PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 099150 - Interior Re-Painting.

.4 Section 230593 - Testing, Adjusting and Balancing (TAB) of Mechanical Systems.

1.2 Equipment List

.1 Complete list of equipment and materials to be used on this project and forming part of tender documents by adding manufacturer's name, model number and details of materials, and submit for approval.

.2 Submit for approval within 48 h after award of contract.

1.3 Trial Usage

.1 Departmental Representative may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.

.2 Trial usage to apply to following equipment and systems:

.1 Lab exhaust systems.

.2 General exhaust systems.

1.4 Protection of Openings

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

1.5 Painting

.1 To Section 099150 - Interior Re-Painting.

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

.3 Restore to new condition, finishes which have been damaged too extensively to be merely primed and touched up.

1.6 Spare Parts

.1 Furnish spare parts in accordance with Section 017800 - Closeout Submittals as follows:
.1 One set of bearings for one (1) new exhaust fan.

1.7 Special Tools

.1 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Section 017800 - Closeout Submittals.

1.8 Demonstration and Operating and Maintenance Instructions

.1 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.

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

.3 Use operation and maintenance manual, as-built drawings, audio visual aids, etc. as part of instruction materials.

.4 Instruction duration time requirements as specified in appropriate sections.

.5 Where deemed necessary, Departmental Representative may record these demonstrations on video tape for future reference.

.6 Note phased nature of the project and phasing requirements.

1.9 Closeout Submittals for Substantial Performance

.1 Provide operation and maintenance data for incorporation into manual specified in Section 017800 - Closeout Submittals.

.2 Operation and maintenance manual to be approved by, and final copies deposited with, Departmental Representative before final inspection.

.3 Operation data to include:
.1 Control schematics for each system including environmental controls.
.2 Description of each system and its

controls.

.3 Description of operation of each system at various loads together with reset schedules and seasonal variances.

.4 Operation instruction for each system and each component.

.5 Description of actions to be taken in event of equipment failure.

.6 Revise the existing operation and maintenance manuals for the existing fans (including affected associated systems), LEF- 1/2/3, serving the combined fume hood exhaust and general return/ exhaust system. Request the original manuals from the building operator. The intent is to provide an updated manual that shows the new fans integrated with the existing systems complete with, but not limited to, shop drawings, maintenance data, updated operating set points, updated controls drawings, schematics and sequences of operation, balancing and commissioning reports.

.4 Maintenance data shall 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.

.5 Performance data to include:

.1 Equipment manufacturer's performance data sheets with point of operation as left after commissioning is complete.

.2 Equipment performance verification test results.

.3 Special performance data as specified elsewhere.

.4 Testing, adjusting and balancing reports as specified in Section 230593 - Testing, Adjusting and Balancing.

.6 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 so directed by Departmental Representative.

.2 Make changes as required and re-submit as

directed by Departmental Representative.

.7 Additional data:
.1 Prepare and insert into operation and maintenance manual when need for same becomes apparent during demonstrations and instructions specified above.

.8 Ensure air systems have been balanced with a draft report submitted to the Departmental Representative.

.9 Commissioning component sheets and verification test sheets to be completed and draft report submitted to the Departmental Representative. Labs, fume hoods, labs exhaust fans commissioned to the satisfaction of the Departmental Representative.

.10 Ensure lab exhaust air systems have been balanced with a draft report submitted to the Departmental Representative.

.11 Record drawings to be submitted.

.12 Prior to requesting an inspection for Substantial Performance, provide a complete list of items that are deficient.

.13 At the completion of the project, submit one copy of the Maintenance manual in searchable, electronic, PDF format.

1.10 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Section 013300 - Submittal Procedures.

.2 Shop drawings and product data shall show:
.1 Mounting arrangements.
.2 Operating and maintenance clearances. eg. access door swing spaces.
.3 Project specific information (models, sizes, etc.) clearly identified.

.3 Shop drawings and product data shall be accompanied by:
.1 Detailed drawings of bases, supports, and anchor bolts.

.2 Acoustical sound power data, where applicable.
.3 Points of operation on performance curves.
.4 Manufacturer to certify as to current model production.
.5 Certification of compliance to applicable codes.

.4 In addition to transmittal letter referred to in Section 013300 - Submittal Procedures: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.

1.11 Cleaning

.1 Clean interior and exterior of all new systems. Vacuum interior of new ductwork and exhaust fans.

1.12 As-built Drawings

.1 Site records:
.1 Departmental Representative will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of the work. Mark there on all changes as work progresses and as changes occur. This shall include changes to existing mechanical systems, control systems and low voltage control wiring.
.2 On a weekly basis, transfer information to reproducibles, revising reproducibles to show all work as actually installed.
.3 Use different colour waterproof ink for each service.
.4 Make available for reference purposes and inspection at all times.

.2 As-built drawings:
.1 Prior to start of Testing, Adjusting and Balancing (TAB), 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 TAB to be performed using as-built drawings.
.5 Submit completed reproducible as-built

drawings with Operating and Maintenance Manuals.

.6 Provide AutoCAD drawing files with as-built information in both hard and electronic copies in latest version of AutoCAD as described in 017800 clause 1.7.7.

.3 Submit copies of as-built drawings for inclusion in final TAB report.

1.13 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Departmental Representative.

.3 Dispose of unused paint material at official hazardous material collections site approved by Departmental Representative.

.4 Do not dispose of unused paint material into sewer system, into streams, lakes, onto ground or in other locations where it will pose health or environmental hazard.

.5 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.6 Dispose of corrugated cardboard, polystyrene and plastic packaging material in appropriate on-site bin for recycling in accordance with site waste management program.

.7 Hazardous waste (metallic and non-metallic) removed from the fume hood exhaust system will need to be securely stored in 6mil plastic bags within a sealed, locking container provided by the contractor within the fenced area at the staging area noted on the site plan. The container contents will then need to disposed of at a licensed hazardous waste landfill. The contractor shall supply to the Departmental Representative a copy of the landfill's invoice and/or waybill proving that the contents were delivered and disposed of. See Section 013500 - Special Procedures.

.8 Construction dumpsters shall be located at the primary staging area, in the greenhouse parking lot. Contractor shall be responsible for providing dumpsters and their disposal.

1.14 Trades Coordination

.1 Refer to Section 230983 for related EMCS coordination work.

.2 Refer to Division 26 for electrical coordination work.

PART 2- PRODUCTS

NOT USED

PART 3- EXECUTION

NOT USED

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

1.2 References

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

.1 ASHRAE 90.1-04, Energy Code for Buildings Except Low-Rise Residential Buildings.

.2 Electrical Equipment Manufacturers' Advisory Council (EEMAC)

1.3 Sections Includes

.1 Electrical work to conform to Division 26 including the following:

.1 Supplier and installer responsibility is indicated in Motor, Control and Equipment Schedule on electrical drawings and related mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.

.2 Control wiring and conduit is specified in Division 26 except for conduit, wiring and connections below 50 V which are related to control systems specified in Division 23. Refer to Division 26 for quality of materials and workmanship.

1.4 Shop Drawings

.1 Submit shop drawings in accordance with Section 013300 - Submittal Procedures.

1.5 Closeout Submittals

.1 Provide maintenance data for motors, drives and guards for incorporation into manual specified in Section 013300 - Submittal Procedures.

1.6 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Divert unused metal and wiring materials from

landfill to metal recycling facility approved by Departmental Representative.

.3 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.4 Dispose of corrugated cardboard, polystyrene and plastic packaging material in appropriate on-site bin for recycling in accordance with site waste management program.

PART 2 - PRODUCTS

2.1 General

.1 Motors to be high efficiency, in accordance with local BC Hydro company standards and the requirements of ASHRAE 90.1.(2004)

2.2 Motors

.1 Provide motors for mechanical equipment as specified.

.2 If delivery of specified motor will delay delivery or installation of equipment, install motor approved by Departmental Representative for temporary use. Final acceptance of equipment will not occur until specified motor is installed.

.3 Motors under 373 W: speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated.

.4 Motors 373 W and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 40 ° C, 3 phase, 575 V, unless otherwise specified or indicated.

.5 Motors driven by Variable Frequency Drives shall be inverter duty, suitable for the application.

2.3 Temporary Motors

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

2.4 Belt Drives

.1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.

.2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise specified.

.3 For motors under 7.5 kW: standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.

.4 For motors 7.5 kW and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.

.5 Correct size of sheave to be determined during commissioning.

.6 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.

.7 Motor slide rail adjustment plates to allow for centre line adjustment.

.8 Supply one set of spare belts for each set installed in accordance with Section 230500 and 017800.

2.5 Drive Guards

.1 Provide guards for unprotected drives.

.2 Guards for belt drives;
- .1 Expanded metal screen welded to steel frame.
- .2 Minimum 1.2 mm thick sheet metal tops and bottoms.
- .3 38 mm dia holes on both shaft centres for insertion of tachometer.
- .4 Removable for servicing.

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

.4 Install belt guards to allow movement of motors for adjusting belt tension.

.5 Guard for flexible coupling:

.1 "U" shaped, minimum 1.6 mm thick galvanized mild steel.
.2 Securely fasten in place.
.3 Removable for servicing.

.6 Unprotected fan inlets or outlets:
.1 Wire or expanded metal screen, galvanized, 19 mm mesh.
.2 Net free area of guard: not less than 80% of fan openings.
.3 Securely fasten in place.
.4 Removable for servicing.

PART 3 - EXECUTION

3.1 Installation

.1 Fasten securely in place.

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

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

1.2 References

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

- .1 ANSI/ASME B31.1-04, Power Piping, (SI Edition).

.2 American Society for Testing and Materials (ASTM)

- .1 ASTM A 125-R2001, Specification for Steel Springs, Helical, Heat-Treated.
- .2 ASTM A 307-04, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
- .3 ASTM A 563-04a, Specification for Carbon and Alloy Steel Nuts.

.3 Factory Mutual (FM)

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

- .1 MSS SP58-2002, Pipe Hangers and Supports - Materials, Design and Manufacture.
- .2 MSS SP69-2003, Pipe Hangers and Supports - Selection and Application.
- .3 MSS SP89-2003, Pipe Hangers and Supports - Fabrication and Installation Practices.

.5 Underwriter's Laboratories of Canada (ULC)

1.3 Design Requirements

.1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.

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

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

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

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

1.4 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Section 013300 - Submittal Procedures.

.2 Submit shop drawings and product data for following items:
- .1 Bases, hangers and supports.
- .2 Connections to equipment and structure.
- .3 Structural assemblies.

1.5 Closeout Submittals

.1 Provide maintenance data for incorporation into manual specified in Section 017800 - Closeout Submittals.

1.6 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Divert unused metal from landfill to metal recycling facility approved by Engineer.

.3 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.4 Dispose of corrugated cardboard, polystyrene and plastic packaging material in appropriate on-site bin for recycling in accordance with site waste management program.

PART 2 - PRODUCTS

2.1 General

.1 Fabricate hangers, supports and sway braces in

accordance with ANSI B31.1 and MSS SP58.

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

2.2 Pipe Hangers

.1 Upper attachment structural: Suspension from lower flange of I-Beam.
- .1 Cold piping NPS 2 maximum: Malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
  - .1 Rod: 9 mm UL listed.
- .2 Cold piping NPS 2 1/2 or greater, all hot piping: Malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed to MSS-SP58 and MSS-SP69.

.2 Upper attachment structural: Suspension from upper flange of I-Beam.
- .1 Cold piping NPS 2 maximum: Ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed to MSS SP69.
- .2 Cold piping NPS 2 1/2 or greater, all hot piping: Malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed.

.3 Upper attachment to concrete.
- .1 Ceiling: Carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.
- .2 Concrete inserts: wedge shaped body with knockout protector plate UL listed to MSS SP69.

.4 Shop and field-fabricated assemblies.
- .1 Trapeze hanger assemblies: ASME B31.1 and MSS SP58.
- .2 Steel brackets: ASME B31.1 and MSS SP58.

.5 Hanger rods: threaded rod material to MSS SP58.
- .1 Ensure that hanger rods are subject to tensile loading only.
- .2 Provide linkages where lateral or axial movement of pipework is anticipated.
- .3 Do not use 22 mm or 28mm rod.

.6 Pipe attachments: material to MSS SP58.
- .1 Attachments for steel piping: carbon steel.
- .2 Attachments for copper piping: copper plated black steel.
- .3 Use insulation shields for hot pipework.
- .4 Oversize pipe hangers and supports.

.7 Adjustable clevis: material to MSS SP69 UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
- .1 Ensure "U" has hole in bottom for rivetting to insulation shields.

.8 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP69.

.9 U-bolts: carbon steel to MSS SP69 with 2 nuts at each end to ASTM A 563.
- .1 Finishes for steel pipework: black.

.10 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP69.

2.3 Riser Clamps

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

.2 Bolts: to ASTM A 307.

.3 Nuts: to ASTM A 563.

2.4 Insulation Protection Shields

.1 Insulated cold piping:
- .1 64 kg/m³ density insulation plus insulation protection shield to: MSS SP69, galvanized sheet carbon steel. Length designed for maximum 3 m span.

.2 Insulated hot piping:
- .1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP69.

2.5 Equipment Anchor Bolts and Templates

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

2.6 House-keeping Pads

.1 For base-mounted equipment: Concrete, at least 100 mm high, 50 mm larger all around than equipment, and with chamfered edges.

PART 3 - EXECUTION

3.1 Installation

.1 Install in accordance with:
  .1 manufacturer's instructions and recommendations.

.2 Vibration Control Devices:
  .1 Install on piping systems at pumps, boilers, chillers, cooling towers, elsewhere as indicated.

.3 Clamps on riser piping:
  .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
  .2 Bolt-tightening torques to be to industry standards.
  .3 Steel pipes: Install below coupling or shear lugs welded to pipe.
  .4 Cast iron pipes: Install below joint.

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

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

3.2 Hanger Spacing

.1 Plumbing piping: most stringent requirements of Canadian Plumbing Code.

.2 Fire protection: to applicable fire code.

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

.4 Within 300 mm of each elbow.

Maximum Pipe Size: NPS	Maximum Spacing Steel	Maximum Spacing Copper
up to 1-1/4	2.1 m	1.8 m
1-1/2	2.7 m	2.4 m
2	3.0 m	2.7 m
2-1/2	3.6 m	3.0 m
3	3.6 m	3.0 m
3-1/2	3.9 m	3.3 m
4	4.2 m	3.6 m
5	4.8 m	
6	5.1 m	
8	5.7 m	
10	6.6 m	
12	6.9 m	

3.3 Hanger Installation

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

.2 Adjust hangers to equalize load.

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

3.4 Horizontal Movement

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

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

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 230593 - Testing, Adjusting and Balancing (TAB) of Mechanical Systems.

1.2 References

.1 National Fire Protection Association (NFPA)
.1 NFPA 13-2002, Installation of Sprinkler Systems.

.2 National Building Code of Canada (NBC) 2010

1.3 Shop Drawings

.1 Submit shop drawings in accordance with Section 013300 - Submittal Procedures.

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

1.4 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Departmental Representative.

.3 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.4 Dispose of corrugated cardboard, polystyrene and plastic packaging material in appropriate on-site bin for recycling in accordance with site waste management program.

PART 2 - PRODUCTS

2.1 General

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

2.2 Elastomeric Pads

.1 Type EP1 - neoprene waffle or ribbed; 9mm minimum thick; 50 durometer; maximum loading 350kPa.

.2 Type EP2 - rubber waffle or ribbed; 9 mm minimum thick; 30 durometer natural rubber; maximum loading 415 kPa.

.3 Type EP3 - neoprene-steel-neoprene; 9 mm minimum thick neoprene bonded to 1.71 mm steel plate; 50 durometer neoprene, waffle or ribbed; holes sleeved with isolation washers; maximum loading 350 kPa.

.4 Type EP4 - rubber-steel-rubber; 9 mm minimum thick rubber bonded to 1.71 mm steel plate; 30durometer natural rubber, waffle or ribbed; holes sleeved with isolation washers; maximum loading 415 kPa.

2.3 Elastomeric Mounts

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

2.4 Springs

.1 Design stable springs so that ratio of lateral to axial stiffness is equal to or greater than 1.2 times the ratio of static deflection to working height. Select for 50% travel beyond rated load. Units to be complete with levelling devices.

.2 Ratio of height when loaded to diameter of spring to be between 0.8 to 1.0.

.3 Colour code springs.

2.5 Spring Mount

.1 Zinc or cadmium plated hardware; housings coated with rust resistant paint.

.2 Type M2 - stable open spring: support on bonded 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad.

.3 Type M3 - stable open spring: 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad, bonded under isolator and on isolator top plate; levelling bolt for rigidly mounting to equipment.

.4 Type M4 - restrained stable open spring: supported on bonded 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad; built-in resilient limit stops, removable spacer plates.

.5 Type M5 - enclosed spring mounts with snubbers for isolation up to 950 kg maximum.

2.6 Hangers

.1 Colour coded springs, rust resistant, painted box type hangers. Arrange to permit hanger box or rod to move through a 30° arc without metal to metal contact.

.2 Type H1 - neoprene - in-shear, moulded with rod isolation bushing which passes through hanger box.

.3 Type H2 - stable spring, elastomeric washer, cup with moulded isolation bushing which passes through hanger box.

.4 Type H3 - stable spring, elastomeric element, cup with moulded isolation bushing which passes through hanger box.

.5 Type H4 - stable spring, elastomeric element with precompression washer and nut with deflection indicator.

2.7 Acoustic Barriers for Anchors and Guides

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

2.8 Structural Bases

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

.2 Type B2 - Steel rail base: structural steel, positioned for alignment of drive and driven equipment; without supplementary hold down devices; complete with isolation element attached to base brackets arranged to minimize height; and pre-drilled holes to receive equipment anchor bolts.

.3 Bases to clear housekeeping pads by 25 mm minimum.

2.9 Inertia Base

.1 Type B3 - Full depth perimeter structural or formed channels, frames: welded in place reinforcing rods running in both directions; spring mounted, carried by gussetted height-saving brackets welded to frame; and clear housekeeping pads by 50 mm minimum.

.2 Pump bases: "T" shaped, where applicable, to provide support for elbows.

PART 3 - EXECUTION

3.1 Installation

.1 Install vibration isolation equipment in accordance with manufacturers instructions and adjust mountings to level equipment.

.2 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping, conduit and ducting passage through walls and floors do not transmit vibrations.

.3 Unless indicated otherwise, support piping connected to isolated equipment with spring mounts or spring hangers with 25 mm minimum static deflection as follows:
.1 Up to NPS4: first 3 points of support. NPS5 to NPS8: first 4 points of support. NPS10 and Over: first 6 points of support.
.2 First point of support shall have a static deflection of twice deflection of isolated equipment, but not more than 50 mm.

.4 Where isolation is bolted to floor use vibration isolation rubber washers.

.5 Block and shim level bases so that ductwork and piping connections can be made to a rigid system at the operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.

3.2 Site Visit

.1 Manufacturer to visit site and provide written certification that installation is in accordance with manufacturer's instructions and submit report to Departmental Representative.

.2 Provide Departmental Representative with notice 24 h in advance of visit.

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

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 017800 - Closeout Submittals.

1.2 References

.1 Canadian Standards Association (CSA)
- .1 CSA G40.20/G40.21-[04], General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.

.2 National Building Code of Canada (NBC) - 2010

1.3 Definitions

.1 Priority Two (P2) Buildings: buildings in which life safety is paramount concern.
It is not necessary that P2 buildings remain operative during or after an earthquake.

.2 SRS: acronym for Seismic Restraint System.

1.4 System Description

.1 This section covers design, supply and installation of complete SRS for all systems, equipment specified for installation on this project. This includes laboratory exhaust systems, MCC's, VFD's, roof-mounted fans, all other equipment and system impacted by this project scope of work, and vibration isolated and statically supported.

.2 SRS to be fully integrated into, compatible with:
- .1 Noise and vibration controls specified elsewhere.
- .2 Structural, mechanical, electrical design of project.

.3 Systems, equipment not required to be operational during and after seismic event.

.4 During seismic event, SRS to prevent systems and equipment from causing personal injury and from moving from normal position.

.5 Design to be by Professional Engineer specializing in design of SRS and registered in Province of British Columbia.

1.5 Submittals

.1 Submit shop drawings and product data in accordance with Section 013300 - Submittal Procedures.

.2 Shop drawings: submit drawings stamped and signed by Professional Engineer registered or licensed in Province of British Columbia, Canada.

.3 Submittals to include:

.1 Full details of design criteria.
.2 Working drawings (prepared to same standard of quality and size as documents forming these tender documents), materials lists, schematics, full specifications for components of each SRS to be provided.
.3 Design calculations (including restraint loads resulting from seismic forces in accordance with National Building Code, detailed work sheets, tables).
.4 Separate shop drawings for each SRS and devices for each system, equipment.
.5 Identification of location of devices.
.6 Schedules of types of SRS equipment and devices.
.7 Details of fasteners and attachments to structure, anchorage loadings, attachment methods.
.8 Installation procedures and instructions.
.9 Design calculations including restraint loads to be to NBC and Supplement.
.10 Detailed work sheets, tables. Simplified, conservative assumptions may be acceptable.
.11 Detailed design of SRS including complete working drawings prepared to same standard of quality and size as Contract Documents, materials lists, design calculations, schematics, specifications.

.4 Submit additional copy of shop drawings and product data to Structural Engineer for review of connection points to building structure.

1.6 Closeout Submittals

.1 Provide maintenance data including monitoring requirements for incorporation into manuals specified in Section 017800 - Closeout Submittals.

1.7 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Departmental Representative.

.3 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.4 Dispose of corrugated cardboard, polystyrene, plastic packaging material in appropriate on-site bin for recycling in accordance with site waste management program.

PART 2 - PRODUCTS

2.1 SRS Manufacturer

.1 SRS to be from one manufacturer regularly engaged in production of same.

2.2 General

.1 SRS to provide gentle and steady cushioning action and avoid high impact loads.

.2 SRS to restrain seismic forces in every direction.

.3 Fasteners and attachment points to resist same load as seismic restraints.

.4 SRS of Piping systems to be compatible with:
- .1 Expansion, anchoring and guiding requirements.
- .2 Equipment vibration isolation and equipment SRS.

.5 SRS utilizing cast iron, threaded pipe or other brittle materials not permitted.

.6 Attachments to RC structure:
- .1 Use high strength mechanical expansion anchors.
- .2 Drilled or power driven anchors not permitted.

.7 Seismic control measures not to interfere with integrity of firestopping.

2.3 SRS for Static Equipment, Systems

.1 Floor-mounted equipment, systems:
- .1 Anchor equipment to equipment supports.
- .2 Anchor equipment supports to structure.
- .3 Use size of bolts scheduled in approved shop drawings.

.2 Suspended equipment, systems:
- .1 Use one or combination of following methods:
  - .1 Install tight to structure.
  - .2 Cross-brace in all directions.
  - .3 Brace back to structure.
  - .4 Slack cable restraint system.
- .2 SCS to prevent sway in horizontal plane, "rocking" in vertical plane, sliding and buckling in axial direction.
- .3 Hanger rods to withstand compressive loading and buckling.

2.4 SRS for Vibration Isolated Equipment

.1 Floor mounted equipment, systems:
- .1 Use one or combination of following methods:
  - .1 Vibration isolators with built-in snubbers.
  - .2 Vibration isolators and separate snubbers.
  - .3 Built-up snubber system approved by Departmental Representative, consisting of structural elements and elastomeric layer.
- .2 SRS to resist complete isolator unloading.
- .3 SRS not to jeopardize noise and vibration isolation systems. Provide 4-8 mm clearance between seismic restraint snubbers and equipment during normal operation of equipment and systems.
- .4 Cushioning action to be gentle and steady by utilizing elastomeric material or other means in order to avoid high impact loads.

.2 Suspended equipment, systems:
- .1 Use one or combination of following methods:
  - .1 Slack cable restraint system.
  - .2 Brace back to structure via vibration isolators and snubbers.

2.5 Slack Cable Restraint System (SCS)

.1 Use elastomer materials or similar to avoid high impact loads and provide gentle and steady cushioning action.

.2 SCS to prevent sway in horizontal plane, "rocking" in vertical plane, sliding and buckling in axial direction.

.3 Hanger rods to withstand compressive loading and buckling.

PART 3 - EXECUTION

3.1 Installation

.1 Attachment points and fasteners:
- .1 To withstand same maximum load that seismic restraint is to resist and in all directions.

.2 Slack Cable Systems (SCS):
- .1 Connect to suspended equipment so that axial projection of wire passes through centre of gravity of equipment.
- .2 Use appropriate grommets, shackles, other hardware to ensure alignment of restraints and to avoid bending of cables at connection

points.

.3 Piping systems: provide transverse SCS at 10 m spacing maximum, longitudinal SCS at 20 m maximum or as limited by anchor/slack cable performance.

.4 Small pipes may be rigidly secured to larger pipes for restraint purposes, but not reverse.

.5 Orient restraint wires on ceiling hung equipment at approximately 90° to each other (in plan), tie back to structure at maximum of 45° to structure.

.6 Adjust restraint cables so that they are not visibly slack but permit vibration isolation system to function normally.

.7 Tighten cable to reduce slack to 40 mm under thumb pressure. Cable not to support weight during normal operation.

.3 Install SRS at least 25 mm from equipment, systems, services.

.4 Miscellaneous equipment not vibration-isolated:
.1 Bolt through house-keeping pad to structure.

.5 Co-ordinate connections with all disciplines.

3.2 Inspection and Certification

.1 SRS to be inspected and certified by a Province of British Columbia licensed Seismic Engineer upon completion of installation.

.2 Provide written report to Departmental Representative with certificate of compliance.

3.3 Commissioning Documentation

.1 Upon completion and acceptance of certification, hand over to Departmental Representative complete set of construction documents, revised to show "as-built" conditions.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 099100 - Painting.

1.2 References

.1 Canadian Gas Association (CGA)
- .1 CSA/CGA B149.1-05, Natural Gas and Propane Installation Code.

.2 Canadian General Standards Board (CGSB)
- .1 CAN/CGSB-1.60-97, Interior Alkyd Gloss Enamel.
- .2 CAN/CGSB-24.3-92, Identification of Piping Systems.

.3 National Fire Protection Association
- .1 NFPA 13-2002, Installation of Sprinkler Systems.
- .2 NFPA 14-2003, Standpipe and Systems.

1.3 Product Data

.1 Submit product data in accordance with Section 013300 - Submittal Procedures.

.2 Product data to include paint colour chips, other products specified in this section.

.3 Wherever practical, match existing identification in the facility (methods, coding, colours, etc.).

1.4 Samples

.1 Submit samples in accordance with Section 013300 - Submittal Procedures.

.2 Samples to include nameplates, labels, tags, lists of proposed legends.

1.5 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Dispose of unused paint material at official hazardous material collections site approved by

Departmental Representative.

.3 Do not dispose of unused paint material into sewer system, into streams, lakes, onto ground or in other locations where it will pose health or environmental hazard.

PART 2 - PRODUCTS

2.1 Manufacturer's Equipment Nameplates

.1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.

.2 Lettering and numbers to be raised or recessed.

.3 Information to include, as appropriate:
- .1 Equipment: Manufacturer's name, model, size, serial number, capacity.
- .2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.2 Existing Identification Systems

.1 Apply existing identification system to new work.

.2 Where existing identification system does not cover for new work, use identification system specified in this section.

.3 Before starting work, obtain written approval of identification system from Departmental Representative.

.4 Identify outdoor equipment as well as indoor.

2.3 Piping Systems Governed by Codes

.1 Identification:
- .1 Natural gas: to CSA/CGA B149.1.
- .2 Sprinklers: to NFPA 13.

2.4 Identification of Piping Systems

.1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.

.2 Pictograms:
- .1 Where required, to Workplace Hazardous

Materials Information System (WHMIS) regulations.

.3 Legend:
.1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.

.4 Arrows showing direction of flow:
.1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.
.2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.
.3 Use double-headed arrows where flow is reversible.

.5 Extent of background colour marking:
.1 To full circumference of pipe or insulation.
.2 Length to accommodate pictogram, full length of legend and arrows.

.6 Materials for background colour marking, legend, arrows:
.1 Pipes and tubing 20 mm and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.
.2 All other pipes: Pressure sensitive plastic-coated cloth vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100%RH and continuous operating temperature of 150° C and intermittent temperature of 200° C.

.7 Colours and Legends:
.1 Where not listed, obtain direction from Departmental Representative.
.2 Colours for legends, arrows: To following table:

Background colour:	Legend, arrows:
Yellow	BLACK
Green	WHITE
Red	WHITE

.3 Control air tubing - To Section 230906
.4 Conduit for low voltage - To Section 230906

2.5 Identification Ductwork Systems

.1 50 mm high stenciled letters and directional arrows 150 mm long x 50 mm high.

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

.3 Ensure that all new ductwork is clearly labeled, such as fume hood exhaust, general exhaust/ return, other exhaust systems. All new ductwork located on roof is to be also labeled.

2.6 Valves, Controllers

.1 Brass tags with 12 mm stamped identification data filled with black paint.

.2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

2.7 Controls Components Identification

.1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section.

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

.3 Provide labels to the temperature override switches.

2.8 Language

.1 Identification to be in English.

.2 Use one nameplate, label, etc. for both languages.

PART 3 - EXECUTION

3.1 Timing

.1 Provide identification only after all painting specified Section 099150 - Interior Re-Painting has been completed.

3.2 Installation

.1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.

.2 Provide ULC or CSA registration plates as required by respective agency.

.3 Identify systems, equipment to conform to PWGSC PMSS.

.4 Identification symbols, legends and colors shall match with existing and approved by the Departmental Representative.

3.3 Nameplates

.1 Locations:
  .1 In conspicuous location to facilitate easy reading and identification from operating floor.

.2 Standoffs:
  .1 Provide for nameplates on hot and/or insulated surfaces.

.3 Protection
  .1 Do not paint, insulate or cover in any way.

3.4 Location of Identification on Piping and Ductwork Systems

.1 On long straight runs in open areas: At not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

.2 Adjacent to each change in direction.

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

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

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

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

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

.8 At point immediately upstream of major manually operated or automatically controlled valves,

dampers, etc. Where this is not possible, place identification as close as possible, preferably on upstream side.

.9 Identification to be easily and accurately readable from usual operating areas and from access points.

.1 Position of identification to be approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.5 Valves, Controllers

.1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.

.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Departmental Representative. Provide one copy (reduced in size if required) in each operating and maintenance manual.

.3 Number valves in each system consecutively.

PART 1 - GENERAL

1.1 General

.1 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.

.2 TAB all the laboratory general exhaust, general return, and fume hood exhaust systems.

.3 Conduct flow measurement on the existing and new fume hood exhaust valves and tabulate results to compare exhaust air valves flow set points and valve flow reading (valve flow readings are readings from valve controller).

.4 TAB the dual duct box serving room 4161 (NIC).

1.2 Qualifications of TAB Personnel

.1 Names of personnel it is proposed to perform TAB to be submitted to and approved by Departmental Representative within 90 days of award of contract. Personnel must have experience specifically with the air systems at the Summerland PARC facility.

.2 Testing and certification of fume hoods to be by a qualified contractor with NSF-49 (National Sanitation Foundation) accreditation.

.3 Provide documentation confirming qualifications, successful experience.

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

- .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1-[2002].
- .2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems-[1998].
- .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing-[2002].

.5 Recommendations and suggested practices contained

in the TAB Standard: mandatory.

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

.6 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.

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

.8 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 so as 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.

.4 Contractor is responsible for commissioning and verification of all fume hoods.

1.4 Exceptions

.1 TAB of systems and equipment regulated by codes, standards to be 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 so as to ensure completion before acceptance of project. Coordinate with controls contractor for TAB of new and existing lab exhaust fans at each phase of construction. Refer to Section 011100 - Summary of Work.

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

1.6 Pre-TAB Review

.1 Review contract documents before project construction is started and confirm in writing to Departmental Representative adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.

.2 Review specified standards and report to Departmental Representative in writing all proposed procedures which vary from standard.

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

1.7 Start-up

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

.2 Follow special start-up procedures specified elsewhere in Division 23.

1.8 Operation of Systems During TAB

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

1.9 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 weather stripping, sealing, caulking.

.5 All pressure, leakage, other tests specified elsewhere Division 23.

.6 All provisions for TAB installed and operational.

.7 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
- .1 Proper thermal overload protection in place for electrical equipment.
- .2 Air systems:
  - .1 Filters in place, clean.
  - .2 Duct systems clean.
  - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
  - .4 Correct fan rotation.
  - .5 Fire, smoke, volume control dampers installed and open.
  - .6 Coil fins combed, clean.
  - .7 Access doors, installed, closed.
  - .8 Outlets installed, volume control dampers open.

1.10 Application Tolerances

.1 Do TAB to following tolerances of design values:
- .1 Laboratory HVAC systems: plus 5 %, minus 0 %.
- .2 Other HVAC systems: plus 5 %, minus 5 %.

1.11 Accuracy Tolerances

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

1.12 Instruments

.1 Prior to TAB, submit to Departmental Representative list of instruments to be 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.

1.13 Submittals

.1 Submit, prior to commencement of TAB:

.2 Proposed methodology and procedures for performing TAB if different from referenced standard.

1.14 Preliminary TAB Report

.1 Submit for checking and approval of Departmental Representative, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
- .1 Details of instruments used.
- .2 Details of TAB procedures employed.
- .3 Calculations procedures.
- .4 Summaries.

1.15 TAB Report

.1 Format to be 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 6 copies of TAB Report to Departmental Representative for verification and approval, in English in D-ring binders, complete with index tabs.

1.16 Verification

.1 Reported results subject to verification by Departmental Representative.

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

.3 Number and location of verified results to be at discretion of Departmental Representative.

.4 Bear costs to repeat TAB as required to satisfaction of Departmental Representative.

1.17 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. Markings not to be eradicated or covered in any way.

1.18 Completion of TAB

.1 Note that the project is phased. Each phase needs to be tested, balanced, commissioned and made fully functional before proceeding with the next phase.

.2 At completion of the project, all existing laboratory exhaust branches, fume hoods and general exhaust shall be tested and balanced, and a separate final TAB report submitted.

.3 TAB to be considered complete when final TAB Report received and approved by Departmental Representative.

1.19 Air Systems

.1 Standard: TAB to be to most stringent of this section or TAB standards of AABC NEBB SMACNA ASHRAE NSF-49.

.2 Do TAB of systems, equipment, components, controls specified Division 23.

.3 Qualifications: personnel performing TAB to be current member in good standing of AABC or NEBB and NSF-49 for fumehood testing.

.4 Quality assurance: Perform TAB under direction of supervisor qualified by AABC or NEBB and NSF-49 for fumehood testing.

.5 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.

.6 Locations of equipment measurements: To include, but not be limited to, following as appropriate:

.1 Inlet and outlet of dampers, filter, coil, fan, other equipment causing changes in

conditions.

.2 At controllers, controlled device.

.3 At all airflow measuring stations to confirm values indicated by airflow stations

.7 Locations of systems measurements to include, but not be limited to, following as appropriate: Main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).

1.20 Fume hood (Room 4161 (NIC))

.1 Complete the table "Test Instrumentation Summary" on the fume hood test sheet. Stated accuracy of the anemometer must be better than +/-5%. Calibration within the last six months.

.2 Measure cross drafts in locations shown in Fig. 1 of attached test sheets and record in the appropriate table. Readings to be taken over a 30 second time period to determine average and maximum values on three axis for each location. Cross drafts must not exceed 50% of average face velocity. If so TAB to adjust room ventilation.

.3 Perform small volume smoke visualization test, as per ANSI/ASHRAE 110 - 1995 Standard: Starting with baffles at mid-point setting, adjust baffle lever as necessary to provide no visible escapes and minimal reverse or lazy flow.

.4 Perform large volume smoke visualization test as per ASHRAE 110 - 1995 Standard: Starting with baffles at position determined in test 3 above, adjust baffle lever as necessary to provide containment, good capture, and relatively quick clearance (1 minute or less). Repeat test 3 successfully. Fix baffle lever to ensure that it cannot be further adjusted by user.

.5 Face velocity (sash in normal operating position of 12") as per ASHRAE 110-1995 Standard plus: .a Hot wire anemometer with averaging function, 10 second time constant or the output of the anemometer shall be recorded for a minimum of 10 seconds at a rate of one reading per second using a data logger. .b use a ring stand, microphone stand, or other device to fix probe at the center

of each grid location. .c Grids to be approximately 12" x 12" for a 12" sash opening.

.6 When the average face velocity at a sash opening of 12" meets specifications of 0.5 m/s, move the sash to an opening of 6". Average face velocity not to exceed 1.0 m/s.

.7 Fumehood monitor reading to be calibrated to match average face velocity reading within +/-5%, when sash is at "normal operating position".

.8 Confirm fumehood monitor initiates an alarm following a five second delay when the face velocity goes beyond +/-20% of the face velocity set point.

.9 Attach any supporting data (instrumentation print outs etc.) to the Fumehood Test Summary.

.10 Fumehood testing to be completed following commissioning of all other related systems.

1.21 Other TAB Requirements .1 General requirements applicable to work specified this paragraph

- .1 Qualifications of TAB personnel: as for air systems specified this section.
- .2 Quality assurance: as for air systems specified this section.

.2 Laboratory fume hoods:

- .1 Standard: Treasury Board of Canada Handbook of Occupational Health and safety, 4th edition, Canada Labour Code, WorkSafe BC.
- .2 TAB procedures: as described in standard.

1.22 Post-Occupancy TAB .1 Participate in systems checks twice during Warranty Period - #1 approximately 3 months after acceptance and #2 within 1 month of termination of Warranty Period.

PART 2 - PRODUCTS .1 NOT USED

PART 3 - EXECUTION .1 Refer to attached fume hood test sheets including:

- .1 Hood Inspection

.2 Summary Performance Rating
.3 Test Conditions
.4 Test Instrumentation Summary
.5 Cross Draft Test Results
.6 Smoke Visualization Results
.7 Face Velocity Traverse Results (300 mm sash opening)
.8 Face Velocity Traverse Results By-pass Effectiveness (Sash at 150 mm)
.9 Fume hood Monitor, Alarm & Sensors

.2 Provide TAB to all new fume hoods with cross draft test, smoke visualization test (not tracer gas test) and face velocity test and submit reports as the attached test sheets to the Engineer.

.3 Test all new fume hoods to meet the MD1518 Minimum Guideline for Laboratory Fume Hood which is published by PWGSC.

TEST PROCEDURE:

1. Complete the table "Test instrumentation Summary" on the fume hood test sheet. Stated accuracy of the anemometer must be better than +/- 5%. Calibration within the last six months.

2. Measure cross drafts in locations shown in Fig. 1 and record in the appropriate table. Readings to be taken over a 30 second time period to determine average and maximum values on three axis for each location. Cross drafts must not exceed 50% of average face velocity.

3. Perform small volume smoke visualization test, as per ANSI/ASHRAE 110 — 1995 Standard: Starting with baffles at mid-point setting, adjust baffle lever as necessary to provide no visible escapes and minimal reverse or lazy flow.

4. Perform Large volume smoke visualization test as per ASHRAE 110 - 1995 Standard: starting with baffles at position determined in test 3 above, adjust baffle lever as necessary to provide containment, good capture, and relatively quick clearance (1 minute or less). Repeat test 3 successfully. Fix baffle lever to ensure that it cannot be further adjusted by user.

5. Face velocity (sash in normal operating position of 12") as per ASHRAE 110-1995 Standard plus:

   a. Hot wire anemometer with averaging function, 10 second time constant or the output of the anemometer shall be recorded for a minimum of 10 seconds at a rate of one reading per second using a data logger.
   b. For repeatable test results use a ring stand, microphone stand, or other device to fix probe at the center of each grid location.
   c. Grids to be approximately 12" x 12" for a 12" sash opening.

   Note: Individual face velocity readings at each grid point not to exceed +/- 20% of the average face velocity.

6. When the average face velocity at a sash opening of 12" meets specifications move the sash to an opening of 6". Average face velocity not to exceed 1.0 m/s.

7. Fume hood monitor reading to be calibrated to match average face velocity reading within +/- 5% of actual value.

.8 Confirm fume hood monitor initiates an alarm following a five second delay when the face velocity goes beyond +/- 20% of the face velocity set point.

9. Attach any supporting data (instrumentation print outs etc.) to the Fume Hood Test Summary.

Hood ID Room#

Test Agencies

Date:

Hood Inspection

		Comments:
Hood Integrity	Liner/Baffle Integrity	
ED Sash Operation	Monitor Operation	
EH Light Operation	Alarm Operation	

Summary Performance Rating

Rating:
- ☐ Pass
- ☐ Fail
- ☐ N/A
- ☐ Restricted Use
- ☐ Pass/Fail
- ☐ Marginal

Reason-Comments:

General Comments:

Recommendations:

Laboratory Hood Performance Test Results

Test Conditions

Sash Opening Dimensions	Width: mm. Height: mm Area: m^2
Baffle Opening:	
Apparatus in Hood:	Y e s N o
Monitor Reading:	
Additional Test Comments:	

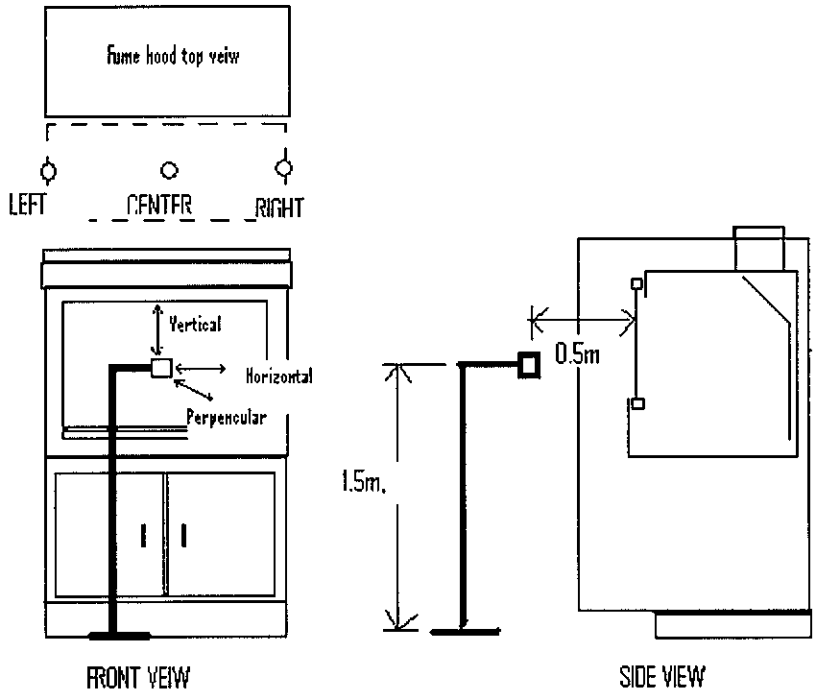
Test instrumentation summary:

Instruments Used	Manufacturer	Model Number	Specified Accuracy	Last Calibrated

Cross drafts Tests:

1) Set up anemometer as shown in Fig. 1
2) Take three readings for horizontal ,vertical & perpendicular axis at each location.(left, center & right)
3) Each reading to be taken over 30 second time period to determine average and maximum values.

Fig 1



Cross Draft Test Results:

Horizontal Draft	
Maximum m/s	
Average m/s	
Vertical Draft	
Maximum m/s	
Average m/s	
Perpendicular Draft	
Maximum m/s	
Average m/s	

Note: Cross Drafts not to exceed 50% of average face velocity

Smoke Visualization Results:

Test1 Low Volume Rating:	□ Fail □ **Low Pass** - Poor □ **Pass** - Fair □ High Pass - Good □ N/A	Perform low volume smoke visualization challenge as per: ASHRAE 110-1995 Visible smoke device used: Baffle at mid position, adjust baffle lever as necessary to provide no visible escapes and minimal reverse or lazy flow. FINAL BAFFLE POSITION: Comments:

Test 2 High Volume Rating:	2 Fail □ **Low Pass** - Poor □ **Pass** - Fair □ High Pass - Good N / A	Perform Large volume smoke visualization challenge as per: ASHRAE 110-1995 Visible smoke device used: Approximate Clearance Time: Start with baffle as left in test 1, adjust baffle lever as necessary to provide containment, good capture, and clearance within 1 minute. FINAL BAFFLE POSITION: Comments:

Test 3 Low Volume Rating:	3 Fail □ **Low Pass** - Poor □ **Pass** - Fair □ High Pass - Good N / A	Without moving the baffle, and as per ASHRAE 110-1995 , repeat low volume smoke visualization challenge successfully Comments:

Face Velocity Traverse Results (300mm Sash opening):

	Col 1	Col 2	Col 3	Col 4	Col 5
Row 1					

Ave. Velocity: ____ m/s Max. Velocity: ____ m/s Min. Velocity: ____ m/s

Note: Individual face velocity readings not to exceed +/- 20% of average face velocity

Exhaust Flow: l/s

Face Velocity Traverse Results, By-Pass Effectiveness (Sash at 150mm):

	Col	Col 2	Col 3	Col 4	Col 5
Row 1					

Ave. Velocity:, _m/s Max. Velocity:, m/s Min. Velocity: m/s

Note: Average face velocity not to exceed 1.0 m/s

Exhaust Flow: l/s

Fume Hood Monitor, Alarm & Sensors:

Calibration: all sensors reporting to BAS calibrated	Yes	No
Monitor display: to at least 2 decimal points	Yes	No
Monitor accuracy: display is within +/- 5% of actual value	Yes	No
Alarm Enunciation: occurs when beyond +/- 20% of design flow setpoint	Yes	No
Alarm Response: enunciation delay (maximum 5 seconds)	seconds	

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230529 - Bases, Hangers and Supports.

1.2 References

.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
- .1 ASHRAE Standard 90.1- 2004.

.2 American Society for Testing and Materials (ASTM).
- .1 ASTM B 209M- 10, Specification for Aluminum and Aluminum Alloy Sheet and Plate.
- .2 ASTM C 335- 10e1, Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
- .3 ASTM C 921- 10, Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

.3 Canadian General Standards Board (CGSB)
- .1 CAN/CGSB-51.2- 95, Thermal Insulation, Calcium Silicate, for Piping, Machinery and Boilers.
- .2 CAN/CGSB-51.9- 92, Mineral Fibre Thermal Insulation for Piping and Round Ducting.
- .3 CAN/CGSB-51.10- 92, Mineral Fibre Board Thermal Insulation.
- .4 CAN/CGSB-51.11- 92, Mineral Fibre Thermal Insulation Blanket.
- .5 CAN/CGSB-51.40- 95, Thermal Insulation, Flexible, Elastomeric, Unicellular, Sheet and Pipe Covering.
- .6 CGSB 51-GP-52Ma- 89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.

.4 Manufacturer's Trade Associations.
- .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (R2005).

.5 Underwriters Laboratories of Canada (ULC)
- .1 CAN/ULC-S102-03, 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" - will mean "not concealed" as defined herein.
- .3 "EXTERIOR" shall mean outside, and exposed to extreme temperature differential, or exposed to weather.

.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 Shop Drawings

.1 Submit shop drawings in accordance with Section 013300 - Submittal Procedures.

.2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.

1.5 Samples

.1 Submit samples in accordance with Section 013300 - Submittal Procedures.

.2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix typewritten label beneath sample indicating service.

1.6 Manufacturer's Instructions

.1 Submit manufacturer's installation instructions in accordance with Section 013300 - Submittal Procedures.

.2 Installation instructions to include procedures to be used, installation standards to be achieved.

1.7 Qualifications

.1 Installer to be specialist in performing work of this section, and have at least 3 years successful experience in this size and type of project, qualified to standards member of TIAC.

1.8 Delivery, Storage and Handling

.1 Deliver materials to site in original factory packaging, labeled with manufacturer's name, address.

.2 Protect from weather and construction traffic.

.3 Protect against damage from any source.

.4 Store at temperatures and conditions required by manufacturer.

1.9 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal and Waste Reduction Work plan Waste Management Plan.

.2 Place packaging materials in designated containers.

.3 Place excess or unused insulation and insulation accessory materials in designated containers. .

.4 Divert unused metal materials from landfill to metal recycling facility approved by Departmental Representative.

.5 Divert unused adhesive material from landfill to official hazardous material collections site approved by Departmental Representative.

.6 Do not dispose of unused adhesive materials into sewer systems, into lakes, streams, onto ground or in other locations where it will pose health or environmental hazard.

1.10 Environmental

.1 Insulation to have recycled content certified by the manufacturer. Glass fibre products should contain over 35% recycled content by weight. Mineral wood products should contain over 50% recycled content by weight and cellulose products should contain over 75% recycled content by weight.

.2 Adhesives, caulking and similar materials not to contain VOCs in excesses of 5% by weight when tested in accordance with one of the following:

.1 EPA Method 24-24A, 40 C.F.R., Part 60, Appendix A
.2 Method 18,48 Federal Register 48, No. 202,
.3 Method 1400 NIOSH Manual of Analytical Methods, Volume 1,
.4 Environmental Protection Agency Method 8240 GC/MS Method for Volatile Organics.

PART 2 - PRODUCTS

2.1 Fire and Smoke Rating

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

2.2 Insulation

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

.2 Thermal conductivity ("k" factor) not to exceed specified values at 24C mean temperature when tested in accordance with ASTM C 335.

.3 TIAC Code C-1: Rigid mineral fibre board to CAN/CGSB 51.10, with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).

.4 TIAC Code C-2: Mineral fibre blanket to CAN/CGSB-51.11 faced with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
.1 Mineral fibre: to CAN/CGSB-51.11.
.2 Jacket: to CGSB 51-GP-52Ma.
.3 Maximum "k" factor: to CAN/CGSB-51.11.

2.3 Jackets

.1 Canvas:
.1 220 gm/m ² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
.2 Aluminum:
.1 0.5 mm smooth aluminum sheet for ducting.

.3 Lagging adhesive: Compatible with insulation.

2.4 Internal Duct Liner Application

.1 Adhere insulation with insulation adhesive applied to the whole of the metal surface, with the coating side of insulation exposed to the airstream.

.2 Ducts 610 mm [24"] in width and less require no further adhesion.

.3 Ducts sides and plenum panels greater than 610 mm [24"] in width shall also have metal clips or nylon pins adhered to the metal surface at 300 mm [12"] to supplement the adhesive. (Welding pins may be used provided a capacitor type gun is used.) Impale insulation or the pins or clips, with the coated side of the insulation exposed to the airstream and secured with holding washers. Cover holding washers with reinforcing membrane and insulation coating / sealer.

.4 Seal all transverse joints, raw edges, and other points of penetration of the coating with reinforcing membrane and insulation coating/sealer.

.5 Seal all longitudinal joints with insulation coating sealer.

.6 No raw edges of internal insulation material shall be exposed to the moving airstream.

.7 NOTE: duct size shown is dimension inside the insulation. Metal duct sizes shall be increased to allow for the internal acoustic insulation thickness.

2.5 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 C 449.

.4 ULC Listed Canvas Jacket:
- .1 220 gm/m ^{2} cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.

.5 Outdoor Vapour Retarder Mastic:
- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: Fibrous glass,

untreated 305 g/m2.

.6 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.

.7 Contact adhesive: quick-setting

.8 Canvas adhesive: washable.

.9 Tie wire: 1.5 mm stainless steel.

.10 Banding: 19 mm wide, 0.5 mm thick stainless steel.

.11 Facing: 25 mm galvanized steel hexagonal wire mesh stitched on both faces of insulation.

.12 Fasteners: 4 mm diameter pins with 35 mm diameter clips, length to suit thickness of insulation.

PART 3 - EXECUTION

3.1 Pre-installation Requirements

.1 Pressure testing of ductwork systems to be complete, witnessed and certified.

.2 Surfaces to be clean, dry, free from foreign material.

3.2 Installation

.1 Install in accordance with TIAC National Standards.

.2 Apply materials in accordance with manufacturer's instructions and this specification.

.3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.

.4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
- .1 Hangers, supports to be outside vapour retarder jacket.

.5 Supports, Hangers in accordance with Section 230529 Bases, Hangers and Supports
- .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.

.6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.

.7 Insulate all new exterior exhaust ductwork on roof. Provide aluminum jacket to all new exterior insulated ducts on roof. For the fume hood exhaust branches, aluminum jacket shall match that of existing. Secure jacket with aluminum bands on 200 mm centers or screws on 150 mm centers. Lap joints 75 mm minimum and seal with compatible waterproof lap cement.

.8 Weatherproof all exterior jacket joints on roof to weather proof and water seal.

.9 Insulated manifold and ducts on roof shall be supported by use of saddles.

.10 Provide canvas jackets to all exposed insulated ducts inside building, except insulated ducts located in concealed ceiling or space.

.11 All insulated ducts located in concealed space and ceiling shall have aluminum foil cover.

3.3 Ductwork Insulation Schedule

.1 Insulation types and thicknesses: Conform to following table:

	TIAC Code	Vapour Retarder	Thickness (mm)
Return and exhaust ducts exposed in space being served		No	25
Outdoor, Exhaust	C-1	Special	50
Acoustically Lined ducts	None		25

.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: As specified in clause 3.2.

PART 1 - GENERAL

1.1 Intent

.1 This section specifies general requirements common to all Division 23 Component and Systems Testing.

.2 Read this section in conjunction with related sections, which specify portions of Division 23 Component and Systems Testing, and sections 018100, 230903, 230801, 230802 and 262250.

.3 Except where otherwise specified, arrange and pay for the testing and related requirements specified in this and related Sections.

.4 If test results do not conform to applicable requirements, repair, replace or adjust or balance components and systems. Repeat testing as necessary until results acceptable to the Departmental Representative are achieved.

1.2 Related Sections

.1 Section 011100, Summary of Work

.2 Section 018100, Commissioning

.3 Section 230903 - EMCS: Commissioning

.4 Section 230802, Division 23, Commissioning Components Testing

.5 Section 230802, Division 23, Commissioning Systems Testing

.6 Section 230593, Testing, Adjusting and Balancing (TAB) of Mechanical Systems

.7 Division 26 Electric Motors and Motor Control Centres

1.3 Verification Forms

.1 Project specific component forms are provided in Section 230802 for verification of components. Verifications for systems are provided in Section 230802.

.2 The Contractor shall provide the required shop drawing information and verify the correct

installations and operation of each item on these forms. This to include information such as equipment/component code, location and nameplate data.

.3 The systems verification cannot take place before all related components have been verified as correct and approved by the Departmental Representative.

.4 Typical verification forms will be provided for information to the Contractor and will not relieve the Contractor of responsibility for verification of components or systems not included on the verification forms.

.5 Component Forms:
- .1 Define completing the sheets as follows:
  - .1 Specification column to be completed by the Contractor.
  - .2 Shop drawing to be completed by the Contractor.
  - .3 Installed column to be completed by the Contractor.
  - .4 Witnessed - Approved to be completed by the Departmental Representative.

.6 System verification forms are to be completed by the Contractor, witnessed and approved by the Departmental Representative.

.7 A verification form is to be completed for <u>each</u> individual component or system in a category requiring verification.

.8 Where additional forms are required, but are not available from the Departmental Representative, develop appropriate verification forms and submit them to Departmental Representative for approval prior to use.

.9 Submit completed reports immediately after tests are performed.
- .1 Record all data gathered on site on approved verification forms.
- .2 Provide the Departmental Representative with original of each completed verification form.
- .3 Maintain one photocopy on site of all data taken during starting and testing period.
- .4 Maintain one copy of all final starting,

testing, balancing and adjusting reports on site up to the issue of the interim certificate for reference purposes.

.10 All final component forms are to be typewritten.

.11 Submit to Departmental Representative for approval.

.12 Make corrections and re-submit as requested by Departmental Representative.

.13 Manufacturer's Reports:
- .1 Arrange for manufacturer to submit copies of all production test records for production tests required by these specifications prior to shipping.
- .2 Arrange for manufacturer to submit brief step-by-step description of entire starting procedure to allow Departmental Representative to repeat starting at any time.

1.4 Starting and Testing - General

.1 Prior to testing ensure all mechanical components are cleaned and free of dust

.2 After testing, protect components subject to dust from construction activities.

.3 Notify Departmental Representative when starting and testing of all components has been completed.

.4 Do not conceal or cover components until inspected, tested and approved by Departmental Representative.

.5 Assume all liabilities associated with starting, testing.

.6 Assume all costs associated with starting, testing, and adjusting including the supply of testing equipment.

1.5 Witnessing of Starting and Testing

.1 Prior to starting and testing of mechanical equipment or systems, prepare a schedule for the required testing. Review schedule with Departmental Representative.

.2 Provide sufficient notice (minimum ten days) prior to commencing tests.

.3 Departmental Representatives may witness all or any portion of testing and starting procedures performed by the Contractor.

.4 Contractor to be present for all tests.

1.6 Quality Assurance

.1 All starting, testing, adjusting and balancing procedures shall be in accordance with:
- .1 These contract documents.
- .2 Requirements of authorities have jurisdiction.
- .3 Manufacturers' published instructions.
- .4 Applicable portions of ASME, ASHRAE, AABC, NEBB, CSA, NFPA, SMACNA, ASTM, ASPE.

.2 Personnel involved in starting, testing, adjusting and balancing procedures shall have experience in Division 23 Component and Systems Testing and shall be able to interpret results of readings and tests and report state of systems in a clear and concise manner.

.3 If the requirements of this or any related section conflict, notify Departmental Representative before proceeding with tests and obtain written clarification.

1.7 Manufacturer's Starting Recommendations

.1 Prior to starting components or systems, obtain and review manufacturer's installation, operation and starting instructions. Read in conjunction with procedures specified in Section 230801 and 230802.

.2 Use manufacturer's and supplier's starting personnel where required to maintain validity of manufacturer's warranty. Confirm with manufacturer that all testing specified in these specifications will not void any warranties.

.3 Compare installation to manufacturer's published data and record discrepancies. Modify procedures detrimental to components performance prior to starting equipment.

1.8 Manufacturer's Service on Site

.1 Arrange and pay for qualified manufacturer's representatives to supervise Division 23 Component and Systems Testing as required in the reference sections.

.2 Manufacturer's personnel shall be experience in

the design and operation of components and systems being started and have the ability to interpret results of readings and tests and report results in a logical fashion.

1.9 Presiding Authorities

.1 Starting procedures defined in this section may duplicate verification conducted by presiding authorities. To facilitate expedient turnover of building, arrange for the appropriate authorities to witness procedures in a manner that avoids unnecessary duplication of tests.

.2 Obtain certificates of approval, acceptance and comply with rules and regulation of authorities having jurisdiction. Provide copies of all certificates to the Departmental Representative.

1.10 Use of Instruments Supplied Under Contract

.1 Use balancing valve pressure tapping, orifice plates, annubars, etc. to measure fluid flow rates.

.2 Calibrated DDC temperature, humidity and pressure sensors may be used to gather system performance data provided the Departmental Representative confirms that the DDC sensor calibrations have been accepted.

.3 Instruments for testing, adjusting and balancing supplied under contract may be used provided the Departmental Representative is satisfied that instrument accuracy complies with this Specification and the calibration certificate has been provided with each instrument.

1.11 Correction of Deficiencies

.1 Correct all contract deficiencies found during Division 23 Component and Systems Testing and 30 day operational test.

1.12 Compliance With Defined Procedures

.1 Failure to follow the specific instructions defined herein pertaining to correct starting procedures may result in re-evaluation of components by independent testing agency selected by Owner at Contractor's expense. Should results reveal components haven't been started in accordance with specified requirements, components may be rejected. If rejected, remove components from site and replace. Replacement components shall also be subject to full starting procedures, using same procedures specified on the originally installed components.

1.13 Departmental Representative's Commissioning

.1 Commissioning of any component or system by the Departmental Representative does not reduce the Contractor's obligations for complete testing and start-up of systems as specified.

.2 The Contractor will provide support for these at his own expense.

.3 Any tests duplicated by the Departmental Representative will be conducted under the same terms of reference applied to the Contractor.

.4 The Contractor can choose to witness any testing conducted by the Agent.

.5 Should any component or system fail the Contractor will correct the deficiency and retest to the satisfaction of the Departmental Representative at the Contractor's expense.

1.14 Specialty Agencies and Testing Laboratories

.1 All reports generated by special testing agencies or testing laboratories shall be submitted directly to Departmental Representative.

.2 All agencies and testing laboratories shall have facilities and qualifications acceptable to Departmental Representative.

1.15 Co-Ordination

.1 Co-ordinate all sub-trades, other divisions, manufacturers, suppliers and other specialists as required to ensure all phases of work shall be properly organized prior to commencement of each particular testing procedure. Establish all necessary manpower requirements.

.2 Coordinate the activities of this Section with the starting and testing of:

- .1 DDC components and systems specified in Division 23.
- .2 Electrical components and systems specified in Division 26.
- .3 Other components and systems specified in other Divisions.

.3 Where any components or systems require testing prior to starting, ensure that such work has been completed and approved prior to starting of the components and systems.

1.16 Implementation

.1 Unless otherwise specified in writing by the Departmental Representative all testing and related requirements specified herein will be performed prior to the issue of the interim certificate of completion.

1.17 Scheduling

.1 Provide a Contractor start-up schedule as specified in 018100.

.2 Air systems will be tested according to the following sequence:
- .1 Division 23 Commissioning Components Testing (Section 230801).
- .2 Division 23 Commissioning Systems Testing (Section 230802).
- .3 Section 230593 Testing, Adjusting and Balancing (TAB) of Mechanical Systems.

1.18 Phased Construction

.1 Note that the construction is phased. Refer to the project phasing as shown on drawings and as described in Section 011100.

.2 At the completion of each phase, lab exhaust and general exhaust systems need to be fully tested, balanced, commissioned, and made functional prior to commencing the next phase. Coordinate with the controls contractor for the required commissioning at each phase.

PART 2 - PRODUCTS

2.1 Contractor Testing Instruments

.1 Provide two-way radios, ladders and other equipment as required to complete the program and as outlined in this specification.

.2 Provide all safety equipment required for personnel involved in the starting, testing, adjusting and balancing program.

.3 Provide a list of equipment and instruments which will be used in starting, testing, adjusting and balancing of mechanical equipment for approval and review by the Departmental Representative.

.4 Use instruments supplied or calibrated by approved laboratory or manufacturer. Show the Departmental Representative the current calibration certificate for each instrument to be used. Provide a copy of the calibration certificates with test reports.

PART 3 - EXECUTION

3.1 Procedures

.1 Procedures shall be identified in the following distinct phases:

.1 Phase 1 - Delivery and Installation: Confirm tagged components matches specification and shop drawing information. Visual inspection of quality of installation.

.2 Phase 2 - Starting: Actual starting procedure and equipment run-in phases and stages, refer to sections 01111 and 01810 for construction stages and phases.

.3 Phase 3 - Pre-Substantial Performance of the Work: Final cleaning, re-testing, balancing, adjusting and maintenance prior to issue of the interim certificate of completion.

.4 Phase 4 - Post-Substantial Performance of the Work: Repeat tests and fine-tuning after corrective action to clean-up deficiencies prior to issue of the final certificate of completion.

.5 Phase 5- Post Construction: Provide tests and seasonal fine-tuning as requested by the Departmental Representative during the warranty period. Issue test reports for the Departmental Representative's record.

.2 After each distinct phase of work is completed, correct deficiencies, make the systems functional, and facility fully functional. Obtain approvals before commencing the next phase.

.3 Document all required tests using verification forms provided or approved by the Departmental Representative.

.4 Contractor shall retain a Professional Engineer licensed in the Province of British Columbia to sign and seal the verification forms and documentation that shall be part of the commissioning report submission.

PART 1 - GENERAL

1.1 Intent

.1 Inspect, start and test each piece of mechanical equipment. Verify that the equipment has been properly installed and is operating at a level, which meets the specified requirements.

1.2 Related Requirements

.1 Section 230800 Division 23, Commissioning Testing Requirements.

1.3 Related Work in Other Sections

.1 Section 011100 - Summary of Work

.2 Section 018100 - Commissioning

.4 Section 230903 - EMCS: Commissioning

.5 Section 230800 - Commissioning Testing Requirements

.6 Section 230802 - Commissioning System Testing

.7 Section 230593 - Testing, Adjusting & Balancing (TAB) of Mechanical Systems

.8 Section 262250 - Motor Control Center

1.4 Documentation

.1 Provide manufacturer's information as directed by individual sections throughout Division 23.

.2 Complete project specific verification forms for components defined in this Section and section 230802. Refer to procedures identified in Section 230800, Commissioning Testing Requirements.

.3 Complete project specific verification forms for components defined in this section. Refer to procedures identified in Section 230800, Commissioning Testing Requirements. The Component Verification (and Testing) Forms are required in the following two categories:

.1 Individual Component Verification Forms. These are required for each piece of equipment (new and existing), e.g. for lab exhaust fans and associated dampers. A separate individual Component Verification Form must be filled out for each lab exhaust fan even though the fans are

identical in size and specification. Individual Component Forms are required for the following items/components:

.1 Physical Point Confirmation Spreadsheet
.2 Fume Hood exhaust valve FHEV-4161 NIC
.3 Fans
.4 Variable Frequency Drives
.5 Motorized Dampers
.6 Airflow Measuring Stations (Existing serving LEF-01 through 03)
.7 Fume Hood 3446 (Fume Hood 4161 NIC)

.2 Attached to this section is a single set of referenced forms. These forms must be duplicated and read in conjunction with pertinent specifications to determine the extent of testing and contractual obligation.

1.5 Phased Construction

.1 Note that the construction is phased. Refer to the project phasing requirements outlined in Section 011100 and as noted on drawings.

.2 At the completion of each phase, lab exhaust, general exhaust, and general return systems need to be fully tested, balanced, commissioned, and made functional prior to commencing the next phase. Refer to phasing requirements in Section 011100.

PART 2 - PRODUCTS

.1 NOT USED

PART 3 - EXECUTION

3.1 Delivery and Installation

.1 Complete all shop drawing information and conduct a static inspection of the installation for all mechanical components.

.2 Record this information on the verification forms and submit copies to the Departmental Representative for approval prior to starting or testing of components.

3.2 Air Systems

.1 Lab Exhaust Fans (existing and new).

.1 Check the installation including:

.1 Ensure that the fans operate in a controlled manner in both normal and normal power failure mode.
.2 Verify proper controlled operation of associated fan isolation dampers and speed drives.
.3 Verify that the general return duct pressure sensors have been relocated as noted on drawing M103.
.4 Verify that the exhaust main pressure switches have been reassigned and installed as noted on drawing m103.
.5 Verify proper controlled operation of relocated fan EF-75.

.2 Verification of performance will be proven per Section 230800.

.3 Refer to Section 230593.

.2 Existing Exhaust Air Valves

.1 Controls:

.1 General exhaust and general return air valves will now be associated with the new lab exhaust fans, LEF-4 through 6. Verify that the air valves have been associated with the new lab exhaust fans on the BMS.
.2 Verify that FHEV 3446 controls properly after alteration of downstream ductwork.

.3 Air Flow Measuring Stations (Existing serving fans LEF-01 through 03)
.1 Check the installation including:
.1 Verification of performance will be proven per Section 230802.
.3 Refer to Section 230593.

3.3 Speciality Systems .1 DDC General Requirements: Refer to section 230903 for specified requirements.

.1 Hardware

.1 Ensure that each hardware component has been properly installed as per manufacturer's recommendations and is

functioning correctly.

.2 Hardware testing shall be completed before any logic and control software is added to the system.

.3 Pressure test all new pneumatic air tubing.

.4 Gauge all wiring used to ensure conformance to CSA and specifications. Ensure all circuits are complete and all terminal wiring connections are tight.

.5 Adjust control dampers. Ensure tight shut-off closure and measure leakage. Check failsafe operation.

.6 Put all electric hardware into operation in accordance with manufacturer's recommendations. Replace all defective components. Prove proper operation, use software diagnostic.

.7 Test to ensure all interfaces with Division 23 and Division 26 are complete. Test to ensure all interfaces with other control packages are complete.

.8 Ensure the proper operation of colour graphics including but not limited to:

- .1 Dynamic valve/damper actuators displayed on screen.
- .2 Screen refresh period.
- .3 Colour change on status change.
- .4 Proper identification of systems on points on screen.
- .5 Reaction to alarms.
- .6 Trend log and trend graph reporting.

.9 Check all interface cabinets to ensure compliance with the specifications and all applicable codes.

.2 Point Check Out

.1 Label field devices associated with each hardware point connected to system. Provide in required information from specification and approved shop drawings. The point tag will contain the information as specified in the point schedules.

.2 Confirm the point mnemonic, hardware address, correct physical location and completed installation of each hardware point on the system.

.3 Calibrate the following components per manufacturer's recommendations.

- Current sensitive relays
- Damper operators and positioners
- Gauges, thermometers, etc.
- Electrical system interfaces

.1 Calibration corrections may be written in software provided the correction is not greater than 5 times the specified accuracy for the device.

.2 Document each calibration on the component "Physical Point Confirmation" form.

.3 Check accuracy of each analog input sensor over operating range. Document on "Sensor/Transmitter Calibration" sheets.

.4 Check range and repeatability of each analog output point. Document on "Physical Point Confirmation - Analog Output Device Range" sheets.

.4 Calibrate all control damper actuators and positioners. Hysteresis shall not be greater than 5% of range. This calibration will be tested according to the following:

.1 Ensure no overlap of control ranges.

.2 No leakage when device is closed.

.3 Failsafe operation.

.4 Test Procedures:

.1 Confirm proper operation of analog output devices such as control damper actuators, over their specified range of output.

.2 The device's true range is tested by commanding the DDC output value to zero and checking the actual position of the device.

.3 If the device is fully closed (fully open in the case of reverse-action), then slowly increase the DDC output until the device starts its first change in position - this is the output at which the device starts to operate.

.4 Continue increasing the DDC output until the device no longer changes its position - this is the output at which the device is at its end-of-range.

.5 Check to ensure that these actual device positions correspond to the maximum and minimum of the physical range of motion - if not, then the device is out of calibration and this must be noted as a contract deficiency.

.6 Record the start and end-of-range DDC output values and whether the device fully opens and fully closes.

.7 Record up to three other pairs of different test values in the range between the fully open and fully closed device positions. For each sample, command the DDC output value ("SYSTEM") and record the observed actual output value ("FIELD").

.8 List any remarks regarding the output device's performance and

make note of any other system-related factors that influence the device's successful operation.

.9 If device performs correctly complete the Physical Point Confirmation form.

.3 DDC Application Software

.1 Ensure all hardware is installed, tested and fully operational before any applicable software is enabled.

.2 Enter physical point database and operating set-points and schedules into RPUs.

.3 Enter trend logs for each physical analog input and output point in the DDC database. Trend logs shall retain a minimum of 3 readings per hour for 24 hours. The trend logs shall be continuous and shall overwrite information that is 24 hours old. Provide an additional trend log of 60, one minute interval, readings for each P.I.D. loop controlling and controlled variables.

.4 Capture Trend log data during system performance verification test (reference Division 23 section 230802) to demonstrate system performance and provide supporting documentation.
Attach Trend data to system performance tests.

.5 Complete all documentation and submit to Departmental Representative for approval.

3.4 Component Forms

.1 Mechanical component verification forms have been included and are as follows:

.1 Motorized Dampers
.2 Airflow Measuring Stations

Equipment Tag:

MECHANICAL COMMISSIONING: COMPONENT FORM

PROJECT: **Summerland Lab Exhaust Systems Alteration**
JOB NO: R.018297.001

MOTORIZED DAMPER SHEET

	Specification	Shop Drawing	Installed
Serial Number:			
Manufacturer:			
Model number:			
Special Construction:			
Location:			
Dimensions:			
Voltage:			
Phase:			
Amps:			

REMARKS/COMMENTS : . .....

.....

.....

CHECKED BY CONTRACTOR:..... ....OF .. ..DATE:

WITNESSED BY DEPARTMENTAL REPRESENTATIVE.. .... DATE:

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland Lab Exhaust Systems Alteration**
JOB NO: R.018297.001

1 TESTING OVERVIEW AND GENERAL REQUIREMENTS (Air flow measuring stations)

1.1 Purpose

1.1.1 The purpose of the airflow measuring testing is to determine the total system operation and response to normal and emergency conditions, which may arise.
1.1.2 "C" denotes contractor sign off.
1.1.3 "D" denotes Departmental Representative's verification.

1.2 Pre-requisites

1.2.1 The DDC system may be used to record the data. Where DDC system points are not available manually recorded parameters are to be provided.

1.2.2 The balancing of all related components and installed systems will be complete and test results shall be available.

1.3 All applicable contractors and manufacturers are required to be represented during systems testing.

1.4 Procedure

1.4.1 Conduct testing as described.

1.4.2 The effects on the systems relating to the various operational and failure conditions will be monitored, recorded and response times noted. The variables will be measured on a real time basis and utilization of collected data fine-tuning adjustments to the systems will be implemented.

Tests will consist of System and Field checks

1. GENERAL CONDITIONS

Prior to airflow measuring station start-up, ensure that:	C	D
1) Controls system is functional	[ ]	[ ]
2) Electrical system is functional	[ ]	[ ]
3) Component check sheets have been completed and approved	[ ]	[ ]
4) Probes are accessible	[ ]	[ ]
6) Probes are installed correctly with respect to airflow direction	[ ]	[ ]
7) Minimum 1.5 duct diameters upstream of probes	[ ]	[ ]
8) Access doors are installed	[ ]	[ ]
9) Pressure transducer is accessible	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland Lab Exhaust Systems Alteration**
JOB NO: R.018297.001

	Contractor	Engineer
10) Pressure transducer is connected and functional	[ ]	[ ]

	Contractor	Engineer
2. GENERAL TEST CONDITIONS		
1) Airflow indicated on the EMCS	[ ]	[ ]
2) Airflow indicated matches summation of terminal boxes being served	[ ]	[ ]
3) Airflow indicated changes as VFD speed changes	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland Lab Exhaust Systems Alteration**
JOB NO: R.018297.001

Testing Personnel:

Firm: _____

Signature & Date: _____

Witnessed by:

Firm: _____

Signature & Date: _____

Approved By:

Firm: _____

Signature & Date: _____

COMMENTS:

_____

_____

_____

_____

_____

PART 1 - GENERAL

1.1 Intent

.1 Check, start and test each mechanical system, verify that each system is operational and will operate to meet the specified operating criteria.

1.2 Related Requirements

.1 Section 230800, Commissioning Testing Requirements as well as sections 018100, 230801, 230903, 230593, and 262250

1.3 Related Work in Other Sections

.1 Section 010100 - Summary of Work

.2 Section 018100 - Commissioning

.3 Section 230800 - Commissioning Testing Requirements

.4 Section 230801, Division 23, Commissioning Component Testing

.5 Section 230903 - EMCS: Commissioning

.6 Section 230593 - Testing, Adjusting and Balancing (TAB) of Mechanical Systems

.7 Section 262250- Motor Control Center

1.4 Factory Trained Representatives

.1 Use factory trained representatives when required for starting of specialty systems.

.2 Use manufacturers representatives where required to ensure warranty is valid.

1.5 Documentation

.1 Provide manufacturer's information as directed by individual sections throughout Division 23.

.2 Complete project specific verification forms for systems defined in this Section. Refer to procedures identified in Section 230800, Division 23, Commissioning Testing Requirements.

.3 Project specific forms are provided at the end of this section for system verification. Actual forms are required for each individual component tested in a given category and will display project specific information.

1.17 Phased Construction

.1 Note that the construction is phased. Refer to the project phasing requirements in Section 011100.

.2 At the completion of each phase, lab exhaust, general exhaust, and fume hood exhaust systems need to be fully tested, balanced, commissioned, and made functional prior to commencing the next phase.

PART 2 - PRODUCTS

.1 NOT USED

PART 3 - EXECUTION

3.1 General

.1 Prior to conducting system tests identified in this section:

.1 All components in each system is complete prior to performing system cleaning, starting, and testing.

.2 Verify related component start-up tests outlined in section 230801, Commissioning Components Testing have been completed and approved by the Departmental Representative.

.3 Record test information on system verification forms. Submit copies to the Departmental Representative for approval following testing.

.2 DDC General

.1 Each DDC system shall be tested to verify the installed components are operating properly as a system and meets the specified requirements.

.2 Testing to include check out each system through the terminal by:

.1 Simulation of system start/stop functions.
.2 Simulation of systems operation including:
.1 high limit functions
.2 low limit functions
.3 safety features (override values)

.4 operation sequences specified
.5 Testing of system component hard wired interlocks.

.3 Testing of operations for specific routines such as (but not limited to) :

.1 Optimization
.2 Setback
.3 Power fail recovery

.4 Simulation of alarm conditions and verify alarm printouts.

.5 Check out reports generation.

.6 Check out communication network, input and output.

.7 Check operation of system under failure modes.

.8 Complete DDC checkout documentation and submit to Departmental Representative for approval.

.3 Systems Testing

.1 Conduct in direct cooperation with Division 23, full operating tests of all balanced systems.

.2 Reference this Section for samples of systems tests. Project specific system tests shall be provided prior to testing.

.3 An individual systems tests will be provided for each of the following:

.1 Lab Exhaust Fan Systems (LEF-1/2/3/4/5 & 6).
.2 Fume hood Exhaust Valves and flow verification.

.4 Demonstration of System Integrity

.1 Provide custom control software as specified and required to operate the DDC Control Systems as outlined in Division 23.

.2 Demonstration of user control software operation will include start-up and shutdown sequences, software interlocks, etc., initiation of failsafe, emergency shutdown and alarm condition control strategies.

.5 Integrated system commissioning and demonstration tests

.1 Provide integrated system commissioning and demonstration tests to show the response of integrated security, electrical, mechanical systems under the occupied modes, unoccupied modes, fire alarm mode, loss of power mode and loss of power with fire alarm mode.

.2 Testing of the emergency generator shall be included in the integrated test.

.3 The integrated tests shall provide for the return to normal operation, and include all required alarms to be sent out to the emergency services personnel and/or maintenance group as directed by Departmental Representative.

3.2 Fluid System Tests

.1 Hydronic Systems

.1 No tests are expected.

3.3 Air Handling Systems

.1 No tests are expected.

3.4 System Verification Forms

.1 Attached are verification forms for the following systems:

.1 Lab exhaust fans (LEF-1/2/3/4/5 & 6).
.2 High Plume Dilution Fan Dampers.
.3 Variable Frequency Drives.
.4 Fume Hood Exhaust Valve Control.
.5 General Exhaust Valve Control.
.6 Fume Hoods.

.2 Complete specific system verification forms for all systems in the building. Submit all forms to the Departmental Representative for approval prior to commencement of testing.

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

1 TESTING OVERVIEW AND GENERAL REQUIREMENTS (Lab. Exhaust Fan/ damper)

1.1 Purpose

1.1.1 The purpose of the high plume dilution fan damper system testing is to determine the total system operation and response to normal and emergency conditions, which may arise.

1.1.2 "C" denotes contractor sign off.
"D" denotes Departmental Representative's verification.

1.2 Pre-requisites

1.2.1 The DDC system may be used to record the data. Where DDC system points are not available manually recorded parameters are to be provided.

1.2.2 The balancing of all related components and installed systems will be complete and test results shall be available.

1.3 All applicable contractors and manufacturers are required to be represented during systems testing.

1.4 Procedure

1.4.1 Conduct testing as described.

1.4.2 The effects on the systems relating to the various operational and failure conditions will be monitored, recorded and response times noted. The variables will be measured on a real time basis and utilization of collected data fine-tuning adjustments to the systems will be implemented.

Tests will consist of System and Field checks

1. GENERAL CONDITIONS

Prior to Strobic fan damper system start-up mode being energized, ensure that:	C	D
1) Controls system is functional	[ ]	[ ]
2) No cracks around damper frame	[ ]	[ ]
3) Blades close fully and seal tight	[ ]	[ ]
4) Damper is accessible and identified	[ ]	[ ]
5) Motorized damper strokes full open to full closed	[ ]	[ ]
6) All component test sheets have been completed and approved	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

2. GENERAL TEST CONDITIONS

1) All motor starter controls in auto position	[ ]	[ ]
2) All DDC system operator overrides "OFF"	[ ]	[ ]
3) DDC system point checks completed and approve	[ ]	[ ]
By-pass Dampers are normally closed.	[ ]	[ ]
One exhaust fan fails and an isolation damper closes.	[ ]	[ ]
BMS exhaust fan failure alarm is activated.	[ ]	[ ]
Exhaust fan restarts and isolation damper opens.	[ ]	[ ]

3. EMERGENCY MODE TEST CONDITIONS

1) All motor starter controls in auto position	[ ]	[ ]
2) All DDC system operator overrides "OFF"	[ ]	[ ]
3) DDC system point checks completed and approve	[ ]	[ ]
By-pass Dampers are normally closed.	[ ]	[ ]
exhaust fan shutdowns and the associated isolation damper closes.	[ ]	[ ]
BMS exhaust fan failure alarm is activated.	[ ]	[ ]
Exhaust fan restarts and isolation damper opens.	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

Testing Personnel:

Firm: _____

Signature & Date: _____

Witnessed by:

Firm: _____

Signature & Date: _____

Approved By:

Firm: _____

Signature & Date: _____

COMMENTS:

_____

_____

_____

_____

_____

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Upgrade**
JOB NO: *R.018297.001*

1 TESTING OVERVIEW AND GENERAL REQUIREMENTS (VFD)

1.1 Purpose

1.1.1 The purpose of the variable frequency drive testing is to determine the total system operation and response to normal and emergency conditions, which may arise.

1.2 "C" denotes contractor sign off.
"D" denotes Departmental Representative's verification.

1.2 Pre-requisites

1.2.1 The DDC system may be used to record the data. Where DDC system points are not available manually recorded parameters are to be provided.

1.2.2 The balancing of all related components and installed systems will be complete and test results shall be available.

1.3 All applicable contractors and manufacturers are required to be represented during systems testing.

1.4 Procedure

1.4.1 Conduct testing as described.

1.4.2 The effects on the systems relating to the various operational and failure conditions will be monitored, recorded and response times noted. The variables will be measured on a real time basis and utilization of collected data fine-tuning adjustments to the systems will be implemented.

Tests will consist of System and Field checks

1. GENERAL CONDITIONS

Prior to variable speed drive start-up mode being energized, ensure that:	C	D
1) Controls system is functional	[ ]	[ ]
2) Electrical system is functional	[ ]	[ ]
3) Component check sheets have been completed and approved	[ ]	[ ]
4) Drive current is greater than total FLA of motor	[ ]	[ ]
5) Disconnect is interlocked to drive	[ ]	[ ]
6) Unit is mounted vertical	[ ]	[ ]
7) Separate conduits for input power, output power and control wiring	[ ]	[ ]
8) Drives are grounded individually	[ ]	[ ]
9) Differential pressure sensors are installed as per drawings	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Upgrade**
JOB NO: *R.018297.001*

	C	D
2. GENERAL TEST CONDITIONS		
1) Bypass switch starts and operates equipment	[ ]	[ ]
2) Drive restarts after power failure	[ ]	[ ]
3) Drive speed ramps slowly on load variation	[ ]	[ ]
4) RPM readout in EMCS matches VFD readout	[ ]	[ ]
3) Drive speed ramps slowly on load variation	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Upgrade**
JOB NO: *R.018297.001*

Testing Personnel:

Firm: _____

Signature & Date: _____

Witnessed by:

Firm: _____

Signature & Date: _____

Approved By:

Firm: _____

Signature & Date: _____

COMMENTS:

_____

_____

_____

_____

_____

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

1 TESTING OVERVIEW AND GENERAL REQUIREMENTS

1.1 Purpose

1.1.1 The purpose of the digital fume hood exhaust valve (FHEV) control system testing is to determine the total system operation and response to normal and emergency conditions that may arise.

1.2 "C" denotes contractor sign off.
"D" denotes Departmental Representative's verification.

1.3 Pre-requisites

1.3.1 The DDC System may be used to record the data. Where DDC System points are not available manually recorded parameters are to be provided.

1.3.2 The balancing of all related components and installed systems will be complete and test results shall be available.

1.4 All applicable contractors and manufacturers are required to be represented during systems testing.

1.5 Procedure

1.5.1 Conduct testing as described.

1.5.2 The effects on the systems relating to the various operational and failure conditions will be monitored, recorded and response times noted. The variables will be measured on a real time basis and utilization of collected data fine-tuning adjustments to the systems will be implemented.

Tests will consist of system and field checks.

1. GENERAL CONDITIONS

Prior to digital FHEV control system start-up mode being energized, ensure that:		C	D
1)	Electrical system is functional	[ ]	[ ]
2)	Fume hood is installed and functional	[ ]	[ ]
3)	Air balancing has been performed	[ ]	[ ]
4)	Air system is functional	[ ]	[ ]
5)	Air handling unit is functional	[ ]	[ ]
6)	Component check sheets have been completed and approved	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

2.	**GENERAL TEST CONDITIONS**	C	D
1)	All motor start controls in auto position	[ ]	[ ]
2)	All DDC System operator overrides "OFF"	[ ]	[ ]
3)	DDC System point checks completed and approved	[ ]	[ ]
	Digital controller provided for each FHEV	[ ]	[ ]
	Each controller maintains set flow	[ ]	[ ]
	Controller provides auxiliary control of interlocking DD box and GE box	[ ]	[ ]
	Controller has stand-alone capability	[ ]	[ ]
	Controller communicates with the BAS	[ ]	[ ]
	Room sensor has plug-in connection	[ ]	[ ]
	All parameters loaded/monitored at the digital FHEV controller and at BAS	[ ]	[ ]
	Following variables loaded/monitored at the central station for the digital FHEV		
	• Air volume	[ ]	[ ]
	• Minimum volume setting	[ ]	[ ]
	• Maximum volume setting	[ ]	[ ]
	• Occupied/Unoccupied mode	[ ]	[ ]
	• Damper operator position	[ ]	[ ]
	Room sensor input and velocity pressure transmitter provide basic inputs	[ ]	[ ]
	Electric motor operates the air valve as an output	[ ]	[ ]
	Occupied/Unoccupied mode selection through BAS	[ ]	[ ]
	Manual override switch provided at the sensor	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

Testing Personnel:

Firm: _____

Signature & Date: _____

Witnessed by:

Firm: _____

Signature & Date: _____

Approved by:

Firm: _____

Signature & Date: _____

COMMENTS: _____

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

1 TESTING OVERVIEW AND GENERAL REQUIREMENTS (GE VAV Boxes)

1.1 Purpose

1.1.1 The purpose of the digital GE VAV box control system testing is to determine the total system operation and response to normal and emergency conditions that may arise.

1.2 "C" denotes contractor sign off.
"D" denotes Departmental Representative's verification.

1.3 Pre-requisites

1.3.1 The DDC System may be used to record the data. Where DDC System points are not available manually recorded parameters are to be provided.

1.3.2 The balancing of all related components and installed systems will be complete and test results shall be available.

1.4 All applicable contractors and manufacturers are required to be represented during systems testing.

1.5 Procedure

1.5.1 Conduct testing as described.

1.5.2 The effects on the systems relating to the various operational and failure conditions will be monitored, recorded and response times noted. The variables will be measured on a real time basis and utilization of collected data fine-tuning adjustments to the systems will be implemented.

Tests will consist of system and field checks.

1. GENERAL CONDITIONS

Prior to digital GE VAV box control system start-up mode being energized, ensure that:		C	D
1)	Electrical system is functional	[ ]	[ ]
2)	Water balancing has been performed	[ ]	[ ]
3)	Air balancing has been performed	[ ]	[ ]
4)	Air system is functional	[ ]	[ ]
5)	Air handling unit is functional	[ ]	[ ]
6)	Component check sheets have been completed and approved	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

2.	**GENERAL TEST CONDITIONS**	C	D
1)	All motor start controls in auto position	[ ]	[ ]
2)	All DDC System operator overrides "OFF"	[ ]	[ ]
3)	DDC System point checks completed and approved	[ ]	[ ]
	Digital controller provided for each GE VAV box	[ ]	[ ]
	Each controller maintains set flow	[ ]	[ ]
	Controller provides auxiliary control of hot deck and cold deck	[ ]	[ ]
	Controller has stand-alone capability	[ ]	[ ]
	Controller communicates with the BAS	[ ]	[ ]
	Room sensor has plug-in connection	[ ]	[ ]
	All parameters loaded/monitored at the digital GE VAV controller and at BAS [ ]	[ ]	
	Following variables loaded/monitored at the central station for the digital GE VAV box		
	• Room temperature	[ ]	[ ]
	• Air volume	[ ]	[ ]
	• Minimum volume setting	[ ]	[ ]
	• Maximum volume setting	[ ]	[ ]
	• Room temperature set point	[ ]	[ ]
	• Occupied/Unoccupied mode	[ ]	[ ]
	• Hot deck and cold deck damper position	[ ]	[ ]
	• Supply Air Damper operator position	[ ]	[ ]
	Room sensor input and velocity pressure transmitter provide basic inputs	[ ]	[ ]
	Electric motor operates the air valve as an output	[ ]	[ ]
	Occupied/Unoccupied mode selection through BAS	[ ]	[ ]
	Unoccupied mode set point reset to _____ Heating, _____ Cooling	[ ]	[ ]
	Manual override switch provided at the sensor	[ ]	[ ]
	Enable switch in all non-public areas	[ ]	[ ]
	Disable switch in all public areas	[ ]	[ ]

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT: **Summerland, Lab Exhaust System Alteration**
JOB NO: *R.018297.001*

Testing Personnel:

Firm: _____

Signature & Date: _____

Witnessed by:

Firm: _____

Signature & Date: _____

Approved by:

Firm: _____

Signature & Date: _____

COMMENTS: _____

Lab DD Box/Valve Flow Settings (l/s)

Room No.	Box/ Valve Type	Box/ Valve Tag	Occupied Mode			Occupied Override			Unoccupied Override / Fumehood Override			Unoccupied Mode		
			Day Occupied (FH ON)			Day Occupied (FH OFF)			Night Occupied (FH ON)			Night Unoccupied (FH OFF)		
			Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.
2109	GEV	GEV-212	0	0	177	0	0	177	0	0	177	47	0	0
2110	GEV	GEV-211	0	0	196	0	0	196	0	0	196	67	0	0
2114/2116	GEV	GEV-210	0	0	177	0	0	177	0	0	177	65	0	0
2117	GEV	GEV-213	0	0	217	0	0	217	0	0	217	83	0	0
2235	GEV	GEV-2235	0	122	0	0	0	0	0	122	0	102	0	0
	FHEV	FH-2235A	0	0	257	39	0	0	0	0	257	39	0	0
	FHEV	FH-2235B	0	0	236	98	0	0	0	0	236	98	0	0
2261	GEV	GEV-224	0	0	80	0	0	80	0	0	80	45	0	0
2270	GEV	GEV-218	0	0	224	0	0	224	0	0	224	111	0	0
2273	GEV	GEV-217	0	0	214	0	0	214	0	0	214	117	0	0
2291	GEV	GEV-207	0	0	179	0	0	179	0	0	179	59	0	0
2302	GEV	GEV-206	0	0	142	0	0	142	0	0	142	71	0	0
2312	GEV	GEV-223	47	0	0	47	0	0	47	0	0	47	0	0
2316	GEV	GEV-222	0	0	260	0	0	260	0	0	260	260	0	0
	GEV	GEV-221	0	0	212	0	0	212	0	0	212	106	0	0
2317/2318	FHEV	FHEV-2318	0	0	472	0	0	0	0	0	472	0	0	0
	GEV	GEV-220	0	0	229	0	0	229	0	0	0	129	0	0
2320/2321	FHEV	FHEV-2320	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-219	0	52	0	0	0	209	0	52	0	38	0	0
2325	FHEV	FHEV-2325	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-216	0	280	0	0	0	280	0	280	0	181	0	0
2330	FHEV	FHEV-2330	0	0	595	0	0	0	0	0	595	0	0	0
	GEV	GEV-215	0	0	219	0	0	219	0	0	219	113	0	0
2345	FHEV	FHEV-2345A	0	0	255	98	0	0	0	0	255	98	0	0
	FHEV	FHEV-2345B	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-205	0	335	0	0	0	500	0	335	0	113	0	0
2346	GEV	GEV-204	0	0	241	0	0	241	0	0	241	90	0	0
3410	FHEV	FHEV-3410	0	0	252	98	0	0	0	0	252	98	0	0
	GEV	GEV-322	0	186	0	0	0	346	0	186	0	107	0	0
3411	GEV	GEV-324	0	0	240	0	0	240	0	0	240	86	0	0
3413	GEV	GEV-323	0	0	66	0	0	66	0	0	66	45	0	0
3414	GEV	GEV-325	0	0	278	0	0	278	0	0	278	86	0	0
3415/3416	GEV	GEV-321A	0	0	307	0	0	307	0	0	307	97	0	0
3420/3422	GEV	GEV-319	0	0	260	0	0	260	0	0	260	130	0	0
3421	FHEV	FHEV-3421	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-318	125	0	0	0	0	256	125	0	0	0	126	0
3423	FHEV	FHEV-3423	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-320	99	0	0	0	0	256	99	0	0	0	126	0
3424	GEV	GEV-321B	236	0	0	236	0	0	236	0	0	109	0	0
3425	FHEV	FHEV-3425	0	0	250	98	0	0	0	0	250	98	0	0
	GEV	GEV-317	0	122	0	0	0	275	0	122	0	97	0	0
3427	GEV	GEV-316	189	0	0	189	0	0	189	0	0	90	0	0
3430	GEV	GEV-314	0	0	330	0	0	330	0	0	330	115	0	0
	FHEV	FHEV-3430			247	98					247	98		
	GEV	GEV-313	0	0	118	0	0	118	0	0	118	59	0	0
3432	GEV	GEV-327	0	0	118	0	0	118	0	0	118	59	0	0
3440	FHEV	FHEV-3440A	0	0	242	98	0	0	0	0	242	98	0	0

Lab DD Box/Valve Flow Settings (l/s)

Room No.	Box/ Valve Type	Box/ Valve Tag	Occupied Mode			Occupied Override			Unoccupied Override / Fumehood Override			Unoccupied Mode		
			Day Occupied (FH ON)			Day Occupied (FH OFF)			Night Occupied (FH ON)			Night Unoccupied (FH OFF)		
			Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.
	FHEV	FHEV-3440B	0	0	242	98	0	0	0	0	242	98	0	0
3440	GEV	GEV-310	69	0	0	0	0	226	69	0	0	69		0
CONT.	GEV	GEV-312	69	0	0	0	0	226	69	0	0	69		0
3445	GEV	GEV-308	0	0	472	0	0	472	0	0	472	128	0	0
3446	FHEV	FHEV-3446	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-307	0	90	0	0	0	232	0	90	0	50	0	0
3447/48	GEV	GEV-306	0	175	0	0	0	329	0	175	0	107	0	0
	FHEV	FHEV-3448	0	0	255	98	0	0	0	0	255	98	0	0
3449	FHEV	FHEV-3449	0	0	252	98	0	0	0	0	252	98	0	0
	GEV	GEV-305	50	0	0	0	0	232	50	0	0	50	0	0
3450	FHEV	FHEV-3450	0	0	252	98	0	0	0	0	252	98	0	0
	GEV	GEV-304	0	95	0	0	0	246	0	95	0	65	0	0
	GEV	GEV-391	0	0	345	0	0	345	0	0	345	65	0	0
3455	FHEV	FHEV-3455	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-303	0	220	0	0	0	374	0	220	0	114	0	0
3456	FHEV	FHEV-3456	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-302	0	210	0	0	0	374	0	210	0	114	0	0
4111	GEV	GEV-428	0	0	203	0	0	203	0	0	203	94	0	0
4120	FHEV	FHEV-4120	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-426	0	363	0	0	0	475	0	363	0	116	0	0
4121/23/24	FHEV	FHEV-4121	0	0	252	98	0	0	0	0	252	98	0	0
	GEV	GEV-425	50	0	0	0	0	222	50	0	0	0	64	0
	GEV	GEV-424	0	0	274	0	0	274	0	0	274	101	0	0
4122	GEV	GEV-427	0	0	212	0	0	212	0	0	212	106	0	0
4125	FHEV	FHEV-4125	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-423	0	225	0	0	0	383	0	225	0	107	0	0
4126	GEV	GEV-422	0	0	223	0	0	223	0	0	223	112	0	0
4130	FHEV	FHEV-4130	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-421	0	232	0	0	0	383	0	232	0	154	0	0
4131/33	FHEV	FHEV-4131	0	0	272	132	0	0	0	0	272	132	0	0
	GEV	GEV-420	0	0	38	0	0	157	0	38	0	0	38	0
4132/4134	FHEV	FHEV-4132A	0	0	255	98	0	0	0	0	255	98	0	0
	FHEV	FHEV-4132B	0	0	525	0	0	0	0	0	525	0	0	0
	FHEV	FHEV-4134			257	103					257	103		
	GEV	GEV-419B	0	0	100	0	0	100	0	0	100	50	0	0
	GEV	GEV-419A	0	0	38	0	0	38	0	0	38	38	0	0
4135	FHEV	FHEV-4135A	0	0	255	98	0	0	0	0	255	98	0	0
	FHEV	FHEV-4135B	0	0	242	98	0	0	0	0	242	98	0	0
	GEV	GEV-418	0	306	0	0	0	322	0	306	0	166	0	0
4136	FHEV	FHEV-4136	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-415	0	328	0	0	0	471	0	328	0	160	0	0
4137	GEV	GEV-417	0	0	137	0	0	137	0	0	137	61	0	0
4140/4142	GEV	GEV-413	0	0	79	0	79	0	0	79	0	38	0	0
4141	FHEV	FHEV-4141	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-412	0	107	0	0	0	246	0	107	0	84	0	0
	GEV	GEV-414	0	0	320	0	0	320	0	0	320	113	0	0
4143	GEV	GEV-411	0	0	119	0	0	119	0	0	119	54	0	0

Lab DD Box/Valve Flow Settings (l/s)

Room No.	Box/ Valve Type	Box/ Valve Tag	Occupied Mode			Occupied Override			Unoccupied Override / Fumehood Override			Unoccupied Mode		
			Day Occupied (FH ON)			Day Occupied (FH OFF)			Night Occupied (FH ON)			Night Unoccupied (FH OFF)		
			Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.
4144	GEV	GEV-410	0	0	321	0	0	321	0	0	321	109	0	0
4145	FHEV	FHEV-4145	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-409	0	319	0	0	0	330	0	319	0	67	0	0
4150	FHEV	FHEV-4150A	0	0	255	98	0	0	0	0	255	98	0	0
	FHEV	FHEV-4150B	0	0	255	98	0	0	0	0	255	98	0	0
	GEV	GEV-408	0	265	0	0	0	408	0	265	0	94	0	0
4155	FHEV	FHEV-4155	0	0	252	98	0	0	0	0	252	98	0	0
	GEV	GEV-407	0	116	0	0	0	270	0	116	0	50	0	0
4156	GEV	GEV-406	0	0	165	0	0	165	0	0	165	48	0	0
4160	GEV	GEV-404	0	0	255	0	0	255	0	0	255	118	0	0
4161	GEV	GEV-491	0	0	304	0	0	304	0	0	304	212	0	0
	FHEV	FHEV-4161 (Future, NIC)	0	0	255	98	0	0	0	0	255	98	0	0
4162	GEV	GEV-496	0	0	260	0	0	260	0	0	260	118	0	0
4163	FHEV	FHEV-4163	0	0	242	98	0	0	0	0	242	98	0	0
	GEV	GEV-492	0	215	0	0	0	360	0	215	0	109	0	0
4164	GEV	GEV-493	0	0	243	0	0	243	0	0	243	113	0	0
4165	GEV	GEV-494	0	0	455	0	0	455	0	0	455	219	0	0
4170	GEV	GEV-495	0	0	245	0	0	245	0	0	245	118	0	0
4160a	GEV	GEV-405	0	0	38	0	0	157	0	0	38	38	0	0
	FHEV	FH-4160	0	0	255	98	0	0	0	0	255	98	0	0
unknown	GEV	GEV-203			630			630			630	310		
unknown	GEV	GEV-2311			222			222			222	106		
unknown	GEV	GEV-2316			1320			1320			1320	375		
unknown	GEV	GEV-50			800			800			800	800		

Fume Hood Tag:

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT:	**Summerland, Lab Exhaust System Alteration**
JOB NO:	R.018297.001

1. Test Purpose

.1 The intent is to test all HVAC and EMCS components through a series of checks and procedures designed to exercise the control system as it would be used in normal and abnormal operating conditions.

.2 To ensure system operation is as per contract documents.

.3 Make adjustments to system components as required to suit the design intent and operational requirements.

.4 "C" denotes contractor sign off.
"D" denotes Departmental Representative's verification

2. Test Pre-Requisites

			C	D
.1	Mechanical:			
	.1	All component verifications are complete and approved	[ ]	[ ]
	.2	Air system balancing is complete and approved	[ ]	[ ]
	.3	All testing agent's report forms are completed and accepted	[ ]	[ ]
	.4	All vendor system start up tests are completed and accepted	[ ]	[ ]
.2	Controls:			
	.1	All component verifications are complete and approved	[ ]	[ ]
	.2	All control device calibrations and physical point verifications are complete and approved.	[ ]	[ ]
	.3	All manual overrides and jumpers have been removed to allow for automatic / normal operation	[ ]	[ ]
	.4	Final control program is loaded and operational	[ ]	[ ]
	.5	All hardwired interlocks and safeties (if any) are operational	[ ]	[ ]
	.6	All software interlocks and safeties (if any) are operational	[ ]	[ ]
	.7	All trend logs are operational for: Physical points, setpoints and and performance variables	[ ]	[ ]

Fume Hood Tag:

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT:	**Summerland, Lab Exhaust System Alteration**
JOB NO:	R.018297.001

3. System Sequencing

			C	D
.1	UNOCCUPIED MODE			
	.1	Light switch is in the off position.	[ ]	[ ]
	.2	Supply terminal(s) are at UNOCCUPIED position.	[ ]	[ ]
	.3	Fume hood exhaust terminal is at minimum position.	[ ]	[ ]
.2	OCCUPIED MODE			
	.1	Light switch is in the on position.	[ ]	[ ]
	.2	Fume hood exhaust terminal moves to OCCUPIED position.	[ ]	[ ]
	.3	Supply terminal(s) move to OCCUPIED position.	[ ]	[ ]
.3	UNOCCUPIED OVERRIDE MODE			
	.1	Light switch is in the on position.	[ ]	[ ]
	.2	Fume hood exhaust terminal moves to UNOCCUPIED OVERRIDE position.	[ ]	[ ]
	.3	Supply terminal(s) move to UNOCCUPIED OVERRIDE position.	[ ]	[ ]
.4	OCCUPIED OVERRIDE MODE			
	.1	Light switch is in the off position.	[ ]	[ ]
	.2	Fume hood exhaust terminal moves to OCCUPIED OVERRIDE position.	[ ]	[ ]
	.3	Supply terminal(s) move to OCCUPIED OVERRIDE position.	[ ]	[ ]
.5	FUMEHOOD OVERRIDE MODE			
	.1	Light switch is in the on position.	[ ]	[ ]
	.2	Fume switch is in the on position.	[ ]	[ ]
	.3	Fume hood exhaust terminal moves to FUMEHOOD OVERRIDE position.	[ ]	[ ]
	.4	Supply terminal(s) move to FUMEHOOD OVERRIDE position.	[ ]	[ ]
	.5	Repeat steps 3.5.2 to 3.5.4 with light switch in the off position.	[ ]	[ ]

Fume Hood Tag:

MECHANICAL COMMISSIONING: SYSTEM TEST FORM

PROJECT:	**Summerland, Lab Exhaust System Alteration**
JOB NO:	R.018297.001

6. Test Sign Off:

Testing Personnel: (Contractor)

Firm: _____

Signature : _____

_____

Approved By: (Departmental Representative)

Firm: _____

Signature : _____

COMMENTS:

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PART 1 - GENERAL

1.1 Related Sections

.1 Section 099110 - Interior Painting.

.2 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.3 Section 230902 - EMCS: Start-up and Checkout.

.4 Section 230903 - EMCS: Commissioning.

.5 Section 230904 - EMCS: Project Record Documents.

.6 Section 230905 - EMCS: Training.

.7 Section 230906 - EMCS: Identification.

.8 Section 230915 - EMCS: Building Controller Family of Controllers.

.9 Section 230913 - EMCS: Field Control Devices.

.10 Section 230983 - EMCS: Field Installation.

.11 Section 230993- EMCS: Site Requirement Applications and System Sequence of Operation.

.12 Section 018100 - Commissioning General Requirements

1.2 References

.1 American National Standards Institute (ANSI)

.1 ANSI/ISA S5.5-1985, Graphic Symbols for Process Displays.

.2 ANSI/IEEE 260.1-2004, Letter Symbols for SI and Certain Other Units of Measurements (SI Units, Customary Inch-Pound Units and Certain Other Units).

.2 Canadian Standards Association (CSA)

.1 CAN/CSA-C22.2 No.0 (2010), General Requirements, Canadian Electrical Code, Part II.

.2 CAN/CSA-Z234.1-00(R2011), Canadian Metric Practice Guide.

.3 Electrical and Electronic Manufacturers Association (EEMAC)

.1 EEMAC 2Y-1-1958, Light Gray Colour for Indoor Switch Gear.

.4 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

.1 ASHRAE STD 135-2010, BACNET - Data Communication Protocol for Building Automation and Control Network.

.5 Consumer Electronics Association (CEA).

.1 CEA-709.1-[B-2002], Control Network Protocol Specification.

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

.1 Material Safety Data Sheets (MSDS).

1.3 Acronyms, Abbreviations and Definitions

.1 Acronyms used in EMCS.

.1 AI - Analog Input
.2 AO - Analog Output
.3 BACnet - Building Automation and Control Network
.4 BI - Binary Input
.5 BO - Binary Output
.6 CAD - Computer Aided Design
.7 CDL - Control Description Logic
.8 COSV - Change of State or Value
.9 CPU - Central Processing Unit
.10 EMCS - Energy Monitoring and Control System
.11 HVAC - Heating, Ventilation, Air Conditioning
.12 IDE - Interface Device Equipment
.13 I/O - Input/Output
.14 ISA - Industry Standard Architecture
.15 LAN - Local Area Network
.16 B-BC Bacnet Building Controller-
.17 B-AAC Bacnet Advanced Application
.18 BLN - BACnet Ethernet Building Level Network Controller
.19 OS - Operating System

.20 O&M - Operation and Maintenance
.21 B-OWS - BACnet Operator Work Station
.22 PC - Personal Computer
.23 PCI - Peripheral Control Interface
.24 PCMCIA - Personal Computer Micro-Card Interface Adapter
.27 RAM - Random Access Memory
.26 ROM - Read Only Memory
.27 USB - Universal Serial Bus
.28 UPS - Uninterruptible Power Supply
.29 ATE - Air Terminal Exhaust
.30 ATS - Air Terminal Supply
.31 B-SS BACnet Smart Sensor

.2 Definitions:

.1 Point: a point may be logical or physical.
Logical points are values calculated by system such as totals, counts, derived corrections i.e. as result of and/or statements in CDL's.
Physical points are inputs or outputs which have hardware wired to controllers which are measuring or providing status conditions of contacts or relays providing interaction with related equipment (stop, start) or valve or damper actuators.

.2 Point Name: composed of two parts, point identifier and point expansion.

.1 Point identifier: comprised of three descriptors, "area" descriptor, "system" descriptor and "point" descriptor, for which database to provide 25 character field for each point identifier. "System" is system that point is located on.
.1 Area descriptor: building or part of building where point is located.
.2 System descriptor: system that point is located on.
.3 Point descriptor: physical or logical point description. For point identifier "area", "system" and "point" will be

shortforms or acronyms. Database must provide 25 character field for each point identifier.

.2 Point expansion : comprised of three fields, one for each descriptor. Expanded form of shortform or acronym used in "area", "system" and "point" descriptors is placed into appropriate point expansion field. Database must provide 32 character field for each point expansion.

.3 Bilingual systems to include additional point identifier expansion fields of equal capacity for each point name for second language.

.1 System to support use of numbers and readable characters including blanks, periods or underscores to enhance user readability for each of the above strings

.3 Symbols and engineering unit abbreviations utilized in displays: to ANSI/ISAS 5.5.

.1 Printouts: to ANSI/IEEE 260.1.

.2 Refer also to Section 230906 - EMCS: Identification.

1.4 Permits and Fees

.1 In accordance with General Conditions of Contract.

.2 Submit certificate of acceptance from authority having jurisdiction to Departmental Representative.

1.5 General Description

.1 Refer to control schematics and other mechanical drawings for system architecture.

.2 Provide work covered by sections referred to above consisting of a fully operational EMCS, including, but not limited to, following:

.1 Provide new standalone control panel

(system), powered by emergency power and UPS. New panel to be connected to existing building control network. Provide all necessary control hardware, wiring, and work to meet design intent.

.2 Provide all Control devices as listed in I/O Summaries and sequence of operation.

.3 B-OWS complete with graphics development software . Provide graphics for new & existing systems as necessary.

.4 Data communications equipment and or cabling necessary to effect an EMCS data transmission system including connection to existing network.

.5 Provide Back-up UPS power source for new DDC system controllers for a minimum of 15 minutes.

.6 All field control end devices.

.7 Software complete with full documentation for software and equipment.

.8 Complete operating and maintenance manuals and field training of operators, programmers and maintenance personnel.

.9 Acceptance tests, technical support during commissioning, full documentation

.10 Provide wiring and interface co-ordination of equipment supplied by Division 23 (i.e. lab exhaust fans and speed drives).

.11 Miscellaneous work as specified in these sections and as indicated.

.12 Software provided shall be of the manufacturer's most recent version available. Provide one copy of an B-OWS graphical operator workstation and programmers tool complete with implemented dynamic graphics and PC workstation as specified. Provide one copy of graphical webserver operator

interface complete with webserver PC to be connected to the BAS and the client intranet LAN for operator interface from standard PC's with internet browser software.

1.6 Metric References

.1 Conform to CAN/CSA-Z234.1.

.2 Provide required adapters between Metric and Imperial components.

1.7 Standards Compliance

.1 All equipment and material to be from manufacturer's regular production, CSA certified where line voltage switching is required, manufactured to standard quoted plus additional specified requirements.

.2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.

.3 Submit proof of compliance to specified standards with shop drawings and product data. Label or listing of specified organization is acceptable evidence.

.4 In lieu of such evidence, submit certificate from testing organization, approved by Departmental Representative, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.

.5 For materials whose compliance with organizational standards/codes/specifications is not regulated by an organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.

1.8 EMCS Contractor Qualifications

.1 Have local office within 65 km of project for at least 5 years, staffed by trained personnel capable of providing instruction, routine maintenance, and emergency service on systems. Typical emergency response time to be on site

shall be no longer than approximately four hours.

1.9 System Design Responsibility

.1 Design and provide all conduit and wiring linking all elements of system, including future capability.

.2 Supply sufficient programmable controllers of all types to meet project requirements. Quantity and points contents to be approved by Departmental Representative prior to installation.

.3 Location of controllers to be approved by Departmental Representative prior to installation.

.4 Provide utility and emergency power to controllers.

1.10 Language Operating Requirements

.1 Operator to interface to system in English through operator selectable access codes.

.2 Use non-linguistic symbols for displays on graphic terminals. All other information to be in English.

.3 Operating system executive: primary hardware-to-software interface (specified as part of hardware purchase) with associated documentation to be in English.

.4 System manager software: to include system definition point database, additions, deletions or modifications, control loop statements, use of high level programming languages, report generator utility and other OS utilities used for maintaining optimal operating efficiency. These functions to be in English.

.5 EMCS operator: include, in English:

.1 All input and output commands and messages from operator-initiated functions and/or field related changes and/or alarms as defined in CDL's or assigned limits (i.e. all commands

relating to day-to-day operating functions and not related to system modifications, additions, or logic re-definements).

.2 Graphic "display" functions, point commands to turn systems on or off, manually override automatic control of specified hardware points. To be in English at all specified OWS and to be able to operate one terminal in English. Point name expansions in both languages.

.3 Reporting function such as trend log, trend graphics, alarm report logs, and maintenance generated messages.

1.11 Delivery Storage and Handling

.1 Material Delivery Shdedule: provide Departmental Representative with schedule within 2 weeks after award of Contract.

.2 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins.

.4 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste in accordance with Waste Management Plan.

.5 Place materials defined as hazardous or toxic in designated containers.

.6 Handle and dispose of hazardous materials in accordance with Regional and Municipal regulations.

.7 Label location of salvaged material's storage areas and provide barriers and security devices.

.8 Ensure emptied containers are sealed and stored safely.

.9 Fold up metal and plastic banding, flatten and place in designated area for recycling

1.12 Existing Conditions - Control components

.1 Utilize existing control wiring and piping as indicated.

.2 Re-use field control devices that are usable in their original configuration provided that they conform to applicable codes, standards specifications.
- .1 Do not modify original design of existing devices without written permission from Departmental Representative.
- .2 Provide for new, properly designed device where re-usability of components is uncertain.

.3 Non functioning items:
- .1 Provide with report specification sheets or written functional requirements to support findings.
- .2 Departmental Representative will repair or replace existing items judged defective yet deemed necessary for EMCS.

.4 Submit written request for permission to disconnect controls and to obtain equipment downtime before proceeding with Work.

.5 Assume responsibility for controls to be incorporated into EMCS after written receipt of approval from Departmental Representative.
- .1 Be responsible for items repaired or replaced by Departmental Representative.
- .2 Be responsible for repair costs due to negligence or abuse of equipment.
- .3 Responsibility for existing devices terminates upon final acceptance of EMCS applicable portions of EMCS as approved by Departmental Representative.

.6 Remove existing controls not re used or not required. Place in approved storage for disposition as directed

1.13 Phased Construction

.1 Note that the construction is phased. Refer to the project phasing requirements outlined in Section 011100 and as noted on drawings.

.2 At the completion of each phase, lab

exhaust, general exhaust, and general return systems need to be fully tested, balanced, commissioned, and made functional prior to commencing the next phase. Refer to phasing requirements in Section 011100.

PART 2 - PRODUCTS

2.1 Acceptable Systems Manufacturers

.1 Delta Controls ORCA BACnet DDC Systems, no substitution. The systems shall fully meet all the technical specification sections under Division 23.

.2 Complete list of equipment and materials to be used on project and forming part of bid documents by adding manufacturer's name, model number and details of materials, and submit for approval.

2.2 Lockable Panels

.1 Panel to be NEMA for network panels in mechanical penthouse and in service core area.

.2 To have hinged doors equipped with standard keyed-alike cabinet locks, keyed to same key.

PART 3 - EXECUTION

3.1 Manufacturer's Recommendations

.1 Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.2 Painting

.1 Painting to be in accordance with Section 099110 - Interior Painting, supplemented as follows:

.2 Clean and touch up marred or scratched surfaces of factory finished equipment to match original finish.

.3 Restore to new condition, finished surfaces which have been damaged too extensively to be primed and touched up to make good.

.4 Clean and prime exposed hangers, racks, fastenings, and other support components.

.5 Paint all unfinished equipment installed indoors to EEMAC 2Y-1.

3.3 General

.1 Provide EMCS controls to new fume hoods of the renovated laboratories with control function and operation to match with existing renovated laboratory rooms (NIC).

.2 Modify existing EMCS controls as required to suit new installation and site conditions.

.3 Provide Native BACNet controllers for new fumehood in room 4161 (NIC). New controllers shall match with and compatible to existing EMCS controllers.

.4 Provide testing and commissioning to the EMCS systems in the renovated laboratories and rooms including fume hood exhaust systems, general exhaust systems and dual-duct supply air systems. Provide test and commissioning report for review prior to substantial performance inspection.

.5 Provide EMCS shop drawings for the renovated laboratories and rooms for review prior to new installation.

.6 Provide identification to all new/modified EMCS components and systems to match with existing base building EMCS system.

.7 Provide power supply to new/relocated control devices, controllers and components. Provide all control devices, components, relays, transformers, E/P switches, wirings and conduits as required for this renovation work.

.8 Coordinate with the balancing agent and fume hood testing agent for testing and commissioning work.

.9 Re-commission existing laboratories to ensure their operation and control sequences meet the requirements of the Departmental Representative.

.10 Connect fume hood air flow monitor for new fume hood FH 4161 to EMCS system (NIC). When the air flow monitor is not in use, the monitor shall be changed to night mode setting.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230900 - EMCS: General Requirements.

.2 Section 230903 - EMCS: Commissioning.

1.2 Design Requirements

.1 Preliminary Design Review

.1 Within 5 working days after tender closing and before contract award, submit preliminary design document for review by Departmental Representative, containing following contractor and systems information:

.1 Location of local office.
.2 Description and location of installing and servicing technical staff.
.3 Location and qualifications of programming design and programming support staff.
.4 List of spare parts.
.5 Location of spare parts stock.
.6 Names of sub-contractors and site-specific key personnel.
.7 Sketch of site-specific system architecture.
.8 Specification sheets for each item including memory provided, programming language, speed, type of data transmission.
.9 Descriptive brochures.
.10 Sample CDL and graphics (systems schematics).
.11 Response time for each type of command and report.
.12 Item-by-item statement of compliance.
.13 Proof of demonstrated ability of system to communicate utilizing BACnet.

.2 Preliminary Design Review Meeting

.1 Convene meeting within 15 working days of award of contract to:

.1 Undertake functional review of preliminary design documents, resolve inconsistencies.

.2 Resolve conflicts between contract document requirements and actual items (e.g.: points list inconsistencies).

.3 Review interface requirements of materials supplied by others.

.4 Review "Sequence of Operations".

.2 Contractor's programmer to attend meeting.

.3 Departmental Representative retains right to revise sequence or subsequent CDL prior to software finalization without cost to Owner.

1.3 Shop Drawings

.1 Submit shop drawings in accordance with Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.2 Shop drawings to consist of 3 hard copies and 1 soft copy of design documents, shop drawings, product data and software.

.3 Shop drawings are to show not only new added equipment but also existing LEF -1/2/3 fans as well associated mechanical AHU's system, as these systems are dependable on operation of new exhaust systems LEF- 4/5/6 operation. This also means revised sequences on existing systems are to be part of shop drawings. Please show revised design air flow and static pressure requirements for existing LEF -1/2/3 fans. Update actual required settings on controls record drawings.

.4 Hard copy to be completely indexed and coordinated package to assure compliance with contract requirements and arranged in same

sequence as specification and cross-referenced to specification section and paragraph number.

.5 Soft copy to be in AutoCAD - latest version and Microsoft Word latest version format, structured using menu format for easy loading and retrieval on OWS.

.6 Preliminary Shop Drawing Review

.1 Submit preliminary shop drawings within 30 working days of award of contract.

.2 Include:

.1 Specification sheets for each item. To include manufacturer's descriptive literature, specification, drawings, diagrams, performance and characteristic curves, catalogue cuts, manufacturer's name, trade name, catalogue or model number, nameplate data, size, layout, dimensions, capacity, other data to establish compliance.

.2 Detailed system architecture showing all points associated with each controller including signal levels, pressures where new EMCS ties into existing control equipment.

.3 Spare point capacity of each controller by number and type.

.4 Controller locations.

.5 Auxiliary control cabinet locations.

.6 Single line diagrams showing cable routings, conduit sizes, spare capacity between control centre, field controllers and systems being controlled.

.7 Dampers: sketches showing module assembly, interconnecting hardware, operator locations, operator spring range, pilot range, required torque, actual torque.

.7 Detail Shop Drawing Review

.1 Submit detailed shop drawings within 45 working days after award of contract and before start of installation.

.2 Include:

.1 Corrected and updated versions (hard copy only) of submissions made during preliminary review.
.2 Wiring diagrams.
.3 Piping diagrams and hook-ups.
.4 Interface wiring diagrams showing termination connections and signal levels for equipment to be supplied by others.
.5 Shop drawings for each input/output point, sensors, transmitters, showing information associated with each particular point including:

.1 Sensing element type and location.
.2 Transmitter type and range.
.3 Associated field wiring schematics, schedules and terminations.
.4 Pneumatic schematics and schedules.
.5 Complete Point Name Lists.
.6 Setpoints, curves or graphs and alarm limits (high and low, 3 types), signal range.
.7 Software and programming details associated with each point.
.8 Manufacturer's recommended installation instructions and procedures.
.9 All signal levels/pressures where new system ties into existing control equipment.

.3 Control schematics, narrative description, CDL's fully showing and describing automatic and manual procedure required to achieve proper operation of project, including under complete failure of EMCS.

.4 Graphic system schematic displays of air systems with point labels and textual description of system, and typical floor plans as specified.

.5 Complete system CDL's including companion English language explanations on same sheet but with different font and italics. CDL's to contain all specified energy optimization programs.

.6 Listing and example of reports.

.7 Listing of time schedules.

.8 Detailed to-scale drawing of control room showing location of equipment and operator work space.

.9 Type and size of memory with statement of spare capacity.

.10 Full description of software programs provided.

.11 Sample of "Operating Instructions Manual" to be used for training purposes.

.12 Outline of proposed start-up and verification procedures. See also Section 230902 - EMCS: Start-up and Check Out.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230900 - EMCS: General Requirements.

.2 Section 230903 - EMCS: Commissioning.

.3 Section 018100 - Commissioning General Requirements

1.2 Definitions

.1 AEL: ratio between total test period less any system downtime accumulated within that period and test period.

.2 Downtime: results whenever EMCS is unable to fulfill all required functions due to malfunction of equipment defined under the responsibility of EMCS contractor. Downtime is measured by duration, in time, between the time that the Contractor is notified of failure and the time system is restored to proper operating condition. Downtime not to include following:

.1 Outage of main power supply in excess of back-up power sources, provided that:
.1 Automatic initiation of back-up was accomplished.
.2 Automatic shut-down and re-start of components was as specified.

.2 Failure of communications link, provided that:

.1 Controller automatically and correctly operated in stand-alone mode.
.2 Failure was not due to failure of any specified EMCS equipment.
.3 Functional failure resulting from individual sensor inputs or output devices, provided that:

.1 System recorded said fault.
.2 Equipment defaulted to fail-safe mode.
.3 AEL of total of all input

sensors and output devices is at least 99 % during test period.

1.3 Acronyms .1 Acronyms: Refer to Section 230900 - EMCS: General Requirements.

1.4 System Description .1 Work includes:

.1 Start-up testing and verification of all systems.

.2 Demonstration of proper operation of all components.

.3 On-site operational tests.

.4 Staged and sequence of construction as Sections 011110 and 018100.

.5 Integrate with existing control systems that are required to run the facility and labs during construction.

.6 Interim testing and acceptance when both the new and existing control systems are operating as required to maintain the plant and labs operation during construction.

.7 Provide start-up and check out schedule to Departmental Representative for approval prior to new construction.

.2 Provide test equipment, two-way radios.

.3 Co-ordinate with other trades.

.4 Correct deficiencies, re-test until satisfactory performance is obtained.

.5 Acceptance of tests will not relieve Contractor from responsibility for ensuring that complete systems meet every requirement of Contract.

.6 Load system with project software.

1.5 Quality Assurance .1 Completion Testing

.1 General: test after installation of each part of system, after each phase and after completion of mechanical and electrical hook-ups, to verify correct installation and functioning.

.2 Include the following activities:

.1 Test and calibrate field hardware including stand-alone capability of each controller.
.2 Test and calibrate 100% of AI using calibrated digital instruments.
.3 Test each BI to ensure proper settings and switching contacts.
.4 Test each BO to ensure proper operation and lag time.
.5 Test each AO to ensure proper operation of controlled devices. Verify tight closure and signals.
.6 Test operating software.
.7 Debug software.
.8 Blow out flow measuring and static pressure stations with high pressure air at 700 kPa.

.3 Final Startup Testing (at each phase):

.1 Upon satisfactory completion of tests, perform point-by-point test of entire system under direction of Departmental Representative and EMCS Commissioning Engineer.

.2 Provide:
.1 2 technical personnel capable of re-calibrating field hardware and modifying software.
.2 Detailed daily schedule showing items to be tested and personnel available.
.3 Key document for recording procedures to be listing of system database, including keyname, English description,

point type and address, engineering units, low and high limits. Include space on listing for remarks and signatures of commissioning technician and Departmental Representative.

.4 Departmental Representative's acceptance signature to be on executive and applications programs.

.4 Final Operational Testing (after each phase):

.1 Purpose: to demonstrate that EMCS functions in accordance with contract requirements.

.1 Prior to the commencement of 30 day test Contractor must demonstrate that operating parameters (set-points, alarm limits and CDL's) have been implemented so as to ensure proper operation and operator notification in event of off-normal operation. Repetitive alarm conditions to be resolved so as to minimize reporting of nuisance conditions.

.2 Test to last at least 30 consecutive 24 hour days.

.3 Tests to include:

.1 Demonstration of correct operation of monitored and controlled points.

.2 Operation and capabilities of sequences, reports, special control algorithms, diagnostics, software.

.4 System will be accepted when:

.1 EMCS equipment operates to meet overall performance requirements. Downtime as defined in item 1.2.2. must not

exceed allowable time calculated for this site.

.2 Requirements of Contract have been met.

.5 In event of failure to attain specified AEL during test period, extend test period on day-to-day basis until specified AEL is attained for test period.

.6 Correct defects when they occur and before resuming tests.

1.6 Commissioning

.1 Do commissioning in accordance with Section 230903 - EMCS: Commissioning and coordinate the commissioning work in sections 018100, 230800, 230801, 230802, 230593 and 262250 - Commissioning and Testing sections.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 017800 - Closeout Submittals.

.2 Section 018100 -Commissioning.

.3 Section 230900 - EMCS: General Requirements.

.4 Section 230800 - Commissioning Testing Requirements

.5 Section 230801 - Commissioning Component Testing

.6 Section 230802 - Commissioning System Testing

1.2 System Description

.1 Commissioning to be carried out under general direction of Departmental Representative and in presence of Departmental Representative.

.2 Approvals

.1 Obtain approval to start commissioning from Departmental Representative in writing at least 7 days prior to start. Information to include:

.1 Systems to be commissioned.

.2 Procedures, anticipated results.

.3 Names of commissioning personnel.

.3 Purpose

.1 To ensure that facility is fully commissioned following the Commissioning process, after each phase, and includes assurance that systems meet design criteria, design intents and requirements of specifications.

1.3 Design Requirements

.1 Commissioning Agent to confirm with Departmental Representative that Design Criteria and Design Intents are still applicable.

.2 Commissioning personnel to be fully aware of and qualified to interpret Design Criteria and Design Intents.

1.4 Co-ordination

.1 Co-ordinate commissioning procedures with other Divisions. In particular, coordinate with the balancing and commissioning agent for required commissioning activities at each phase of construction. Refer to Section 011100.

1.5 Timing

.1 Commissioning to commence only after satisfactory completion of start-up, verification of performance and 30 day test period as specified above.

.2 Commissioning of occupancy-, weather-, and seasonal- sensitive systems to take place during four (4) consecutive seasons, after facility has been accepted, taken over and fully occupied, except as follows:

.1 Commission systems considered as life safety systems after each phase to verify that the facility is safe and fully functional before commencing the next phase.

1.6 Instrumentation

.1 Provide sufficient permanent and temporary instrumentation. Verify locations, access, illumination for readings.

.2 Instrumentation accuracy tolerances: higher order of magnitude than equipment, or system, being tested.

.3 Locations to be approved, readily accessible and readable.

.4 Application: to conform to normal industry standards.

1.7 Operation of Systems

.1 Operate systems as long as necessary to commission entire project.

1.8 Supervision and Monitoring

.1 Commissioning to be supervised by qualified supervisory personnel and Departmental Representative.

.2 Monitor progress. Keep detailed records of activities, results.

1.9 Documentation

.1 Documentation, O&M Manuals, training of O&M personnel to be complete to satisfaction of Departmental Representative before starting commissioning. Refer to Section 017800 - Closeout Submittals.

.2 Provide check sheets and system sheets to the Departmental Representative for review and approval prior to starting work.

.3 Provide report after each phase to confirm that the facility is safe and fully functional before commencing the next phase.

1.10 Use of O&M Personnel

.1 O&M personnel to assist in commissioning procedures as part of training.

1.11 Procedures

.1 Test each system independently and then in unison with other related systems after each phase to verify that the facility is safe and fully functional before commencing the next phase.

.2 Test weather-sensitive systems twice - once at near winter design conditions and again under near summer design conditions.

.3 Commission each system using procedures prescribed by Departmental Representative.

.4 Commission integrated system using procedures prescribed by Departmental Representative.

.5 Debug system software.

.6 Optimize operation, performance of systems by

fine-tuning PID values and modifying CDL's as required.

.7 Test full scale emergency evacuation and life safety procedures including operation and integrity of smoke management systems under Normal and Emergency Power conditions as applicable.

1.12 Verification of Results

.1 Departmental Representative will verify 30 % of reported results.

1.13 Demonstrations

.1 Demonstrate to Departmental Representative operation of systems including sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down, interlocks, lock-outs after each phase to verify that the facility is safe and fully functional before commencing the next phase.

1.14 Final Settings

.1 Upon completion of commissioning as reviewed by Departmental Representative, set and lock devices in final position, permanently mark settings.

1.15 Final Report

.1 Submit report to Departmental Representative after each phase to verify that the facility is safe and fully functional before commencing the next phase. Report to:

- .1 Include measurements, final settings, certified test results.
- .2 Bear signature of commissioning technician and supervisor.
- .3 Be subject to verification by Departmental Representative.

.2 Report format to be approved by Departmental Representative before commissioning started.

1.16 Commissioning

.1 Continue system debugging and optimization.

Activities During Warranty Period

.1 Perform two (2) checks of environmental conditions. Submit written report to Departmental Representative.

.2 Revise "As-built" documentation, commissioning reports to reflect changes, adjustments, modifications to EMCS as set during commissioning.

.3 Recommend additional changes, modifications deemed advisable in order to improve performance, environmental conditions, energy consumption.

1.17 Maintenance Activities During Warranty Period

.1 Provide services, materials, equipment and maintain EMCS for specified warranty period. Provide detailed preventative maintenance schedule for system components.

.2 Perform as minimum (3) three minor inspections and one major inspections (more often if required by manufacturer) per year. Provide detailed written report to Departmental Representative.

.3 Major inspections to include, but not limited to:

.1 Minor inspection.
.2 Clean OWS(s) peripheral equipment, BC's, interface and other panels, micro-processor interior and exterior surfaces.
.3 Check signal, voltage and system isolation of BC's, peripherals, interface and other panels.
.4 Provide mechanical adjustments, new ribbons or cartridges, and necessary maintenance on printers.
.5 Run system software diagnostics as required.
.6 The following inspections will be considered minimum requirements, and shall not be interpreted to mean satisfactory performance. Calibrations will be performed using test equipment having traceable, certifiable accuracy at minimum 50% greater than the accuracy of system displaying or logging the

value. Check and/or calibrate each field input/output device. Provide dated, maintenance task lists to Departmental Representative as proof of execution of complete system verification. Maintenance task lists to include the following sensor and output point detail; point name, location, device type and range, measured value, system displayed value, calibration detail, indication if adjustment required, and any other action taken of recommended.

.7 Install software and firmware enhancements to ensure components are operating at most current revision for maximum capability and reliability. Perform network analysis and provide report of results with detailed recommendations to correct any problems found.

.4 Minor inspections to include, but not limited to:

.1 Perform visual, operational checks to BC's, peripheral equipment, interface equipment and other panels.

.2 Check equipment cooling fans as required.

.3 Perform inspections during regular working hours, 0800 to 1630 h, Monday through Friday, excluding legal holidays.

.4 Visually check for mechanical faults, air leaks and proper pressure settings on pneumatic components.

.5 Review system performance with Operations Supervisor and/or the Director and discuss suggested or required changes.

.5 Emergency Service Calls:

.1 Service calls will be initiated when there is indication that EMCS is not functioning correctly. Have qualified control personnel available during contract period to provide service to "CRITICAL" components whenever required at no extra cost. Furnish Departmental

Representative with telephone number where service personnel may be reached at any time. Service personnel to be on site ready to service EMCS within 2 h after receiving request for service. Perform work continuously until EMCS restored to reliable operating condition.

.6 Operation: foregoing and other servicing to provide proper sequencing of equipment and satisfactory operation of EMCS based on original design conditions and to be as recommended by manufacturer.

.7 Records and logs: maintain records and logs of each maintenance task. Organize cumulative records for each major component and for entire EMCS chronologically. Complete forms and submit after inspection indicating that planned and systematic maintenance has been accomplished.

.8 Work requests: record each service call request, when received separately on approved form. Form to include serial number identifying component involved, its location, date and time call received, nature of trouble, names of personnel assigned, instructions of work to be done, amount and nature of materials used, time and date work started, time and date of completion.

.9 System modifications: provide in writing. No system modification, including operating parameters.

PART 1 - GENERAL

1.1 General

.1 Conform to requirements of Section 017800 - Closeout Submittals, supplemented and modified by requirements specified in this section.

.2 Project records and O&M manuals specified in this section are to be completely separate entity from those specified in Section 017800 - Closeout Submittals

.3 Submit a report to the Departmental Representative after each phase to verify that the facility is safe and fully functional before commencing the next phase of the project.

1.2 Acronyms

.1 Acronyms: refer to Section 230900 - EMCS: General Requirements.

1.3 Final Control Diagrams

.1 Provide before acceptance in both hard and soft copy.

.2 Show:
- .1 Changes to contract documents as well as addenda and contract extras.
- .2 Changes to interface wiring.
- .3 Major routing of conduit and control air lines.
- .4 Signal levels, setpoints, reset curves, schedules.

.3 Where possible, bind with specified Operating and Maintenance Manuals.

.4 Provide listing of alarm messages.

.5 Provide soft copy of updated drawings on system and soft copy back-up.

.6 Provide 3 non-fading "As-Built" copies showing control and/or adjustment procedures. Seal in plastic laminate in rigid metal bound loose leaf.

1.4 Language

.1 Provide record documents and Operation and Maintenance manual in English.

1.5 O&M Manuals

.1 O&M Manuals (both hard and soft copy) to be custom designed and contain material pertinent to this project including all existing systems that are dependable on LEF- 4/5/6 operation (such as LEF- 1/2/3, AHU's etc.).

.2 Provide 2 soft copies and 2 hard copies in hard-back, 50 mm 3 ring, D-ring binders.
- .1 Binders to be 2/3 maximum full.
- .2 Provide index to full volume in each binder.
- .3 Identify contents of each manual on cover and spine.
- .4 Include names, addresses, telephone numbers of each sub-contractor having installed equipment, local representative for each item of equipment, each system.
- .5 Provide Table of Contents in each manual. Assemble each manual to conform to Table of Contents with tab sheets placed before instructions covering subject.

.3 Furnish 1 complete set of hard and soft copies prior to system or equipment tests. Furnish remainder upon acceptance.

.4 Include complete coverage in concise language readily understood by operating personnel using common terminology of functional and operational requirements of system. Do not presume knowledge of computers, electronics or in-depth control theory.

.5 Functional description to include:

- .1 Functional description of theory of operation.
- .2 Design philosophy.
- .3 Specific functions of design philosophy and system.
- .4 Full details of data communications, including data types and formats, data processing and disposition data link

components, interfaces and operator tests or self-test of data link integrity.

.5 Explicit description of hardware and software functions, interfaces, requirements for components in functions and operating modes.

.6 Description of person-machine interactions required to supplement system description, known or established constraints on system operation, operating procedures currently implemented or planned for implementation in automatic mode.

.6 System operation to include:

.1 Complete step-by-step procedures for operation of system including required actions at each OWS.

.2 Operation of computer peripherals, input and output formats.

.3 Emergency, alarm and failure recovery.

.4 Step-by-step instructions for start-up, back-up equipment operation, execution of all systems functions and operating modes, including key strokes for each command so that operator need only refer to these pages for keystroke entries required to call up display or to input command.

.7 Software to include:

.1 Documentation of theory, design, interface requirements, functions, including test and verification procedures.

.2 Detailed descriptions of program requirements and capabilities.

.3 Data necessary to permit modification, relocation, reprogramming and to permit new and existing software modules to respond to changing system functional requirements without disrupting normal

operation.

.4 Software modules, fully annotated source code listings, error free object code files ready for loading via peripheral device.

.5 Complete program cross reference plus any linking requirements, data exchange requirements, necessary subroutine lists, data file requirements, other information necessary for proper loading, integration, interfacing, program execution.

.6 Software for each Controller and single section referencing all Controller common parameters and functions.

.7 The OWS currently has ORCAview version 3.33. The intent is not to upgrade the OWS to version 3.40. Update the OWS graphics to reflect the new lab exhaust fans. Scope would include, but not be limited to adding new graphics and editing the existing graphics to depict relationships between the lab exhaust fans and the associated air handling units. Update the programming to suit the revised sequence of operations.

.8 Maintenance: document maintenance procedures including inspection, periodic preventive maintenance, fault diagnosis, repair or replacement of defective components, including calibration, maintenance, repair of sensors, transmitters, transducers, Controller interface firmware's, plus diagnostics and repair/replacement of system hardware.

.9 Test procedures and reports: record implementation, description of test procedures. Provide for measurement or observation of results.

.10 System configuration document:

.1 Basic system design and configuration.

.2 Provisions and procedures for planning, implementing, recording hardware and

software modifications required during installation, test and operating lifetime of system.

.3 Information to ensure co-ordination of hardware and software changes, data link or message format/content changes, sensor or control changes in event that system modifications are required.

.4 Full documentation of new system configurations.

.11 Programmer control panel documentation: provide where panels are independently interfaced with BECC, including interfacing schematics, signal identification, timing diagrams, fully commented source listing of applicable driver/handler.

PART 1 - GENERAL

1.1 Training Proposal

.1 Provide training proposal complete hour-by-hour schedule including brief overview of content of each segment to Departmental Representative 30 days prior to anticipated date of commencement of training.

.1 List name of trainer, visual and audio aids to be used.

.2 Show coordinated interface with other EMCS mechanical and electrical training programs.

1.2 Instructors

.1 To be competent, thoroughly familiar with all aspects of EMCS installed in this facility.

.2 Departmental Representative reserves right to approve instructors, based on qualifications.

1.3 Instruction

.1 Provide instruction to designated personnel in adjustment, operation, maintenance, pertinent safety requirements of EMCS installed.

.2 Training to be project-specific.

1.4 Time for Instruction

.1 Number of person-days of instruction to be as specified in this section (1 person-day = 8 h including two 15 min breaks and excluding lunch time).

1.5 Training Materials

.1 Provide equipment, visual and audio aids, and materials for classroom training.

.2 Provide manual for each trainee, describing in detail data included in each training program.

1.6 Training Program .1 To be in 2 phases over 6 month period:

.1 Phase 1: for 2 days before 30 day test period at time mutually agreeable to Contractor, Departmental Representative and EMCS Commissioning Manager. Train O&M personnel in functional operations and procedures to be employed for system operation. Supplement with continuous on-the-job training during 30 day test period. To include overview of system architecture, communications, operation of computer and peripherals, report generation; detailed training on operator interface functions for control of mechanical systems, CDL's for each system, and elementary preventive maintenance.

.2 Phase 2: 8 weeks after acceptance, for 1 day. For operators, equipment maintenance personnel and programmers. Use multiple instructors on pre-arranged schedule. Include at least following:

.1 Operator training: provide operating personnel, maintenance personnel and programmers with condensed version of Phase 1 training.

.2 Equipment maintenance training: provide personnel with training within 5 day period in maintenance of EMCS equipment, including general equipment layout, trouble shooting and preventive maintenance of EMCS components, maintenance and calibration of sensors and controls.

.3 Programmers: provide personnel with training within 5 day period in following subjects in approximate percentages of total course shown:
Software and architecture: 10 %,
Applications 15 %,:
Controller programming: 50 %,
Trouble shooting and debugging: 10%,
Colour graphic generation: 10 %

1.7 Additional Training

.1 List courses offered by name, duration and approximate cost per person per week. Note courses recommended for training supervisory personnel.

.4 If required, this additional training will be contracted for at later date.

PART 1 - GENERAL

1.1 General

.1 Provide identification for all control items.

.2 Follow identification, coding and procedures existing in the facility for all control items.

1.2 References

.1 Canadian Standards Association (CSA)

.1 CSA C22.1-02, The Canadian Electrical Code, Part I (19th Edition), Safety Standard for Electrical Installations.

1.3 Submittals

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures supplemented and modified by requirements of this Section.

.2 Submit to Departmental Representative for approval samples of nameplates, identification tags and list of proposed wording.

PART 2 - PRODUCTS

2.1 Language

.1 Provide nameplates and identification tapes and tags in English.

2.2 Nameplates for Panels

.1 Identify faces with laminated plastic nameplates.

.2 Sizes: 25 x 67 mm minimum.

.3 Lettering: 7 mm minimum high, black.

.4 Inscriptions: machine engraved to identify function and, where applicable, [fail-safe] position.

.5 Nameplates: plastic laminate, 3 mm thick Melamine, matt white finish, black core, square corners, lettering accurately aligned and engraved into core.

2.3 Nameplates for

.1 Identify by plastic encased cards attached by chain.

Field Devices

.2 Sizes: 50 x 100 mm minimum.

.3 Lettering: 5 mm minimum high produced from laser printer in black.

.4 Data to include: point name, schematic designation number, model, capillary length, size, range, set point, other pertinent data, function, fail-safe position.

.5 Companion cabinet: identify interior components using plastic enclosed cards.

2.4 Nameplates for Room Sensors

.1 Interior: identify by stick-on labels.

.2 Exterior: identify point name on face of cover using plastic laminate nameplates.

.3 Sizes: to suit.

.4 Lettering: to suit. Clearly legible.

2.5 Warning Signs

.1 Equipment including motors, starters under remote automatic control: provide orange coloured signs warning of automatic starting under control of EMCS.

.2 Sign to read: "Caution: This equipment is under automatic remote control of EMCS" or equivalent to Departmental Representative's approval.

2.6 Nameplates for Wiring

.1 Provide numbered tape markings on wiring at panels, junction boxes, splitters, cabinets, outlet boxes.

.2 Colour coding: to CSA C22.1. Use colour coded wiring in communications cables, matched throughout system.

.3 Power wiring: identify circuit breaker panel/circuit breaker number inside each EMCS panel.

2.7 Nameplates for Pneumatic Tubing

.1 Numbered tape markings on tubing to provide uninterrupted tracing capability.

2.8 Nameplates for Conduit

.1 Colour code all EMCS conduit.

.2 Locate coding on conduits, in exposed and concealed locations including removable suspended ceilings, tunnels, shafts, on both sides of walls, floors, and at 15 m intervals.

.3 Coding: use plastic tape or paint, 25 mm wide, fluorescent orange. Confirm colour with Departmental Representative during "Preliminary Design Review".

.4 Pre-paint box covers and conduit fittings.

PART 3 - EXECUTION

3.1 Nameplates and Labels

.1 Ensure that manufacturer's nameplates, CSA labels and identification nameplates are visible and legible at all times.

3.2 Existing Panels

.1 Correct existing legends to reflect changes made during work.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230900 - EMCS: General Requirements.

.2 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.3 Section 230904 - EMCS: Project Records and "As-Built" Records.

.4 Section 230908 - BACnet Operator Workstation B-OWS Software and Hardware Requirements.

.5 Section 230914 - BACnet Building Controller B-BC Hardware and Software Definition Requirements.

.6 Section 230915 - BACnet Advanced Application Controller & TCU-AAC Hardware and Software Definition Requirements.

1.2 Acronyms

1. Acronyms used in this section include:

AI - Analog Input
AO - Analog Output
CAD - Computer Aided Design
GCL - General Control Language
CPU - Central Processing Unit
BI - Binary Input
BO - Binary Output
EISA - Extended Industry Standard Architecture
HVAC - Heating, Ventilation, Air Conditioning
I/O - Input/Output
ISA - Industry Standard Architecture
LAN - Local Area Network
B-AAC - BACnet Advanced Application Controller
B-BC - BACnet Building Controller
B-SS - Bacnet Smart Sensor
Native - Native BACnet
OS - Operating SystemOWS - Operator Work Station
PC - Personal Computer
RAM - Random Access Memory
ROM - Read Only Memory
TCU (B-AAC) - BACnet Advanced Application Controller Terminal Control Unit
Ethernet - BACnet TCP/IP Ethernet

MS/TP - BACnet Master-Slave/Token-Passing MS/TP
PTP - BACnet Point-to-Point protocol
BAS - Building Automation System
(B-BC, B-AAC & existing Delta Intellisys Equipment)

.2 Refer to section 23 09 00

1.3 References

.1 Canadian Standards Association
CSA C22.2no.205- M1983 (R2009), Signal Equipment.

.2 Institute of Electrical and Electronic Engineers.

.1 IEEE 472
.2 IEEE 587

.3 National Institute of Standards and Technology

.1 NISTIR 6392 GSA Guide to Specifying Interoperable Building Automation and Control Systems Using ANSI/ASHRAE Standard 135-2010, BACnet.

.4 Native BACnet

.1 All new DDC controllers provided must be NATIVE BACnet

.1 Native BACnet means that no translation software will be used internal to the BACnet Standardized Device Profile for B-OWS, B-BC, B-AAC and TCU(B-AAC)to convert from a proprietary protocol to BACnet Standard Object Types, Standard Application Services and devices.

.2 Gateways are not native BACnet.

.2 BACnet Testing Laboratory Listing (BTL)

.1 All controllers used on this project must have passed BTL listing for the level of controller tested to date by BTL.
This will cover B-ASC and B-AAC controllers.

.3 BACnet Interoperability Building Blocks (BIBB's)

.1 BACnet Interoperability Building Blocks, BIBBs, is the current standard on which to specify interoperability between BACnet Devices. Each BIBB typically has two aspects; an initiation action and the resultant executed action. The two aspects are designated by A or B after the BIBB's name, such as DS-RP-**A** or DS-WP-**B**.
Refer to the applicable controller description for a list of required BIBB's.

.4 The ASHRAE Standard divides each Device's capabilities into 5 functional areas. The Description column provides a synopsis of the BIBB.

.1 Data Sharing - Indicates whether the Device can initiate action, and if it is read only or can be written to (edited).

.2 Alarm and Event Management - This section describes whether a Device can generate or process alarms, handle acknowledgements, and alarm summaries.

.3 Scheduling - indicates what Devices can store the annual and daily schedules, what Devices can edit the schedules.

.4 Trending - describes where the trend data is collected and stored, also what Devices can automatically call up and display the information.

.5 Device and Network Management - This functional area can be broken into five segments:

.1 looking for and identifying Devices on the network
.2 exchanging data with the Device
.3 synchronizing time with the

Devices on the network
.4 "Re-booting" a Device to get it working
.5 providing backups and downloads of Device databases

.5 BACnet Product Description and Relative Capability

Type	BACnet Device	Device	Description
Native BACnet	B-OWS	OWS	Operator Work Station
	B-BC	BC	Building Controller
	B-AAC	AAC	Advanced Application Controller
Gate Ways			

BACnet Device Programmability and System Applications

Device	Program Level Low, Med, Hi	☐	Approved System Applications
OWS		☐	Operator work station
BC		☐	Primary mechanical systems, Air Handling Units, Exhaust Fans includes VAV controls, Chillers etc
AAC		☐	Rooftop units
ASC		☐	
SAS		☐	
SP1		☐	
SP2		☐	
POT		☐	
GW1		☐	
GW2		☐	

Profile of BACnet Devices –
BACnet Interoperability Building Blocks

Data Sharing		B-OWS ☐	B-BC ☐	B-AAC ☐
DS-RP-A	Read Data	☐	☐	☐
DS-RP-B	Sends Data	☐	☐	☐
DS-RPM-A	Read Multiple	☐	☐	
DS-RPM-B	Sends Multiple Data	☐	☐	☐
DS-WP-A	Write Data	☐	☐	☐
DS-WP-B	Allows Editing	☐	☐	☐
DS-WPM-A	Write Multiple	☐	☐	
DS-WPM-B	Allows Multiple changes at once	☐	☐	☐
DS-COV-A	Accepts COV Notification	☐	☐	☐
DS-COV-B	Send COV Notification	☐	☐	☐
DS-COVU-A,B	Reads and Sends Unsolicited Data	☐	☐	☐
Alarm and Event Mgmt.		B-OWS ☐	B-BC ☐	B-AAC ☐
AE-N-A	Process Alarms	☐	☐	
AE-N-I-B	Generate Alarms on Local Objects	☐	☐	☐
AE-N-E-B	Generate Alarms on Remote Objects	☐	☐	☐
AE-ACK-A	Acknowledge Alarms	☐		
AE-ACK-B	Process Acknowledgements	☐	☐	☐
AE-INFO-A	Requests Summary			
AE-INFO-B	Provides Summary			
AE-ESUM-A	Requests Advanced Summary	☐	☐	
AE-ESUM-B	Provides Advanced Summary	☐	☐	☐
Scheduling		B-OWS ☐	B-BC ☐	B-AAC ☐
SCHED-A	Read and Edit Schedules	☐	☐	☐
SCHED-I-B	Provides Date and Time Schedules for Local Objects	☐	☐	☐
SCHED-E-B	Provides Date and Time Schedules for Remote Objects	☐	☐	☐
Trending		B-OWS ☐	B-BC ☐	B-AAC ☐

T-VMT-A	Displays Trend Data	☐		
T-VMT-B	Collects Trend Data		☐	☐
T-VMT-I-B	Trending-Viewing and modifying trends-internal -B	☐		
T-VMT-E-B	Trending-Viewing and modifying trends-external -B	☐		
T-ATR-A	Archives Trend Data	☐		
T-ATR-B	Sends Trend Log Data	☐	☐	☐
Device and Network Mgmt.		B-OWS ☐	B-BC ☐	B-AAC ☐
DM-DDB-A	Looks for new Devices on Network	☐	☐	☐
DM-DDB-B	Provides info about Itself	☐	☐	☐
DM-DOB-A	Seeks Address Info	☐		
DM-DOB-B	Sends Address Info	☐	☐	☐
NM-CE-A	Establishes Network connection	☐	☐	☐
NM-CE-B	Establishes Network connection	☐	☐	☐
DM-DCC-A	Instigates Communication	☐		
DM-DCC-B	Responds to Request for Communication	☐	☐	☐
DM-TS-A	Provides Time Synchronization using Local Time	☐	☐	
DM-TS-B	Receives Local Time Broadcasts		☐	☐
DM-UTC-A	Provides Time Synchronization using Greenwich Mean Time	☐	☐	
DM-UTC-B	Receives Time Synchronization using Greenwich Mean Time		☐	☐
DM-RD-A	Reinitialize a Device	☐		
DM-RD-B	Performs Reinitialize command		☐	☐
DM-BR-A	Over-writes Device from Backup files	☐		
DM-BR-B	Provides Device Backup			
DM-OCD_A	Can create objects in controllers	☐		
DM-OCD_B	Can have objects created in it	☐	☐	☐

END OF SECTION

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.2 Section 230902 - EMCS: Start-up and Check-out.

.3 Section 230904 - EMCS: Project Records and "As-Built" Records.

.4 Section 230907 - EMCS: BACnet Protocol Requirements.

.5 Section 230908 - BACnet Operator Workstation Software and Hardware Requirements.

.6 Section 230914 -BACnet Building Controller B-BC Hardware and Software Definition Requirements.

.7 Section 230915 - BACnet Advanced Application Controller & TCU - AAC Hardware and Software Definition Requirements.

1.2 Acronyms

.1 Acronyms used in this section (refer to section 230900)include:

AI - Analog Input
AO - Analog Output
CAD - Computer Aided Design
CDL - Control Description Logic
CPU - Central Processing Unit
BI - Binary Input
BO - Binary Output
EISA - Extended Industry Standard Architecture
HVAC - Heating, Ventilation, Air Conditioning
I/O - Input/Output
ISA - Industry Standard Architecture
LAN - Local Area Network
B-AAC - Building Advanced Application Controller
B-BC - Building Controller
OS - Operating System

OWS - Operator Work Station - also referenced as B-OWS, BACnet operator workstation
PC - Personal Computer
PCI - Peripheral Control Interface
PCMCIA - Personal Computer Micro-Card Interface Adapter
PCU - Programmable Control Unit (generic term which includes B-AAC, B-BC)
RAM - Random Access Memory
ROM - Read Only Memory
TCU - Refer to B-AAC

.2 Refer to Section 23 09 00.

1.3 System Description .1 Reuse the existing BACnet operator workstation (B-OWS) including BACnet software located in the Summerland Research Building.

.2 Modify and add graphics, modify and add programming to support operation of new lab exhaust fans LEF-4 through LEF-6 and revised operation of existing lab exhaust fans LEF-1 through LEF-3.

1.4 Submittals .1 In accordance with Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.2 Include:

.1 All information as specified for each item.

.2 Manufacturer's detailed installation instructions.

1.5 Maintenance .1 In accordance with Section 230904 - EMCS: Project Records and "As-Built" Records.

PART 2 - PRODUCTS

2.1 Hardware

.1 All real-time control functions to reside in B-BCs, B-AACs, TCU (B-AAC)s.

2.2 Programming Software

.1 The OWS is a fully compliant BACnet OWS. Refer to BACnet Operator Workstation (B-OWS) in section 230907 and clause 1.3 of this section.

.2 Programming software to support BAS hardware and software.

.3 Definition of operator device characteristics, programmable controllers, individual points, applications, control sequences to be performed through:

.1 Use of high level control process language, not template approach.

2.3 BACnet Compliance

.1 Refer to Section 230907 for BACnet requirements.

2.4 Operator's Control Software

.1 Enable non-programmer operator to easily perform tasks which form part of daily routine.

.2 For newly added software and programs, facilitate keyboard visual displays; keyboard, disk, tape, or network entry of information into system; display and logging of system information and following tasks:

.1 Automatic logging of digital alarms and change of status messages.
.2 Automatic logging of analog alarms.
.3 System changes (such as alarm limits, set-points, alarm lockouts).
.4 Display specific point values, states as selected.
.5 Provide reports as requested and on scheduled basis when so required.
.6 Display graphics as requested, and on alarm receptions (user's option).
.7 Display error messages library.
.8 Display list of points within system.
.9 Display list of systems within

building.

.10 Provide trend logs as required.

.11 Provide manual control of DO and AO as required.

.12 Direct output of information to selected device.

.13 On-line changes:

- .1 Alarm limits.
- .2 Setpoints.
- .3 Deadbands.
- .4 Control and change of state changes.
- .5 Time, day, month, year.
- .6 Control loop configuration changes for controller-based CDLs.
- .7 Control loop tuning changes.
- .8 Schedule changes.
- .9 Changes, additions, deletions of points and graphics to total systems.

.14 Following functions under password protection system:

- .1 Initiate BO commands. Where BO normally originated by software, operator to be able to terminate automatic PCU CDL control of any output and to originate manual DO command. Operator to be able to return DO command functions to automatic PCU CDL software control.

- .2 Initiate AO. Where AO normally originated by software, operator to be able to terminate automatic PCU CDL software control of any output or standby mode. Operator to be able to return AO functions to automatic PCU CDL software control.

- .3 Requests for status, analog, graphic displays, logs, controls to be from operator's console. Use mouse or pointing

device to "point and click" for menu selections so as to minimize use of keyboard.

2.5 Error Messages

.1 Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, failure of communications between components of EMCS.

.2 Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

2.6 Access Control to Field Equipment

.1 The intent is to not change the existing access control. Minimum 5 levels of password access protection to limit control, display, data base manipulation capabilities as follows:

.1 No password: data access, display only.
.2 Level 1: Operator overrides.
.3 Level 2: Level 1 + database modifications.
.4 Level 3: Level 2 + database generation.
.5 Level 4: Level 3 + password assignment: addition, modification.

.2 System administration functions to be overlapped with operational functions, ie. ensure password assignment is provided for each function independently and does not default to blocks of functionality.

.3 User-definable, automatic log-off timers from 1 to 60 min. to prevent operators leaving devices on-line inadvertently. Default setting = 3 minutes.

2.7 Trend Data

.1 Includes historical, archival, trend points, control loop plots.

.2 Trend Data shall be provided for

.1 All new and revised input and output

points

.2 One associated software variable per new and revised input and output point.

.3 All trend data shall be stored in the B-BC or B-AAC. TCU trend data will be stored in it's associated B-BC or B-AAC.

.4 All trend data reports will be provided through the OWS.

.5 Trend reports: to trend continuously points selected by operator including at least present value of BI, BO, AI, AO, set points, and calculated values. To trend concurrently at least 40 selectable points from created trend logs in each B-BC and B-AAC at operator-selectable rate 1 seconds to 3600 seconds, individually selected for each point. To permit display or printout of any point individually or in selectable groups. Store trends on 24h basis in temporary storage until point removed from trend program by operator. Provide ability to specify report type, point name, output device, add trend point, delete trend point, scan rate. Display trend plots on OWS. To plot up to 8 selectable points concurrently. For soft copy output, display to automatically index to left when screen becomes full. Trend data to be available in disk form for use in third party PC applications. Provide plotting capabilities to display collected data based on selected range of value being displayed against time/date as is.

.6 Historical data collection: collect concurrently at least 25% of all trend logs available from all B-BC's, B-AAC's and TCU (B-AAC)'s. All data shall be online retrievable using operator control software. Third party software WILL NOT be required to view trend or historical data.

.7 Data collection to be continuous, stored in temporary storage until point is removed from program by operator.

Automatically dump temporary report storage to OWS on periodic 24h basis as minimum or when temporary storage is filled. Inform operator when dump has occurred. Temporary storage to have at least 72h capacity. Implement following reports using Report Generator Program. All reports to include time, day, month, year, report title, operator's initials.

2.8 Report Programs

.1 General:

.1 Refer to Section 230914 - EMCS: Bacnet Building Controller (B-BC).

.2 All reports to include time, day, month, year, report title, operator's initials.

.2 Message control:

.1 Message and alarm buffering to prevent loss of information.
.2 Error detection correction and retransmission to guarantee data integrity.
.3 Default device definition to prevent loss of alarms or data, ensure alarms are reported as quickly as possible in event that operator device does not respond.
.4 Synchronization of real-time clocks in all B-BC panels.

.3 Periodic/automatic report:

.1 To generate specified report(s) automatically including options of start time and date, interval between reports (hourly, daily, weekly, monthly), output device. Software to permit modifying periodic/automatic reporting profile at any time.

.2 Reports to include:

.1 Power demand and duty cycle summary: see application program for same.

.2 Disabled "Locked-out" point summary: include point name, description, whether disabled by system or by operator.
.3 Run time summary: summary of accumulated running time of selected equipment. Include point acronym, description, run time to date, alarm limit setting. Run time to accumulate until reset individually by operator.
.4 Summary of run time alarms: include point acronym, description, run time to date, alarm limit.
.5 Summary of start/stop schedules: include start/stop times and days, point acronym, description.
.6 Motor status summary.

.4 Report types:

.1 Dynamic reports: printout or display of any dynamic value requested by operator. To indicate status at time of request, when displayed, updated at scan frequency or operator-selected time interval. Provide option as to report type, point name, scan rate, output device. Reports to be available on following basis:

.1 All points in system (total connected for this location), multiple "areas".
.2 Area (all points in Area).
.3 Area system (all points in system).
.4 Area system points (individual points).
.5 System (all points by system type).
.6 System point (all points by system and point type).
.7 Area point (all points by system and point type).
.8 Point (all points by point type).

.2 Summary report: printout or display of any data base value selected by operator. To indicate status at time of request. Reports to be available on same basis as Dynamic reports. Provide option as to report type, point name, output device.

2.9 Graphics

.1 Add and modify graphics as required to permit operator to start and stop new equipment, change set-points, modify alarm limits, override system functions and points from graphic displays through mouse or similar pointing device.

.2 Display particular graphics: provide for manual and/or automatic activation. To include capability to call up and cancel display of graphic picture.

.3 New and revised dynamic data (such as temperature, humidity, flow, status) to be shown in actual schematical locations, be automatically updated to show current values without operator intervention.

.7 Utilize existing graphics package to generate schematic diagrams as specified in I/O summaries, as directed by Departmental Representative.

.9 Complete directory of system functions, schematics list, other pertinent information. Utilize mouse to "point and click" to activate selected function.

2.10 Alarms

.1 All new alarms to be classified as "critical", "cautionary", "maintenance". Personnel having required password level to designate alarms and alarm classifications.

.2 Presentation of alarms to include features identified under applicable report definitions of report program paragraph.

.3 Alarm reports to include:

.1 Summary of all points in critical alarm. Include at least point name, point description, alarm type, current value, limit exceeded.
.2 Summary of all points in maintenance alarm. Include at least point name, point description, alarm type, current value.
.3 Analog alarm limit summary: include point acronym, alarm limits, deviation limits.
.4 Summary of all alarm messages: include associated point name, description, alarm description.

.4 Use existing software to notify operator of occurrence of alarm conditions for new equipment. Each new point to have its own alarm message.

.5 EMCS to notify operator of occurrence of alarms within following time period of detection:
.1 Critical - 2 seconds.
.2 Cautionary - 8 seconds.
.3 Maintenance - upon operator's request.

.6 Display alarm messages in English.

.7 Primary alarm message to include as minimum: location of alarm, time of occurrence, type of alarm. Provide for initial message to be automatically presented to operator whenever associated alarm is reported. Assignment of secondary messages to point to be operator- editable function. Provide operator-editable secondary messages giving further information (such as telephone lists, maintenance functions) on per point basis.

.8 System reaction to alarms: alarm annunciation to be by split format screen OWS and visual and audible hardware indication. Acknowledgement of alarm to change visual indicator from flashing to steady state and to silence audible device. Steady state to remain until alarm condition is corrected but must not to impede reporting of new alarm conditions.

Notification of any type of alarm not to impede notification of other alarms or operation of PCU/CDL.
Random occurrence of alarms at any rate not to cause loss of any alarm or over-burden system. Any single alarm (on per B-BC basis) to be recognized by OWS for appropriate alarm handling within 2 seconds of its occurrence. Acknowledgement of one alarm not to be considered as acknowledgement of any other alarms.

.9 Controller network alarms: system supervision of controllers and communications lines to provide following alarms as minimum:

.1 Controller not responding - where possible delineate between controller and communication line failure.
.2 Controller responding - return to normal.
.3 Controller communications bad - high error rate.
.4 Controller communications normal - return to normal.

.10 Digital/alarm status to be interrogated every 2 seconds as minimum or be direct interrupting non-polling type. Annunciate each non-expected status with alarm message.

2.11 Archiving

.1 Store back-up copies of all new controller databases on the existing OWS.

.2 Provide continuous supervision of integrity of all new controller databases. If controller loses database, system to automatically download new copy of database to restore proper operation.

.3 Data base back-up and downloading to occur over LAN. Operator to be able to manually download entire controller data base or parts thereof.

2.12 Utility Software

.1 Enter all soft copy submissions, including

"Record" drawings specified Section 230901 - EMCS: Shop Drawings, Product Data and Review Process in OWS and available via the graphical display through an ICON by an operator without having to switch to another software application first.

PART 3 - Execution

3.1 Installation Requirements

.1 Provide all necessary power as required from local 120 V emergency power branch circuit panels to all controller equipment, controllers, applicable terminal devices. Install tamper locks on breakers of circuit panels.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.2 Section 230904 - EMCS: Project Records Documents.

1.2 References

.1 American National Standards Institute (ANSI)
- .1 ANSI C12.7-2005, Requirements for Watt hour Meter Sockets.
- .2 ANSI/IEEE C57.13-2008, Requirements for Instrument Transformers.

.2 American Society for Testing and Materials International, (ASTM).
- .1 ASTM B148-97(2009), Standard Specification for Aluminum-Bronze Sand Castings

.3 National Electrical Manufacturer's Association (NEMA)
- .1 NEMA 250-2011, Enclosures for Electrical Equipment (1000 Volts Maximum).

.4 Air Movement and Control Association, Inc. (AMCA).
- .1 AMCA Standard 500-D-2012, Laboratory Method of Testing Dampers For Rating.

.5 Canadian Standards Association (CSA International).
- .1 CSA-C22.1-09, Canadian Electrical Code, Part 1 (21st Edition), Safety Standard for Electrical Installations

1.3 Submittals

.1 Submit shop drawings and manufacturer's installation instructions in accordance with Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.2 Include:

- .1 Information as specified for each device.
- .2 Manufacturer's detailed installation instructions.

.3 Manufacturer's Instructions

.1 Submit manufacturer's installation instructions for specified equipment and devices.

1.4 Closeout Submittals .1 Submit operating and maintenance data for inclusion in operation and maintenance manual in accordance with Section 230904 - EMCS: Project Records Documents.

1.5 Existing Conditions .1 Repair surfaces damaged during execution of Work.

.2 Turn over to Departmental Representative existing materials removed from Work not identified for re use.

PART 2 - PRODUCTS

2.1 General .1 Control devices of each category to be of same type and manufacturer.

.2 External trim materials to be corrosion resistant. Internal parts to be assembled in watertight, shockproof, vibration-proof, heat resistant assembly.

.3 Operating conditions: 0 - 32 °C with 10 - 90 % RH (non-condensing) unless otherwise specified.

.4 Terminations: use standard conduit box with slot screwdriver compression connector block unless otherwise specified.

.5 Transmitters to be unaffected by external transmitters including walkie-talkies.

.6 Account for hysteresis, relaxation time, maximum and minimum limits in applications of sensors and controls.

.7 Outdoor installations: use weatherproof construction in NEMA 4 enclosures.

.8 Devices to be installed in user occupied space must not exceed Noise Criteria (NC) of 35. Noise

generated by any device must not be detectable above space ambient conditions.

2.2 Pressure/Current (P/I) Transmitters

.1 Requirements:

.1 Range: as indicated in I/O summaries.
  .1 Pressure sensing elements: bourdon tube, bellows or diaphragm type.
  .2 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.
.2 Output signal: 4 - 20 mA into 500 ohm maximum load.
.3 Output variations: less than 0.2 % full scale for supply voltage variations of plus or minus 10 %.
.4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 0.5 % of full scale output over entire range.
.5 Integral zero and span adjustment.
.6 Temperature effects: not to exceed plus or minus 1.5 % full scale/ 50 °C.
.7 Over-pressure input protection to at least twice rated input pressure.
.8 Output short circuit and open circuit protection.
.9 Pressure ranges: see I/O Summaries.
.10 Accuracy: plus or minus 1% of Full Scale.

2.3 Differential Pressure (kPa) Transmitters

.1 Requirements:

.1 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.
.2 Output signal: 4 - 20 mA into 500 ohm maximum load.
.3 Output variations: less than 0.2 % full scale for supply voltage variations of plus or minus 10 %.
.4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 0.5 % of full scale output over entire range.
.5 Integral zero and span adjustment.

.6 Temperature effects: not to exceed plus or minus 1.5 % full scale/ 50 °C.
.7 Over-pressure input protection to at least twice rated input pressure.
.8 Output short circuit and open circuit protection.
.9 The unit to have a 12.5 mm N.P.T. conduit connection. The enclosure shall be an integral part of the unit.

2.4 Differential Pressure (Pa) Transmitters

.1 Requirements:

.1 Output signal: 4 - 20 mA into 500 ohm maximum load.
.2 Output variations: less than 0.2% full scale for supply voltage variations of plus or minus 10%.
.3 Integral zero and span adjustment.
.4 Temperature effects: not to exceed plus or minus 1.5% full scale/ 50 C.
.5 Output short circuit and open circuit protection.
.6 The unit to have a 12.5 mm N.P.T. conduit connection. The enclosure shall be an integral part of the unit.
.7 Pressure ranges: see I/O Summaries.

2.5 Fan System Static Pressure Sensors

.1 Requirements:

.1 Multipoint element with self-averaging manifold.
.1 Maximum pressure loss: 160 Pa at 10 m/s. (Air stream manifold).
.2 Accuracy: plus or minus 1 % of actual duct static pressure.

2.6 Fan System Static Pressure Transmitters

.1 Requirements:

.1 Output signal: 4 - 20 mA linear into 500 ohm maximum load.
.2 Calibrated span: not to exceed 150 % of duct static pressure at maximum flow.
.3 Accuracy: 0.4 % of span.
.4 Repeatability: within 0.5 % of output.
.5 Linearity: within 1.5 % of span.
.6 Deadband or hysteresis: 0.1 % of span.
.7 External exposed zero and span adjustment.

.8 The unit to have a 12.5 mm N.P.T. conduit connection. The enclosure shall be an integral part of the unit.

2.7 Velocity Pressure Sensors

.1 Requirements:

.1 Multipoint static and total pressure sensing element with self-averaging manifold with integral air equalizer and straightener section.
.2 Maximum pressure loss: 37Pa at 1000 m/s.
.3 Accuracy: plus or minus 1% of actual duct velocity.

2.8 Velocity Pressure Transmitters

.1 Requirements:

.1 Output signal: 4-20 mA linear into 500 ohm maximum load.
.2 Calibrated span: not to exceed 125% of duct velocity pressure at maximum flow.
.3 Accuracy: 0.4% of span.
.4 Repeatability: within [0.1] [___] % of output.
.5 Linearity: within 0.5% of span.
.6 Deadband or hysteresis: 0.1% of span.
.7 External exposed zero and span adjustment.
.8 Unit to have 12.5 mm N.P.T. conduit connection. Enclosure to be integral part of unit.

2.9 Pressure and Differential Pressure Switches

.1 Requirements:

.1 Internal materials: suitable for continuous contact with compressed air, water, steam, etc., as applicable.
.2 Adjustable setpoint and differential.
.3 Switch: snap action type, rated at 120V, 15 amps AC or 24 V DC.
.4 Switch assembly: to operate automatically and reset automatically when conditions return to normal. Over pressure input protection to at least twice rated input pressure.
.5 Accuracy: within 2% repetitive switching.
.6 Provide switches with isolation valve and snubber, where code allows, between sensor and pressure source.
.7 Switches on steam and high temperature hot water service: provide pigtail syphon

2.10 Electromechanical Relays

.1 Requirements:

.1 Double voltage, DPDT, plug-in type with termination base.
.2 Coils: rated for 120V AC or 24V DC. Other voltage: provide transformer.
.3 Contacts: rated at 5 amps at 120 V AC.
.4 Relay to have visual status indication.

2.11 Solid State Relays

.1 Requirements:

.1 Double voltage, DPDT, plug-in type with termination base.
.2 Coils: rated for 120V AC. Other voltage: provide transformer.
.3 Contacts: rated at 5 amps at 120 V AC.
.4 General:
- To be socket or rail mounted.
- To have LED indicator.
- Input and output Barriers Strips to accept 14 to 28 AWG wire.
- Operating temperature range to be -20 degrees C to 70 degrees C.
- Relays to be CSA certified.
- Input/output isolation voltage to be 4000 VAC at 25 degrees for 1 second Maximum duration.
- Operational frequency range, 45~65 Hz

.5 Input:
- Control voltage, 3 to 32 VDC
- Drop out voltage, 1.2 VDC
- Maximum input current to match AO (Analog Output) board.

.6 Output:
- AC/DC output model to suit application

2.12 Current Transducers

.1 Requirements:

.1 Range: as indicated on I/O Summaries.

.2 Purpose: combined sensor/transducer, to measure line current and produce proportional signal in one of following ranges:

.1 4-20 mA DC.
.2 0-1 volt DC.
.3 0-10 volts DC.
.4 0-20 volts DC.

.3 Frequency insensitive from 10 - 80 hz.

.4 Accuracy to 0.5% full scale.

.5 Zero and span adjustments. Field adjustable range to suit motor applications.

.6 Adjustable mounting bracket to allow for secure/safe mounting inside the MCC.

2.13 Current Sensing Relays

.1 Requirements:

.1 Suitable to detect belt loss or motor failure.
.2 Trip point adjustment, output status LED.
.3 Split core for easy mounting.
.4 Induced sensor power.
.5 Relay contacts: capable of handling 0.5 amps at 30 VAC / DC. Output to be NO solid state.
.6 Suitable for single or 3 phase monitoring. For 3 Phase applications: provide for discrimination between phases.
.7 Adjustable latch level.

2.14 Control Dampers

.1 Construction: blades, 152 mm wide, 1219 mm long, maximum. Modular maximum size, 1219 mm wide x 1219 mm high. Multiple sections to have stiffening mullions and jack shafts.

.2 Materials:

.1 Frame: 2.3 mm minimum thickness galvanized steel.

.2 Blades: galvanized steel with two sheets 0.5 mm thick or otherwise reinforced to ensure specified low leakage when fully closed.

.3 Bearings: oil impregnated sintered bronze. Provide thrust bearings for vertical blades.

.4 Linkage and shafts: zinc plated steel.

.5 Seals: replaceable neoprene or stainless

steel spring on sides, top, bottom of frame, along all blade edges and blade ends.

.3 Performance: minimum damper leakage meet or exceed AMCA Standard 500-D ratings.

.1 Size/Capacity: refer to damper schedule.
.2 0.02 L/s.m ^{2} maximum allowable leakage against 1000 Pa static pressure.
.3 Temperature range: minus 50 °C to plus 100 °C.

.4 Arrangements: dampers mixing warm and cold air to be parallel blade, mounted at right angles to each other, with blades opening to mix air stream.

.5 Jack shafts:
.1 25 mm diameter solid shaft, constructed of corrosion resistant metal complete with required number of pillow block bearings to support jack shaft and operate dampers throughout their range.
.2 Include corrosion resistant connecting hardware to accommodate connection to damper actuating device.
.3 Install using manufacturer's installation guidelines.
.4 Use same manufacturer as damper sections.

2.15 Electronic Control Damper Operators

.1 Requirements:

.1 Direct mount proportional type as indicated.

.2 Spring return for "fail-safe" in Normally Open or Normally Closed position as indicated.

.3 Operator: size so as to control dampers against maximum pressure or dynamic closing pressure (whichever is greater).

.4 Power requirements: 5 VA maximum at 24 V AC.

.5 Operating range: 0-10 V DC or 4-20 mA DC.

.6 Damper actuator to drive damper from full open to full closed in less than 120 seconds.

2.16 Panels

.1 Either free-standing or wall mounted enameled steel cabinets with hinged and key-locked front door.

.2 To be modular multiple panels as required to handle requirements with additional space to accommodate future capacity as required by Departmental Representative without adding additional cabinets.

.3 Panels to be lockable with same key.

2.17 Air Flow Measuring Stations

.1 Differential Pressure Airflow Probes:

.1 Air flow measuring station with dual chamber extrusion and downstream low pressure pickup to amplify differential pressure.

.2 Probe lengths and numbers to be provided to suit duct locations as shown on the drawings. Probe material to be extruded aluminum.

.3 Pressure loss from probes to be not greater than 10% of the velocity pressure at maximum design flow.

.4 Probes greater than 400 mm in length to be supported at both ends.

.5 Maximum operational temperature to 121 degrees Celsius.

.6 Manufacturer: Hydro-Air Technical Services.

.2 Pressure Transducer

.1 Panel mounted transmitter for accurate, repeatable measurement of differential and static pressure for airflow measuring stations.

.2 The pressure sensing element to be constructed of non-corrosive parts.

.3 Sensor range to cover 25 Pa to 2485 Pa.

.4 4-20 mA or 1-10V output.

.5 Manufacturer: Setra.

2.18 Variable Speed Drive Controller

.1 Minimum Requirements:

.1 Unit to operate with an input, line side power factor of 0.94 or better at all speeds and loads.

.2 All units supplied to the project must be of the same manufacturer and model type. Match existing where practical.

.3 Factory C.S.A. certified.

.4 Unit to operate in ambient temperatures ranging from 0°C to +40°C.

.5 Unit to operate at full load with a variation of -15% and +10% of rated building voltage.

.6 Unit to operate at full load with a variation of +5% of rated frequency.

.7 Printed circuit board design using the latest "state of the art" components including microprocessor control of protective circuits.

.8 Suitable for use with the standard or high efficiency EEMAC Design B motors used on this project.

.9 VSD module and all additional peripheral components as specified herein, to be integrated and mounted in one common EEMAC 1 (use EEMAC 3R for outdoor units) floor mounted enclosure.

.10 Transformers shall not be used on either the input or output of unit.

.11 The VSD shall have an adjustable PWM carrier/switching frequency from nominal 1 through 12 kHz.
Units unable to adjust to a minimum upper level of 12 kHz are not acceptable.
Maximum switching frequency of 16 kHz.

.12 The VSD shall include reactors or LRC filters as necessary to protect the motor from PWM - IGBT voltage spikes and limit the voltage rise times and maximum peak voltages throughout the specified building voltage range and for all operating conditions at the related motor connections as follows:

.1 Maximum peak voltage 1000 volts.
.2 Maximum voltage rate of rise: 500 volts/microsecond.

.13 Unit shall be provided with protection against:

.1 Stalls caused by overcurrent.
.2 Stalls caused by regenerative overvoltage.
.3 Overcurrent protection.,
.4 Regenerative overvoltage protection.
.5 Overload protection (thermal type).
.6 Ground fault protection.
.7 Instantaneous power failure protection.
.8 Alarm against overload.
.9 Over temperature of heat sink.
.10 Input power under voltage, over voltage and phase loss.
.11 DC bus over voltage.

.14 The unit shall have the following features:

.1 Adjustable acceleration and deceleration. Across the line starting shall not be possible. A ramp up time from 0 RPM to 1800 RPM of 30 seconds shall be the minimum possible ramp up time.
.2 Dynamic breaking for acceleration and stopping.
.3 Critical speed avoidance will allow for the selection of two skip speeds

and a rejection band of 0 - 10Hz around each speed.

.4 Voltage/frequency ratio and adjustment.

.5 Power failure restart to be selectable and programmable for number of attempt's & time interval between attempt's. Unit also to have circuits to permit a start into a rotating motor, in either direction without trip or failure.

.6 Frequency range (output) 2 - 60 Hz minimum.

.7 Frequency resolution of 0.5 Hz or better.

.8 Frequency accuracy of +/-0.5% at 25°C.

.9 Able to accept a 4-20 milliamp, 0 to 5 vdc or 0 to 10 vdc external control signal for speed control.

.10 Able to accept a remote start / stop control.

.11 Minimum of 3 programmable preset speeds to facilitate operation of the unit from interlocks, at fixed speeds.

.15 Provide EMI filters to reduce EMI to FCC acceptance levels.

.16 The units shall have the following components:

.1 Run and Stop pushbuttons or switch.

.2 Hand-Off-Auto selector switch.

.3 Manual speed adjusting potentiometer.

.4 Fused disconnect switch rated for the full connected load and complete with lockable, through door operator, defeatable with screw driver. Fuses to be suitable semi-conductor rated.

.5 Trip relay with light.

.6 Run relay with light.

.7 Digital speed indicator, 0 - 110%.

.8 110 volt control transformer, fused in the primary and secondary.

.9 Auto reset thermal overload - relay interlocked in run circuit.

.10 Terminal strip to accept N.C. safety contacts such as freeze stats and smoke alarms to safety shut down VSD when in Hand or Auto position.

.11 BACnet Interface card for interface

with BMS to provide full control, status and alarm interface.

.12 Form C contacts to indicate run mode.

.13 Form C contacts to indicate fault or alarm mode.

.14 0 to 10 vdc output signal directly proportional to controller's speed.

.15 Provide integral factory wired and mounted bypass provisions, such that the controlled motors can be manually put into operation bypassing the VSD. Bypass to consist of a motor contactor and overload relay rated for the connected load.
The bypass must have its own isolating device to allow corrective work on the VSD whilst operating in the bypass mode.
Bypass contactor and VSD must be fully interlocked to prevent both outputs being enabled simultaneously.
Control of the bypass will be by means of an enclosure door mounted VSD Bypass selector and Start Stop pushbuttons.
Two door mounted lamps shall be provided to indicate operating mode (VSD or Bypass).

.17 Units shall be equipped with a 5% line reactor and a harmonic filter on the power input side to prevent the back feeding of harmonics into the power system. Filters should control the THD within the values specified by IEEE 519.

.18 Refer to Schedule - VARIABLE SPEED DRIVES. VSD's serve general exhaust/general return high plume dilution fans.

.19 VSD's shall be installed by the Controls Contractor. All power wiring connections shall be by Division 26 and all control wiring by the Controls Contractor.

.20 The manufacturer's representative shall be present at start-up and shall supervise the start-up and test the voltage at the motor connection with the Commissioning Agency present with a digital oscilloscope with

storage capacity and with a sufficiently fast sample time to accurately measure voltage rate of rise to confirm that the voltage spikes and rate of rise are within the specified level. Submit the results to the Consultant including the input voltage on all three phases to the VSD at the time of measurement.

.21 The manufacturer's representative shall be present for a minimum of 1/2 day to instruct the building maintenance personnel in the correct use and operation of the VSD units following the commissioning of the systems.

.22 Provide a parts and labour warranty for three years subsequent to Substantial Completion for the Variable Speed Drives.

.23 Provide a three year parts and labour warranty against VSD related failure for each motor connected to a VSD power output.

.24 Shop drawings shall include:

.1 Dimensional drawings.
.2 All connection points.
.3 Power circuit diagrams.
.4 Installation and maintenance manuals.
.5 Warranty description.
.6 Certification of agency approvals.
.7 Conformance to each specified requirement.
.8 Placement of input and output reactors / filters, EMI filters, semi-conductor rated fuses (where required).
.9 Harmonic analysis indicating the level of harmonic distortion that the drives will cause.

.25 Variable speed drives shall be configured with hand-off-auto override capability. For applicable fans, the hand position shall override the normal EMCS control output but not the FFPC control output or the freeze protection interlock. When the VSD is bypassed for maintenance or due to failure the controlled motor shall operate as if in hand position such that the FFPC

control output and the freeze protection interlock (if applicable) are not overridden.

.26 Manufacturer: Benshaw to match existing, no substitutions.

PART 3 - EXECUTION

3.1 Installation

.1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.

.2 Install field control devices in accordance with manufacturers recommended methods, procedures and instructions.

.3 Temperature transmitters, humidity transmitters, current-to-pneumatic transducers, solenoid air valves, controllers, relays: install in NEMA I enclosure or as required for specific applications. Provide for electrolytic isolation in all cases when dissimilar metals make contact.

.4 Support field-mounted transmitters, sensors on pipe stands or channel brackets.

.5 Install wall mounted devices properly attached to wall.

.6 Provide a new air flow measuring station to the laboratory exhaust fans' by-pass damper section.

.7 Fire stopping: provide space for fire stopping. Maintain fire rating integrity.

.8 Electrical:

.1 Complete installation in accordance with Section 26 05 00 - Electrical General Requirements.

.2 Modify existing starters to provide for EMCS as indicated in I/O Summaries and as indicated.

.3 Refer to electrical control schematics included as part of control design schematics in Section 23 09 93 - EMCS: Site Requirements, Applications and Systems Sequences of Operation. Trace existing

control wiring installation and provide updated wiring schematics including additions, deletions to control circuits for review by Departmental Representative before beginning Work.

.4 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.

.5 Install communication wiring in conduit.

.1 Provide complete conduit system to link Building Controllers, field panels and OWS(s).

.2 Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems.

.3 Maximum conduit fill not to exceed 40%.

.4 Design drawings do not show conduit layout.

.6 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Departmental Representative to review before starting Work. Wiring in mechanical rooms, wiring in service rooms and exposed wiring must be in conduit.

3.2 Panels

.1 Arrange for conduit and tubing entry from top, bottom or either side.

.2 Use modular multiple panels if necessary to handle all requirements, with space for additional 10% spare capacity without adding additional hardware for all main mechanical room areas.

.3 Wiring and tubing within panels: locate in trays or individually clipped to back of panel.

.4 Identify wiring and conduit clearly.

3.3 Pressure and Differential Pressure Switches and Sensors

.1 .1 Install isolation valve and snubber on sensors between sensor and pressure source where code allows.

3.4 I/P Transducers

.1 Install air pressure gauge on fan discharge outlet.

3.5 Air Pressure Gauges	.1	Install on new pneumatic systems only.
	.2	Install on E to P Transducers
3.6 Field Mounted Transmitters and Sensors	.1	Support properly on pipe stands or channel brackets.
	.2	Install wall mounted devices on plywood panel attached properly to wall.
3.7 Identification	.1	Identify field devices properly.
3.8 Air Flow Measuring Stations	.1	Cap manifold until cleaning of ducts is completed.
3.9 Variable Speed Drive Controller	.1	Follow Manufacturer's recommendations.
	.2	Test and calibrate VSD at startup.
	.3	Optimize, set and record operating variables. Include in the Maintenance Manual.
	.4	Refer to the startup requirements listed under clause 2.18.
3.10 Testing	.1	Calibrate and test field devices for accuracy and performance. Submit report detailing tests performed, results obtained to Departmental Representative for approval. Departmental Representative will verify results at random. Provide testing equipment and manpower necessary for this verification.
3.11 Commissioning	.1	Refer to Section 230903 - EMCS: Commissioning.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230900 - EMCS: General Requirements.

.2 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.3 Section 230904 - EMCS: Project Records and "As-Built" Records.

.4 Section 230907 - EMCS: BACnet Protocol Requirements.

1.2 Acronyms

.1 Acronyms used in this section include:

AI - Analog Input
AO - Analog Output
CAD - Computer Aided Design
GCL - General Control Language
CPU - Central Processing Unit
BI - Binary Input
BO - Binary Output
EISA - Extended Industry Standard Architecture
HVAC - Heating, Ventilation, Air Conditioning
I/O - Input/Output
ISA - Industry Standard Architecture
LAN - Local Area Network
B-AAC - Local Control Unit
B-BC - Master Control Unit
OS - Operating System
B-OWS - Operator Work Station
PC - Personal Computer
RAM - Random Access Memory
ROM - Read Only Memory
TCU (B-AAC) - Terminal Control Unit
B-BC - BACnet Building Controller
B-AAC - BACnet Advanced Application Controller
B-SS - BACnet Smart Sensor
Ethernet - BACnet TCP/IP Ethernet
MS/TP - BACnet Master-Slave/Token-Passing MS/TP
PTP - BACnet Point-to-Point protocol

.2 Refer to section 23 09 00.

1.3 Reference

.1 American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. (ASHRAE).
.1 ASHRAE [2011], Applications Handbook, SI Edition.

.2 Canadian Standards Association
.1 CSA C22.2no.205- M1983(R2009), Signal Equipment.

.3 Institute of Electrical and Electronic Engineers (IEEE).

.1 IEEE C37.90.1 [02], Surge Withstand Capabilities (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

.4 Public Works and Government Services Canada (PWGSC)/Real Property Branch/Architectural and Engineering Services.
.1 MD13800-[September 2000], Energy Management and Control Systems (EMCS) Design Manual. English:
ftp://ftp.pwgsc.gc.ca/rps/docentre/mechanical/me214-e.pdf

1.4 System Description

.1 Refer to section 230907 for additional BACnet requirements.

.2 B-BCB-BC BACnet overview: A B-BCB-BC is a general purpose, field programmable controller capable of carrying out a variety of building automation and control tasks. It enables the specification of the following:

.1 Data Sharing

- Ability to provide the values of any of its BACnet objects
- Ability to retrieve the values of BACnet objects from other devices
- Ability to allow modification of all of its BACnet objects by another device

.2 Alarm and Event Management

- Generation of alarm/event notifications and the ability to direct them to recipients
- Maintain a list of unacknowledged alarms/events
- Notification of other recipients that the acknowledgment has been received
- Adjustment of alarm/event parameters

.3 Scheduling

- Ability to schedule output actions, both in the local device and in other devices, both binary and analog, based on date and time

.4 Trending

- Collection and delivery of (time, value) pairs.

.5 Device and Network Management

- Ability to respond to information about its status
- Ability to respond to requests for information about any of its objects
- Ability to respond to communication control messages
- Ability to synchronize its internal clock upon request
- Ability to perform re-initialization upon request
- Ability to upload its configuration and allow it to be subsequently restored
- Ability to command half-routers to establish and terminate connections

Provide sufficient number of B-BCB-BC's to fully meet all requirements of this specification plus specified spare point capacity.
B-BC's must be used in central mechanical areas for all fan systems, air handling systems, boilers, heat exchangers, chillers,etc.
It is mandatory to have a mininum of one B-BC connected to the BACnet ethernet WAN in each mechanical room.
An Ethernet gateway connecting the WAN to the building B-BC is NOT acceptable.

.3 B-BC to be stand-alone intelligent controller. B-BC panel to:

.1 Be microprocessor based, multi-tasking, multi-user, real-time digital control processors capable of supervising other lower level programmable controllers through secondary networks.

.2 Consist of modular hardware with plug-in processors, communication controllers, power supplies, I/O modules.

.3 Provide MS/TP BACnet LAN port for local B-

AAC and/or TCU network.

.4 Provide on board LAN interface for ethernet BACnet peer-to-peer communication between B-BCs and at least 2 data communication ports to support simultaneous operation of multiple operator I/O devices such as industry standard printers, lap-top workstations, PC work-stations and/or portable B-OWS's. One RS-232C data port, will support point to point PTP BACnet protocol and 2nd port to support BACnet MSTP (RS485 protocal).

.5 Allow temporary use of portable devices without interrupting normal operation of permanently connected modems, printers, B-OWS's.

.6 Interface field sensors via local I/O terminations located on B-BC located in processor cabinet.

.7 In standalone mode execute programmable logic control (direct digital or closed loop process control) of associated HVAC equipment without interacting with other processors or B-OWSs.

.8 Dial-up Communications:

.1 Auto-dial/auto-answer communications to allow B-BCs to communicate with remote B-OWS on non-continuous basis via telephone lines.

.2 To analyze and set priorities for all alarms to minimize of calls. Non-critical alarms to be buffered in memory and reported as group or until operator manually requests upload of alarms.

1.5 Basic Functional Requirements

.1 To include scanning of binary and analog inputs, binary change of state (alarm) monitoring, analog input (alarm) monitoring, on-off binary control with programmable logic (including PID) with adjustable dead bands and deviation alarms, control of HVAC systems as required to meet design intent.

.2 Optimization functions such as scheduled start-stop, optimal start-stop, timed setpoint reset may reside in B-BC or B-AACs as applicable.

1.6 Submittals

.1 In accordance with Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.2 Include:

.1 All information as specified for each device.
.2 Manufacturer's detailed installation instructions.
.3 One line diagrams from sensors or control point to B-BC, including all components, signal values and cable identification and TXPG.
.4 Termination cabinets with termination listings.
.5 Control diagrams, sequences of operation for each system, control logic, electrical interface drawings for safeties and automatic motor control using industry standard symbols.

.3 Shop drawings to be in hard and soft copy.

1.7 Maintenance

.1 In accordance with Section 230904 - EMCS: Project Records and "As-Built" Records.

PART 2 - PRODUCTS

2.1 Environmental Conditions

.1 B-BC and associated hardware and software to operate in conditions of 0 °C to 44 °C and 20 % to 90 % non-condensing RH.

2.2 Purpose of B-BC

.1 The Main function of B-BC is to provide direct control of all main central mechanical systems such as chillers, boilers, heat exchangers, domestic hot water, and HVAC units. Coordinate peer to peer high speed BACnet ethernet fully programmable NATIVE BACnet communications, and supervision of subordinate MSTP (RS485) native BACnet B-AAC fully programmable devices.

2.3 B-BC Controller

.1 When I/O is required it is to have a minimum of

Capacity

20 universal I/O points as specified in this section. All I/O shall be universal not dedicated binary or analog types.

.2 Models can be selected that can be expanded at the B-BC to allow up to 144 points.

.3 All points of logical mechanical system to be within one B-BC.

2.4 Spare Capacity

.1 Provide 10% spare point capacity (a minimum of 10% of input points and 10% of output points) for each B-BC (or mechanical room upon approval of Departmental Representative) without additional cards, terminals.

.2 Provide 10% spare capacity for all new and upgraded existing B-BCs.

2.5 Central Processor Unit (CPU)

.1 Processor is existing and shall be reused.

.2 All point descriptors shall be stored resident at the B-BC and NOT on the operator work station terminal.

2.6 Lockable Panels

.1 To be EEMAC rated to suit environmental requirements and to match existing panels on site.

.2 To have hinged doors equipped with standard key-alike cabinet locks, keyed to same key as existing panels.

2.7 Local B-BC Input/Output Boards

.1 To electronically interface sensors and control devices to processor unit.

.2 To include, but not be limited to, following:

.1 Programmable software logic to meet functional and technical requirements.
.2 Power supplies for operation of associated field equipment.
.3 Lockable wall cabinet with tamper alarm (unless housed in processor unit cabinet).
.4 All required communications equipment for high speed BACnet ethernet communications and BACnet MS/TP (RS485).

.5 Leave controlled systems in "fail-safe" mode in event of loss of communication with, or failure of, processor unit.
.6 To include as minimum AI, AO, BI, BO functions as specified.
.7 Conveniently located screw type or spade lug removable terminals for I/O field wiring.

.3 AI interface equipment to:

.1 Convert analog signals to digital format with 12 bit analog-to-digital resolution.
.2 Provide for following input signal types and ranges:
.1 4-20 mA.
.2 0-10 V DC.
.3 1 - 5 VDC

.3 Meet IEEE 472 surge withstand capability.

.4 Have common mode signal rejection greater than 60 dB to 60 Hz.

.4 AO interface equipment to:

.1 Convert digital data from processor to acceptable analog output signals to digital format with 8 bit digital-to-analog resolution.

.2 Provide for following output signal types and ranges:

.1 4-20 mA.
.2 0-10 V DC.
.3 Meet IEEE 472 surge withstand capability.

.3 For each AO serving major mechanical equipment (see clause Part 2.2.1), provide a monitored "Hand-Off-Auto"(HOA) switch (in all three positions) in conjunction with a gradual manual potentiometer monitored for output position to allow control of the respective Analog output when the HOA switch is in "manual" mode. The B-OWS graphical display shall show the positions of the override switch and potentiometer.

.5 BI interface equipment to:

.1 Be able to sense relay contact closure.
.2 Meet IEEE 472 surge withstand capability.
.3 Accept pulsed inputs up to 10 kHz.

.6 BO interface equipment to:

.1 Switch outputs up to 0.5 amps at 24 VAC.

.2 Switch up to 5 amps at 120 VAC using operational relay interface.

.3 For each BO, serving major mechanical equipment (see clause Part 2.2.1), provide a monitored "Hand-Off-Auto"(HOA) switch (in all three positions) to allow control of the respective digital output when the HOA switch is in "manual" mode. The B-OWS graphical display shall show the positions of the override switch and potentiometer.

2.8 Surge and Transient Protection

.1 Provide isolation at all network terminations as well as all field point terminations to suppress induced voltage transients consistent with IEEE 587.

.2 In event of loss of normal power, provide orderly shutdown of all B-BC's to prevent loss of database or operating system software. Incorporate EEPROM for all critical controller configuration data. Provide battery back-up to support real-time clock and all volatile memory for 72 h minimum.

.3 Upon restoration of normal power, B-BC to automatically resume full operation without manual intervention.

.4 In event of B-BC memory loss, user to be able to reload B-BC via remote B-OWS, local RS-232C port, telephone line dial-in.

2.9 Software

.1 General:

.1 Include as minimum operating system executive, communications, application programs, operator interface, and GCL.

.2 Include all initial programming of all PCU's, B-BC's and entire system.

.2 Program and data storage:

.1 Store all executive programs and site configuration data in ROM, RAM or other non-volatile memory.

.2 Maintain CDL and operating data such as setpoints, operating constants, alarm limits in battery-backed RAM or EEPROM for modification by operator.

.3 Programming languages:

.1 All GCL General Control Language software to be programmed in general control type or high level control language supporting full BACnet objects and functionality.

.2 General Control Language (GCL) - Refer to Section 230993.

.3 Self documenting control programs (similar to Basic Language Programs) created to regulate the control points in a easy to understand, recognizable format.

Example:

```
AVG-TEMP = AVG (TEMP-1 TEMP-2 TEMP-3 )
IF AVG-TEMP > 24.2 THEN START COOLING
IF AVG-TEMP < 24.2 THEN STOP COOLING
```

.4 The following functions are to be provided:

- Average, High Select, Low Select, Abs Value
- Add, Subtract, Multiply, Divide, Square Root
- Equal, Greater than, Less than, Between
- Time delays, On-for, Off-for
- Or, Nor, And, Nand, Xor
- Subroutines,
- Print

.4 Operator interface:

.1 B-BC to perform operating and control functions specified Section 230914 EMCS: Operator Work Stations (B-OWS), including:

.1 Multi-level password access protection to allow user/manager to limit workstation control.

.2 Alarm management: processing and

messages.
.3 Operator commands.
.4 Reports.
.5 Displays.
.6 Point identification.
.7 Full programming

.5 Pseudo or calculated points:

.1 Software to have access to any value or status in controller or other networked controller so as to define and calculate pseudo point from other values/status of controller. When current pseudo point value derived, normal alarm checks to be performed or value used to totalize.

.2 Inputs and outputs for any process to be able to include data from any and all controllers to permit development of network-wide control strategies. Processes also to permit operator to use results of one process as input to any number of other processes (e.g. cascading).

.6 Control Description Logic (CDL):

.1 Capable of generating on line project specific CDLs which are software based, programmed into RAM or EEPROM and backed up to OWS. Owner must have access to these algorithms for modification or to be able to create new ones and to integrate these into CDLs on BC(s) from OWS.

.2 Write CDL in high level language that allows algorithms and interlocking programs to be written simply and clearly. Use parameters entered into system (e.g. setpoints) to determine operation of algorithm. Operator to be able to alter operating parameters on line from OWS and BC(s) to tune control loops.

.3 Perform changes to GCL on-line from any B-OWS or local to the B-BC.

.4 GCL to have access to values or status of all points in any B-BC, B-AAC or TCU (B-AAC).

.5 GCL programs shall include totally

customizable energy optimization routines such as:

.1 Night setback control.
.2 Enthalpy (economizer) switchover.
.3 Peak demand limiting.
.4 Temperature compensated load rolling.
.5 Fan speed/flow rate control.
.6 Supply air reset
.7 Hot water reset.
.8 Chilled water reset.
.9 Chiller sequencing.

.6 B-BC to be able to perform following pre-tested control algorithms:

.1 Two position control.
.2 Proportional control.
.3 Proportional plus integral control.
.4 PID control.
.5 Automatic control loop tuning.

.7 Control software to limit number of times each piece of equipment may be cycled within any one hour period.

.8 Provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

.9 Power Fail Restart: upon detection of power failure system to verify availability of Emergency Power as determined by emergency power transfer switches and analyze controlled equipment to determine its appropriate status under Emergency power conditions and start or stop equipment as defined by I/O Summary. Upon resumption of normal power as determined by emergency power transfer switches, B-BC to analyze status of controlled equipment, compare with normal occupancy scheduling, turn equipment on or off as necessary to resume normal operation.

.7 Energy management programs:

.1 B-BC to provide for the following pre-packaged energy management routines:

.1 Time of day scheduling.
.2 Calendar based scheduling.
.3 Holiday scheduling.
.4 Temporary schedule overrides.
.5 Optimal start.
.6 Optimal stop.

.2 All programs to be executed automatically without need for operator intervention and be flexible enough to allow customization.

.3 Apply programs to equipment and systems.

.8 Function totalization:

.1 B-BCs to accumulate and store automatically run-time for binary input and output points.

.2 Totalization routine to have sampling resolution of 1 min or less.

.3 User to be able to define warning limit and generate user-specified messages when limit reached.

.9 Analog/pulse totalization:

.1 B-BC to automatically sample, calculate and store consumption totals on daily, weekly or monthly basis for user-selected analog or binary pulse input-type points.

.2 Totalization to provide calculations and storage of accumulations up to 99,999.9 units (eg. kWH, litres, tonnes, etc.).

.3 Totalization routine to have sampling resolution of 1 min or less.

.4 User to be able to define warning limit and generate user-specified messages when limit is reached.

.10 Event totalization:

.1 B-BC to automatically count events (such as number of times pump is cycled off and on) daily, weekly or monthly basis.

.2 Store totalization records with minimum of 9,999,999 events before reset.

.3 User to be able to define warning limit and generate user-specified messages when limit is reached.

2.10 Priority Level .1 B-BC shall provide for 14 levels of priority from all outputs. The priority levels shall conform to the BACnet object specifications.

2.11 Trend Logging .1 See section 230914 trend data. All trend log information shall be stored at B-BC and not at B-OWS.

2.12 Levels of Address .1 Upon operator's request, system to present condition of any single point, system, area, or whole system on printer or B-OWS as selected by operator. Display analog values digitally to 1 place of decimals with negative sign as required. Update displayed analog values and status when new values received. Flag points in alarm by blinking, reverse video, different colour, bracketed or other means to differentiate from points not in alarm. Updates to be change-of-value (COV)-driven or if polled not exceeding 2 second intervals.

.2 Refer also to Section 230900 - EMCS: General Requirements.

PART 3 - EXECUTION

3.1 Installation .1 Install B-BC in secure enclosures and cabinets.

.2 Provide all necessary power from local emergency power & UPS branch circuit panel to all control panels, controllers and devices.

.3 Install tamper locks on breakers of circuit panel.

.4 Use emergency power & UPS where available when equipment must operate in emergency mode.

.5 Install new DDC panels in Penthouse where shown on drawing M104. Provide all necessary control devices, controllers and interface control equipment as required to integrate with existing

control devices and equipment and to provide a complete fully functional DDC control system.

3.2 Commissioning .1 Refer to Section 230903 - EMCS: Commissioning.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230900 - EMCS: General Requirements.

.2 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.3 Section 230904 EMCS: Project Records and "As-Built" Records.

.4 Section 230907 - EMCS: BACnet Protocol Requirements

1.2 Acronyms

.1 Acronyms used in this section (refer to section 230900) include:

AI - Analog Input
AO - Analog Output
CAD - Computer Aided Design
GCL - General Control Language
CPU - Central Processing Unit
BI - Binary Input
BO - Binary Output
EISA - Extended Industry Standard Architecture
HVAC - Heating, Ventilation, Air Conditioning
I/O - Input/Output
ISA - Industry Standard Architecture
LAN - Local Area Network
LCU - Local Control Unit, refer to B-AAC
MCU - Master Control Unit, refer to B-BC
OS - Operating System
OWS - Operator Work Station
PC - Personal Computer
RAM - Random Access Memory
ROM - Read Only Memory
TCU - Terminal Control Unit
B-AAC - BACnet Advanced Application Controller
Ethernet - BACnet TCP/IP Ethernet
MS/TP - BACnet Master-Slave/Token-Passing MS/TP
PTP - BACnet Point-to-Point protocol

.2 Refer to section 23 09 00.

1.3 Reference

.1 Canadian Standards Association
.1 CSA C22.2no.205- M1983(R2009), Signal Equipment.

.2 Institute of Electrical and Electronic Engineers.
.1 IEEE 472- current new version

.2 IEEE 587- current new version

.3 National Institute of Standards and Technology
.1 NISTIR 6392 GSA Guide to Specifying Interoperable Building Automation and Control Systems Using ANSI/ASHRAE Standard 135-2010, BACnet.
.2 B-AAC minimum capabilities equivalent to the BACnet Advanced Application Controller (B-AAC).

1.4 System Description .1 Refer to section 230907 for additional BACnet requirements.

.2 B-AAC BACnet overview: A B-AAC is a general purpose, field programmable controller capable of carrying out a variety of building automation and control tasks. It enables the specification of the following:
.1 Data Sharing(As specified for B-BC section 233914)
.2 Alarm and Event Management(As specified for B-BC section 230914)
.3 Scheduling As specified for B-BC section 230914)
.4 Trending As specified for B-BC section 230914)
.5 Device and Network Management As specified for B-BC section 230914)

.3 B-AAC to be stand-alone intelligent controller. B-AAC panel to:
.1 Be microprocessor based, multi-tasking, multi-user, real-time digital control processors capable of supervising other lower level programmable controllers through secondary networks.
.2 Provide BACnet LAN port for local TCU (B-AAC) network or B-SS devices.
.3 Provide on board LAN interface for MS/TP BACnet peer-to-peer communication between B-AAC's
.4 Interface field sensors directly to I/O terminations located on B-AAC in processor cabinet.
.5 In standalone mode execute programmable logic control (direct digital or closed loop process control) of associated HVAC equipment without interacting with other processors or OWSs.

1.5 Basic Functional Requirements — (As specified for B-BC Section 230914).

1.6 Submittals — (As specified for B-BC Section 230914)

1.7 Maintenance

.1 In accordance with Section 230904 - EMCS: Project Records and "As-Built" Records.

PART 2 - PRODUCTS

2.1 Environmental Conditions — (As specified for B-BC Section 230914).

2.2 Purpose of B-AAC

.1 The Main function of B-AAC is to provide direct control of all remote small mechanical systems such as unit ventilators, rooftop units, fan coils, etc. Coordinates peer to peer medium speed MS/TP fully programmable NATIVE BACnet communications, and/or supervision of subordinate native BACnet B-SS.

.2 In addition, the TCU for Dual duct box (DD) controls, General Exhaust box (GEV) controls, and fume hood exhaust controls for each laboratory shall be B-AAC controller(s). Fixed algorithmic or application specific controllers will NOT be accepted for this function. Full programmable and ability to trend and store data on local controller is a mandatory requirement.

.3 All points of system to be within one B-AAC.

2.3 Spare Capacity

.1 As specified for B-BC section 230914, and also included 10% spare capacity for B-AAC in each laboratory.

2.4 Central Processor Unit (CPU)

.1 Processor is existing to remain.

.2 All point descriptors shall be stored resident at the B-AAC and NOT on the operator work station terminal.

2.5 Lockable Panels	.1	To be EEMAC rated to suit environmental requirements.
	.2	To have hinged doors equipped with standard key-alike cabinet locks, keyed to same key.
2.6 Portable Service Terminal (ST)	.1	Not required.
2.7 Surge and Transient Protection	.1	As specified for B-BC section 230914
2.8 Software	.1	As specified for B-BC section 230914
2.9 Priority Level	.1	As specified for B-BC section 230914
2.10 Trend Logging	.1	As specified for B-BC section 230914
2.11 Levels of Address	.1	As specified for B-BC section 230914
	.2	Speed of Response: dampers for the laboratory exhaust fans shall be less than 30 seconds as specified in section 233400.

PART 3 - EXECUTION

3.1 Installation	.1	As specified for B-BC section 230914.
3.2 Commissioning	.1	Refer to Section 230903 - EMCS: Commissioning.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 011100 - Summary of Work.

.2 Section 017300 - Execution.

.3 Section 078400 - Fire Stopping.

.4 Section 230500 - Mechanical General Requirements.

.5 Section 260100 - Electrical General Requirements.

1.2 References

.1 American National Standards Institute (ANSI)

.1 ANSI/ASME B16.22-2001(R2010), Wrought Copper and Copper Alloy Solder Joint Pressures Fittings.
.2 ANSI C2-2012, National Electrical Safety Code.
.3 ANSI/NFPA 70-2011, National Electrical Code.

.2 Canadian Standards Association (CSA)

.1 CSA C22.1-2009, Canadian Electrical Code, Part 1.
.2 CAN/CSA C22.3 No.1-10, Overhead Systems.

1.3 System Description

.1 Electrical:

.1 Provide power wiring from existing emergency power panels to EMCS main panels. Circuits to be for exclusive use of EMCS equipment. Panel breakers to be identified on panel legends tagged and locks applied to breaker switches.

.2 Modify existing starters to provide for EMCS as indicated in I/O Summaries and as indicated.

.2 Mechanical:

.1 Pipe Taps Required For EMCS equipment will be supplied and installed by Division 23.

.2 Wells and Control Valves Shall Be Supplied by EMCS Contractor and Installed by Division 23.

.3 Installation of air flow stations, dampers, and other devices requiring sheet metal trades to be mounted by Division 23. Costs to be carried by designated trade.

.3 VAV, DD, GEV, FHEV Terminal Units.

.1 Air flow probe for VAV boxes, DD boxes, GEV boxes and FHEV to be supplied and installed under Division 23. Air flow dp sensors, actuators and associated terminal unit controls to be supplied, installed and calibrated by EMCS contractor. Tubing from air probe to dp sensor as well as installation and adjustment of air flow sensors and actuators to be the responsibility of EMCS contractor. Coordinate air flow adjustments with balancing and commissioning trades.

.4 Structural:

.1 Special steelwork as required for installation of work.

.5 EMCS:

.1 Provide UPS power back-up at the DDC panel for a minimum of 15 minute uninterruptable power.

.2 Hard wiring between field control devices and EMCS field panels.

.3 Communication wiring between EMCS field panels and OWS's including main control centre BECC.

.4 Trace existing control wiring installation and provide updated wiring

schematics including additions and/or deletions to control circuits for approval by Departmental Representative before commencing work.

.5 Provide power wiring from existing emergency power panels/branches to EMCS field panels.

.6 Provide a true on-line UPS (no power dip when power fails) for the DDC panels and the OWS. DDC shall monitor normal power.

1.4 Personnel Qualifications

.1 Qualified supervisory personnel to:

.1 Continuously direct and monitor all work.

.2 Attend all site meetings.

1.5 Existing Conditions

.1 Cutting and Patching: refer to Section 017300 - Execution supplemented as specified herein.

.2 Repair all surfaces damaged during execution of work.

.3 Turn over to Departmental Representative existing materials removed from work not identified for re-use.

PART 2 - PRODUCTS

2.1 Special Supports

.1 Structural grade steel, primed and painted after construction and before installation.

2.2 Wiring

.1 As per requirements of Division 26.

.2 For 70V and above copper conductor with chemically cross-linked thermosetting polyethylene insulation rated RW90 and 600V. Colour code to CSA 22.1.

.3 For wiring under 70 volts use FT6 rated wiring where wiring is not run in conduit. All other cases use FT4 wiring.

.4 Sizes:

.1 120V Power supply: to match or exceed breaker, size #12 minimum.

.2 Wiring for safeties/interlocks for starters, motor control centres, to be stranded, #14 minimum.

.3 Field wiring to digital device: #18AWG.

.4 Analog input and output: shielded #18 minimum solid copper. Wiring must be continuous without joints.

.5 More than 4 conductors: #22 minimum solid copper.

.5 Terminations:

.1 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.

2.3 Conduit

.1 As per requirements of Division 26.

.2 Electrical metallic tubing to CSA C22.2 83. Flexible and liquid tight flexible metal conduit to CSA C22.2 56. Rigid steel threaded conduit to CSA C22.2 45.

.3 Junction and pull boxes: welded steel.

.1 Surface mounting cast FS: screw-on flat covers.

.2 Flush mounting: covers with 25 mm minimum extension all round.

.4 Cabinets: sheet steel, for surface mounting, with hinged door, latch lock, 2 keys, complete with perforated metal mounting backboard. Panels to be keyed alike for similar functions

and or entire contract as approved.

.5 Outlet boxes: 100 mm minimum, square.

.6 Conduit boxes, fittings:

.1 Bushings and connectors: with nylon insulated throats.

.2 With push pennies to prevent entry of foreign materials.

.7 Fittings for rigid conduit:

.1 Couplings and fittings: threaded type steel.

.2 Double locknuts and insulated bushings: use on sheet metal boxes.

.3 Use factory "ells" where 90 degree bends required for 25 mm and larger conduits.

.8 Fittings for thin wall conduit:

.1 Connectors and couplings: steel, set screw type.

2.4 Wiring Devices, Cover Plates

.1 Conform to CSA.

.2 Receptacles:

.1 Duplex: CSA type 5-15R.

.2 Single: CSA type 5-15R.

.3 Cover plates and blank plates: finish to match other plates in area.

2.5 Supports for Conduit, Fastenings, Equipment

.1 Solid masonry, tile and plastic surfaces: lead anchors or nylon shields.

.1 Hollow masonry walls, suspended drywall ceilings: toggle bolts.

.2 Exposed conduits or cables:

.1 50 mm diameter and smaller: one-hole steel straps.

.2 Larger than 50 mm diameter: two-hole steel straps.

.3 Suspended support systems:

.1 Individual cable or conduit runs: support with 6 mm diameter threaded rods and support clips.

.2 Two or more suspended cables or conduits: support channels supported by 6 mm diameter threaded rod hangers.

PART 3 - EXECUTION

3.1 Installation

.1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.

3.2 Supports

.1 Install special supports as required and as indicated.

3.3 Electrical General

.1 Do complete installation in accordance with requirements of:

.1 Division 26, this specification.

.2 CSA 22.1 Canadian Electrical Code.

.3 ANSI/NFPA 70.

.4 ANSI C2.

.2 Fully enclose or properly guard electrical wiring, terminal blocks, high voltage above 70 V contacts and mark to prevent accidental injury.

.3 Do underground installation to CAN/CSA C22.3 No.7, except where otherwise specified.

.4 Conform to manufacturer's recommendations for storage, handling and installation.

.5 Check factory connections and joints. Tighten where necessary to ensure continuity.

.6 Install electrical equipment between 1000 and 2000 mm above finished floor wherever possible and adjacent to related equipment.

.7 Protect exposed live equipment such as panel, mains, outlet wiring during construction for personnel safety.

.8 Shield and mark live parts "LIVE 120 VOLTS" or other appropriate voltage.

.9 Install conduits, and sleeves prior to pouring of concrete.

.10 Holes through exterior wall and roofs: flash and make weatherproof.

.11 Make necessary arrangements for cutting of chases, drilling holes and other structural work required to install electrical conduit, cable, pull boxes, outlet boxes.

.12 Install cables, conduits and fittings which are to be embedded or plastered over, neatly and closely to building structure to minimize furring.

.13 Remove all existing abandoned control wires and conduits in the space.

3.4 Conduit System

.1 Communication wiring shall be installed in conduits. Provide complete conduit system to link Building Controllers to BECC. Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems. Maximum conduit fill not to exceed 40%. Design drawings do not show conduit layout. Plenum rated cable located in concealed air plenum ceiling is not in conduits.

.2 Install conduits parallel or perpendicular to

building lines, to conserve headroom and to minimize interference.

.3 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Obtain approval from Departmental Representative before starting such work. Provide complete conduit system to link field panels and devices with main control centre. Conduit size to match conductors plus future expansion capabilities as specified.

.4 Locate conduits at least 150 mm from parallel steam or hot water pipes and at least 50 mm at crossovers.

.5 Bend conduit so that diameter is reduced by less than 1/10th original diameter.

.6 Field thread on rigid conduit to be of sufficient length to draw conduits up tight.

.7 Limit conduit length between pull boxes to less than 30 m.

.8 Use conduit outlet boxes for conduit up to 32 mm diameter and pull boxes for larger sizes.

.9 Fastenings and supports for conduits, cables, and equipment:

- .1 Provide metal brackets, frames, hangers, clamps and related types of support structures as indicated and as required to support cable and conduit runs.
- .2 Provide adequate support for raceways and cables, sloped vertically to equipment.
- .3 Use supports or equipment installed by other trades for conduit, cable and raceway supports only after written approval from Departmental Representative.

.10 Install polypropylene fish cord in empty conduits for future use.

.11 Where conduits become blocked, remove and replace blocked sections.

.12 Pass conduits through structural members only

after receipt of Departmental Representative's written approval.

.13 Conduits may be run in flanged portion of structural steel.

.14 Group conduits wherever possible on suspended or surface channels.

.15 Pull boxes:
- .1 Install in inconspicuous but accessible locations.
- .2 Support boxes independently of connecting conduits.
- .3 Fill boxes with paper or foam to prevent entry of construction material.
- .4 Provide correct size of openings. Reducing washers not permitted.
- .5 Mark location of pull boxes on record drawings.
- .6 Identify AC power junction boxes, by panel and circuit breaker.

.16 Install terminal blocks or strips indicated in cabinets to Section 260000.

.17 Install bonding conductor for 120 volt and above in conduit.

3.6 Tests

.1 General:

.1 Perform following tests in addition to tests specified Section 230903 - EMCS: Commissioning.

.2 Give 14 days written notice of intention to test.

.3 Conduct in presence of Departmental Representative and authority having jurisdiction.

.4 Conceal work only after tests satisfactorily completed.

.5 Report results of tests to Departmental Representative in writing.

.6 Preliminary tests:

.1 Conduct as directed to verify compliance with specified requirements.

.2 Make needed changes, adjustments, replacements.

.3 Insulation resistance tests:

.1 Megger all circuits, feeders, equipment for 120 - 600V with 1000V instrument. Resistance to ground to be more than required by Code before energizing.

.2 Test insulation between conductors and ground, efficiency of grounding system to satisfaction of Departmental Representative and authority having jurisdiction.

3.7 Identification .1 Refer to Section 230906 - EMCS:Identification.

PART 1 - GENERAL

1.1 General

.1 The control sequences contain a general description of the intent of the operation of the systems to be controlled. The Contractor shall review individual systems to ensure equipment and life safety interlocks are not overridden.

.2 The relationships between the points, systems and building are described in the control sequences.

.3 Review with the Departmental Representative during the shop drawing stage to finalize the control sequences for each system.

PART 2 - PRODUCTS

.1 Not used.

PART 3 - EXECUTION

3.1 General Site requirements

.1 Provide database for all hardware points listed for system operation to meet specification operating sequences.

.2 Contractor shall review existing control systems and determine necessary extent of work to satisfy design intent.

.3 Contractor shall be responsible for supply, installation and commissioning a complete fully functional DDC system including to provide all required components, relays, transformers, EP switches, and control devices to interface and control of existing control equipment and devices.

.4 Upgrade existing DDC programming and graphics to make functional the revised lab exhaust fans LEF-1 through LEF-3 and the new lab exhaust fans LEF-4 through LEF-6.

PART 4 - CONTROL SEQUENCES

4.1 Existing HVAC Controls (Existing Control Sequence)

.1 Refer to the existing HVAC Control Sequence in Appendix B.

4.2 General Laboratory Mode Control

.1 The laboratory systems will operate in either the UNOCCUPIED, OCCUPIED, FUME HOOD OVERRIDE, OCCUPIED OVERRIDE or UNOCCUPIED OVERRIDE modes on a programmed time schedule. The schedule is to be on a 7 day, 24 hour format and is to be operator adjustable on an hourly basis. The time schedules are set by PARC as per individual occupancy requirements. The new fume hood (NIC) will follow the same controls sequence as the existing. Refer to the existing HVAC Control Sequence and also the Laboratory Fume Hood Airflow Control Sequences of Operation in Appendix B. The sequences below provide further detail.

.1 OCCUPIED Mode

.1 The OCCUPIED mode shall be defined as the use of the occupancy pushbutton on the room temperature sensor. The air supply to each lab space will be set to the specified maximum flow value and the supply temperature will modulate to satisfy the space temperature set point. All supply systems will be enabled only after the exhaust system has been enabled. A space temperature dead band is provided that is to be operator adjustable. The occupied mode shall be enabled upon the activation of the occupancy button.

.2 The general exhaust box shall be set to exhaust 23 l/s or 10% more total exhaust air than is being supplied (whichever is the larger amount) during the OCCUPIED mode. Note that exact air flow differentials shall be determined during commissioning of the control systems.

.2 UNOCCUPIED Mode

.1 The air supply to each space shall be limited to the specified minimum value.

A space temperature dead band is provided that is to be operator adjustable.

.2 The general exhaust box shall be set to exhaust 23 l/s or 10% (whichever is the larger amount) more total exhaust air than is being supplied.

.3 The supply system should be reset down to minimum first before the exhaust air system be reset to minimum.

.3 UNOCCUPIED OVERRIDE

.1 Enabling the occupancy switch (the occupancy/unoccupied switch shall be supplied and installed by control contractor, modify existing fan on/off switch at each fume hood to be the occupancy/unoccupied switch if existing switches are suitable) shall override the system during the scheduled unoccupied period. This will be referred to as the UNOCCUPIED OVERRIDE. The system will switch to operate in the OCCUPIED mode. When the occupancy switch is pushed to Unoccupied then, the system will revert back to the UNOCCUPIED mode of operation.

.2 The general exhaust box shall be set to exhaust 10% more air than is being supplied during the UNOCCUPIED OVERRIDE.

.4 OCCUPIED OVERRIDE

.1 Operating the unoccupied switch shall override the system during the scheduled occupied period. This will be referred to as the OCCUPIED OVERRIDE mode (as fume hood is off). The supply system will operate to vary supply air flow from minimum to maximum to maintain the space temperature set point.

.2 The general exhaust box shall be varied according to the supply air and to exhaust 10% more air than is being supplied.

.5 FUME HOOD OVERRIDE

.1 Fume hoods shall be activated by a local emergency switch (supplied by the fume hood control module manufacturer) and shall override the air supply to the maximum scheduled airflow value. The FUME HOOD OVERRIDE shall operate regardless of the present system mode. If the system is operating in the OCCUPIED OVERRIDE mode and the FUME HOOD

OVERRIDE is engaged, the FUME HOOD OVERRIDE mode will have precedence.

.2 FUME HOOD OVERRIDE mode shall override all prior exhaust settings.

4.3 Air Terminal Exhaust Units ATE (FHEV and GEV)

.1 Laboratory ATE Fume Hood Units (FHEV)

.1 The existing laboratory fume hoods will remain and the existing fume hood exhaust terminals (FHEV Valves) shall remain. The new FHEV (NIC) shall be equipped with a new DDC fume hood control module which will operate the unit as outlined in the control sequences. The FHEV valves shall be located in the Penthouse mezzanine (unless otherwise specified on the drawings) and wired down to the control module located at each existing laboratory fume hood using new electrical EMT conduits.

.2 The controls contractor is responsible for the wiring of the fume hood control signal to the new FHEV valve as well as the mounting and wiring of the control module to each new fume hood. The fume hood control module shall provide dry contact status points for interface to a local DDC controller for emergency conditions and future sash position. In addition, the fume hood control module shall provide a 0 - 10vdc signal for fume hood air volume.

.3 The controls contractor is responsible for re-commissioning the existing FHEVs to verify proper controlled operation. Coordinate with the balancing and commissioning agent for adjusting the exhaust air rates.

.2 Laboratory General Exhaust Units (GEV)

.1 The existing GEVs have variable volume of exhaust air in order to maintain the amount of exhaust air 10% more than the total supply air to the labs space. All GEV boxes are tied in and controlled via the lab DDC system.

.2 Similar to the FHEVs, the controls contractor is responsible for re-commissioning the GEVs to verify proper controlled operation. Coordinate with the balancing and commissioning agent for

adjusting the exhaust air rates.

.3 The existing GEVs are currently connected to the exhaust system served by lab exhaust fans LEF-1, 2, and 3. Update the programming associating the GEVs with the existing lab exhaust fans to reflect association with new lab exhaust fans LEF-4, 5, and 6. Note phasing of disconnecting the general return and general exhaust risers from LEF-1, 2, and 3 and connecting to new fans LEF-4, 5, and 6.

4.4 Laboratory Exhaust Fans LEF-1, 2, 3 Normal Operation (Integration with Existing Control Sequence)

.1 Refer to the existing automatic Control Sequence in Appendix B. The existing controls sequence will remain largely unchanged with revisions as noted below.

.2 Existing laboratory exhaust fans LEF 1, 2 and 3 - Normal operation

.1 Existing duct static pressure sensors at the general exhaust and general return ducts are currently used to modulate the control dampers mounted on LEF-1, 2, and 3. Disable the points as control will be associated with new lab exhaust fans LEF-4, 5, and 6. Close the dampers at the existing lab exhaust fan plenum.

.2 An existing hard wired pressure sensor in the LEF plenum and one in each of the general exhaust and general return ducts currently will shut down all the existing LEFs, whenever the pressure in the LEF plenum exceeds 1250 Pa or the pressure in either of the exhaust ducts exceeds 950 Pa. Rewire the duct mounted pressure sensors such that they are no longer associated with LEF-1, 2, and 3, but are associated with new fans LEF-4, 5, and 6. Note phasing of disconnecting the general return and general exhaust risers from LEF-1, 2, and 3 and connecting to new fans LEF-4, 5, and 6. Each of the 3 pressure switches have their own manual reset button and indicating light located on the exterior of the DDC panel enclosure

controlling the LEFs. Relocate the switches for the duct sensors from the existing LEF control panel and mount the switches at the control panel for the new LEFs.

.3 Presently all three existing LEF fans run full speed with no bypass air to meet demand. After the system alteration, one fan is expected to run at a time with the remaining two fans on standby. Revised static pressure set point is expected to be 750Pa and shall be optimized during the commissioning process. The fan shall be controlled by the associated variable speed drive (VFD) in order to maintain the static pressure and the fan discharge velocity at a minimum of 3000 FPM (no change). When the discharge velocity is less than 3000 FPM, the existing outdoor air by-pass damper shall be modulated to open to provide make-up air to the fan. In the event that two fans are required to run, the associated VFD shall regulate each fan to the same speed.

.4 The duty fan shall be duty cycled with the standby fans on a two week (adjustable) cycle. The isolation damper of the stand-by fans shall be normally closed. Upon scheduled changeover or in the event of a failure of one of the LEFs, the isolation damper of the stand-by fan shall open, and the stand-by fan shall be enabled. The fan shall be controlled by the associated VFD and the by-pass damper modulated as described above.

.5 While one fan is running and the load on the fan requires the fan to reach 90% (adjustable) speed, then a second fan shall be started as per regular startup sequence and the associated VFDs shall regulate each fan to the same speed. Similarly, as the load on a pair of fans requires the fans to reach 35% (adjustable) speed, then one fan shall be commanded off and its isolation damper commanded closed. Optimum speed settings for starting/stopping a second fan shall be determined through the commissioning

process.

.6 The duty fan(s) shall be duty cycled with the standby fan(s) on a two week (adjustable) cycle.

.3 Refer to the existing low temperature freeze alarm shut down; coordinate operation of LEF 4, 5 and 6.

4.5 Laboratory Exhaust Fans LEF-4, 5, 6 Normal Operation (Integration with Existing Control Sequence)

.1 New laboratory exhaust fans LEF 4, 5 and 6 - Normal operation

.1 On initial start-up, restart due to power failure or return to normal power, see sequences Automatic startup below.

.2 Provide a discharge velocity sensor for each of the LEF fans. The velocity sensor will provide an input to the DDC system which in turn will modulate the outdoor air damper in the exhaust duct plenum near the new LEFs, to maintain a minimum velocity of 3000 FPM.

.3 Existing duct static pressure sensors at the general exhaust and general return ducts shall modulate the new associated control dampers maintain the duct static pressure at -450 Pa (adjustable) in the west side general exhaust ducting and -725 Pa (adjustable) in the east side general return ducting. Set fan plenum static pressure initially to 750Pa and optimize such that the general return control damper (the more restrictive duct main) remains 100% open during normal operation while satisfying the lab exhaust demand.

.4 Provide a hard wired pressure sensor in the new LEF plenum. Rewire the existing pressure sensor in each of the general exhaust and general return ducts to shut down all the new LEFs, whenever the pressure in the LEF plenum exceeds 1250 Pa or the pressure in either of the exhaust ducts exceeds 950 Pa. Provide each of the 3 pressure switches with their own manual reset button and indicating light located

on the exterior of the DDC panel enclosure controlling the LEFs. The indicating light will illuminate indicating which pressure switch has tripped and its associated manual reset button must be pressed before the LEFs will re-start.

.5 Only two of the new LEFs are to run at a time with the remaining fan on standby. The fans shall be controlled by their associated variable speed drive (VFD) in order to maintain the static pressure and the fan discharge velocity at a minimum of 3000 FPM. When the discharge velocity is less than 3000 FPM, the outdoor air by-pass damper shall be modulated to open to provide make-up air to the fans. The associated VFDs shall regulate each fan to the same speed.

.6 While two fans are running and the load on the fans requires the fans to reach 35% (adjustable) speed, then one fan shall be commanded off and its isolation damper commanded closed. Similarly, as the load on one fan requires the fan to reach 90% (adjustable) speed, then a second fan shall be started as per regular startup sequence and the associated VFDs shall regulate each fan to the same speed. Optimum speed settings for starting/stopping a second fan shall be determined through the commissioning process.

.7 The duty fans shall be duty cycled with the standby fans on a two week (adjustable) cycle. The isolation dampers of the stand-by fan shall be normally closed. Upon scheduled changeover or in the event of a failure of one of the LEFs, the isolation damper of the stand-by fan shall open, and the stand-by fan shall be enabled. The by-pass damper modulates to open as needed to maintain internal exhaust duct static pressure.

.8 Upon any fan failure, the DDC system will generate an alarm at the terminal.

.9 The DDC system monitors the HAND/OFF/AUTO

switches for all the 3 new LEFs. The DDC system is sent a signal when the HAND/OFF/AUTO switch is in the AUTO position.

.10 An LEF VFD can be operated in by-pass mode by either operating (turning) the associated by-pass switch on the VFD to the ON position, or by manually turning the associated DDC control point ON.

.11 Provide current sensors installed on each of the new LEF motors to provide operating feed back to the DDC system. This will allow monitoring of the LEFs when in by-pass mode and normal operating mode.

.2 Refer to the existing low temperature freeze alarm shut down; coordinate operation of LEF-1, 2 and 3.

4.6 Emergency Shutdown and Automatic Restart (Integration with Existing Control Sequence)

.1 Refer to the existing automatic re-start sequence in Appendix B. The re-start follows power outage, restoration of normal power, and any incidental shutdown.

.2 Automatic start up

.1 Laboratory AHUs: re-start.

.2 Laboratory fume hood exhaust fans LEF-1, 2, and 3: re-starts (per the existing control sequence).

.3 Laboratory general exhaust and general return fans LEF-4, 5, and 6 re-start with the laboratory fume exhaust fans, in a comparable sequence:

.1 On a loss of building power or return to normal power, the DDC system turns off the control points for AHU-1 to 13 and all of the LEFs.
.2 After 20 sec. on a loss of building power or return to normal power, the DDC system enables AHU-3 to operate.
.3 After 60 sec. on a loss of building power or return to normal power, the DDC system enables AHU-4 to operate.

.4 After 90 sec. on a loss of building power or return to normal power, the DDC system enables AHU-6, 10, 13 to operate.

.5 After 120 sec. on a loss of building power or return to normal power, the DDC system enables AHU-1, 2, 5, 7 to operate.

.6 After 300 sec (5 min.), the DDC system enables AHU-9 and AHU-11 to operate.

.7 If AHU-9 and AHU-11 have been operating for 30 sec., the DDC system enables the LEF 1, 2 and 3 fans (only the one or two duty fans start) and they are ramped up to their minimum speed of 66%. The bypass damper is modulated as required. 10 seconds later, the DDC system enables the LEF 4, 5 and 6 fans (only the two duty fans start) with a 10 second delay between each and they are ramped up to their minimum speed of 66%. The bypass damper is modulated as required.

.8 If AHU-9 and AHU-11 have been operating for 60 sec., the DDC system enables AHU-8 and AHU-12 and the operating LEFs (1 to 6) fans are allowed to reach their maximum speed.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 230900 - EMCS General Requirement.

.2 Section 230901 - EMCS: Shop Drawings, Product Data and Review Process.

.3 Section 230902 - EMCS: Start-up and Checkout.

.4 Section 230903 - EMCS: Commissioning.

.5 Section 230904 - EMCS: Project Record Documents.

.6 Section 230905 - EMCS: Training.

.7 Section 230905 - EMCS: Identification.

.8 Section 230915 - EMCS: Building Controller Family of Controllers.

.9 Section 230913 - EMCS: Field Control Devices.

.10 Section 230983 - EMCS: Field Installation.

.11 Section 230993 - EMCS: System Documentation.

.12 Section 018100 - Commissioning General Requirements

1.2 General

.1 A point is a specific software address which is resident in the DDC controller and which is identified with a particular field sensor, instrument or sensor.

.2 The point schedule contains a general list and description of the points to be connected. The contractor shall examine the point schedule and ensure that all points required to make the described control sequences work are provided whether included in the point schedule or not.

.3 The relationships between the points, systems and building are described in the control sequences section 230993.

.4 Consult with the Departmental Representative during the shop drawing stages to finalize the physical terminal address of each point within the controllers.

.5 Contractor shall allow 3% additional control points which are not indicated in this section into the tender price for the new exhaust fan control panels.

PART 2 - PRODUCTS

.1 NOT USED

PART 3 - EXECUTION

3.1 Installation

.1 Refer to the attached Point Schedule.

.2 Provide all required control points to perform the control sequences specified in section 230993, and to provide a fully operational, functional, tested and commissioned DDC system.

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DDC POINTS LIST — Revision 0 — Summerland - Steeple Fans Alteration — Control Points list

DEVICE TYPE

		FS	FREEZE PROTECTION	VPS	VALVE POSITION (POSITIVE FEEDBAK)
ATS	AVERAGING DUCT TEMPERATURE SENSOR	FST	FLOW STATION (flow measuring device)	VPT	VELOCITY PRESSURE TRANSMITTER
AUX	AUXILIARY CONTACT	FSW	FLOW SWITCH	VSD	VARIABLE FREQUENCY DRIVE
AFR	AIR FLOW RATE	HS	HUMIDITY SENSOR	VTE	VALVE ACTUATOR TWO POSITION ELECTRONIC
CO2	CO2	MFT	VAV BOX FLOW TRANSMITTER	WCS	WINDOW CONTACT SWTICH
CR	CURRENT SENSOR	OTS	OUTDOOR TEMPERATURE SENSOR	WFS	WATER FLOW MEASURING STATION
DHS	DUCT HUMIDITY SENSOR	PSW	PRESSURE SWITCH	WM	WATER METER
DME	DAMPER ACTUATOR MODULATING ELCTRONIC	ROS	ROOM OCCUPANCY SENSOR	WTS	WELL TEMPERATURE SENSOR
DPS	DAMPER POSITION (POSITIVE FEEDBAK)	RTS	ROOM TEMPERATURE SENSOR	OHS	OUTDOOR HUMIDITY SENSOR
DPT	DIFFERENTIAL PRESSURE TRANSMITTERS OR PRESSURE DIFF. SENSOR	RT&HS	ROOM TEMPERATURE AND HUMIDITY SENSOR	DC	DRY CONTACT
DTE	DAMPER ACTUATOR TWO POSITION ELECTRONIC	RY	RELAY	RY	RELAY
DTS	DUCT TEMPERATURE SENSOR	SD	SMOKE DETECTOR SENSOR	AUX	AUXILLARY CONTACT (DRY CONTACT, RELAY)
ER	ELECTRIC RELAY	SPT	STATIC PRESSURE TRANSMITTER	LS	ULTRASONIC LEVEL INDICATOR
ES	ENERGY STATION (FLOW, SUP. TEMP.& RET. TEMP.)	VME	VALVE ACTUATOR MODULATING ELECTRONIC	CT	CURRENT TRANSMITTER
ESW	END SWITCH	ROS	ROOM OCCUPANCY SENSOR	GFS	GAS FLOW STATION
FMS	ELECTRONIC FLOW MEASURING STATION				

POINTS LIST

No.	POINT DESCRIPTION	POINT LABEL	POINT LOCATION	EQUIP. TAG	DIGITAL IN	DIGITAL OUT	ANALOGUE IN	ANALOGUE OUT	COMMENTS
	HVAC								
	Lab Exhaust Fans								
	Controls Contrator is to allow for any harwdware and programming in addition to monitoring and control points listed below to meet design intent. Provide the following monitoring and control points as a minimum:								
	New Lab Exhaust Fans:								
	LEF-04								
	Lab Exhaust Fan VSD Alarm	LEF-04 VSD-A				AUX			
	Lab Exhaust Fan VSD Start/Stop (Proof)	LEF-04 VSD-CS				ER	CR		
	Lab Exhaust Fan VSD Output	LEF-04 VSD						VSD	
	Lab Exhaust Fan VSD Manual Reset	LEF-04 VSD-MR				ER			
	Lab Exhaust Fan Not In Auto	LEF-04 NOT_IN_AUTO			AUX				
	Lab Exhaust Fan In Bypass	LEF-04 IN_BYPS			AUX				
	Lab Exhaust Fan In DDC Bypass	LEF-04 DDC_BYPS_SS				ER			
	Lab Exhaust Fan Discharge Nozzle velocity	LEF-04 DNV					VPT		
	Lab Exhaust Fan Suction Static Pressure	LEF-04 SP					SPT		
	Lab Exhaust Fan Status	LEF-04 S					CT		
	Lab Exhaust Fan Isolation Damper	LEF-04 ID			ESW	DTE	DPS		
	LEF-05								
	Lab Exhaust Fan VSD Alarm	LEF-05 VSD-A				AUX			
	Lab Exhaust Fan VSD Start/Stop (Proof)	LEF-05 VSD-CS				ER	CR		
	Lab Exhaust Fan VSD Output	LEF-05 VSD						VSD	
	Lab Exhaust Fan VSD Manual Reset	LEF-05 VSD-MR				ER			
	Lab Exhaust Fan Not In Auto	LEF-05 NOT_IN_AUTO			AUX				
	Lab Exhaust Fan In Bypass	LEF-05 IN_BYPS			AUX				
	Lab Exhaust Fan In DDC Bypass	LEF-05 DDC_BYPS_SS				ER			
	Lab Exhaust Fan Discharge Nozzle Velocity	LEF-05 DNV					VPT		
	Lab Exhaust Fan Suction Static Pressure	LEF-05 SP					SPT		
	Lab Exhaust Fan Status	LEF-05 S					CT		
	Lab Exhaust Fan Isolation Damper	LEF-05 ID			ESW	DTE	DPS		
	LEF-06								
	Lab Exhaust Fan VSD Alarm	LEF-06 VSD-A				AUX			
	Lab Exhaust Fan VSD Start/Stop (Proof)	LEF-06 VSD-CS				ER	CR		
	Lab Exhaust Fan VSD Output	LEF-06 VSD						VSD	
	Lab Exhaust Fan VSD Manual Reset	LEF-06 VSD-MR				ER			
	Lab Exhaust Fan Not In Auto	LEF-06 NOT_IN_AUTO			AUX				
	Lab Exhaust Fan In Bypass	LEF-06 IN_BYPS			AUX				
	Lab Exhaust Fan In DDC Bypass	LEF-06 DDC_BYPS_SS				ER			
	Lab Exhaust Fan Discharge Nozzle Velocity	LEF-06 DNV					VPT		
	Lab Exhaust Fan Suction Static Pressure	LEF-06 SP					SPT		
	Lab Exhaust Fan Status	LEF-06 S					CT		
	Lab Exhaust Fan Isolation Damper	LEF-06 ID			ESW	DTE	DPS		
	COMMON:								
	Common exhaust plenum static pressure (System Static Pressure)	LE-SSP					SPT		
	Common exhaust plenum static pressure (System Static Pressure) set point	LE-SPSP						4-20amp	or 0-10V signal
	Lab General Exhaust Riser Damper	LE-GED			ESW	DME	DPS		
	Lab General Return Riser Damper	LE-GRD			ESW	DME	DPS		
	Lab Exhaust Plenum By-Pass Damper	LE-BD			ESW	DME	DPS		

Lab Exhaust System Alteration- Points List						
Description	**Device**	**AO**	**AI**	**DO**	**DI**	**Remarks**
A Typical Lab with One FH, One DD box and One GE box (Typical of 1)						
Dual Duct Box/Fumehood/GEV						B-AAC (Existing)
DD Box (Existing)						
Cold Deck Damper - Open/Close				2		floating pt modulation
Total Airflow			1			
Hot Deck Damper - Open/Close				2		floating pt modulation
Airflow Common			1			
Supply Air Temperature			1			
Hot Deck Airflow			1			
						virtual point
Fume hood (New)						
Occupied/Unoccupied				1		Indicates to Phoenix if room is occupied.
Sash Position (future)	supplied by fumehood				1	Fume c/w discreet Dry contacts to indicate if sash is open
Phoenix Alarm					1	Fume c/w discreet Dry contacts to indicate if emergency
Phoenix Airflow			1			
GE Box (Existing)						
Damper - Open/close				2		
Airflow			1			
Space Temperature						Existing
Space temperature			1			Existing
Setpoint Adjustment			1			Existing
Occupied/Unoccupied					1	Existing

Rooms:

Rm 4161 (NIC)

Part 1 General

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation for piping, valves and fittings for gas fired equipment.

.2 Related Sections:

.1 Section 01 33 00 - Submittal Procedures.
.2 Section 01 45 00 - Quality Control.
.3 Section 01 35 50 - Waste Management and Disposal.
.4 Section 01 78 00 - Closeout Submittals.

1.2 REFERENCES

.1 American Society of Mechanical Engineers (ASME)

.1 ASME B16.5-09, Pipe Flanges and Flanged Fittings.
.2 ASME B16.18-12, Cast Copper Alloy Solder Joint Pressure Fittings.
.3 ASME B16.22-12, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
.4 ASME B18.2.1-10, Square and Hex Bolts and Screws Inch Series.

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

.1 ASTM A47/A47M-99(2009), 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 B75M-11, Standard Specification for Seamless Copper Tube Metric.
.4 ASTM B837-10, Standard Specification for Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.

.3 Canadian Standards Association (CSA International)

.1 CSA W47.1-09, Certification of Companies for Fusion Welding of Steel.

.4 Canadian Standards Association (CSA)/Canadian Gas Association (CGA)

.1 CAN/CSA B149.1-10, Natural Gas and Propane Installation Code.
.2 CAN/CSA B149.2-10, Propane Storage and Handling Code.

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

.1 Material Safety Data Sheets (MSDS).

1.3 SUBMITTALS

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

.2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.

.3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.4 Instructions: submit manufacturer's installation instructions.

.5 Closeout Submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 QUALITY ASSURANCE

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance with Section 01 70 50 - Health and Safety.

1.5 DELIVERY, STORAGE AND HANDLING

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling in accordance with Section 01 35 50 - Waste Management and Disposal.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan (WMP).

.4 Separate for reuse and recycling and place in designated containers Steel, Metal and Plastic waste in accordance with Waste Management Plan (WMP).

.5 Divert unused metal materials from landfill to metal recycling facility as approved by Departmental Representative.

Part 2 Products

2.1 PIPE

.1 Steel pipe: to ASTM A53/A53M, Schedule 40, seamless as follows:

.1 NPS 1/2 to 2, screwed.

.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, lubricated plug or 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, CAN/CSA B149.1, CAN/CSA B149.2 and supplemented as specified.

.2 Install drip points:

.1 At low points in piping system.

.2 At connections to equipment.

.3 Modify, relocate, and extend existing natural gas piping for new fume hood installation in lab 4161. Remove the existing natural gas outlets on counter tops as noted and turn over to Departmental Representative.

3.3 VALVES

.1 Install valves with stems upright or horizontal unless otherwise approved by Departmental Representative.

.2 Install valves at branch take-offs to isolate pieces of equipment, and as indicated.

3.4 FIELD QUALITY CONTROL

.1 Site Tests/Inspection:

.1 Test system in accordance with CAN/CSA B149.1, CAN/CSA B149.2 and requirements of authorities having jurisdiction.

.2 Obtain reports within 3 days of review and submit immediately to Departmental Representative.

3.5 ADJUSTING

.1 Purging: purge after pressure test in accordance with CAN/CSA B149.1 and CAN/CSA B149.2.

.2 Pre-Start-Up Inspections:

.1 Check vents from regulators, control valves, terminate outside building in approved location, protected against blockage, damage.

.2 Check gas trains, entire installation is approved by authority having jurisdiction.

3.6 CLEANING

.1 Cleaning: in accordance with CAN/CSA B149.1 and CAN/CSA B149.2.

.2 Perform cleaning operations in accordance with manufacturer's recommendations.

.3 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 233101 - Pressure Testing of Ducted Air Systems.

.4 This section includes the scope of work for the laboratory fume hood exhaust system; laboratory general exhaust system on roof, inside the penthouse.

1.2 References

.1 American Society for Testing and Materials (ASTM)

.1 ASTM A 653/A653M-11, Specification for Steel Sheet, Zinc-Coated or Zinc-Iron Alloy Coated by the Hot-Dip Process.

.2 ASTM A480 / A480M - 12 Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

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

.1 SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2006.

.2 SMACNA HVAC Air Duct Leakage Test Manual, 2012.

1.3 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Section 013300 - Submittal Procedures.

.2 Indicate the following:

.1 Sealants.
.2 Tape.
.3 Proprietary joints.
.4 Fittings.

1.4 Certification of Ratings

.1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

1.5 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Collect and separate plastic, paper packaging and corrugated cardboard in accordance with Waste Management Plan

.3 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 - PRODUCTS

2.1 Ductwork

.1 Material:

.1 Stainless Steel (All fume hood exhaust ducts)

.1 ASTM A480 / A480M - 12 Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip,
Type 316 for all fume hood exhaust duct and manifold located on roof and inside the penthouse, the rest of fume hood exhaust duct to be Type 304.

.2 Thickness 18 gauge as minimum, fabrication and reinforcement: to SMACNA as indicated.

.3 Joints: to be SMACNA continuous inert gas butt welded, tested to the SMACNA approved leakage rate for high pressure ducts.

.4 Ductwork rated for minimum 6" (1500 Pa) negative.

.2 Laboratory general exhaust return system.

.1 Galvanized steel with Z90 designation zinc coating lock forming quality: to ASTM A653 / A653M - 11 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

.2 Thickness: to SMACNA standards.

.3 Joints: to SMACNA standards, tested to the SMACNA approved leakage rate.

.4 Ductwork rated for minimum 6"WC (1500 Pa) negative.

.2 Construction - round:

.1 Ducts: factory fabricated, spiral wound, with matching fittings and specials to SMACNA.

.2 Transverse joints up to 900 mm: slip type with tape and sealants.

.3 Transverse joints over 900 mm: Vanstone.

.4 Fittings:

.1 Elbows: smooth radius. Centreline radius: 1.5 x diameter.

.2 Branches: conical transition with conical branch at 45° and 45° elbow.

.3 Construction - rectangular:

.1 Ducts: to SMACNA standards.

.2 Transverse joints: SMACNA seal Class A and B.

.3 Fittings:

.1 Elbows: smooth radius; centreline radius 1.5 x width of duct. No vanes.

.2 Branches: with conical branch at 45° and 45° elbow.

.4 Firestopping:

.1 50 x 50 x 3 mm retaining angles around duct, on both sides of fire separation.

.2 Firestopping material must not distort duct.

2.2 Seal Classification

.1 Classification as follows:

Maximum Pressure Pa	SMACNA Seal Class
2500	A
1500	A
1000	A
750	B

.2 Seal classification:

.1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.

.2 Class B: longitudinal seams, transverse joints and connections made airtight with gaskets, sealant, tape, or combination thereof.

2.3 Sealant

.1 Oil resistant, polymer type flame resistant high velocity duct sealing compound.

2.4 Tape

.1 Polyvinyl treated, open weave fibre glass, 50 mm wide.

2.5 Hangers and Supports

.1 Band hangers: use on round and oval ducts up to 500 mm diameter, of same material as duct but next sheet metal thickness heavier than duct.

.2 Trapeze hangers: ducts over 500 mm diameter or longest side, to SMACNA.

.3 Hangers: galvanized steel angle with galvanized steel rods, following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

.4 Upper hanger attachments:

.1 For concrete: manufactured concrete inserts.

.2 For steel joist: manufactured joist clamp or steel plate washer.

.3 For steel beams: manufactured beam clamps:

PART 3 - EXECUTION

3.1 General

.1 Supply and install in accordance with NFPA 90A, NFPA 90B, ASHRAE, SMACNA standards.

.2 Do not break continuity of insulation vapour barrier with hangers or rods.

.3 Support risers in accordance with SMACNA.

.4 Install breakaway joints in ductwork on sides of fire separation.

.5 Ensure installation of firestopping does not distort duct.

3.2 Hangers

.1 Band hangers: install in accordance with SMACNA.

.2 Angle hangers: complete with locking nuts and washers.

.3 Hanger spacing: 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 one coat of sealant to manufacturer's recommendations.

.3 Reseal all the existing laboratory general exhaust and general return ducts to air tight.

.4 Reseal all the existing laboratory fume hood exhaust ducts to air tight.

3.4 Leakage Tests

.1 Refer to Section 233101 - Pressure Testing of Ducted Air Systems.

.2 In accordance with SMACNA HVAC Duct Leakage Test Manual.

.3 Perform leakage tests in sections.

.4 Perform trial leakage tests, as instructed to demonstrate workmanship.

.5 Install no additional ductwork until trial tests have been achieved.

.6 Test section minimum of 30 m long with not less than three branch takeoffs and two 90 elbows.

.7 Complete tests before insulation or concealment.

.8 Test all the new/altered fume hood exhaust dust systems. Submit test report to Departmental Representative for review.

1 - GENERAL

1.1 General

.1 Pressure test new duct components.

.2 New and relocated ducts over 5 m in length, forming part of a return or exhaust ductwork system directly or indirectly connected to (lab exhaust fans LEF-1, 2 & 3, or LEF-4, 5 & 6, fume hood exhaust fans) to be pressure tested for leaks.

.3 Pressure test ducts in accordance with the system pressure rating.

1.2 Timing

.1 Ducts to be tested before installation of insulation or any other form of concealments.

.2 Test after seals have cured.

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

1.3 Exclusions

.1 Flexible connections to terminal boxes.

1.4 References

.1 ANSI/SMACNA 016-2012 - HVAC Air Duct Leakage Test Manual.

1.5 Test Procedures

.1 Maximum lengths of ducts to be tested to be consistent with capacity of test equipment.

.2 Section of duct to be tested to include:
.1 Fittings, branch ducts, tap-ins.

.3 Repeat tests until specified pressures are attained. Bear costs for repairs and repetition to tests.

.4 Base partial system leakage calculations on Reference Standard.

.5 Seal leaks that can be heard or felt, regardless of their contribution to total leakage.

1.6 Testing Agency

.1 Installing Contractor.

1.7 Verification

.1 Departmental Representative to witness tests and to verify reported results.

.2 To be certified by the same TAB agency approved by Departmental Representative to undertake TAB on this project.

1.8 Test Instruments

.1 Testing agency to provide instruments for tests.

.2 Test apparatus to include:

- .1 Fan capable of producing required static pressure.
- .2 Duct section with calibrated orifice plate mounted and accurately located pressure taps.
- .3 Flow measuring instrument compatible with the orifice plate.
- .4 Calibration curves for orifice plates used.
- .5 Flexible duct for connecting to ductwork under test.
- .6 Smoke bombs for visual inspections.

.3 Test apparatus to be accurate to within +/- 3 % of flow rate and pressure.

.4 Submit details of test instruments to be used to Departmental Representative at least three months before anticipated start date.

.5 Test instruments to be calibrated and certificate of calibration deposited with Departmental Representative no more than 28 days before start of tests.

.6 Instruments to be re-calibrated every six months thereafter.

1.9 Equipment Leakage Tolerances

.1 Equipment and system components such as terminal boxes, duct heating Leakage: 5%.

1.10 Report Forms

.1 Submit proposed report form and test report format to Departmental Representative for

approval at least three months before proposed date of first series of tests. Do not start tests until approval received in writing from Departmental Representative.

1.11 Pressure Test Reports

.1 Prepare report of results and submit to Departmental Representative within 24 hours of completion of tests. Include:

- .1 Schematic of entire system.
- .2 Schematic of section under test showing test site.
- .3 Required and achieved static pressures.
- .4 Orifice differential pressure at test sites.
- .5 Permissible and actual leakage flow rate (L/s) for test sites.
- .6 Witnessed certification of results.

.2 Include test reports in final TAB report.

PART 2- PRODUCTS

NOT USED

PART 3- EXECUTION

NOT USED

PART 1 - GENERAL

1.1 Related Sections

.1 Section 01330 - Submittal Procedures.

.2 Section 01355 - Waste Management and Disposal.

.3 Section 15814 - Pressure Testing of Ducted Air Systems.

.4 This section includes the scope of work for DD system (from DD box discharge to air outlets only), kitchen exhaust system and general exhaust system (Exhaust air inlet section of GEV box only).

1.2 References

.1 American Society for Testing and Materials (ASTM)
- .1 ASTM A 480/A480M-12, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
- .2 ASTM A 635/A635M-09b, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot Rolled.
- .3 ASTM A 653/A653M-11, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

.2 National Fire Protection Agency (NFPA)
- .1 NFPA 90A-12, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .2 NFPA 90B-12, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- .3 NFPA 91-10, Standard for Exhaust System for Air Conveying of Vapours, Gases, Mists, and Noncombustible Particle Solids.
- .4 NFPA 96-11, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2006.
- .2 SMACNA HVAC Air Duct Leakage Test Manual,

2012.

1.3 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Section 01330 - Submittal Procedures.

.2 Indicate following:
- .1 Sealants.
- .2 Tape.
- .3 Proprietary Joints.

1.4 Certification of Ratings

.1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

1.5 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 01355 - Waste Management and Disposal.

.2 Collect and separate plastic, paper packaging and corrugated cardboard in accordance with Waste Management Plan

.3 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 - PRODUCTS

2.1 Seal Classification

.1 Classification as follows:

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

.2 Seal classification:
- .1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.
- .2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant, tape or combination thereof.

.3 Class C: transverse joints and connections made air tight with gaskets sealant, tape or combination thereof. Longitudinal seams unsealed.
.4 Unsealed seams and joints.

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

2.3 Tape
.1 Tape: polyvinyl treated, open weave fiberglass tape, 50 mm wide.

2.4 Duct Leakage
.1 In accordance with SMACNA HVAC Duct Leakage Test Manual.

2.5 Fittings
.1 Fabrication: to SMACNA.

.2 Radiused elbows:
.1 Rectangular: Centreline radius: 1.5 times width of duct.
.2 Round: Centreline radius: 1.5 times diameter.

.3 Mitred elbows, rectangular:
.1 To 400 mm: with single thickness turning vanes.
.2 Over 400 mm: with double thickness turning vanes.

.4 Branches:
.1 Rectangular main and branch: with 45 entry on branch.
.2 Round main and branch: enter main duct at 45with 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: 20maximum included angle.
.2 Converging: 30maximum included angle.

.6 Offsets:
.1 Short radiused elbows as indicated.

.7 Obstruction deflectors: maintain full cross-sectional area. Maximum included angles: as for transitions.

2.6 Firestopping

.1 Retaining angles around duct, on both sides of fire separation.

.2 Firestopping material and installation must not distort duct.

2.7 Galvanized Steel

.1 Lock forming quality: to ASTM A 653, Z90 zinc coating.

.2 Thickness, fabrication and reinforcement: to SMACNA.

.3 Joints: to SMACNA.

2.8 Hangers and Supports

.1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct. Maximum size duct supported by strap hanger: 500 mm.

.2 Hanger configuration: to SMACNA.

.3 Hangers: galvanized steel angle with galvanized steel rods to SMACNA following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25x25x3	6
751 to 1050	40x40x3	6
1051 to 1500	40x40x3	10
1501 to 2100	50x50x3	10
2101 to 2400	50x50x5	10
2401 and over	50 x 50 x 6	10

.4 Upper hanger attachments:
- .1 For concrete: manufactured concrete inserts.
- .2 For steel joist: steel plate washer.
- .3 For steel beams: manufactured beam clamps:

PART 3 - EXECUTION

3.1 General

.1 Supply and install in accordance with NFPA90A, NFPA90B, ASHRAE and SMACNA standards.

.2 Do not break continuity of insulation vapour barrier with hangers or rods.

.3 Support risers in accordance with SMACNA.

.4 Install breakaway joints in ductwork on sides of fire separation.

.5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.

.6 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

3.2 Hangers

.1 Strap hangers: install in accordance with SMACNA.

.2 Angle hangers: complete with locking nuts and washers.

.3 Hanger spacing: as follows:

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

3.3 Watertight Duct

.1 Provide watertight duct for:
.1 Fresh air intake.

.2 Form bottom of horizontal duct without longitudinal seams. Weld joints of bottom and side sheets. Seal other joints with duct sealer.

.3 Slope horizontal branch ductwork down towards fume hoods served. Slope header ducts down toward risers.

.4 Fit base of riser with 150 mm deep drain sump and 32 mm drain connected, with deep seal trap and valve and discharging to open funnel drain.

3.5 Sealing and Taping

.1 Apply sealant to outside of joint to manufacturer's recommendations.

.2 Bed tape in sealant and recoat with minimum of one coat of sealant to manufacturers recommendations.

3.6 Leakage Tests

.1 Refer to Section 23 31 01 Pressure Testing of Ducted Air Systems.

.2 In accordance with SMACNA HVAC Duct Leakage Test Manual.

.3 Do leakage tests in sections.

.4 Make trial leakage tests as instructed to demonstrate workmanship.

.5 Do not install additional ductwork until trial test has been passed.

.6 Test section minimum of 30 m long with not less than three branch takeoffs and two 90 degrees elbows.

.7 Complete test before performance insulation or concealment Work.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

1.2 References

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

.1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible, 2006.

1.3 Product Data

.1 Submit product data in accordance with Section 013300 - Submittal Procedures.

.2 Indicate the following:

.1 Flexible connections.
.2 Duct access doors.
.3 Turning vanes.
.4 Instrument test ports.

1.4 Certification of Ratings

.1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

1.5 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Collect and separate plastic, paper packaging and corrugated cardboard in accordance with Waste Management Plan

.3 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 - PRODUCTS

2.1 General

.1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.

2.2 Flexible Connections

.1 Frame: galvanized sheet metal frame 2 mm thick with fabric clenched by means of double locked seams.

.2 Material:

.1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40C to plus 90C, density of 1.3 kg/m².

2.3 Access Doors in Ducts

.1 Non-insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.

.2 Insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.

.3 Gaskets: neoprene.

.4 Hardware:

.1 Up to 300 x 300 mm: two sash locks complete with safety chain.
.2 301 to 450 mm: four sash locks complete with safety chain.
.3 451 to 1000 mm: piano hinge and minimum two sash locks.
.4 Doors over 1000 mm: piano hinge and two handles operable from both sides.
.5 Hold open devices.

2.4 Turning Vanes

.1 Factory or shop fabricated single thickness (with trailing edge), to recommendations of SMACNA and as indicated.

2.5 Instrument Test

.1 1.6 mm thick steel zinc plated after manufacture.

.2 Cam lock handles with neoprene expansion plug and handle chain.

.3 28 mm minimum inside diameter. Length to suit

insulation thickness.

.4 Neoprene mounting gasket.

PART 3 - EXECUTION

3.1 Installation

.1 Flexible connections:

.1 Install in following locations:

.1 Inlets and outlets to supply air units and fans.
.2 Inlets and outlets of exhaust and return air fans.
.3 As indicated.

.2 Length of connection: 100 mm.

.3 Minimum distance between metal parts when system in operation: 75 mm.

.4 Install in accordance with recommendations of SMACNA.

.5 When fan is running:

.1 Ducting on sides of flexible connection to be in alignment.
.2 Ensure slack material in flexible connection.

.2 Access doors and viewing panels:

.1 Size:
.1 600 x 600 mm for person size entry.
.2 400 x 400 mm for servicing entry.
.3 As indicated.

.2 Locations:

.1 Fire and smoke dampers.
.2 Control dampers.
.3 Devices requiring maintenance.
.4 Required by code.
.5 Reheat coils.
.6 Elsewhere as indicated.

.3 Instrument test ports.

.1 General:

.1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.

.2 Locate to permit easy manipulation of instruments.

.3 Install insulation port extensions as required.

.4 Locations.

.1 For traverse readings:

.1 Ducted inlets to roof and wall exhausters.
.2 Inlets and outlets of other fan systems.
.3 Main and sub-main ducts.
.4 And as indicated.

.2 For temperature readings:

.1 At outside air intakes.
.2 In mixed air applications in locations as approved by Departmental Representative.
.3 At inlet and outlet of coils.
.4 Downstream of junctions of two converging air streams of different temperatures.
.5 And as indicated.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 233300 - Duct Accessories.

1.2 References

.1 American Society for Testing and Materials (ASTM)

.1 ASTM A 653M/A653M-11, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process.

1.3 Product Data

.1 Submit product data in accordance with Section 013300 - Submittal Procedures.

1.4 Closeout Submittals

.1 Provide maintenance data for incorporation into manual specified in Section 017800 - Closeout Submittals.

1.5 Certification of Ratings

.1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency.

1.6 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal, and with the Waste Reduction Workplan.

.2 Place materials defined as hazardous or toxic waste in designated containers.

.3 Ensure emptied containers are sealed and stored safely for disposal away from children.

PART 2 - PRODUCTS

2.1 Multi-Leaf Dampers

.1 Opposed and or Parallel blade type as indicated.

.2 Structurally formed steel, interlocking blades, complete with extruded vinyl seals, spring stainless steel side seals, structurally formed and welded galvanized steel frame.

.3 Pressure fit self-lubricated bronze bearings.

.4 Linkage: plated steel tie rods, brass pivots and plated steel brackets, complete with plated steel control rod.

.5 Performance:

.1 Leakage: in closed position to be less than 2% of rated air flow at 1,000 Pa differential across damper.
.2 Pressure drop: at full open position to be less than 25 Pa differential across damper at 27 m/s.

.6 Insulated aluminum dampers:

.1 Frames: insulated with extruded polystyrene foam with R factor of 5.0.
.2 Blades: constructed from aluminum extrusions with internal hollows insulated with polyurethane or polystyrene foam, R factor of 5.0.

2.2 Back Draft Dampers

.1 Automatic gravity operated, multi single leaf, aluminum steel construction with nylon bearings, centre pivoted spring assisted or counterweighted.

PART 3 - EXECUTION

3.1 Installation

.1 Install where indicated.

.2 Install in accordance with recommendations of SMACNA and manufacturer's instructions.

.3 Seal multiple damper modules with silicon sealant.

.4 Install access door adjacent to each damper. See Section 233300 - Duct Accessories.

.5 Ensure dampers are observable and accessible.

.6 Provide four heavy duty opposed blade dampers for general exhaust main ducts. Locate the damper between the air silencer and the heat recovery coil of each exhaust main duct.

.7 Adjust relief pressure (counterweights or springs) on all back draft dampers.

PART 1 - GENERAL

1.1 References

.1 AMCA 99-2010, Standards Handbook.

.2 ANSI/AMCA 210-2007, Laboratory Methods of Testing Fans for Rating.

.3 AMCA 300-2008, Reverberant Room Method for Sound Testing of Fans.

.4 AMCA 301-2006, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

.5 ANSI/ASHRAE 51-2007, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.6 CGSB 1.181-99, Ready-Mixed Organic Zinc-Rich Coating.

.7 NFPA 45-2011, Fire Protection for Laboratories Using Chemicals.

1.2 Shop Drawings

.1 Submit shop drawings and product data in and Product Data in accordance with Section 013400 - Shop Drawings, Product Data, Samples and Mock-ups.

.2 Provide fan curves and sound rating data, showing point of operation, bhp and efficiency.

.3 Indicate following: motors, wheels, bearings, shafts, dimensions, capacity, and special coatings.

.4 Mixed flow induced dilution fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, stack extension., if any, and all related accessories specified herein have been pre-tested at the factory and that the fan curves have been de-rated for any and all system effects created by the accessories.

1.3 Operation and Maintenance Data

.1 Provide operation and maintenance data for incorporation into manual specified in Section 23 05 00.

1.4 Maintenance Materials

.1 Provide maintenance materials in accordance with Section 017800 - Maintenance Materials, Special Tools and Spare Parts.

.1 Spare parts to include:

.1 One set of bearings for one (1) new exhaust fan.

1.5 Manufactured Items

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards in force.

1.6 Commissioning

.1 Do commissioning in accordance with Section 13833 - EMCS: Commissioning.

PART 2 - PRODUCTS

2.1 Fans General

.1 Capacity: flow rate, total static pressure, bhp, revolutions per minute, power, model, size, sound power data as indicated on schedule.

.2 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.

.3 Sound ratings: comply with AMCA (Air Moving and Conditioning Association) 301, tested to AMCA 300. Unit shall bear AMCA certified sound rating seal.

.4 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210, and ANSI/ASHRAE 51. Unit shall bear AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.

.5 Motors:

.1 For use with variable speed controllers as indicated.

.2 Sizes as indicated.

.3 Provide a maintenance free, circumferential, conductive micro fiber

shaft grounding ring (AEGIS SGR) on all motors. All shaft currents to be discharged to ground.

.6 Vibration isolation: to Section 230548 - Vibration Isolation and Seismic Control.

.7 Provide disconnect switch for all new fans and where indicated. Roof-mounted fans to have weatherproof disconnect.

.8 Disconnects on motors driven by VFD's shall include auxiliary switches (wired to VFD's to shut down the VFD if disconnect is disconnected)

2.2 Mixed Flow Induced Dilution Fans (Lab Exhaust Fans)

.1 Capacity (flow rate and the external static pressure) indicated on the schedule are based on the inlet to the mixing plenum. The losses in the plenum, fan, silencer, discharge cone etc. are considered internal to the package, and are not included in the external static pressure requirement.

.2 Impellers shall be mounted direct to the motor shaft to provide a direct drive arrangement 4-type fan. Motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service. Belt drives are not acceptable.

.3 Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impellers shall have non-stall and non-overloading performance characteristics with stable operation at any point on the fan curves.

.4 Stationary discharge guide vane sections shall be provided to increase fan efficiencies.

.5 Fan dynamic balance not to exceed 0.5 mil, peak to peak, at the blade pass area when operating at fan frequency. Vibration isolation shall be limited to rubber-in-shear pad type isolators. Fans requiring spring isolators are not acceptable.

.6 Fan assemblies shall be designed for mounting on roof steel beam supports without the need for guy wire supports or spring isolated bases.

.7 Discharges shall include twin FRP nozzles with passive third central stacks that are capable of

generating aspiration. The FRP shall be chemically and UV resistant.

.8 Steel entrainment windbands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. Windbands shall discharge up to 270% of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.

.9 A non-ferrous inlet bell shall be provided in order to reduce sparking in the event of a motor bearing failure.

.10 Fans shall be modular construction and capable of being assembled on the roof.

.11 PTFE gaskets shall be provided at all companion flanged joints.

.12 Fasteners shall be 316 stainless steel.

.13 A hinged, bolted access door shall be provided for impeller inspection on each fan.

.14 Fans and accessories shall have internal drain systems to prevent rain water from entering building duct system, or the building itself.

.15 Electric motors shall be TEFC Mill & Chemical duty with a 1.15 service factor and an L-10 bearing life of 340,000 hours. Motors on BS-1 and larger fans shall be C-Face and foot mounted. Refer to Section 230513. Motors shall be inverter duty. Motor sizes shall not exceed scheduled values.

.16 A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to the motor.

.17 Coatings - All steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching. Coating will be epoxy (8-10 mils) for protection against weather, chemical vapours and splashes.

.18 Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirements of the number of fans listed on the schedule. Multiple fan plenums shall be insulated double wall construction with structural stiffeners. Double wall plenums shall have an overall minimum wall thickness of 1.5'', and the insulation shall

have a minimum R value of 4.34. Outer skin of double wall plenums shall be coated 18-22Ga Galvaneal steel. Inner skin shall be uncoated 18-22Ga 316 stainless steel. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors and safety screens over primary air inlets. The primary air inlets shall be located on the side as indicated. Coatings shall be the same as specified for the fans. Exhaust air plenum should be sized to minimize system effects on fans as a result of the in-coming air coming from the opposite directions or from the sides. Maximum permissible plenum footprint shall not exceed 5486mm x 1525mm [216''x60''].

.19 Stainless safety screens shall be supplied over bottom primary air inlets.

.20 Bypass dampers shall be provided with all mixing plenums for outside make-up air with primary exhaust. Dampers will be:

.1 Opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction. The dampers shall be controlled by operators supplied by EMCS Refer to schedule on drawings.

.21 The by-pass damper, mounted on the duct main, shall be able to open from closed position to fully open position in 30 seconds.

.22 Low leakage isolation dampers shall be constructed of aluminum air foil extrusions and coated with epoxy. Operators shall be 2 position, spring return and shall be 24V electric. The electric operator shall be factory wired, complete with a transformer, to the fan disconnect switch to open when the fan is energized and close via a spring return when de-energized. When the fan ships separate from the plenum, all wiring and conduit shall be factory supplied for easy connection in the field.

.23 Vortex breakers shall be provided on all side inlet and multiple fan plenums.

.24 The units shall be provided with attenuators.
.1 The outer shell of sound attenuator to be constructed of fiber reinforced plastic with minimum 3/16'' wall thickness.
.2 Attenuator to be packed with sound attenuating fiberglass. Acoustical media

to be isolated from air stream by tedlar lining.

.3 Air passageway of attenuator to be lined with perforated metal.

.4 Attenuator must not increase the height of the fan unit. Acoustical screening may not be used.

.5 Attenuator must meet following dynamic insertion losses as tested with fan unit:

Fan Size	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
TS-2	0	4	9	11	12	13	9	4
TS-3	8	7	12	15	15	13	10	6
TS-4	5	8	9	11	12	12	10	6

Fan noise shall not exceed 67 dBA at 10 feet with two fans operating using discharge silencers.

.6 Access to the motor junction box of the fan unit cannot be blocked by the sound attenuator.

.7 The fan performance curves must include any performance losses due to the addition of sound attenuator per factory-tested data

.25 Inlet mixing plenum completed with access door as shown on plans shall be provided by the fan manufacturer.

.26 A wide flange galvanized steel seismic roof curb shall be provided with the units to support the fans/plenums. The curb shall be approximately 450mm high to match the existing lab exhaust fan. The curb shall be seismically secured to the steel support structure on the roof.

.27 High Plume dilution package.

.28 Provide extended lube lines to the bearings. Provide also an extended return line for viewing the condition of the bearing grease.

.29 Maximum fan mass including all accessories not to exceed 4906kg. Maximum fan height including plenum and wide flange curb not to exceed 5004mm [197''].

PART 3 - EXECUTION

3.1 Fan Installation

.1 Install fans as indicated complete with resilient mountings specified in Section 230548 - Vibration Isolation and Seismic Control, flexible

electrical leads and flexible connections in accordance with Section 233300 - Duct Accessories.

.2 Provide sheaves and belts required for final air balance (as applicable).

.3 Bearings and extension tubes to be easily accessible.

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

.5 Install fans with 100 mm flexible connection on inlet ductwork and on discharge ductwork. Ensure metal bands of connectors are parallel with minimum 75 mm flex between ductwork and fan during running.

.6 Install restraining snubbers.

.7 Where inlet or outlet is exposed, provide safety screen.

.8 Fan base to be securely fastened to curb by means of stainless steel bolts. Provide hemi-grommets (Mason HG) under hold-down bolts. Use lock nuts and ensure bolt can be turned by hand after lock nut secured.

PART 1 - GENERAL

1.1 References

.1 ANSI/AMCA Standard 210-07|ANSI/ASHRAE 51-07, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

.2 ANSI/ASHRAE 51-1985, Laboratory Methods of Testing Fans for Rating.

.3 UL 181-2005, Factory-Made Air Ducts and Connectors.

.4 ISO 3741-2010, Acoustics-Determination of Sound Power Levels of Noise Sources-Precision Methods for Broad-band Sources in Reverberation Rooms.

1.2 Shop Drawings and Project Data

.1 Submit shop drawings and product data in accordance with Section 013300 - Submittal Procedures.

.2 Indicate the following:
- .1 Capacity
- .2 Performance
- .3 Pressure drop
- .4 Noise rating
- .5 Leakage
- .6 Dimensions
- .7 Controls
- .8 Accessories

1.3 Test Reports

.1 To ANSI/AMCA 210 ANSI/ASHRAE 51. Submit published test data on DIN (Direct Internal Noise), in accordance with ISO 3741 made by independent testing agency for 0, 2.5 and 6 m/s branch velocity or inlet velocity. Sound power level with minimum inlet pressure of 0.25 and 1.5 kPa in accordance with ISO 3741 for 2nd through 7th octave band, also made by independent testing agency. Pressure loss through silencer shall not exceed 60% of inlet velocity pressure maximum.

1.4 Maintenance Data

.1 Provide maintenance data for incorporation into manual specified in Section 017800 - Closeout Submittals.

1.5 Maintenance Materials

.1 Provide maintenance materials in accordance with Section 017800 - Closeout Submittals.

PART 2 - PRODUCTS

2.1 General

.1 Performance: as indicated on drawings and specified below.

.2 CSA certified.

.3 Comply with Section 233353 - Acoustic Duct Lining for internal lining of terminal units.

2.2 Variable Air Volume Thermal Unit (Dual Duct and GEV boxes)

.1 Pressure independent variable air volume control assemblies.

.2 Include factory fabricated components for volume regulation independent of varying inlet static pressure conditions, dampers and flow sensors.

.3 Field mount and calibrate electronic DDC controller and actuator supplied by EMCS section. Refer to section 230983 clause 1.3.

.4 Access door integral with the casing, to □service operators and control devices.

.5 Provide factory mounted sound attenuator or multi port outlet as indicated.

.6 Sealed and gasketed leakproof construction of 0.9 mm thick galvanized steel, internally lined with minimum 25 mm thick 24 kg/mü density acoustical thermal insulation.

.7 Damper blades, shafts in rust proof Delrin □self-lubricating bearings. Seat damper against gasketed stops. Maximum damper leakage 2% at 1.5 kPa pressure and shutoff.

.8 Install the control device to maintain constant flow regardless of inlet flow deflection. Incorporate the flow sensor to maintain flow within 5% of factory minimum and maximum settings regardless of inlet duct angle. Install air flow probe.

.9 Airborne octave band sound power levels with attenuator for air terminal boxes shall not exceed the specified data in drawing schedule.

.10 Radiated octave band sound power levels for air terminal boxes shall not exceed the specified data in drawing schedule.

.11 Provide single shaft actuator to drive the hot deck and cold deck mixing dampers, and a single shaft to drive the variable volume damper of the dual duct boxes. Flow control shall be accomplished with the total flow sensor and VAV control damper. Temperature control shall be accomplished by modulating the hot deck ad cold deck mixing dampers. Provide multi-point sensors.

.12 Acceptable materials: E.H. Price, Titus, Nailor.

.13 All dual duct boxes (DD) and general exhaust boxes (GEV) be capable to operate properly for the maximum and minimum air flow as specified in the drawing schedule.

2.3 Air Valves (FHEV)

.1 Air valves shall be a venture type valve.

.2 The air valves shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifold system.

.3 The air valves shall maintain accuracy within +/- 5% of signal over an airflow turndown range of no less than 16 to 1. No minimum entrance or exit duct diameter shall be required to ensure accuracy and/or pressure independence.

.4 The air valve shall be constructed as follows:

.1 Fume Hoods Exhaust: 16 gauge aluminum shall have a baked on corrosion resistant phenolic coating with no exposed aluminum or stainless steel components. The device's shaft, shaft support brackets, pivot arm and internal mounting link shall be made of 316 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts, and rivets shall be titanium. Shaft, shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked on corrosion resistant phenolic coating. All shaft bearing surfaces shall be made of a Teflon or Celenex composite.

.5 Electronic air valve controllers which supplied

by valve supplier, shall be field mounted and calibrated by EMCS trade. Refer to section 230993 section 4.

.6 Air valve shall provide 0-10V signal to EMCS to indicate valve position.

.7 Airborne octave band sound power levels shall not exceed the following (reference 10 e-12 watts at 150 Pa static pressure drop from inlet to discharge of unit).

Size	Volume(1/s)	125	250	500	1000	2000
12M	565	65	58	53	56	52

.8 Certification:

.1 Each air valve shall be factory calibrated to the job specific airflows using NIST traceable air stations and instrumentation having a combined accuracy of at least +/- 5% of signal at a minimum of eight different airflows across the full operating range of the device.

.2 All airflow control devices shall be individually marked with device specific factory calibration data. As a minimum, it should include: tag number, serial number, model number, eight point characterization information (for electronic devices) and quality control inspection numbers.

.9 Acceptable material: Equal to Phoenix controls.

PART 3 - EXECUTION

3.1 Installation

.1 Install in accordance with manufacturers recommendations.

.2 Install dual duct terminal units in supply air systems.

.3 Install air valves in fume hood exhaust from laboratory areas.

.4 Install general exhaust variable volume terminal units.

.5 Support terminal units independently of ductwork.

.6 Install with minimum of 4 duct diameters of straight inlet duct for DD, GEV and FHEV, same size as inlet unless otherwise specified.

.7 Install isolation valve on inlet and lockshield balancing valve on outlet of each reheat coil.

.8 Arrange for suitable ceiling access to units. Provide access doors or locate above easily removable ceiling components.

3.1 Balancing

.1 Balance in accordance with Section 230593, Testing, Adjusting and Balancing (TAB) of Mechanical Systems.

PART 1 - GENERAL

1.1 Related Sections

.1 Section 013300 - Submittal Procedures.

.2 Section 013550 - Waste Management and Disposal.

.3 Section 017800 - Closeout Submittals.

1.2 Product Data

.1 Submit product data in accordance with Section 013300 - Submittal Procedures.

.2 Indicate the following:
- .1 Capacity.
- .2 Throw and terminal velocity.
- .3 Noise criteria.
- .4 Pressure drop.
- .5 Neck velocity.

1.3 Samples

.1 Submit samples in accordance with Section 013300 - Submittal Procedures.

1.4 Certifications

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

1.5 Waste Management and Disposal

.1 Separate and recycle waste materials in accordance with Section 013550 - Waste Management and Disposal.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Dispose of corrugated cardboard polystyrene plastic packaging material in appropriate on-site bin for recycling in accordance with site waste management program.

1.6 Extra Materials

.1 Provide maintenance materials in accordance with Section 017800 - Closeout Submittals.

.2 Include:
- .1 Keys for volume control adjustment.
- .2 Keys for air flow pattern adjustment.

PART 2 - PRODUCTS

2.1 General

.1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity as indicated.

.2 Frames:
- .1 Full perimeter gaskets.
- .2 Plaster frames where set into plaster or gypsum board at all locations and as specified.
- .3 Concealed fasteners.

.3 Concealed manual volume control damper operators.

.4 Colour: standard as directed by Departmental Representative.

.5 Acceptable materials: E.H. Price, Titus, Nailor

2.2 Manufactured Units

.1 Grilles, registers and diffusers of same generic type to be product of one manufacturer.

2.3 Supply Grilles and Registers

.1 General: with opposed blade dampers.

.2 Type SA: steel, 25 mm border, double deflection with airfoil shape, horizontal face and vertical rear bars. Refer to drawing schedule (may not apply to current project).

2.4 Return and Exhaust Grilles and Registers

.1 General: with opposed blade dampers.

.2 Type RA: aluminum, 19 mm border, single 0° deflection, horizontal face bars. Refer to drawing schedule (may not apply to current project).

2.5 Radial Flow Diffusers

.1 General: high capacity, laminar flow, hinged face with push-button latch mechanism, back pan suitable for surface mounting or duct mounted as indicated.

.2 Aluminum multi angular perforated face and vanes, satin coated steel backpan. Refer to drawing schedule.

PART 3 - EXECUTION

3.1 Installation

.1 Install in accordance with manufacturers instructions.

.2 Install with flat head cadmium plated screws in countersunk holes where fastenings are visible.

.3 Bolt grilles, registers and diffusers, in place, in industrial areas or labs.

.4 Where visible, paint ductwork behind grilles matte black.

Part 1 General

1.1 RELATED WORK

.1 Division 01 General Requirements

.2 Division 12 Steel Laboratory Casework

.3 Division 23 HVAC other sections

.4 Division 25 Integrated Automation

.5 Division 26 Electrical

1.2 SCOPE

.1 **The works specified in this entire section are NIC and are for contractor's information only.**

.2 Repair the defects of the new owner's supplied hoods as listed in the Appendix D.

.3 Move two (2) new constant volume bypass fume hoods stored in the Penthouse of the Pacific Agriculture and Agri-Food Research Center in Summerland, B.C., and install in two labs in accordance with the specifications herein. New fume hoods shall be supplied by the Departmental Representative.

.4 Refer to Departmental Representative, Specification Division 01 to Division 26 for fume hood installation unless otherwise specified herein this section and drawings attached.

.5 Perform "As Installed (AI) Fume Hood Performance" testing after the new fume hoods are installed.

.6 New fume hoods and all attached mechanical and electrical fixtures.

.7 Where the term "hoods" is used it shall refer to fume hoods.

1.3 QUALITY

.1 Where governed by code requirements in their final installed locations, items of this Section shall conform to the National Building Code, ULC Standards, CSA Z316.5-04 Fume hood and associated exhaust systems, and all other standards as noted.

.2 All electrical and operating items shall be CSA or ULC approved and carry the appropriate CSA or ULC label.

.3 Hoods shall be manufactured by a fabricator having a minimum of 10 years experience in the design, fabrication and installation of highest quality research scientific laboratory hoods, manufactured to highest laboratory standards and accuracy.

1.4 AS MANUFACTURED (AM) FUME HOOD PERFORMANCE

.1 Owner's supplied fume hoods have been tested by the manufacturer (or an independent testing agent), and witness by a qualified third party as directed by the Departmental Representative. The test will be conducted at the manufacturer site; and the tested fume hood must pass all of the As Manufactured (AM) tests as outlined in MD15128 Minimum Guidelines for Laboratory Fume Hoods dated March 2008. This compliance is the condition and prerequisite of the contract of purchasing of fume hoods.

.2 The qualified thirty party is responsible for ensuring the test procedures and the test results to meet the MD15128 Minimum Guideline; the acceptance of test instruments, accuracy of the instruments, instrument calibration and set-up to fully meet the MD15128 Minimum Guidelines for Laboratory Fume Hoods dated March 2008.

.3 The AM fume hood test shall be performed at a sash height of 450 mm. Fume hood tests are to be done for the two loading conditions.

Condition 1: Fume hood is non-loaded with simulated experimental apparatus placed within fume hood.

Condition 2: Fume hood is loaded with simulated experimental apparatus placed within fume hood. For each loading condition, the tests shall be done with a challenge 0.25 m/s cross draft of air at the sash plane and the draft shall be directed downward toward the sash at 45 degree.

Tests shall include:
- Face velocity
- Visualization- small and large
- By-pass effectiveness
- Tracer gas
- Cross drafts
- Sash movement effects
- Minimum airflow requirements as per NFPA 45

.4 The passing criteria of the performance tests for both loading conditions shall be as per the MD 15128.

For this specific size of fume hood, Condition 2 shall be conducted as per the Figure 2 on page 20 of MD15128 without the box of 150 mm x 150 mm x 300 mm, located in front of the bigger box. All boxes shall be elevated by 50 mm from work surface with blocks.

.5 A failure of any one of these tests shall constitute a failure of the fume hood and shall relieve the Departmental Representative from any responsibility of purchasing the fume hoods from the manufacturer

.6 Manufacturer shall allow one week in advance notice to the Departmental Representative prior the test and one day to finish the test. Departmental Representative shall be present to witness the tests.

1.5 AS INSTALLED (AI) FUME HOOD PERFORMANCE

.1 All new installed fume hoods must be tested by an independent testing agent, and witness by a qualified third party as directed by the Departmental Representative. The test will be conducted on site; and the tested fume hood must pass all of the As Installed (AI) tests as outlined in MD15128 Minimum Guidelines for Laboratory Fume Hoods dated March 2008.

.2 The qualified thirty party is responsible for ensuring the test procedures and the test results to meet the MD15128 Minimum Guideline; the acceptance of test instruments, accuracy of the instruments, instrument calibration and set-up to fully meet the MD15128 Minimum Guidelines for Laboratory Fume Hoods dated March 2008. Provide a test report to outline the test results.

.3 The AI fume hood test shall be performed at a sash height of 450 mm. Fume hood tests are to be done for the two loading conditions.

Condition 1: Fume hood is non-loaded with simulated experimental apparatus placed within fume hood.

Condition 2: Fume hood is loaded with simulated experimental apparatus placed within fume hood. For each loading condition, the tests shall be done with a challenge 0.25 m/s cross draft of air at the sash plane and the draft shall be directed downward toward the sash at 45 degree.

Tests shall include:
- Face velocity
- Visualization- small and large
- By-pass effectiveness
- Tracer gas
- Cross drafts
- Sash movement effects
- Minimum airflow requirements as per NFPA 45

.4 The passing criteria of the performance tests for both loading conditions shall be as per the MD 15128.

For this specific size of fume hood, Condition 2 shall be conducted as per the Figure 2 on page 20 of MD15128 without

the box of 150 mm x 150 mm x 300 mm, located in front of the bigger box. All boxes shall be elevated by 50 mm from work surface with blocks.

.5 A failure of any of these tests shall constitute a failure of the fume hood and retest the fume hood is required.

.6 Contractor shall allow one week in advance notice to the Departmental Representative prior the test. Departmental Representative shall be present to witness the tests.

1.6 QUALIFICATIONS OF MANUFACTURER

.1 Manufacturers shall have an established organization, experienced engineering department and production facilities specializing in fume hood fabrication. Manufacturers shall have demonstrated ability to produce equipment of the required quality, and the proven capacity to complete an installation of this size and type within the required time limits.

.2 Hood evaluation of the manufacturer's product shall take place in the manufacturer's test facility with samples, apparatus, instruments, and test materials to be supplied by the manufacturer at no cost to the Departmental Representative. At his option, the Departmental Representative may verify data with his own instruments, providing instrument suitability and calibration are mutually acceptable.

.3 Testing shall be performed to CSA C22.2 No. 151 and newest ASHRAE/SAMA/ANSI Standards as well as meeting all requirements specified herein such as MD1528 Minimum Guidelines.

1.7 REFERENCES

.1 ASTM A 167-99, "Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet and Strip".

.2 ASTM A 794/A 794M-12, "Standard Specification for Commercial Steel (CS), Carbon (0.16% Maximum to 0.25% Maximum), Cold-Rolled".

.3 ASTM B 456-11e1, "Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium".

.4 ASTM A 240/A240M-12a, "Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications".

.5 CAN/CGSB-12.1-M90, "Glass, Safety, Tempered or Laminated".

.6 CSA C22.2 No. 151-1979, "Laboratory Equipment".

.7 CSA Z316.5-04(R2009), "Fume Hoods and Associated Exhaust Systems".

.8 NSF, "National Sanitary Foundation Testing Laboratory".

.9 CAN3-0188.1-M78, "Interior Mat-Formed Wood Particlebboard".

1.8 SHOP DRAWINGS

.1 Submit Shop Drawings to the Departmental Representatives for review prior to order equipment.

.2 Provide detail drawings of each article under this Section showing size, installation, preparation, services required and rough-in requirements, operation, materials, finishes, field joints, wiring and piping diagrams, controls, etc.

.3 Manufacturer's publications are acceptable for standard non-custom specialties if the specific model or type fully shown along with all available accessories, features.

.4 Provide factory test reports on hood performance including exhaust air volumes, face velocities of various sash positions (300mm open, 450mm open and fully open) and static pressure loss.

1.9 SAMPLES

.1 Where called for in this Section under the specific item, provides 2 samples minimum size 50 x 100mm, of material or finish.

1.10 MAINTENANCE DATA

.1 Submit Maintenance Data to the Departmental Representative for review.

.2 Provide 2 copies of complete operating and maintenance data for each specific item in this Section together with name, address and telephone number of nearest representative for parts supply.

1.11 PRODUCT DELIVERY STORAGE AND HANDLING

.1 Coordinate with the Departmental Representative for the fume hood delivery schedule.

.2 Finished items, components, assemblies shall be wrapped and crated in a manner to protect materials and finishes from damage during shipping and handling.

.3 Store items carefully protected from moisture and damage, in original wrappings with manufacturer's labels, seals intact.

.4 Tie or secure all moving parts so that no damage will occur during shipping, handling.

.5 Benchtop hoods to be delivered to site fully assembled.

1.12 JOB CONDITIONS

.1 Protect surfaces, materials, finishes of other Work from damage when fume hoods delivered to the site.

.2 Where connections to mechanical, electrical or other trades required, provide all data, dimensions, drawings in time for proper rough-in and preparation required to receive the Work.

Part 2 Products

2.1 MANUFACTURERS

.1 Equipment listed by catalogue number and manufacturer shall be the specified standard required. Alternative manufacturers may be proposed for approval in accordance with Contract Documents.

.2 List of equipment at end of this Section.

.3 The fume hoods specified herein may need to be custom designed and manufactured to meet the requirements.

2.2 MATERIALS

.1 All materials, products shall be the best of their respective kind and suitable in all respects for the specified end use for which each item or assembly is intended in this project.

.2 Exterior Liners: Sheet steel: Stretcher leveled furniture grade to ASTM A1008 /A1008M-12a.

.3 Interior Liners: Stainless steel: To ASTM A167 and ASTM A240, type 316.

.4 Glass: Safety glass to CAN/CGSB-12.1, clear float, tempered laminated minimum 6mm thickness.

.5 Particleboard: To CAN3-0188.1, Type II Industrial grade, sanded, density.

2.3 FABRICATION

.1 All equipment of this Section to be completed in all respects, fully shop assembled and finished with fastenings concealed or countersunk flush, all joints in exposed surfaces to be welded joints, all internal piping, wiring ducting, shop installed and tested, mechanical and electrical fittings and fixtures installed.

.2 Workmanship shall be the best grade of modern shop and field practice know to recognized manufactures specializing in the Work of products listed and design and fabrication of scientific research hoods.

.3 Works and equipment shall be accurately assembled free from distortion or defects detrimental to appearance and/or operation and fully capable of performing the job for which it is specified over the intended life of the building in which it is installed.

.4 All equipment under this Section shall be fully finished in the shop with all metal parts receiving a thorough cleaning and bin given one coat of primer followed by two coats of baked-on enamel or a powder coating finish. Stainless steel shall be given a #4 finish. Extruded aluminum shall be given a clear, anodized finish. Colors shall be as later selected by Departmental Representative.

.5 All operating equipment, both power and manual, shall be fully tested in the shop as an assembled entity before shipping to site.

.6 Equipment shall be provided complete with all fittings, fixtures, accessories requiring only site hook-up to building services to be fully operational.

.7 All hoods shall be fully tested in the factory as an assembled entity before shipping to site.

2.4 MECHANICAL SERVICE FITTINGS

.1 Acceptable Manufactures: (service outlets) Watersaver or Chicago Faucet.

.2 Metals: Use minimum 80% red brass alloy for valve bodies. Make handles and turrets from brass forgings. Use solid brass bar stock or specially selected alloys for assembly components and operating parts such as valve stems, renewable seats and needle cones.

.3 Completely enclose spring mechanisms. Design compression and needle valve stems to operate inside and make them replaceable. Provide needle valves with stainless steel floating needles and removable seats.

.4 Provide fittings with wall flanges, shanks, lock nuts, couplings, nuts and tailpieces.

.5 Finish exposed parts of service fittings inside hoods with corrosion-resistant finish.

.6 Provide isolation valves to all service connections on the building side of the services. Isolation valves compatible with media. Valve colored coding as per universal.

.7 For natural gas, nitrogen, compressed air and vacuum: angle hose cock outlets, complete with remote control handle on front face of hood, colour-coded corrosion resistant finish to match remote control handle colour. Use front loading valves and no remote control rods.

.8 For cold water: side wall mounted gooseneck with vacuum breaker and serrated nozzle complete with remote control handle on front of hood; size to ensure nozzle is centered over integral cup sink; colour-coded corrosion resistant finish to match remote control valve handle colour. Use front loading valves and no remote control rods.

.9 Drill 8-25mm diameter holes for each side. Remote controls on face of hood. Provide SS buttons for unused holes.

.10 Drill holes on interior lining for only those fixtures called for with each fume hood on equipment list/layouts in 3.6.

.11 Pre-pipe fittings as called for with each respective hood per individual lab layouts and schedules, including piping, remote control valves, turrets, buttons, controls, and escutcheons. Piping to end with isolation valves.

2.5 HARDWARE

.1 All rough hardware (screws, nuts, bolts, washers, etc.) Type 316 stainless steel with #4 finishes.

.2 Finish hardware shall be of a type consistent with highest quality items for long hard usage and shall be the best of their respective kinds.

2.6 FINISHES

.1 All sheet steel pretreated and cleaned after fabrication, primed and finished with highest grade chemical resistant laboratory furniture quality baked enamel or modified epoxy powder coating providing a smooth hard satin finish. Surface not exposed to view shall have one coat primer followed by one coat enamel. Colour as later selected by Departmental Representative and shall be a custom colour and

not any manufacturer's standard colour. The colour shall be off white to match the new 5 fume hoods recently purchased.

.2 All stainless steel shall be given a #4 satin finish.

2.7 SUPERSTRUCTURE

.1 Double wall construction consisting of an outer shell and an inner liner. Double wall to house and conceal auxiliary framing members, attaching brackets and service fixture mechanisms. Outer shell, inner shell and frames (where necessary) to be assembled, fastened, and connected into a rigid, self-supporting entity. Wall thickness at sides to be 100mm maximum; front to be 150mm maximum; and rear 12mm maximum.

.2 Outer Shell: 1.588mm cold rolled sheet steel. Continuous welded fabrication. Front of head and sides surrounding sash, to be a 45[] airfoil brake-shape or a curved surface of 50mm radius. Baked enamel finish applied to all surfaces (see finishes). All airfoils shall be 316L stainless steel.

.3 Inner Liner & Countertop/Work surface: 1.5mm stainless steel, Type 316. All interior corners to be radiused and welds ground smooth with seamless corners, #4 satin finish, sides integral with countertop/work surface, with slightly raised edges to contain spills. Provide side safety ledge across the front edge. Underside of work surface/base to be 19mm particleboard bonded to it for rigidity and sound deadening.

.4 Exhaust Collar: 1.5mm stainless steel, Type 316L, sizes 300mm diameter.

.5 Lighting Panel: 6mm safety glass sealed into SS trim with neoprene in a manner which totally insolates light fixture from fumes and vapors.

.6 Access panels for service valves: 1.5mm SS, type 316L, 200 x 750mm on both sides of inner liner.

.7 Data Card Holder: 0.912mm SS frame secured

.8 Cup Sink: 150mm diameter 316 stainless steel raised cup sink and tail piece, integral/seamless with base/countertop.

.9 Equipment Struts: Provide stainless steel channel to each side of inner liner at location and to the dimensions shown. Stiffen liner panel as required from behind to permit positive attachment. Acceptable material: Unistrut P-4000X.

.10 Access Opening: (Benchtop hoods) Provide access opening at the rear of the fume hoods, concealed between the walls on

both sides, to facilitate connection of fume hood service fittings to piping located behind laboratory casework.

.11 Vents: Provide 38 mm diameter polypropylene venting up side walls, through hood liner at each end side wall, vented in behind upper baffle with sealed removable plug.

.12 Baffles: Fabricated from same material as liner, bolted in place to allow removal. Top baffle to be in two segments with slider and thumb-screw adjustment.

.13 By-Pass grilles: Integral with exterior front panel; louvers shall be inward punched and upward facing; louver location to be high enough to conform to design and operation set out in clause 2.12.

.14 Hood construction shall be for seismic rated anchor installation. Manufacturer shall retain a professional seismic engineer, who is registered in the province of BC, to certify the fume hood design suitable for seismic anchor installation to existing storage cabinets and wall structure.

.15 Provide stainless steel flanged and gasketted duct connection at hood exhaust outlet. Gasket shall be corrosive resistant type suitable for this application.

2.8 SASH

.1 Vertical rising sash shall consist of the following:

.1 Opening size: Maximize full view to suit width specified.

.2 6 mm laminated safety glass set into stainless steel glazing channel, maximum 25 mm wide.

.3 Bottom rail to have integral, formed full width flush stainless steel pull.

.4 Top rails to be formed to accept lead weights for fine tuning of sash for exact and positive operation.

.5 Use single weight, pulley and cable counterbalance system, including guides stainless steel) to prevent sash tilting, permit one finger operation at any point along width, and to hold sash at any position without creep.

.6 Pulleys to be nylon tired, ball-bearing type, 38 mm in diameter.

.7 Cables to be stranded stainless steel, minimum 4mm.

.8 Provide SS spring loaded slide bolt to prevent sash from dropping in the event of failure of cables if required.

.9 Sash to open and close against rubber bumpers, top and bottom.

.10 Glass must be resistant to discoloration and crazing by age or exposure to chemicals.

2.9 AIR DEFLECTOR/FOIL

.1 Type 316L, 1.5mm metal core thickness stainless steel aerodynamically shaped deflector attached at the sill location for all fume hoods. Deflectors shall be supported with stainless steel Z-clips, to permit the passage of required volumes of air when sash is in the closed position. Clearances to accommodate passage of standard 20-amp NEMA male plug.

2.10 LIGHTING AND RECEPTACLES

.1 Light Fixtures: 3-lamp, T8, 40 watt (80 lux) , vapour tight heavy duty fluorescent fixtures, c/w ballasts bearing CSA certification, automatic resetting type, thermally protected, energy-saving, high power factor type with an "A" sound rating. Lamps to be new, warm white, from the same manufacturer, switch on hood face c/w SS plate.

.2 Service access must be possible from outside of fume hood.

.3 GFCI receptacles shall be specification grade, duplex receptacle, CSA type 5-15R, 125V, 15A, U ground, white, ground fault LED indicator, stainless steel cover plate.

Hubbell GRF5252-WHI

2.11 WIRING

.1 Provide light switch, exhaust switch, relay, pilot lights and grounding-type receptacles. The relay shall control the fume hood exhaust valve (FHEV) "on" to operate the fume hood at maximum design air flow, and "off" to operate the fume hood at a minimum design air flow.

.2 Pre-wire to a standard consistent with applicable codes, utilizing liquid tight flexible electrical conduit.

.3 Wiring for lighting shall be pre-wired ready to receive connection with supply at the fixture location.

.4 Wiring for the exhaust switch, pilot lights and relay, to be pre- wired, ready to receive connection with supply at the relay junction box. Pilot lights to register red for exhaust off, and green for exhaust on.

.5 Wiring for receptacles shall be pre-wired ready for connection at the perimeter laboratory cable tray.

.6 All escutcheon plates to be stainless steel.

2.12 DESIGN AND OPERATION

.1 Fume hoods shall be custom designed for uniform air flow through the hood face of 0.508 m/s. at a sash height of 300mm. Variations of required face velocity shall not exceed 20% of the average face velocity as measured with the maximum sash opening at left, right and center of the hood face.

.2 Fume hoods shall be "balanced type" which maintains a constant exhaust volume regardless of sash position.

.3 Maximum air volumes for each hood shall conform with the following:

Size (mm) (dia.)	Max. l/s	Duct Collar
1500	255	300 mm

.4 Measured average static pressure loss readings taken 3 diameters above the hood outlet from four points 90à apart, shall not exceed the following for all maximum air volumes as dictated above:

Face Velocity	Measured S.P.L. (W.C.)
0.508 m/s	124 Pa

.5 Baffles shall be provided to control air vectors into and through the fume hood. With the sash positioned 150 mm above the airfoil, the average in flow velocity shall not be less than twice the selected full open face velocity nor greater than three times of that amount. Changes in average face velocity and exhaust volume as a result of baffle adjustment shall not exceed 5% for any baffle position at the specified face velocity. Back baffle shall be fabricated with twenty 25 mm diameter holes in a single horizontal row. Top baffle shall be adjustable to provide a 12.7 mm gap in the closed position through to a 51 mm gap when fully opened.

Part 3 Execution

3.1 GENERAL REQUIREMENTS

.1 Inspect the Work of other Sections upon which the Work of this Section depends. Proceed only after deficiencies, if any, in the Work of other Sections have been corrected.

.2 Verify all dimensions affecting the Work of this Section on the site.

.3 Ensure that all anchors, frames or other items of this Section supplied to other trades for building into their Work are properly located and securely mounted.

.4 Ensure that any services required are properly roughed-in and of the required capacity.

.5 Coordinate with the Departmental Representatives for testing as per the As Installed Fume Hood Performance in section 1.5. Perform the test with the vent kit connected to a chemical storage cabinet.

.6 Contractor shall retain a professional seismic engineer, who is registered in the province of BC, to review and certify the fume hood being seismically anchor installed to new storage cabinets or table and to existing wall structure.

.7 Adjust fume hood air flow monitors. In stand-by mode, change to night mode setting to prevent nuisance alarming.

3.2 INSTALLATION

.1 Install in accordance with the manufacturer's written instructions for installation and connection details.

.2 For equipment to be secured or built-in, provide all necessary fastenings required in order to correctly and neatly complete the installation to the satisfaction of the Departmental Representative.

.3 Loose equipment to be assembled on site shall be put together according to manufacturer's printed instructions unless otherwise noted as being field assembled by manufacturer's own, trained forces.

.4 Power-operated equipment will be wired and connected to power source under Division 26. Motors, controls and switches, unless otherwise specifically noted, shall be supplied under this Section as part of the equipment.

.5 Mechanical services shall be connected to existing building services.

3.3 FIELD QUALITY CONTROL

.1 Where any equipment of this Section is to be site assembled, the manufacturer's representative shall visit the site during installation to ensure the Work is proceeding correctly and comply with all commissioning requirements.

.2 At completion of installation or assembly, contractor shall thoroughly check the completed system and ensure that it operates correctly and complies with all commissioning requirements.

.3 Should the finishes of the equipment be damaged or marked during installation, all such marks are to be made good. If necessary, damaged parts are to be sent back to the factory for refinishing at no additional expense to the Departmental Representative.

3.4 ADJUST & CLEAN

.1 After equipment has been fully installed and seismically anchored into place, check and operate all movable parts and assemblies to ensure the equipment will function correctly as required. Make any adjustment or realignment necessary to ensure smooth, trouble-free operation.

.2 If smooth and correct operation cannot be fully assured by field Work and adjustment, the assembly affected shall be shipped to the factory for reworking and reinstalled in place at no additional cost to the Departmental Representative.

.3 At completion of Work on each piece of equipment, clean according to manufacturer's instructions.

.4 Leave any protective covering in place for later removal immediately prior to final inspection and acceptance.

3.5 LIST OF EQUIPMENT

.1 Install a total of two (2) new fume hoods with the following types:

.1 Two (2) Constant Volume with By-pass Fume Hoods

.1 1498-1500mm wide, cabinet or table mounted

.2 Integral 316 stainless steel base/work surface with all welded construction.

.3 Integral SS raised cupsink and RH side wall mounted cold water gooseneck.

.4 Natural gas on RH mounted with remote control handle.

.5 Compressed air on RH mounted with remote control handle.

.6 Vacuum on RH mounted with remote control handle.

.7 Nitrogen gas on RH mounted with remote control handle. Gas will not actually be connected.

.8 Cold water on RH mounted with remote control handle.

.9 2-115V 15 amp duplex GFI receptacle (one LH and one RH), See section 2.10.3.

.10 3 tubes T8 fluorescent light and switch (80 lux at work surface).

.11 Vent kit for chemical storage cabinets.

.12 Motor switch and pilot light (RH mounted).

.13 Provide a TSI alarm plus one spare alarm and mount on LH side. Hand over the spare alarm to the Departmental Representative.

.14 Hood structure to be for seismic rated anchor installation.

END OF SECTION