mm (22-gauge solid liner). The unit exterior shall be finished with industrial enamel (catalyzed epoxy) paint. An integral welded iron channel frame shall support the unit casing. The structural iron frame shall be sandblasted, primed and finished with industrial enamel (catalyzed epoxy) paint.

## 2.3 BLOWER/MOTOR SECTION

- .1 The fan section and motor assembly shall be constructed in accordance with the requirements of the Air Moving and Conditioning Association (AMCA). The assembly shall be designed to house the fan(s), bearings, motor, and v-belts, which shall be selected for at least 50% above the rated motor capacity. The fan(s) and motor shall be mounted on a welded unitary base made of angle iron frame. The frame shall be sandblasted, primed and finished with industrial enamel (catalyzed epoxy) paint. The unitary base shall be provided with seismic spring vibration isolation. The blower section shall have a hinged access door with Austin Romtech handles to allow easy maintenance of filters and belts. The NEMA T-Frame motor shall be mounted on an adjustable base located within the fan section. The blower shall be a backward inclined blower. The blower wheel shall be statically and dynamically balanced, and mounted on a turned, ground and polished shaft with rigid bearing supports. The shaft shall be designed with a maximum operating speed not exceeding 75% of the first critical speed. The bearings shall be split taper lock ball bearing type L20 minimum life of 100,000 hours (L10 200 kHr).
- .2 Fan performance shall be based on tests conducted in accordance with AMCA Standard Test Code for Air moving Devices. (All fans shall have sharply rising pressure characteristic extending throughout the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics shall be truly non-overloading and shall reach a peak in the normal selection area.) Fan manufacturer shall provide sound power ratings in the eight octave bands, which shall be based on AMCA 300, test, setup number one. Sound power ratings shall be referenced 10-12 watts. A factory dynamic balance shall be made on all fans after their assembly. An IRD or PMC analyzer shall be used to measure velocity, and the final reading shall not exceed 0.1 inches per second. The exact level of vibration shall be recorded on the fan as proof of the final dynamic balance at the factory. Fan performance shall be based on tests conducted in accordance with AMCA Standard Test Code for Air moving Devices. (All fans shall have sharply rising pressure characteristic extending throughout the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics shall be truly non-overloading and shall reach a peak in the normal selection area.) Fan manufacturer shall provide sound power ratings in the eight octave bands, which shall be based on AMCA 300, test, setup number one. Sound power ratings shall be referenced 10-12 watts. A factory dynamic balance shall be made on all fans after their assembly. An IRD or PMC analyzer shall be used to measure velocity, and the final reading shall not exceed 0.1 inches per second. The exact level of vibration shall be recorded on the fan as proof of the final dynamic balance at the factory.
- .3 Each fan motor shall be wired to a junction box for field wiring to the existing VFDs. The VFDs shall be controlled by the BAS.

## 2.4 GAS FIRED HEATER

- .1 The heater shall be designed to ensure 91% efficiency at full firing rate and the power burner has a turndown capacity of 29:1. The heat exchanger and blower shall be constructed so they can easily be disassembled and reassembled in the field if necessary. With the exception of the supply and return fans, the unit shall be equipped to operate from a single point power connection. The heater shall be flame tested before shipment and the manufacturer shall keep a detailed flame test report on file. Factory testing shall be confirmed with a combustion analyzer and flow meter. The heater shall be shipped completely factory assembled and wired including all pre-piped manifold components and fuses, ready for immediate power and fuel connections.
- .2 The heat exchanger shall be of multiple pass design, made up of at least 1.29 mm (16-gauge) stainless steel drum and tubes. The primary and secondary heat transfer surfaces shall be constructed of Type 409 series stainless steel, with internal stainless steel high efficiency enhancing baffles. The stainless steel tubes shall be continuously welded into the secondary front and rear header tube sheets to ensure an airtight seal. After welding, the heat exchanger shall be pressure tested to 140 kPa to ensure that there are no leaks. Manufacturer shall provide complete pressure testing report with Installation Manual. Units shall be provided with multiple condensate drains. The heat exchanger section shall have an internal radiation shield to maintain a jacket loss of less than 2% of rated output. All heat transfer surfaces, including headers and the front collector box, shall be inside the casing and in the airstream. The construction of the heat exchanger shall permit free, unrestricted lateral, vertical, and peripheral expansion during the heating and cooling cycle without damage or strain to any parts.
- .3 The burner shall be constructed with at least 1.63 mm (14-gauge) stainless steel and with the air baffles being made up of 430 stainless steel to ensure high durability and life of the burner. The burner assembly shall be a blow through positive pressure type with an intermittent pilot ignition system. Flame supervision shall be with a solid state programmed flame relay complete with flame rod. The unit's burner motor and modulating gas valve must be electronically controlled to guarantee, to the customer, a highly efficient unit at all times and applications. The unit efficiency shall be greater than 91% through the entire operating range and shall be independently tested and verified by ETL. The main and pilot manifolds shall be completely factory pre-piped to the burner. This assembly must be factory wired and include the following minimum components:
  - .1 Main and pilot manual shut-off valves.
  - .2 Main and pilot regulators.
  - .3 Main and pilot automatic shut-off valves.
  - .4 Test ports for unconstrained service and disposal of condensate formed in the flue gas by means of a 409 stainless steel flue box with drain and heat exchanger drain. Drains shall be made of stainless steel tubing. The flue chimney will be made of stainless steel.
- .4 The packaged gas-fired heater shall be controlled with an analog signal provided by the BAS. The unit shall be controlled electronically to achieve a turndown of at least 29:1 and to guarantee the heat exchanger efficiencies of at least 91%. The unit controller shall be a true proportional integral decay (PID) controller to maintain the turndown and unit efficiencies. The controller shall be able to electronically adjust the burner blower and modulating gas valve to maintain ideal combustion levels and shall monitor the amount of combustion air available to guarantee proper emission standards. The unit control will consist of a feedback control system. Corrective action in this system is taken only when the balance has been upset due to a change in the disturbance variable. The controller analyzes the process and calculates a control error from the measured values. Continuous cycling of the burner or blower is not permitted. The proportional control is to provide an output signal in proportion to the size of the control error. If the control error persists, the output will continue to ramp in the correct direction, until the control error is eliminated. All burner safeties are by the unit controller.

## 2.5 DAMPERS & FILTER SECTION

- .1 The dampers are to be galvanized steel (aluminum airfoil low leak) type (with seals). All dampers shall be equipped with modulating actuators. The outside air louver and damper shall be sized for the maximum supply air volume to allow for economizer operation. The filters shall be 50 mm (2") pleated throwaway type with minimum of 85% arrestance and 30% efficiency. Filter access shall be through a latched and gasketed access doors located on both sides of the unit. Modulating actuators shall be wired back to a terminal strip for control by the BAS.

## 2.6 EVAPORATOR COILS

- .1 Coils are to be designed to maximize performance under specified conditions with minimal air-side pressure drop. Coils shall be UL recognized as Refrigerant Containing Component. Coils to be used with refrigerant R-410A shall have undergone cycle testing, and shall be safety listed with 5,170 kPa (750 psig) rating. Tubes and return bends shall be constructed from seamless UNS C12200 copper conforming to ASTM B224 and ASTM E527. Properties shall be O50 light annealed with a maximum grain size of 0.040 mm. Tubes are to be mechanically expanded into fins (secondary surface) for maximum heat transfer. Secondary surface (fins) shall be of the plate-fin design using aluminum or copper, with die-formed collars. Fin design to be flat, waffle, or sine-wave in a staggered tube pattern to meet performance requirements. Collars will hold fin spacing at specified density, and cover the entire tube surface. Aluminum properties are to be Alloy 1100 per ASTM B209, with O (soft) temper; copper is to be Alloy 11000 per ASTM B152 with soft (anneal) temper. Fins are to be free of oils and oxidation. Headers are to be constructed of seamless UNS C12200, Type L (drawn) copper material sized to match specified connection size. Type K (drawn) copper headers shall be offered as optional material. Die-formed copper end caps are brazed on the inside of the headers. Evaporator coils shall be designed with brass liquid distributors (as required), and copper sweat suction connections. Distributors shall be capped using soft-solder for ease of cap removal; suction connections shall be capped. Coil casing material shall be of Z275 galvanized steel, 1.29 mm (16 gauge) minimum. Heavier material, stainless steel, copper, or aluminum casing are to be provided as required. Intermediate tube supports are to be provided on all coils 1,219 mm (48") and longer fin length. Coil casing on top and bottom of coils are to have double-flange construction, allowing for vertical stacking of coils.
- .2 All coils are to be brazed with minimum 5% silver content (BCup-3) filler material to insure joint integrity.
- .3 Coils shall be tested at 3,790 kPa (550 psig) using dry nitrogen, submerged under water. Dual-operator verification shall determine that all coils are leak-free. Coils shall be shipped with nitrogen charge to verify leak-free integrity, and to prevent moisture migration into coil. Coils shall be certified to withstand 5,170 kPa (750 psig) working pressure.

## 2.7 CONDENSER COILS

- .1 Condenser coils are intended for use with a wide range of applications and refrigerant types. Coils are to be designed to maximize performance under specified conditions with minimal air-side pressure drop.

- .2 Coils shall be UL recognized as Refrigerant Containing Component. Coils to be used with refrigerant R-410A shall have undergone cycle testing, and shall be safety listed with 5,170 kPa (750 psig) rating. Tubes and return bends shall be constructed from seamless UNS C12200 copper conforming to ASTM B224 and ASTM E527. Properties shall be O50 light annealed with a maximum grain size of 0.040 mm. Tubes are to mechanically expanded into fins (secondary surface) for maximum heat transfer. Internally enhanced rifled or cross-hatched tubes can be offered as an option. Secondary surface (fins) shall be of the plate-fin design using aluminum or copper, with die-formed collars. Fin design to be flat, waffle, or sine-wave in a staggered tube pattern to meet performance requirements. Collars will hold fin spacing at specified density, and cover the entire tube surface. Aluminum properties are to be Alloy 1100 per ASTM B209, with O (soft) temper; copper is to be Alloy 11000 per ASTM B152 with soft (anneal) temper. Fins are to be free of oils and oxidation. Headers are to be constructed of seamless UNS C12200, Type L (drawn) copper material sized to match specified connection size. Type K (drawn) copper headers shall be offered as optional material. Die-formed copper end caps are brazed on the inside of the headers. Condenser coils shall be designed with copper sweat connections, and shall be shipped with caps on connections. Coil casing material shall be of Z275 galvanized steel, 1.29 mm (16 gauge) minimum. Heavier material, stainless steel, copper, or aluminum casing are to be provided as required. Coils designed for hot-gas applications shall have oversized tube sheet holes for hot gas feeds to allow for free expansion and contraction of tubes during operation. Intermediate tube supports are to be provided on all coils 1.219 mm (48") and longer fin length. Coil casing on top and bottom of coils are to have double-flange construction, allowing for vertical stacking of coils. All coils are to be brazed with minimum 5% silver content (BCup-3) filler material to insure joint integrity.
- .3 Coils shall be tested at 3790 kPa (550 psig) using dry nitrogen, submerged under water. Dual-operator verification shall determine that all coils are leak-free. Coils shall be shipped with nitrogen charge to verify leak-free integrity, and to prevent moisture migration into coil. Coils shall be certified to withstand 5,170 kPa (750 psig) working pressure.

## 2.8 COMPRESSORS

- .1 Hermetic digital scroll compressors shall be set on resilient neoprene mounts and complete with line voltage break internal overload protection, internal pressure relief valve and crankcase heater. Each unit shall have a minimum of two compressors. Whereby a unit utilizing two compressors the first stage compressor shall be a digital scroll operating with a Emerson EC3 series stand-alone superheat controller with a built in synchronization control for the digital scroll. Unit will provide turndown on cooling. Multiple refrigeration circuits shall be separate from each other. Refrigeration circuits shall be complete with liquid line filter driers and service ports fitted with Schraeder fittings. Units shall incorporate electronic expansion valves, an EC3 digital superheat controller and combination sight glass moisture indicators. System charge will be designed for -12°C (10°F) of superheat. Each system shall be factory run and adjusted prior to shipment. Controls shall include:
- .1 Compressor motor contacts
  - .2 Overload protection control
  - .3 Cooling relays
  - .4 Ambient compressor lockout
  - .5 Dual pressure controls
  - .6 Anti-cycle timers

## 2.9 CONDENSER FANS

- .1 Condenser fans shall be aluminum blade, direct drive, complete with 75 mm (3") high venturi and 1140 RPM condenser fan motor controlled by VFD taking a signal from a transducer located in the discharge line. This, along with an electronic expansion valve allows for Floating Head and condensation down to 21°C (70°F) condensing.

- .2 Packaged units shall operate down to 10°C (50°F) as standard. -40°C low ambient systems shall be available as an option. Compressors shall be located on the side of the unit in a service enclosure complete with hinged access doors.

## 2.10 COOLING CONTROLS

- .1 The packaged direct expansion cooling shall be controlled with an analog signal provided by the BAS. The stages are to be sequenced without turning on and off of compressors to minimize unnecessary wear on the compressors. A lead modulating (digital) compressor shall be utilized to trim between stages. Staging standard compressors shall be unacceptable. Upon receiving a call for cooling from the BAS, the unit controller shall modulate the packaged cooling to the BAS demand signal. The unit controller shall monitor the discharge temperature and adjust cooling output as required to prevent compressors from cycling on and off. The compressor will remain on low setting until cooling is disabled by the BAS.

## 2.11 ELECTRICAL CONTROL EQUIPMENT

- .1 Electrical assembly and components shall be in strict accordance with the latest provisions and requirements of the CSA C22.1. Control cabinet shall be designed and constructed to ETL specifications. A safety disconnect switch shall be mounted on the unit. The controls shall be located in a weatherproof cabinet. Provisions for service padlocking shall be provided. The following items shall be located within the cabinet: fuses, starters, control relays, timing and holding relays, resistors and numbered terminal strips. All components shall be labelled and cross-referenced to control and field wiring diagrams. The control circuit shall be 24V, single phase. Wiring shall be neatly run in "PANDUIT" wiring duct. Unit shall be equipped with automatic low limit freeze protection with bypass timer.
- .2 Unit heating demand, cooling demand, fan speed and damper positions shall be controlled by the BAS. The unit mounted electrical assembly shall include a terminal strip for the following inputs from the BAS:
  - .1 RTU enable: 24 volt ac dry-contact
  - .2 Heating enable: 24 volt ac dry-contact
  - .3 Heating modulation: 0-10 volt dc demand signal
  - .4 Cooling enable: 24 volt ac dry-contact
  - .5 Cooling modulation: 0-10 volt dc demand signal
  - .6 Outside air damper position: 0-10 volt dc demand signal
  - .7 Mixing damper position: 0-10 volt dc demand signal
  - .8 Exhaust/relief damper position: 0-10 volt dc demand signal
- .3 The following outputs shall be provided from the unit controller and wired to a terminal strip for monitoring by the BAS:
  - .1 General unit alarm: 24 volt ac dry-contact
  - .2 Burner alarm: 24 volt ac dry-contact
  - .3 Cooling alarm: 24 volt ac dry-contact
  - .4 Freeze stat alarm: 24 volt ac dry-contact
  - .5 Dirty filters alarm: 24 volt ac dry-contact

## **PART 3 - EXECUTION**

### 3.1 INSTALLATION

- .1 Install as per manufacturers' instructions on roof curbs provided by manufacturer.

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

### 3.2 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 Rooftop Air Handling Units:
    - .1 Set 75% of zone terminal units for full cooling.
    - .2 Set outside air and return air dampers for minimum outside air.
    - .3 Check for smooth, vibration less correct rotation of supply fan impeller.
    - .4 Measure supply fan capacity.
    - .5 Adjust impeller speed as necessary and repeat measurement of fan capacity.
    - .6 OAD: verify for proper stroking, interlock with RAD.
    - .7 Measure DBT, WBT of SA, RA, EA.
    - .8 Measure air cooled condenser discharge DBT.
    - .9 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
    - .10 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
    - .11 Use smoke test to verify no short-circuiting of EA, relief air to outside air intake or to condenser intake.
    - .12 Simulate maximum heating load and:
      - .1 Verify temperature rise across heat exchanger.
      - .2 Perform flue gas analysis. Adjust for peak efficiency.
      - .3 Verify combustion air flow to heat exchanger.
      - .4 Simulate minimum heating load and repeat measurements.
    - .13 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
    - .14 Verify operating control strategies, including:
      - .1 Heat exchanger operating and high limit.
      - .2 Early morning warm-up cycle.
      - .3 Freeze protection.
      - .4 Economizer cycle operation, temperature of change-over.
      - .5 Alarms.
      - .6 Voltage drop across thermostat wiring.
      - .7 Operation of remote panel including pilot lights, failure modes.
    - .15 Set zone terminal units for full heating and repeat measurements.
    - .16 Measure return fan capacity.
    - .17 Adjust impeller speed as necessary and repeat measurement of return fan capacity.
    - .18 Check capacity of heating unit.
  - .2 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
  - .3 Verify accessibility, clean ability, drainage of drain pans for coils, humidifiers.

END OF SECTION

## **PART 1 - GENERAL**

### **1.1 REFERENCE STANDARDS**

- .1 CSA Group
  - .1 CSA C22.1-18, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations (24th Edition).
  - .2 CAN3-C235-83 (R2015), Preferred Voltage Levels for AC Systems 0- 50,000 V.
- .2 Institute of Electrical and Electronics (IEEE)/National Electrical Safety Code Product Line (NESC)
  - .1 IEEE SP1122-2000, The Authoritative Dictionary of IEEE Standards Terms, 7th Edition.

### **1.2 DEFINITIONS**

- .1 Electrical and electronic terms: unless otherwise specified or indicated, terms used in these specifications, and on drawings, are those defined by IEEE SP1122.

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

- .1 Product Data:
  - .1 Submit manufacturer's instructions, printed product literature and data sheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .2 Shop drawings:
  - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Ontario, Canada.
  - .2 Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure co-ordinated installation.
  - .3 Identify on wiring diagrams circuit terminals and indicate internal wiring for each item of equipment and interconnection between each item of equipment.
  - .4 Indicate on drawings clearances for operation, maintenance, and replacement of operating equipment devices.
  - .5 If changes are required, notify Departmental Representative of these changes before they are made.
- .3 Certificates:
  - .1 Provide CSA certified equipment and material.
  - .2 Permits and fees: in accordance with General Conditions of contract.

### **1.4 CLOSEOUT SUBMITTALS**

- .1 Operation and Maintenance Data: submit operation and maintenance data for incorporation into manual.
  - .1 Provide for each system and principal item of equipment as specified in technical sections for use by operation and maintenance personnel.
- .2 Fire alarm verification report.



## **PART 2 - PRODUCTS**

### **2.1 DESIGN REQUIREMENTS**

- .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.
  - .1 Equipment to operate in extreme operating conditions established in above standard without damage to equipment.
- .3 Language operating requirements: provide identification nameplates and labels for control items in English.

### **2.2 MATERIALS AND EQUIPMENT**

- .1 Material and equipment to be CSA certified.
- .2 Factory assemble control panels and component assemblies.

### **2.3 WARNING SIGNS**

- .1 Warning Signs: in accordance with requirements of Departmental Representative.

### **2.4 WIRING TERMINATIONS**

- .1 Ensure lugs, terminals, screws used for termination of wiring are suitable for either copper or aluminum conductors.

### **2.5 EQUIPMENT IDENTIFICATION**

- .1 Identify electrical equipment with nameplates and labels as follows:
  - .1 Nameplates: lamicaid 3 mm , white face, black core, lettering accurately aligned and engraved into core.
  - .2 Sizes as follows:

#### **NAMEPLATE SIZES**

Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	20 x 90 mm	2 lines	5 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters
Size 7	25 x 100 mm	2 lines	6 mm high letters

- .2 Wording on nameplates and labels to be approved by Departmental Representative prior to manufacture.
- .3 Allow for minimum of twenty-five (25) letters per nameplate and label.
- .4 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.

- .5 Disconnects, starters and contactors: indicate equipment being controlled and voltage.
- .6 Terminal cabinets and pull boxes: indicate system and voltage.
- .7 Transformers: indicate capacity, primary and secondary voltages.

## 2.6 WIRING IDENTIFICATION

- .1 Identify wiring with permanent indelible identifying markings, coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
- .2 Maintain phase sequence and colour coding throughout.
- .3 Colour coding: to CSA C22.1.

## 2.7 CONDUIT AND CABLE IDENTIFICATION

- .1 Colour code conduits, boxes and metallic sheathed cables.
- .2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m intervals.
- .3 Colours: 25 mm wide prime colour and 20 mm wide auxiliary colour.

Type	Prime	Auxiliary
up to 600V	Yellow	Green
Fire Alarm	Red	

## 2.8 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 outdoor electrical equipment "equipment green" finish.
  - .2 Paint indoor switchgear and distribution enclosures light grey.

## **PART 3 - EXECUTION**

### 3.1 INSTALLATION

- .1 Do complete installation in accordance with CSA C22.1 except where specified otherwise.

### 3.2 NAMEPLATES AND LABELS

- .1 Ensure manufacturer's nameplates, CSA labels and identification nameplates are visible and legible after equipment is installed.

### 3.3 CO-ORDINATION OF PROTECTIVE DEVICES

- .1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings.

### 3.4 FIELD QUALITY CONTROL

- .1 Conduct following tests.
  - .1 Systems: fire alarm.
  - .2 Insulation resistance testing:
    - .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
    - .2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.
    - .3 Check resistance to ground before energizing.
- .2 Carry out tests in presence of Departmental Representative.
- .3 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.

### 3.5 SYSTEM STARTUP

- .1 Instruct Departmental Representative in operation, care and maintenance of systems, system equipment and components.

## **PART 1 - GENERAL**

### **1.1 RELATED REQUIREMENTS**

- .1 Section 26 05 00 - Common Work Results for Electrical.

## **PART 2 - PRODUCTS**

### **2.1 BUILDING WIRES**

- .1 Conductors: stranded for 10 AWG and larger. Minimum size: 12 AWG.
- .2 Copper conductors: size as indicated, with 1000 V insulation of cross-linked thermosetting polyethylene material rated RW90 XLPE, Jacketted.

### **2.2 TECK 90 CABLE**

- .1 Conductors:
  - .1 Grounding conductor: copper.
  - .2 Circuit conductors: copper.
- .2 Insulation:
  - .1 Ethylene propylene rubber EP.
  - .2 Cross-linked polyethylene XLPE.
  - .3 Rating: 1000 V.
- .3 Inner jacket: polyvinyl chloride material.
- .4 Armour: interlocking aluminum.
- .5 Overall covering: thermoplastic polyvinyl chloride.
- .6 Fastenings:
  - .1 One hole steel straps to secure surface cables 50 mm and smaller. Two hole steel straps for cables larger than 50 mm.
  - .2 Channel type supports for two or more cables.
  - .3 Threaded rods: 6 mm diameter to support suspended channels.
- .7 Connectors:
  - .1 Watertight, approved for TECK cable.

## **PART 3 - EXECUTION**

### **3.1 FIELD QUALITY CONTROL**

- .1 Perform tests in accordance with Section 26 05 00.
- .2 Perform tests before energizing electrical system.

### 3.2 GENERAL CABLE INSTALLATION

- .1 Cable Colour Coding: to Section 26 05 00.
- .2 Conductor length for parallel feeders to be identical.
- .3 Lace or clip groups of feeder cables at distribution centres, pull boxes, and termination points.

### 3.3 INSTALLATION OF TECK 90 CABLE (0 -1000 V)

- .1 Group cables wherever possible on channels.
- .2 Install cable exposed, securely supported by straps.

END OF SECTION

## **PART 1 - GENERAL**

### **1.1 REFERENCE STANDARDS**

- .1 Institute of Electrical and Electronics Engineers (IEEE)
  - .1 IEEE 837-2014, Standard for Qualifying Permanent Connections Used in Substation Grounding.

## **PART 2 - PRODUCTS**

### **2.1 EQUIPMENT**

- .1 Grounding conductors: bare stranded copper, tinned, soft annealed.
- .2 Insulated grounding conductors: green, copper conductors.
- .3 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
  - .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.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION GENERAL**

- .1 Install complete permanent, continuous grounding system including, conductors, connectors, accessories. Where EMT is used, run ground wire in conduit.
- .2 Install connectors in accordance with manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .5 Soldered joints not permitted.
- .6 Install bonding wire for flexible conduit, connected at one end to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .7 Make grounding connections in radial configuration only, with connections terminating at single grounding point. Avoid loop connections.

### 3.2 EQUIPMENT GROUNDING

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to following list.  
Service equipment, transformers, switchgear, duct systems, frames of motors, motor control centres, starters, control panels, building steel work, generators, elevators and escalators, distribution panels, outdoor lighting, cable trays.

END OF SECTION

## **PART 1 - GENERAL**

### **1.1 RELATED REQUIREMENTS**

- .1 Section 26 05 00 - Common Work Results for Electrical .

### **1.2 REFERENCE STANDARDS**

- .1 CSA Group (CSA)
  - .1 CSA C22.1-18, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations (24th Edition).

## **PART 2 - PRODUCTS**

### **2.1 JUNCTION AND PULL BOXES**

- .1 Construction: welded steel enclosure.
- .2 Covers Flush Mounted: 25 mm minimum extension all around.
- .3 Covers Surface Mounted: screw-on turned edge covers.

## **PART 3 - EXECUTION**

### **3.1 JUNCTION AND PULL BOXES INSTALLATION**

- .1 Install pull boxes in inconspicuous but accessible locations.
- .2 Mount cabinets with top not higher than 2 m above finished floor except where indicated otherwise.
- .3 Only main junction and pull boxes are indicated. Install additional pull boxes as required by CSA C22.1.

### **3.2 IDENTIFICATION**

- .1 Equipment Identification: to Section 26 05 00.
- .2 Identification Labels: size 2 indicating system name and voltage and phase.

END OF SECTION



## **PART 1 - GENERAL**

### **1.1 RELATED REQUIREMENTS**

- .1 Section 26 05 00 - Common Work Results for Electrical.

### **1.2 REFERENCE STANDARDS**

- .1 Underwriter's Laboratories of Canada (ULC)
  - .1 CAN/ULC-S524-14, Standard for the Installation of Fire Alarm Systems.
  - .2 CAN/ULC-S537-13, Standard for the Verification of Fire Alarm Systems.

### **1.3 CLOSEOUT SUBMITTALS**

- .1 Operation and Maintenance Data: submit operation and maintenance data for fire alarm system for incorporation into manual.
- .2 Include:
  - .1 Instructions for complete fire alarm system to permit effective operation and maintenance.
  - .2 Technical data - illustrated parts lists with parts catalogue numbers.
  - .3 Copy of approved shop drawings with corrections completed and marks removed except review stamps.
  - .4 List of recommended spare parts for system.

## **PART 2 - PRODUCTS**

### **2.1 DESCRIPTION**

- .1 Existing fire alarm system is Edwards Quick Start.

### **2.2 WIRING**

- .1 Twisted copper conductors: rated 300 V.
- .2 To initiating circuits: 18 AWG minimum, and in accordance with manufacturer's requirements.
- .3 To control circuits: 14 AWG minimum, and in accordance with manufacturer's requirements.

### **2.3 AUTOMATIC ALARM INITIATING DEVICES**

- .1 Smoke detector: photo-electric type air duct type with sampling tubes with protective housing.
  - .1 Plug-in type with fixed base.
  - .2 Wire-in base assembly with integral red alarm LED, and terminals for remote relay alarm LED.

## 2.4 ANCILLARY DEVICES

- .1 Remote relay unit to initiate fan shutdown.

## **PART 3 - EXECUTION**

### 3.1 EXAMINATION

- .1 Verification of Conditions: verify conditions of substrates previously installed under other Sections or Contracts are acceptable for fire alarm 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 Install systems in accordance with CAN/ULC-S524.
- .2 Locate and install detectors and connect to alarm circuit wiring. Locate duct type detectors in straight portions of ducts.
- .3 Install remote relay units to control fan shut down.
- .4 Splices are not permitted.
- .5 Ensure that wiring is free of opens, shorts or grounds, before system testing and handing over.
- .6 Identify circuits and other related wiring at central control unit, annunciators, and terminal boxes.

### 3.3 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 26 05 00 and CAN/ULC-S537.
- .2 Fire alarm system:
  - .1 Test such device and alarm circuit to ensure smoke detectors transmit alarm to control panel and actuate general alarm.
  - .2 Check annunciator panels to ensure zones are shown correctly.
  - .3 Simulate grounds and breaks on alarm and signalling circuits to ensure proper operation of systems.

### 3.4 PROTECTION

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

END OF SECTION