1 General

1.1 USE OF SYSTEMS

.1 Use of new permanent heating or ventilating systems for supplying of temporary heat or ventilation is permitted only under the following conditions:

1. Entire system is complete, pressure tested, cleaned, and flushed out.
2. Building has been closed in, areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes.
3. There is no possibility of damage from any cause.
4. Supply ventilation systems are protected by 60% filters, which shall be inspected daily, changed every week or more frequently as required.
5. Return systems have approved filters over all openings, inlets, outlets.
6. All systems will be:
    a. operated as per manufacturer's recommendations or instructions.
    b. operated by Contractor.
    c. monitored continuously by Contractor.
7. Warranties and guarantees are not thereby relaxed.
8. Regular preventive and all other manufacturers recommended maintenance routines are performed by Contractor at his own expense and under supervision of Departmental Representative.
9. Before static completion, entire system to be refurbished, cleaned internally and externally, restored to "as- new" condition, filters in air systems replaced.
10. Permission from the Departmental Representative must be obtained.

.2 Filters referred to herein are over and above those specified elsewhere in this specification.

.3 Exhaust systems are not included in any approvals for temporary heating and/or ventilation.

END OF SECTION

1 General

1.1 RELATED SECTION

.1 Section 23 31 13 Ductwork - Low Pressure Metallic to 500 Pa

1.2 REFERENCES

.1 American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME):
- .1 ANSI/ASME B31.1, Power Piping.

.2 American Society for Testing and Materials (ASTM):
- .1 ASTM A 125, Specification for Steel Springs, Helical, Heat-Treated.
- .2 ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
- .3 ASTM A 563, Specification for Carbon and Alloy Steel Nuts.

.3 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS):
- .1 MSS SP-58, Pipe Hangers and Supports - Materials, Design and Manufacture.
- .2 MSS SP-69, Pipe Hangers and Supports - Erection and Application.
- .3 MSS SP-89, Pipe Hangers and Supports - Fabrication and Installation.

.4 Underwriter’s Laboratories of Canada (ULC).

1.3 DESIGN REQUIREMENTS

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

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

.3 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.

.4 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment to be in accordance with MSS SP-58.

1.4 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings and product data in accordance with Section 01 33 00 Submittal Procedures and Section 21 05 01 Mechanical General Requirements.

.2 Submit shop drawings and product data for following items:
- .1 All 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 01 78 00 Closeout Submittals.

2 Products

2.1 SYSTEM DESCRIPTION

.1 General 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 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 in accordance with MSS SP58.

2.2 GENERAL

.1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP58.

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

.3 Finishes:

- .1 Pipe hangers and supports: galvanized or painted with zinc rich paint after manufacture but before installation.
- .2 Ensure steel hangers in contact with copper piping are copper plated or epoxy coated.

.4 Upper Attachment:

Structure	Attachment	
Suspension from Lower flange of I-Beam or Joist	malleable iron beam clamp with setscrew, locknut and carbon steel retaining clip	
Suspension from Lower flange of I-Beam or Joist	malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut	

Concrete	Concrete insert	

.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.

.6 Wall brackets: carbon steel prime coated.

3 Execution

3.1 MANUFACTURER’S INSTRUCTIONS

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

3.2 INSTALLATION

.1 Install in accordance with Manufacturer's instructions and recommendations.

.2 All pipes shall be hung securely from structure.

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

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

3.3 HANGER SPACING

.1 Hangers shall be spaced as far apart as economically possible. Maximum spacing shall be as required by the SMACNA.

3.4 HANGER INSTALLATION

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

.2 Adjust hangers to equalize load.

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

3.5 FINAL ADJUSTMENT

.1 Adjust hangers and supports:
  .1 Ensure that rod is vertical under operating conditions.
  .2 Equalize loads.

.2 Adjustable clevis:
  .1 Tighten hanger load nut securely to ensure proper hanger performance.
  .2 Tighten upper nut after adjustment.

.3 C-clamps:
  .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.

.4 Beam clamps:
  .1 Hammer jaw firmly against underside of beam.

END OF SECTION

1 General

1.1 RELATED SECTIONS

.1 Section 01 33 00 Submittal Procedures.

.2 Section 25 05 54 EMCS Identification.

.3 Section 21 05 01 Mechanical General Requirements.

1.2 REFERENCES

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

.2 National Fire Protection Association:
  .1 NFPA 10, Portable Extinguishers
  .2 NFPA 13, Installation of Sprinkler Systems.

1.3 PRODUCT DATA

.1 Submit product data in accordance with Section 01 33 00 Submittal Procedures.

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

1.4 SAMPLES

.1 Submit samples in accordance with Section 01 33 00 Submittal Procedures.

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

1.5 EXISTING IDENTIFICATION

.1 All new identification installed shall match the existing building identification methods as a minimum and shall meet the additional requirements as outlined below.

2 Products

2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES

.1 Metal nameplate with raised or recessed letters mechanically fastened to each piece of equipment by manufacturer.

.2 Information to include, as appropriate:
  .1 Equipment: Manufacturer's name, model, size, serial number, capacity, registration plates where specified or required (e.g. pressure vessel, ULC, CSA).

.2 Motor: voltage, Hz, phase, power, power factor, duty, frame size, rpm.

2.2 SYSTEM NAMEPLATES

.1 Colours:
  .1 Hazardous: red letters, white background.
  .2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).

.2 Construction:
  .1 1/8" thick laminated plastic, matte finish, with square corners, letters accurately aligned and machine engraved into core.

.3 Sizes:
  .1 Conform to following table:

Size #	Sizes	No. of Lines	Height of Letters
1	3/8" x 2"	1	1/8"
2	½" x 3"	1	1/4"
3	½" x 3"	2	1/8"
4	3/4" x 4"	1	1/3"
5	3/4" x 4"	2	1/4"
6	3/4" x 8"	1	1/3"
7	1" x 5"	1	1/2"
8	1" x 5"	2	1/3"
9	1½" x 8"	1	3/4"

  .2 Use maximum of 25 letters/numbers per line.

.4 Locations:
  .1 Terminal cabinets, control panels: Use size # 5.
  .2 Equipment in Mechanical Rooms: Use size # 9.

2.3 IDENTIFICATION DUCTWORK SYSTEMS

.1 2" high stencilled letters and directional arrows 6" long x 2" high.

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

2.4 VALVES, CONTROLLERS

.1 Brass tags with 1/2" 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.

.3 Valve identifiers for Fire Protection System to correspond with that used by Fire Alarm System.

2.5 CONTROLS COMPONENTS IDENTIFICATION

.1 See Section 25 05 54 EMCS Identification.

2.6 EQUIPMENT

.1 Identify Mechanical equipment with black lamicoid plates with white letters attached to equipment. Letters to be a minimum of 3/4" high.

.2 Identification to be visible by an individual standing on the floor.

2.7 ABOVE CEILING EQUIPMENT IDENTIFICATION

.1 Pull and junction boxes for control wiring to be coloured inside and out (red and white).

.2 Where laboratory air valves, and balancing dampers and are installed above accessible ceilings, adhesive discs coloured in accordance with the table below shall be installed on the ceiling spline directly below the valves and boxes. Discs shall be 19 mm diameter, white or black disc to be 6 mm diameter. In no case shall a valve or box be installed in a ceiling space that is not considered accessible unless a proper access hatch is provided by the Mechanical Trade Contractor. Discs shall be similarly applied to access hatches.

.3 Provide framed legend of colour coding used and mount in the main mechanical room or other location as directed by the Departmental Representative. Include a copy of legend in Maintenance Manuals.

.4 Boxes, valves and dampers shall be colour coded as follows:

Service	Colour of Disc
Fire Dampers	Dark Blue
Laboratory Air Valves	Dark Blue
Balancing Dampers	Dark Blue
Control Panels/Junction Boxes	Red/White

.5 Use white lamicoid plates with black letters to identify backflow preventer, balancing damper, air terminal unit, fan, and reheat coil locations.

.6 Use red lamicoid plates with white lettering to identify fire damper locations.

.7 Lamicoid plates referred to in above two (2) sentences to be attached to T-bar splines with two (2) rivets each.

2.8 LANGUAGE

.1 Identification to be in English.

3 Execution

3.1 TIMING

.1 Provide identification only after all painting specified Section 09 91 10 - Painting has been completed.

3.2 INSTALLATION

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

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

.3 Identify all equipment, piping and duct systems.

3.3 NAMEPLATES

.1 Locate nameplates in conspicuous location to facilitate easy reading and identification from operating floor.

.2 Provide standoffs for nameplates on hot and/or insulated surfaces.

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

3.4 LOCATION OF IDENTIFICATION ON DUCTWORK SYSTEMS

.1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: At not more than 25'-0" 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, other confined spaces, at entry and exit points, and at each access opening.

.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. 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 Laboratory air valves and operating controllers 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.

END OF SECTION

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 all other work as specified in this section.

.2 Submit three copies of air and water balancing report to the Departmental Representative for review. Make changes and re-submit if necessary.

.3 Provide a pre-construction TAB report for all supply diffusers, exhaust grilles, canopy hoods, fume hoods and speciality exhaust systems (i.e. extraction arms, snorkels, equipment specific, modified fume hoods / canopy hoods), within the impacted laboratory spaces in both occupied and unoccupied modes. The TAB report shall be provided at least two (2) weeks prior to any construction work beginning on-site.

1.2 QUALIFICATIONS OF TAB PERSONNEL

.1 Names of all personnel it is proposed to perform TAB to be submitted to and approved by the Departmental Representative within thirty (30) days of award of contract.

.2 Provide documentation confirming qualifications, successful experience.

.3 TAB Contractor shall be familiar with the procedures outlined in AABC, NEBB, SMACNA and ASHRAE.

.4 Quality assurance: Perform TAB under direction of supervisor qualified by AABC or NEBB.

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 all other related systems under all normal and emergency loads and operating conditions.

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

1.4 EXCEPTIONS

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

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.

.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. Confirm in writing to the Departmental Representative adequacy or inadequacy of provisions for TAB and all other aspects of design and installation pertinent to success of TAB.

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

.3 During construction, co-ordinate location and installation of all 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 - Heating, Ventilating and Air Conditioning (HVAC).

1.8 OPERATION OF SYSTEMS DURING TAB

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

1.9 START OF TAB

.1 Notify the Departmental Representative seven (7) days prior to start of TAB.

.2 Start TAB only when building is essentially completed, including:
- .1 Installation of ceilings, doors, windows, other construction affecting TAB.
- .2 Application of weather-stripping, sealing, caulking.
  - .1 All pressure, leakage, other tests specified elsewhere Division 23 - Heating, Ventilating and Air Conditioning (HVAC).
  - .2 All provisions for TAB installed and operational.

.3 Start-up, verification for proper, normal and safe operation of all 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 All outlets installed, volume control dampers open.

.3 Liquid systems:
.1 Flushed, filled, vented.
.2 Correct pump rotation.
.3 Strainers in place, baskets clean.
.4 Isolating and balancing valves installed, open.
.5 Calibrated balancing valves installed, at factory settings.
.6 Chemical treatment systems complete, operational.

1.10 APPLICATION TOLERANCES

.1 Do TAB to following tolerances of design values:
.1 Positive rooms: +5%/-0% for supply and +0%/-5% for exhaust.
.2 Negative rooms: +5%/-0% for exhaust and +0%/-5% for supply.
.3 All other spaces: +5%/-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 the Departmental Representative list of instruments to be used together with make, model and serial numbers.

.2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.

.3 Calibrate within three (3) months of TAB. Provide certificate of calibration to the Departmental Representative.

.4 The balancing contractor is responsible for providing all tools necessary to obtain results; the EMCS contractor will not be supplying any tools.

1.13 SUBMITTALS

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

1.14 PRELIMINARY TAB REPORT

.1 Submit (electronically in PDF format) for checking and approval of the

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 AABC and/or NEBB.

.2 TAB report to show all results in SI units and to include:
- .1 Project record drawings.
- .2 System schematics.

.3 Submit three copies of TAB Report to the Departmental Representative for verification and approval, in English in D-ring binders, complete with index tabs.

1.16 VERIFICATION

.1 All reported results subject to verification by the Departmental Representative.

.2 Provide manpower and instrumentation to verify up to 10% of all reported results.

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

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

1.17 SETTINGS

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

.2 Permanently mark all 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 TAB to be considered complete only when final TAB Report received and approved by the Departmental Representative.

1.19 AIR SYSTEMS

.1 Standard: TAB to be to most stringent of TAB standards of AABC, NEBB, SMACNA or ASHRAE.

.2 Do TAB of all systems, equipment, components and controls specified.

.3 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, amps, voltage, and noise. Full octave band acoustical monitoring/testing shall be completed by this Contractor prior to building turnover. A minimum of four separate rooms shall be tested (at the discretion of the Departmental Representative) for each air handling unit (AHU) system. Determine room NC valves and submit report to the Departmental Representative for review.

.4 Locations of equipment measurements: To include, but not be limited to, following as appropriate:
- .1 Inlet and outlet of each damper, filter, coil, humidifier, fan, other equipment causing changes in conditions.
- .2 At each controller, controlled device.

.5 Locations of systems measurements to include, but not be limited to, following as appropriate: each main duct, main branch, sub-branch, run-out including grilles, registers or diffusers.

.6 Include room identification for grilles, registers and diffusers in report.

.7 Voltage and current measurements for motors to be reported for each phase for three (3) phase motor systems.

.8 Permanently mark the final position of the numerous balancing dampers with a permanent ink marker.

1.20 OTHER TAB REQUIREMENTS

.1 General requirements applicable to all work specified this paragraph:
- .1 Qualifications of TAB personnel: as for air systems specified in this section.
- .2 Quality assurance: as for air systems specified this section.

.2 Building pressure conditions:
- .1 Adjust HVAC systems, equipment, controls to ensure specified pressure conditions during all times.

END OF SECTION

1 General

1.1 GENERAL

.1 Test a minimum of three (3) new exhaust ductwork branches connecting into existing fume exhaust system, including horizontal runout to diffuser. Test section to include transitions, branch connections, joints, and elbows.

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 REFERENCES

.1 SMACNA HVAC Air Duct Leakage Test Manual, latest edition.

1.4 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.

1.5 TESTING AGENCY

.1 Installing Contractor.

1.6 VERIFICATION

.1 The Departmental Representative to witness tests and to verify reported results. Submit reports to the Departmental Representative for review.

.2 To be certified by the same TAB agency approved by the Departmental Representative to undertake TAB on this project.

1.7 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 generator 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 Department Representatives at least two (2) months before anticipated start date.

.5 Test instruments to be calibrated and certificate of calibration submitted to Departmental Representative no more than 28 days before start of tests.

.6 Instruments to be re-calibrated every six months thereafter.

1.8 SYSTEM LEAKAGE TOLERANCES

.1 System leakage tolerances specified herein are stated as a percentage of total flow rate handled by the system. Therefore, when testing sections of ductwork this acceptable leakage shall be pro-rated to entire system. Leakage for sections of duct systems shall not exceed the total allowable leakage.

.2 Leakage tests on following systems not to exceed specified leakage rates.
  .1 Small duct systems up to 1" w.c.: Leakage 2%.
  .2 Large low-pressure duct systems up to 2" w.c.: Leakage 2%.

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

1.9 EQUIPMENT LEAKAGE TOLERANCES

.1 Equipment and system components such as chilled beams, fan coil units: Leakage 2%.

1.10 REPORT FORMS

.1 Submit proposed report form and test report format to the 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 the Departmental Representative.

1.11 PRESSURE TEST REPORTS

.1 Prepare report of results and submit to the Departmental Representative within 48 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 (cfm) for test sites.
 .6 Witnessed certification of results.

.2 Include test reports in final TAB report.

2 Products

Not Used

3 Execution

Not Used

END OF SECTION

1 General

1.1 RELATED SECTION

.1 Section 21 05 01 Mechanical General Requirements.

.2 Section 23 05 29 Bases Hangers and Supports.

.3 Section 23 05 53 Mechanical Identification.

.4 Section 23 05 94 Pressure Testing of Ducted Air Systems.

1.2 REFERENCES

.1 American Society for Testing and Materials International, (ASTM).
 .1 ASTM A480/A480M , Standard Specification for General Requirements for Flat Rolled Stainless and Heat Resisting Steel Plate, Sheet and Strip.
 .2 ASTM A635/A635M, Standard Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Carbon, Hot Rolled.
 .3 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy Coated (Galvannealed) by the Hot Dip Process.

.2 National Air Duct Cleaners Association (NADCA)
 .1 NADCA ACD, Assessment, Cleaning, and Restoration of HVAC Systems.

.3 National Fire Protection Association (NFPA).
 .1 NFPA 33 - Standard for Spray Applications Using Flammable or Combustible Materials.
 .2 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 .3 NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition.
 .2 SMACNA HVAC Air Duct Leakage Test Manual, latest edition.

1.3 SUBMITTALS

.1 Shop Drawing and Maintenance Manual submittals in accordance with Section 01 33 00 Submittal Procedures and Section 21 05 01 Mechanical General Requirements.

1.4 DELIVERY, STORAGE AND HANDLING

.1 Protect stored or installed material from moisture damage and dirt.

2 Products

2.1 DUCT CONSTRUCTION

.1 Galvanized Steel Duct
  .1 Round ductwork
    .1 Construction shall be of galvanized steel of the following US Standard Gauges:

Duct Diameter	Spiral Duct Work	Plain Duct Gauge
< 200 mm	28	24
225 – 350 mm	26	24
400 mm	24	22

    .2 Longitudinal joints for round duct shall be butt welded, SMACNA Type RL-4 or grooved seam, SMACNA Type RL-5.
    .3 Concealed round branch ducts up to 400 mm diameter may be constructed with longitudinal seams.
    .4 Concealed round branch ducts over 400 mm and all exposed round ducts shall be factory fabricated conduit consisting of helically wound galvanized iron strips with spiral lock seams. Fittings for these conduits shall be fabricated of 20-gauge galvanized sheet steel with butt welded seams.
    .5 Transverse joints beaded crimp joints with at least 25 mm lap to accommodate screws at a maximum of 375 mm centres. Minimum of three (3) screws per joint.

  .2 Square / Rectangular Duct
    .1 Construction shall be of galvanized steel of the following US Standard Gauges:

<table>
<tr><th rowspan="2">Longest Duct side</th><th rowspan="2">Duct Ga</th><th colspan="2">Transverse Joints</th><th colspan="2">Reinforcing</th></tr>
<tr><th>Short Side</th><th>Long Side</th><th>Size</th><th>Spacing</th></tr>
<tr><td>< 300 mm</td><td>28</td><td>T1, T6</td><td>T1, T6</td><td colspan="2">none</td></tr>
<tr><td>325 – 450 mm</td><td>22</td><td>T1, T6</td><td>T1, T6</td><td colspan="2">none</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">26</td><td>T1, T6</td><td>T1, T6</td><td>19 mm x 19 mm x 20 ga. L</td><td>Each Joint Max 2,400 mm</td></tr>
<tr><td>T10</td><td>T10</td><td colspan="2">none</td></tr>
</table>

.2 Ductwork is to be prefabricated using drive slip joints sized 450 mm or greater. Joints 350 mm or larger are to be reinforced.

.3 Ductmate 25 and 35 and Nexus G and J shall be approved as an acceptable equal to the above requirements, with neoprene gaskets and HM572 sealant for bolted assembly.

.2 Stainless Steel

.1 To ASTM A480/A480M, Type 304.

.2 Finish: No. 4.

.3 Thickness, fabrication and reinforcement: to SMACNA.

.4 Joints:

.1 Unless noted otherwise on drawings as per SMACNA .2 Continuous inert gas welded where noted.

2.2 SEAL CLASSIFICATION

.1 All Ductwork: SMACNA Seal Class A

.2 Seal Classification:

.1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.

2.3 SEALANT

.1 Sealant: oil resistant, water borne, polymer type flame resistant duct sealant. Temperature range of minus 22 degrees Fahrenheit to plus 200 degrees Fahrenheit.

2.4 TAPE

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

2.5 DUCT LEAKAGE

.1 In accordance with section 23 05 94 Pressure Test of Ducted Air Systems.

.2 Departmental Representative reserves the option of using a comparison of air flow measurements in duct or at fan (done with traverse) with measurements of air flow at grilles and diffusers to determine duct leakage.

2.6 FITTINGS

.1 Fabrication: to SMACNA.

.2 Radiused elbows.

.1 Rectangular: standard radius (Centreline radius: 1.5 times width of duct) or short radius with single thickness turning vanes.
.2 Round: smooth radius, five piece. 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 to have 45 degrees entry on branch.
.2 Round main and branch: enter main duct at 45 degrees with conical connection.
.3 Provide volume control damper in branch duct near connection to main duct.
.4 Main duct branches: with balancing damper unless shown otherwise.

.5 Transitions:
.1 Diverging: 20 degrees maximum included angle.
.2 Converging: 30 degrees maximum included angle.

.6 Offsets: As Indicated

.7 Obstruction deflectors: maintain full cross sectional area.
.1 Maximum included angles: as for transitions.

2.7 FIRE STOPPING

.1 Retaining angles around duct, on both sides of fire separation in accordance with firestopping requirements.

.2 Fire stopping material and installation must not distort duct.

2.8 GALVANIZED STEEL

.1 Lock forming quality: to ASTM A653/A653M, Z90 zinc coating.

.2 Joints: to SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint to be considered to be a class A seal.

2.9 HANGERS AND SUPPORTS

.1 Hanger Configuration: to SMACNA.

.2 Hanger rods to be galvanized steel rods sized as per tables below

.3 Upper hanger attachments:
.1 For concrete: manufactured concrete inserts.
.2 For steel joist: manufactured joist clamp.
.3 For steel beams: manufactured beam clamps:

.4 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
  .1 Maximum size duct supported by strap hanger: 20" dia. or longest side of rectangular duct to be 20".

.5 Rectangular Air Duct
  .1 Hangers: prime painted black steel or galvanized steel angle with galvanized steel rods to SMACNA and following table:

Duct Width	Angle Size	Rod Size	Spacing
up to 750 mm	25 mm x 25 mm x 4 mm	7 mm	3,000 mm

.6 Round / Oval Air Duct
  .1 Hanger construction and spacing to the following table

<table>
<tr><th>Duct Dia</th><th>Rod dia.</th><th>Strap/Band</th><th>Wire dia</th><th>Spacing</th></tr>
<tr><td>< 250 mm</td><td rowspan="2">7 mm</td><td rowspan="2">25 mm x 22 ga</td><td>1 x 12 ga</td><td rowspan="2">3,000 mm</td></tr>
<tr><td>275 – 450 mm</td><td>2 x 12 ga</td></tr>
</table>

2.10 SHEET METAL PLENUMS

.1 Nominal 18 ga. galvanized steel sheet re-squared and formed into 600 mm wide panels with 50 mm deep standing seams in accordance with SMACNA HVAC equipment and casings standard.

.2 Formed channel sections top and bottom of vertical sections and at all wall and floor intersections.

.3 Galvanized 50 mm x 50 mm x 4 mm thick angle frames around all duct and access door openings.

3 Execution

3.1 GENERAL

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

.2 Do work in accordance with NFPA 90A, NFPA 90B, SMACNA, and as indicated.

.3 Do not break continuity of insulation vapour barrier with hangers or rods.

Provide rigid insulation between hangers and insulated duct.

.4 Support risers in accordance with SMACNA.

.5 Install breakaway joints in ductwork on sides of fire separation.

.6 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.

.7 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

.8 Prior to running ventilation system(s) clean AHUs, supply ductwork, return ductwork, exhaust ductwork attached to air handling units, and ductwork components as described NADCA ACR Duct Cleaning Standard (2013). Provide report to the Departmental Representative.

.9 The following outlines the type of ductwork required in each system:
  .1 All connections, extensions and additions to the existing laboratory exhaust system shall be Type 316 stainless steel, or Type 304 stainless steel to match the existing material.
  .2 All other connections, extensions, additions or modifications to the existing ductwork distribution shall match the existing materials used (i.e. galvanized steel, Type 316 or 304 stainless steel, etc.).
  .2 The exception to the requirement above shall be the new ductwork serving the new exhaust grilles that is connecting into the exhaust branches from the existing fume hoods. The connection point (i.e. t-fitting) shall be Type 316 stainless steel, or Type 304 stainless steel to match the existing material. The exhaust ductwork between the connection point and the exhaust grille (i.e. serving only the ceiling grille) shall be galvanized steel. Note that the transition between materials shall occur beyond where the exhaust airstream from the fume hood is moving.

3.2 HANGERS

.1 Strap: install in accordance with SMACNA.

.2 Angle hangers: complete with locking nuts and washers.

.3 Trim hanger rods so that rods are no further than 1" below supported element.

3.4 SEALING AND TAPING

.1 Apply sealant to outside of joint to manufacturer's recommendations.

.2 Bed tape in sealant and re-coat with minimum of one coat of sealant to manufacturer’s recommendations.

3.5 LEAKAGE TESTS

.1 Refer to Section 23 05 94 Pressure Testing of Ducted Air Systems

END OF SECTION

1 General

1.1 RELATED SECTIONS

.1 Section 01 33 00 Submittal Procedures.

.2 Section 01 74 21 Construction Demolition Waste Management and Disposal.

.3 Section 21 05 01 Mechanical General Requirements.

1.2 REFERENCES

.1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
   .1 SMACNA HVAC Duct Construction Standards Metal and Flexible, latest edition.

1.3 PRODUCT DATA

.1 Submit product data in accordance with Section 01 33 00 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.

2 Products

2.1 GENERAL

.1 Manufacture in accordance with SMACNA HVAC Duct Construction Standards and CSA B228.1.

2.2 ACCESS DOORS IN DUCTS

.1 Non-insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.5 mm thick complete with sheet metal angle frame, gasketted.

.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, gasketted.

.3 Gaskets: neoprene.

.4 Hardware:
  .1 Up to 300 mm x 300 mm: two sash locks complete with safety chain.
  .2 Acceptable Products: NR Murphy Ltd., Nexus, Nailor Industries, AMI, or approved equal.

3 Execution

3.1 INSTALLATION

.1 Access doors and viewing panels:
  .1 Size:
    .1 300 mm x 300 mm for servicing entry.
    .2 150 mm x 150 mm for viewing.
  .2 Locations:
    .1 Fire dampers.
    .2 Control dampers.
    .3 Devices requiring maintenance.
    .4 Elsewhere as indicated.

END OF SECTION

1 General

1.1 REFERENCES

.1 American National Standards Institute/National Fire Protection Association (ANSI/NFPA):
- .1 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.

.2 Underwriters Laboratories of Canada (ULC):
- .1 CAN4-S112, Fire Test of Fire Damper Assemblies.
- .2 CAN4-S112.2, Fire Test of Ceiling Firestop Flap Assemblies.
- .3 ULC-S505, Fusible Links for Fire Protection Service.

1.2 SHOP DRAWINGS

.1 Submit product data in accordance with Section 01 33 00 Submittal Procedures.

.2 Indicate the following:
- .1 Fire dampers.
- .2 Operators.
- .3 Fusible links.
- .4 Design details of break-away joints.

1.3 CLOSEOUT SUBMITTALS

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

1.4 EXTRA MATERIALS

.1 Provide maintenance materials in accordance with Section 01 78 00 Closeout Submittals.

.2 Provide following:
- .1 Six fusible links of each type.

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 signifying adherence to codes and standards.

1.6 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials in accordance with Section 01 35 50 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.

2 Products

2.1 FIRE DAMPERS

.1 Fire dampers: arrangement Type A or B or C, listed and bear label of ULC, meet requirements of ANSI/NFPA 90A and authorities having jurisdiction. Fire damper assemblies to be fire tested in accordance with CAN4-S112.

.2 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation. Provide Fire Dampers (FD) for all ducts penetrating floors and/or penetrating shaft walls.

.3 Top hinged: round or square; guillotine type; sized to maintain full duct cross section as indicated.

.4 Fusible link actuated, weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type or roll door type in horizontal position with vertical air flow.

.5 32 mm x 32 mm x 4 mm retaining angle iron frame, on full perimeter of fire damper, on both sides of fire separation being pierced.

3 Execution

3.1 MANUFACTURER’S INSTRUCTIONS

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

3.2 INSTALLATION

.1 Install in accordance with ANSI/NFPA 90A, SMACNA and in accordance with conditions of ULC listing.

.2 Maintain integrity of fire separation.

.3 After completion and prior to concealment obtain approvals of complete installation from authority having jurisdiction.

.4 Install access door adjacent to each damper. See Section 23 33 00 Duct Accessories.

.5 Coordinate with installer of firestopping.

.6 Ensure access doors/panels, fusible links, damper operators are easily observed and accessible.

.7 Install break-away joints of approved design on each side of fire separation.

END OF SECTION

1 General

1.1 RELATED SECTIONS

.1 Section 01 33 00 Submittal Procedures.

.2 Section 23 33 00 Duct Accessories.

.3 Section 23 31 13 Ductwork Low Pressure Metallic to 2 in.

.4 Section 21 05 01 Mechanical General Requirements.

1.2 REFERENCES

.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

.2 ANSI/ASHRAE 51, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

.3 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.

.4 ISO 3741, Acoustics-Determination of Sound Power Levels of Noise Sources-Precision Methods for Broad-band Sources in Reverberation Rooms.

.5 UL 181, Factory-Made Air Ducts and Connectors.

1.3 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings and product data in accordance with Section 01 33 00 Submittal Procedures.

.2 As a minimum provide performance data relating to airflow capacity, pressure drop, noise rating, leakage, confirm of all materials of construction, specifics of controllers and control points provided and performance of control components. Provide baseline specifications for all equipment submitted.

1.4 MANUFACTURED ITEMS

.1 Terminal units of the same type to be product of one manufacturer.

2 Products

2.1 LABORATORY AIRFLOW CONTROL SYSTEMS

.1 A laboratory airflow control system shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator’s presence in front of the fume hood. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). The laboratory airflow control system shall be capable of operating as a standalone system or as a system integrated with the Building Management System. A locally mounted user interface terminal shall be available to allow room-level control variables to be displayed, and where appropriate, edited to adjust control operation.

2.2 COMPONENTS

.1 Usage Based Control Equipment:

.1 For variable air volume systems, a sash sensor shall be provided to measure the height of each vertically moving fume hood sash. A sash sensor shall also be provided to measure the opening of horizontal overlapping sashes. Control systems employing sidewall-mounted or through the wall velocity sensors to control the fume hood exhaust airflow shall be unacceptable. Sidewall-mounted or through the wall sensors shall only be used as a reference or to provide a secondary alarm indication relative to operating face velocity.

.2 A Zone presence sensor shall be provided to determine an operator's presence in front of a hood by detecting the presence and/or motion of an operator, and to command the laboratory airflow control system from an in-use operating face velocity (e.g., 100 fpm) to a standby face velocity (e.g., 60 fpm) and vice versa.

.1 The sensor shall define an adjustable detection zone that extends approximately 50 cm from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within 30 to 3,000 seconds, it shall command the system to the user-adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in use face velocity within 1.0 second.

.2 The sensor shall sense an inanimate object when placed in the detection zone and remain in the standard mode of operation for 30 to 3,000 seconds, after which it will return to a standby mode. Operators shall enter and leave the zone with the unit adjusting automatically between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall adapt to the change automatically.

.3 The sensor shall have an adjustable detection zone capable of covering a fume hood up to 2,400 mm wide and be mounted from 1,800 mm to 3,600 mm above the floor surface.

.4 The sensor shall be configurable for varying levels of lighting intensity and motion sensitivity.

.5 The sensor shall have the ability to operate on either AC or DC power sources.

.6 Wide area motion detectors (on the hood or at the room level) shall be unacceptable.

.7 Motion detectors that rely solely on Doppler shift radar or similar technology for motion detection shall be unacceptable.

3. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash fully closed.

.2 Airflow Control Device – General:

1. Flow measurement devices will not be an acceptable alternate. All devices shall be mechanically pressure independent. ASHRAE 130 shall not be an acceptable method to determine the minimum pressure for airflow devices.

2. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2008.
3. Airflow control device shall be OSHPD tested and certified per 2013 CBC, 2012, IBC, ASCE 7-10, and ICC-ES-AC-156.
4. All Components of the valve, its controllers, and wiring shall be ROHS compliant.
5. The airflow control device shall be mechanically 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 (within product specifications) or quantity of airflow controllers on a manifolded system.
6. The airflow control device shall maintain accuracy within ±5% of signal to set point over an airflow turndown range of no less than:
   .1 12.5 to 1 (medium pressure all valve sizes)
   .2 16 to 1 (medium pressure w/o 350 mm valve)
   .3 7 to 1 (low pressure all valve sizes)
   .4 11 to 1 (low pressure w/o 350 mm valve)
   .5 8 to 1 (medium pressure shut-off all valve sizes)
   .6 14 to 1 (medium pressure shut-off w/o 350 mm valve)
   .7 5 to 1 (low pressure shut-off all valve sizes)
   .8 9 to 1 (low pressure shut-off w/o 350 mm valve)
7. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
8. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence.
9. The airflow control device shall maintain pressure independence regardless of loss of power. "Electronically pressure independent" devices will not be acceptable.
10. Airflow control devices utilizing ASHRAE 130 minimum operating pressure as a rating for minimum design pressure at required flow will not be acceptable on basis on minimum operating pressure alone. Valve manufacturer will provide minimum required differential pressure in writing for each size valve they offer.
11. Airflow control device shall be able to achieve its maximum turndown ratio at its stated minimum operating differential pressure. I.E. if minimum operating pressure is 300 Pa differential pressure, a 250 mm air valve must be able to achieve its minimum of 23 l/s and its maximum of 472 l/s at stated 300 Pa differential pressure. Devices that require duct static pressure to be increased to achieve maximum flow shall not be acceptable.

12. The airflow control device shall be constructed of one of the following four types. Refer to drawings for specific requirements.
    .1 Class A: The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and internal “S” link shall be made of 316 stainless steel. The shaft support brackets shall be made of galvaneal (non shutoff valves) or 316 stainless steel (shutoff valves). The pivot arm shall be made of aluminum (for non shutoff valves) and 303/304 stainless (for shut off valves). The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.
    .2 Class B: The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal “S” link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene) or PPS (polyphenylene sulfide) composite.
    .3 Class C: The airflow control device for highly corrosive airstreams shall be constructed as defined in 2.2.B.6.B. In addition, these devices shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, and pressure independent springs shall have a baked-on, corrosion-resistant phenolic coating in addition to the materials defined in 2.2.B.6.B. The internal “S” link, nuts, bolts, and rivets shall be epoxy phenolic coated stainless steel. Only devices clearly defined as “high corrosion resistant” on project drawings will require this construction.
    .4 Class D: The airflow control device for extremely corrosive airstreams, such as acid digestion fume hoods, shall have a PVDF (polyvinylidene fluoride fluoropolymer) coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel with PVDF coating. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel with PVDF coating. The pressure independent springs shall be a spring-grade stainless steel with Teflon (PTFE) coating. The internal nuts, bolts and rivets shall be stainless steel with PVDF coating. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite. Only devices clearly defined as “extremely corrosion resistant” on project drawings will require this construction.

Note: Airflow Control Devices utilizing vortex shedding sensors and installed in fume hoods or corrosive environments MUST be constructed with Stainless steel bodies, and MUST have stainless steel Vortex Shedding sensors. PolyCarbonate Vortex Shedding sensors will NOT be acceptable in corrosive environments.

13. Actuation
    .1 For high speed electrically actuated variable air volume operation, a CE certified, UL Listed, IP56 rated for dust and water, electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position and fail-to-last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).
    .2 In fail safe conditions the Airflow Control Device must remain pressure independent and in control of airflow at its failed position. I.E. if a device fails in position at 235 l/s, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 235 l/s at that given control point regardless of duct pressure. Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.
    .3 During normal operation, the high-speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less.
    .3 For Standard Speed electrically actuated VAV operation, a CSA certified, UL recognized (IP54 rating and CE certification optional on single valves, standard on dual valves) electronic actuator shall be factory mounted to the valve. The fail-safe state for standard speed operation valves shall be fail to last position unless otherwise noted.

      In fail-safe conditions the Airflow Control Device must remain pressure independent and in control of airflow at its failed position. I.E. if a device fails in position at 235 l/s, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 235 l/s at that given control point regardless of duct pressure. Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.
    .4 During normal operation, the standard speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 60 seconds (90 seconds for a shutoff valve from shutoff to maximum flow or vice Versa).
        .1 Standard speed actuation should not be used for valves that are connected to VAV fume hoods.

.2 Standard speed actuation can be used on 2-state fume hoods or vented cabinets or snorkels with on/off conditions.

.3 Constant volume valves do not require actuators.

14. The controller for the airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network.

15. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, standard and advanced temperature control, humidity control, and implement occupancy and emergency mode control schemes. A Room controller or programmable logic controller performing these functions shall not be acceptable.

16. The laboratory airflow control system shall have the option of digital integration with the building management system or building automation system. If digital integration device, room controller, laboratory space controller or similar is lost or offline or fails then the valve controllers shall have distributed controllability and will keep the basic room functions of zone balance, temperature, humidity control, offset control, etc. operating to maintain a safe and comfortable zone.

17. NVLAP Accreditation (Lab Code 200992-0)

.1 Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.

.2 Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined accuracy of no more than ±1% of signal (2.360 l/s to 118 l/s), ±2% of signal (117 l/s to 47 l/s) and ±3% of signal (94 l/s to 16 l/s). Electronic airflow control devices shall be further characterized and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.

.3 Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.

18. Airflow control devices that are not venturi valves and are airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall not be acceptable.

.3 <u>Exhaust and Supply Airflow Device Controller:</u>

.1 The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

.2 During normal operation the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:
  .1 1 second or less with high speed actuation.
  .2 60 seconds for standard speed actuation (90 seconds from shutoff to max flow and vice versa).
.3 The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.
.4 Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no separate room-level controller shall be required.
.5 The airflow control device shall use industry standard 24 VAC power.
.6 The airflow control device shall have provisions to connect a commissioning tool and every node on the network shall be accessible from any point in the system.
.7 The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
  .1 Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
  .2 One digital input capable of accepting a dry contact or logic level signal input.
  .3 Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
  .4 One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.
.8 The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
.9 The airflow control device shall be ROHS compliant.

.4 Shut-Off Airflow Control Device:
  .1 Two types of shut-off air flow devices shall be available; standard shut-off (no gasket) and low leakage shut-off (with gasket).
  .2 The shut-off airflow control device shall have shut-off leakage and casing leakage of no greater than the following (with 1,250 Pa static pressure):

Shut-off Valve Type and Airflow Range	Shut-off Leakage	Casing Leakage
Standard shut-off devices up to 472 l/s	3 l/s	0.03 l/s
Low leakage shut-off devices up to 472 l/s	0.002 l/s	
Low leakage shut-off devices up to 708 l/s	0.05 s	

  .3 Manufacturer shall provide comprehensive leakage charts generated from ASME N510 pressure decay testing. Standard shut-off devices shall be tested up to and including 1,250 Pa static pressure. Low-leakage shut-off devices shall be tested up to and including 7,500 Pa static pressure.

.5 Laboratory Office Airflow Control Device:

.1 The airflow control device shall maintain a temperature set point by controlling the airflow and the reheat valve (if required) in response to a room temperature sensor. An additional output shall be provided for supplementary cooling or heating of the office space. If the office airflow supply device is not required for make-up airflow control for fume hoods, then the one-second speed of response and fail-safe conditions required of the laboratory airflow control system shall not apply.

.6 Constant Volume Airflow Control Device:

.1 The airflow control device shall maintain a constant airflow set point. It shall be factory characterized and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.

.2 Constant volume valves must be 100% mechanically pressure independent and require no actuation to maintain set point.

.3 Constant volume valves shall have no required electronics to maintain set point.

.4 Laboratory airflow control system suppliers not employing constant volume venturi airflow control valves shall provide pneumatic tubing or electrical wiring as required for their devices.

.7 Local Display Unit:

.1 The control system shall have an optional local display option that allows monitoring and control of system variables to be displayed on a user interface terminal device.

.2 The display unit shall be a touch screen monitor that shall connect to the room level devices through a room controller or room integrator.

.3 The display unit shall be powered by 24 VAC.

.4 The Local Display Unit shall have the provisions of being flush mounted or surface mounted directly to a standard electrical enclosure. Electrical conductors shall terminate inside the display module housing to a pluggable terminal block.

.5 The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down and general cleaning agents.

.6 The unit's exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride/ hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).

.7 The display unit shall be rated for use in areas where IP54 rating is required.

.8 The display unit shall utilize a 175 mm diagonal touchscreen display with optional color schemes to adapt the display to various lighting conditions.

.9 The display unit shall provide a means of entering and displaying a unique location descriptor (device ID).

.10 The display unit shall allow access to pertinent flow, temperature, humidity, pressure data, as well as occupancy and emergency mode control status, and current device or system alarm status. Data shall be viewable in units of measure appropriate for users of the system.

.11 The display unit shall have the ability to display up to 48 parameters, on two screens organized into display screens of up to 6 tiles, and up to 4 points per tile (24 parameters per page and up to 2 pages).
  .1 Present value, which may be read directly off the network, or conditioned with a fixed multiplier and/or offset to scale the value for the desired units of measure.
  .2 Units of measure, which are configurable based on local user conventions.

.12 Set points and editable control parameters shall be viewable on the View. The user shall have the ability to provide four levels of access. There will be three levels of PIN code access to prevent unauthorized changes to set points and editable control parameters.

.13 Monitor shall have the ability to locally display alarms for:
  .1 Numeric High and Low limits
  .2 Binary inputs (alarm selectable for True or False state)
  .3 Multistate alarms (alarmable on all but one state)

.14 Alarms shall have adjustable volume and the ability to be muted for situations where a visual alarm is acceptable or an audible alarm is not desired.

.8 Fume Hood Display:
  .1 The display screen shall be a 75 mm (diagonal) color LCD resistive touch screen (240 x 320 RGB).
  .2 The touch screen shall support input configurations for fume hood operational parameters done at the touch panel and at a minimum including:
    a. Sash Dimensions
    b. Hood ID
    c. Hood Certification Reminder
    d. Hood Occupancy Status
    e. Stopwatch/Timer
    f. Message Display
  .3 Hood configuration for the following properties shall be viewable and editable from the touch display:
    .1 Sash Dimensions
    .2 Hood ID
    .3 Hood Certification Reminder
    .4 Hood Occupancy Status
    .5 Stopwatch/Timer
    .6 Message Display

  .4 The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down with non-solvent cleaning agents.
  .5 The unit’s exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride/hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
  .6 Two mechanical membrane buttons shall be provided at the front panel of the display to enable users to quickly activate emergency exhaust mode and mute without having to remove protective gloves.
  .7 Flush mount or recess mount shall be installation options.

.8 A USB port shall be provided to support firmware and software upgrades and shall be covered to protect against moisture or Corrosion.

.9 A timer feature shall be provided to enable users to set specific durations for experiments and provide visual and audible alarms when the set time is expired.

.10 The fume hood display shall have an available I/O at its associated valve controller which may be used to receive a 0 – 10 volt signal from a Through-The-Wall (TTW) sensor. The TTW shall not control the valve but provide a drift alert to indicate when the TTW sensor reading is out of range relative to the sash position face velocity value.

.11 Power:
  .1 The device shall be powered by 24 VAC $\pm$ 15% at 10VA, 50/60 Hz.

.12 Configuration:
  .1 Configuration shall be performed from the touch display and/or manufacturer’s software tools.
  .2 The device shall be capable of being added to an existing LON communication network.
  .3 The device shall display fume hood performance data based on control logics embedded inside the valve controller.

.13 Communication:
  .1 The fume hood display unit shall connect to LON communication and link directly to a specific valve controller associated with the hood it is mounted on.
  .2 The device shall display fume hood performance data based on sash movements and valve controller performance over LON.

.14 Information Display:
  .1 The device shall have the ability to indicate when the fume hood face velocity is within the normal operating range as well as energy saving, hood certification, hood ID, timer, and hood occupancy status.
  .2 The device shall be configurable to display one of the following measurement units: cubic feet per minute (CFM), meters cubed per hour (m^3/h), liters per second (l/s), feet per minute (fpm), or meters per second (m/s).
  .3 The device shall have the ability to display system errors caused by the airflow valve or sash travel.
  .4 The device shall have the ability to indicate to users when the hood is due for recertification by stating on the LCD display “Hood Cert. due MM/DD/YYYY”.

.15 Emergency (Purge) Exhaust
  .1 The display shall have a mechanical membrane button on the lower portion that when pressed will initiate an emergency (purge) exhaust mode in the attached fume hood valve(s).
    .1 Button shall be mechanical so that users with rubber, nitrile, vinyl, latex, or other gloves can operate the emergency exhaust button.
  .2 The emergency (purge) exhaust mode, when initiated, will send the attached fume hood exhaust valve(s) to either the maximum flow of the valve or another predefined flow (as configured in the fume hood valve).

.16 Alarms:

.1 The device shall have the ability to show alarms on the main screen using visual and audible alerts.
.2 The main screen background color shall change to flashing red with text stating the type of alarm.
.3 In alarm state, the visual indication shall remain active until the event that triggered the alarm is removed or fixed.
.4 The audible alarm tone shall be cleared only when the event that triggered the alarm is removed or fixed.
.5 The device shall have an Alarm Muting option, which silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm shall override the mute delay and the alarm shall sound again.
.6 The device shall have the ability to customize audible alarms levels and customize mute duration.
.7 Users shall have the ability to change the volume of the alarm tone to low, medium, or high.
.8 The device shall have the ability to show Diversity alarm.
.1 Diversity alarm shall be generated by the valve or from the building management system.
.2 No audible tone for diversity alarm shall be generated at the fume hood display.

.17 <u>Energy Conservation:</u>
.1 The device shall have the ability to enable fume hood hibernation mode.
.1 When activated, with the sash fully closed and no chemicals present in the hood, the exhaust flow through the fume hood goes to the minimum allowed by the exhaust valve (or shut-off where available).
.2 The mode shall be initiated by a sequence including entering the menu and a password on the touch display, an external momentary switch input to the fume hood controller, or a network command via the building management system or building automation system.
.3 When activated, the LCD display shall show “Hood in Hibernation,” and the exhaust valve shall move to its minimum position or shutoff position.
.4 Safety shall be built into the hibernation mode, whereby opening the fume hood sash shall automatically return the fume hood exhaust to an in-use operating volume as determined by the sash sensor. Fume hood hibernation shall be a point that can be integrated to the building management system or building automation system.
.2 The device shall provide night time energy waste alarming to generate a visual and audible alarm to indicate that the fume hood sash is open beyond its minimum flow position and the lights in the room are off.
.1 When activated, the LCD display shall show “Energy Waste Close Sash” and the audible alarm shall sound until the sash is closed.
.2 The light levels at which the alarm is both initiated and cancelled shall be configurable.

.3 The device shall provide sash energy waste alarming, which generates a visual and audible alert to notify when the fume hood sash is open beyond a configurable set position and no one is in front of the fume hood.
.1 When activated, the LCD display shall show "Energy Waste Close Sash" and remain until the sash is closed.

.18 Security:
.1 End users shall have the ability to enable a PIN pass code to prevent unauthorized changes to sash heights, air flow settings and other editable parameters.

.19 Compliance:
.1 The unit shall be certified as meeting regulatory compliance with CE, CUL, and RoHS.
.2 The unit shall be suitable for use with non-solvent wipe down and is designed to meet IP44 test standards.
.3 The device shall comply with part 15 of the FCC Rules. Operation is subject to the following two conditions:
.1 This device shall not cause harmful interference.
.2 This device shall accept any interference received, including interference that may cause undesired operation.

.20 Environment:
.1 The operating temperature range shall be between 0 – 50°C.

.9 Fan Static Reset Kits:
.1 Fan static reset kits to accurately measure static pressure drop across a clean air valve and provide feedback to the building management system.
.2 Kit housed in polycarbonate enclosure that mounts directly to the valve base channel and has 3 wire connection to the valve controller for power and signal.
.3 Complete with:
.1 Two pressure pickups
.2 Two pressure dampers
.3 Two 1,800 mm lengths of silicon tubing
.4 Pressure transmitter:
.1 Range 250 Pa to 1,250 Pa.
.2 Output voltage: 0.25 to 4.0 VDC
.3 Zero Pressure output:0.25 +/- 0.06 VDC
.4 Supply Voltage: 7 to 32 VAC or 7 to 40 VDC
.5 Power consumption 0.12 VA

2.3 PERFORMANCE/DESIGN CRITERIA

.1 Each laboratory shall have a dedicated laboratory airflow control system. Each dedicated laboratory airflow control system shall support a minimum of 20 network controlled airflow devices.

.2 The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1. Use of

Sidewall Sensors or Through The Wall sensors to control the face velocity are unacceptable.

.3 The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.

.4 The hood exhaust airflow control device shall be switched automatically between in-use and standby levels based on the operator’s presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5% overshoot or undershoot.

.5 The laboratory airflow control system shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 75 Pa to 750 Pa).

.6 The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement, vortex shedding measurement, or velocity measurement to control room pressurization are unacceptable.

.7 The laboratory airflow control system shall maintain specific airflow (±5% of signal) with a minimum turndown as specified in 2.2.B.4 to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

.8 Airflow Control Sound Specification:

  .1 The laboratory airflow control system manufacturer shall provide comprehensive sound power level data for each size airflow control device. All data shall be obtained from testing in accordance with ASHRAE/ANSI Standard 130, Methods of Testing Air Terminal Units.

  .2 All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.

  .3 If the airflow control device cannot meet the sound power levels required to achieve the sound criteria appropriate for the space, as determined by the Departmental Representative, a properly sized sound attenuator must be used. All sound attenuators must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device’s maximum rated flow rate not to exceed 0.20 inches of water.

2.4 OPERATION SEQUENCES

.1 The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to hood flow demands, occupancy, and emergency control commands.

.2 Volumetric Offset Pressurization Control:

.1 The laboratory control system shall control supply and auxiliary exhaust airflow devices to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure (within specified range for medium or low-pressure valves). This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.

The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable as a configurable parameter in the laboratory airflow control system as set by startup technician or the building management system or building automation system.

The pressurization control algorithm shall consider both networked devices, as well as:

.1 Up to three non-networked devices providing a linear analog flow signal.

.2 Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.

Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.

The volumetric offset control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

.3 Temperature Control:

.1 Standard Primary Temperature Control:

.1 The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writeable from the building management system, with the option of a local offset adjustment.

.2 Temperature control shall be implemented through independent primary cooling and heating control functions. Primary heating shall be provided through the use of a modulating control of a properly sized reheat coil. Primary cooling shall be provided as a function of volumetric override or through auxiliary modulating control of a chilled water valve. Volumetric override will command both supply and general exhaust valves to maintain desired offset as a high select zone control. Volumetric cooling override may be staged before or after chilled water control valve.

.2 Auxiliary Temperature Control:

.1 The auxiliary modulating temperature control function shall offer the option of either heating or cooling mode and to operate as either a standalone temperature control loop, or staged to supplement the corresponding primary temperature control loop.

.3 Hot Deck/Cold Deck Control:

.1 The laboratory control system shall also provide the built-in capability for being configured for hot deck/cold deck ratio-metric temperature control.

.4 Advanced Temperature Control (ATC) or Cascade Control:

.1 The primary temperature control loop for the lab is based on a comparison between the discharge air temperature and the set point for the discharge air. The space temperature measured by a wall sensor is used to reset the set point for discharge air. The set point may be calculated automatically by using “Adaptive Set Point Range”. Another method enabling “Exhaust Air Temperature Adjustment” will calculate the difference between space temperature and exhaust temperature (within 2.7 degrees F) to reset the set point for the discharge air. The reset schedule for the set point is driven by a small window of temperature above and below the desired room temperature in the space.

.5 Thermal Anticipatory Control (BTU Compensation)Thermal:

.1 Anticipatory Control monitors discharge air temperature sensors, space temperature sensors, and discharge air flow to respond to significant (programmable) changes in air flow to immediately adjust temperature control.

.6 Chilled Beam Control:

.1 Chilled beam control shall be offered to control temperature in a space. Chilled beam control must have the ability to be turned off and or reset if the condensate level rises over a given point. The condensate switch can reset automatically, use a timed latch, or building management system command to reset.

.4 Humidity Control:

.1 The laboratory control system shall have an embedded humidity control function, which allows the monitoring and control of the relative humidity level in the pressurized zone. Using peer-to-peer control, the airflow devices shall have the ability to monitor the relative humidity level of the space and, based on a building management system writeable set point, develop a control signal to drive one or the other humidification or dehumidification control circuits.

.2 The humidity control loop(s) shall share a common set point, with a configurable dead band adjustment to prevent the humidification and dehumidification control functions to operate at the same time. A Dew Point Sensor contact can be used to manually reset or disable humidification/dehumidification output as “Humidity PID Reset”. The contact can reset automatically, use a timed latch, or building management system command to reset.

.5 Occupancy Control:

.1 The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the building management system as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a building management system command.

.6 Emergency Mode Control:

.1 The laboratory control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow set point. The system shall support up to four emergency control modes (zone or valve level). The emergency control modes may be initiated either by a local contact input or building management system command. Valve level emergency modes can be individually programmed on each valve as one of four emergency control modes. Zone level emergency modes will drive supply and exhaust valves to maintain or ignore zone offset (excludes control of hood valves).

.2 Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

.7 Local Alarm Control:

.1 The laboratory control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as well as to the building management system. The alarm mask may be configured differently for each room-level system.

.8 Shut-off Control (Standard and Low Leakage Shut-off Valves Only):

.1 The laboratory control systems shall provide means of commanding air flow devices to shut-off sequence in one of four modes.

.1 Emergency Mode Control: The shut-off sequence can be initiated locally through a universal input or remotely from the building management system or other controller such as Local Display Unit (LDU) using emergency mode(s). Fume hood air flow devices cannot be controlled locally using a universal input (See mode 2 below).

.2 Hibernation Mode Control: The shut-off sequence can be initiated on a fume hood air flow device using hibernation mode in conjunction with a fume hood monitor or a fume hood display in one of three methods: local contact closure, pushbutton sequence using faceplate of fume hood monitor, or remotely via building management system. If the sash on the fume hood is moved when hood is in hibernation mode, hood will automatically return to normal operation with no interaction to the fume hood monitor or fume hood display. Hibernation or decommission modes that require occupant to enter the fume hood monitor or fume hood display menu or settings to return to normal control mode are unacceptable.

.3 Auto Gex Shut-off Mode Control: The shut-off sequence can be initiated on a general exhaust (Gex) air flow device in a lab environment when the total non-Gex exhaust air flow satisfies minimum air change rate and cooling demand for a period greater than 60 seconds. Shut-off must be enabled on the general exhaust air flow device.

.4 IAQ Mode Control: The shut-off sequence can be initiated when exhaust air flow is distributed between a general exhaust and return air flow device. If shut-off is enabled, the general exhaust air flow device will shut when return ratio is 100% and the return air flow device will shut when the return ratio is 0%.

.9 <u>Diversity Alarm:</u>

.1 The laboratory control system shall have the ability of monitoring the airflow values for the pressurized space and generating an alarm signal in the event the total exhaust flow exceeds a predetermined threshold. The diversity alarm is intended to allow the user to take diversity in the design and generate an alarm condition in the event the diversity threshold is compromised. This function must be available in either an integrated or standalone system.

.10 <u>Fume Hood Control:</u>

.1 Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:

.1 Accept command inputs to regulate the flow accordingly and make this command value available to the building management system.

.2 Accept a sash position signal and make this value available to the building management system.

.3 Accept a zone presence sensor usage based control signal to indicate user presence and make this signal available to the building management system. Wide range motion sensors or Doppler radar motions sensors are not acceptable.

.4 Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the building management system.

.5 Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication.

.6 The fume hood airflow control device shall respond to changes in sash position and user presence within one second without hunting, in order to provide a constant 100-feet-per-minute face velocity when the fume hood is in use.

.11 The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and building management system communications are carried out reliably. All air valves in each laboratory space or pressurization zone shall communicate with an integrator and the number of devices shall not exceed 80% of the maximum capacity of the integrator. The integrator shall be used to isolate the subnets in a facility where a building management system or building automation system is used, providing a maximum of 30 valve devices and 20 fume hood monitors per subnet. The control system shall integrate to the building management system or the building automation system through the integrator.

.12 The laboratory airflow control system shall support at least 20 networked valve devices and 10 fume hood displays in each pressurized zone.

.13 All points shall be available through the interface to the building management system for trending, archiving, graphics, alarm notification and status reports. Laboratory airflow control systems performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

.14 Refer to the building management system or building automation system specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.5 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

.1 The laboratory airflow control system network shall digitally interface with the existing building management system and enteliWEB Front End. The required software interface drives shall be developed and housed in one or more dedicated interface devices furnished by the laboratory airflow control system supplier.

.2 All room-level points shall be available to the building management for monitoring or trending as shown in the following section’s Table, Integration Points. The laboratory airflow control system integrator and/or room manager shall maintain a cache of all points to be monitored by the building management system. The room-level airflow control devices shall update this cache continually. Refer to drawings for additional information regarding the interface to and integration with the building management systems.

.3 The Room-level network shall be LonTalk FTT-10A, BACNet MS/TP, BACnet Ethernet or BACnet IP communications protocol.

.4 <u>Room Level Integration:</u>

.1 The room level integration device shall be a standalone piece of hardware and will be used for commissioning and configuration of venturi valves and ancillary components such as Fume Hood Displays, and Input Output (I/O) modules.

.2 After the Room Level Interface is commissioned it shall provide a web based user interface for device, network, and platform diagnostics as well as a Test and Balance web application for zone balance and airflow validation. Room Level interface will also provide a means of integrating on an open BACnet network via IP, Ethernet, or MS/TP to be field selectable at time of commissioning.

.3 Room Level Integration device shall operate with the following platform:
   .1 Platform
      • ARM Cortex A8 or greater processor
      • 1GB DDR SDRAM & 4 GB or greater Flash Memory
      • Data Recovery Services with SDRAM
      • Real-time clock

.4 Room Level Integration device shall support a combination of the following network connection ports and communication protocols as standard or orderable options:
   .1 2 Ethernet Ports (RJ-45 Connectors) – 10/100 Mbps
   .2 2 RS-485 on board port (3 Screw Connector on base board)
   .3 Up to 2 Dual port RS-485 expansion modules
   .4 Up to 4 LON modules 78 Kbps FTT 10
   .5 Building automation system protocol: BACnet over Ethernet, or BACnet over IP, or BACnet over MS/TP
   .6 Building automation system implementation: Conformance Class 3 BIBBS-BBC (BACnet Building Controller)
   .7 Building automation system data transfer rates (points per second): Read requests – 50 sustained, 100 peak; Write commands – 30 maximum
   .8 Room network: ANSI 709.1 LonTalk protocol
   .9 The room level integration device shall also incorporate WiFi capability for commissioning purposes that can be disabled at the time of job acceptance.

.5 Room-level integration device shall support 200 devices maximum, of which up to 120 LON per table below and the rest BACnet.

.6 Each LON FTT-10A adapter on the Room Level interface shall support up to 20 nodes (LVC + LRC + PCM2) within a 30 device maximum per channel.

.7 A total 5,000 points can be reported per room level integration device.

.8 A PCI8000 to support pluggable local Input/Output (I/O) modules with the following options:
   .1 <u>16-Point Module</u>
      • 8 Universal Inputs (Type 3 (10 k) Thermistors, 0 - 100,000 ohms, 0 -
      10 volts, 4 - 20 mA with external resistor), Binary (pulse or dry contact) Input
      • 4 Relay Outputs (Form A contacts, 24 VAC or 24VDC @ 0.5 amp rated)
      • 4 Analog Outputs (0 - 10 VDC @ 4mA max (2500 ohms or greater))
   .2 <u>34-Point Module</u>

- 16 Universal Inputs (Type 3 (10 k) Thermistors, 0 - 100,000 ohms, 0 - 10 volts,
  4 - 20 mA with external resistor), Binary (pulse or dry contact) Input
- 10 Relay Outputs (Form A contacts, 24 VAC or 24 VDC @ 0.5 amp rated)
- 8 Analog Outputs (0 - 10 VDC @ 4mA max (2500 ohms or greater))

.9 If the room level integration device drops off the network or loses power, it shall not cause the zone balance, temperature control, or fume hood devices to lose control. The room level valve devices should operate independently of the room level integration device. Laboratory space controller, room controller with hardwired control of hood, general exhaust and supply valves, or PLC with hardwired control of fume hood, general exhaust or supply valves for zone balance, temperature control, room offset, etc. will not be acceptable.

.10 Room Level Integrator shall be able to integrate to the building automation system shall be through BACnet/IP, BACnet/Ethernet, BACnet MS/TP, or LON through on board communication adapters and shall be field configurable/upgradable.

.5 Integration Points:

.1 1. As a minimum, the laboratory airflow control system shall provide these typical integration points to the existing enteliWEB OWS. Refer to the design drawings for additional integration requirements and for the complete list of points required to be brought into the existing enteliWEB OWS.

Table 1. Typical Integration Points (not all inclusive)

Point Name	**Description**	**Data Type**	**Read/Write**
Alarm Points (available on any digital valve controller)			
JAM_ALARM	The valve is unable to reach the commanded set point	Binary	Read Only
FLOW_ALARM	The pressure switch detected low static pressure	Binary	Read Only
Flow Points (available on any digital valve controller)			
EFF_VLV_FLOW_CMD	Valve flow set point	Analog	Read Only
VLV_FLOW_FDBK	Valve flow feedback	Analog	Read Only
Points Associated with a Hood Valve Controller			
BROKEN_SASH_CABLE	Alarm indicating sash sensor cable or bar is broken	Binary	Read Only
SASH_HEIGHT_ALARM	Alarm indicating sash input signal exceeds maximum sash height set point	Binary	Read Only
HOOD_OVERRIDE	Alarm indicating emergency override function on the fume hood monitor is active	Binary	Read Only
EFF_VLV_FLOW_CMD	Valve flow set point	Analog	Read Only

Point Name	**Description**	**Data Type**	**Read/Write**
VLV_FLOW_FDBK	Valve flow feedback	Analog	Read Only
SASH_OPEN_PERCENT	Calculated Sash Opening (0-100%)	Analog	Read Only
FACE_VELOCITY	Calculated face velocity	Analog	Read Only
FACE_VELOCITY_SETPT	Calculated face velocity set point	Analog	Read Only
USER_STATUS	Zone presence sensor status-Hood Occupied (normal) or Unoccupied (setback) mode	Binary	Read Only
Points Associated with Occupancy Control			
OCCUPANCY_CMD	Commanded room occupancy state (occupied/unoccupied/standby)	Multi-State	Read/Write
EFF_OCC_MODE	Current room occupancy status (occupied/unoccupied/standby/bypass)	Multi-State	Read Only
Points Associated with Emergency Mode Control			
EFF_EMER_MODE	Present emergency mode status (none, 1, 2, 3, or 4 active)	Multi-State	Read Only
EMER_MODE_CMD	Commanded emergency mode state (1, 2, 3, or 4)	Multi-State	Read/Write
Points Associated with Humidity Control			
HUMIDITY_SETPT	Writable relative humidity set point	Analog	Read/Write
HUMIDITY_DEMAND	Relative humidity demand	Analog	Read Only
SPACE_HUMIDITY	Relative humidity present value	Analog	Read Only
Points Associated with Temperature Control (may vary with application)			
OCC_COOL_SETPT	Cooling set point in the occupied mode	Analog	Read/Write
OCC_HEAT_SETPT	Heating set point in the occupied mode	Analog	Read/Write
UNOCC_COOL_SETPT	Cooling set point in the unoccupied mode	Analog	Read/Write
UNOCC_HEAT_SETPT	Heating set point in the unoccupied mode	Analog	Read/Write
EFF_TEMP_SETPT	Average of the cooling and heating set points	Analog	Read Only
OCC_TEMP_SETPT	Occupied temperature set point	Analog	Read/Write
AVG_SPACE_TEMP	Average of temperature sensor inputs used for control	Analog	Read Only
OFFSET_LEVER_ENABLE	Enables or disables temperature offset lever	Binary	Read/Write
COOLING_DEMAND	Cooling demand output (-100% = cooling)	Analog	Read Only
HEATING_DEMAND	Heating demand output (+100% = heating)	Analog	Read Only
DSCHRG_AIR_TEMP	Present value of discharge air temperature sensor	Analog	Read Only

Point Name	Description	Data Type	Read/Write
DSCHRG_TEMP_SETPT	Discharge air temperature set point (used with Advanced Temperature Control function)	Analog	Read Only
PCC_TEMP_MODE	Reports current temperature control state	Multi-State	Read Only
HVAC_MODE_OVERRIDE	Allows building management system to override temperature control to one of eight states (not available on all applications)	Multi-State	Read/Write
Points Associated with Zone Balance			
OFFSET_SETPT	Zone offset set point	Analog	Read/Write
OFFSET	Calculated zone offset	Analog	Read Only
OCC_MIN_SETPT	Occupied minimum ventilation flow set point	Analog	Read/Write
UNOCC_MIN_SETPT	Unoccupied minimum ventilation flow set point	Analog	Read/Write
TOTAL_ZONE_SUPPLY	Total of all networked and non-networked supply devices	Analog	Read Only
TOTAL_ZONE_EXHAUST	Total of all networked and non-networked exhaust devices	Analog	Read Only
TOTAL_CNST_EXH_FLOW (where applicable)	Entered value of constant volume exhaust devices	Analog	Read Only
TOTAL_CNST_SUP_FLOW (where applicable)	Entered value of constant volume supply devices	Analog	Read Only
TOTAL_ADDL_EXH_FLOW (where applicable)	Total of all hard-wired (non-networked) exhaust devices	Analog	Read Only
TOTAL_ADDL_SUP_FLOW (where applicable)	Total of all hard-wired (non-networked) supply devices	Analog	Read Only
Points Associated with Pressure Control			
PRESSURE_ALARM	Alarm indicating over or under pressure alarm condition	Binary	Read Only
EFF_PRES_SETPT	The set point to which the pressure control system will control	Analog	Read Only
PRES_SETPT	Writable differential pressure set point	Analog	Read/Write
ZONE_DIFF_PRESSURE	Present value of the measured zone differential pressure	Analog	Read Only
PRES_PID_CMD	Progressive Offset Control’s current PID value	Analog	Read Only
PRES_ALRM_SETPT	Set point value for the over pressure alarm function	Analog	Read/Write
FREEZE_MODE_STATE	PID control Freeze Mode status	Binary	Read Only

Point Name	Description	Data Type	Read/Write
FRZ_MODE_OFFSET_SETPT	Set point for an alternate offset when the Freeze Mode is active	Analog	Read/Write
Points Associated with Air Change Rate			
AI_ACH_ZONE	Air Change Rate Feedback	AI	Read
AO_ACH_OCC	Occupied Air Change Rate Command	AO	Read/Write
AO_ACH_STANDBY	Stand-by Air Change Rate Command	AO	Read/Write
AO_ACH_UNOCC	Unoccupied Air Change Rate Command	AO	Read/Write

.6 The laboratory airflow control system. critical environment integration shall support distributed network architecture from room level BACnet MS/TP segment or LON FTT-10 bus to a dedicated BACnet MS/TP segment, building BACnet/Ethernet, or BACnet/IP building backbone using single or multiple IP addresses. Backbone communication protocol must be field selectable/upgradable.

.7 Communication between devices in a room or zone will operate independent of building level communications maintaining integrity of the airflow. The laboratory airflow control system. Building level communication, or loss of, will not disrupt the communication between devices in a room or zone.

.8 The laboratory airflow control system critical environment integration shall provide an easy means to access room level device health status at a room-by-room or building wide level via web page. The system health pages shall provide information to assist in diagnostics for:
- .1 Online/Offline status for the room level integration appliance.
- .2 Runtime information such as heap memory usage and CPU usage.
- .3 Communication channel online/offline and configuration data.
- .4 Device level online/offline information.
- .5 Device level alarm information.
- .6 Device level Configuration errors.

.9 The laboratory airflow control system critical environment integration shall provide an easy means to access a Test and Balance function tool at a room-by-room basis. Test and balance functions should include:
- .1 Setting the devices in the room to various conditions in order to read airflow.
- .2 Manually override the outputs for testing purposes.
- .3 Adjust airflow to meet field acceptance tests.
- .4 Output a report for airflow performance test.

.10 The laboratory airflow control system critical environment integration must be able to support SQL database for long term data storage.

.11 The laboratory airflow control system critical environment integration shall provide optional software to manage local backup and restore, entire site device management, building wide test and balance functions, building wide diagnostic tools, and building wide configuration tools. Software shall be field upgradable to support graphical dashboard displays.

3 Execution

3.1 MANUFACTURER’S INSTRUCTIONS

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

3.2 INSTALLATION

.1 Install in accordance with manufacturers recommendations.

.2 Support independently of ductwork.

.3 Install with at least four duct diameters of straight inlet duct, same size as inlet.

.4 Locate so that controls, dampers and access panels are easily accessible. Confirm minimum clearances with box manufacturer and the Controls Contractor.

3.3 INSTALLATION

.1 The building management system or building automation system contractor shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the laboratory airflow control system supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels or use of fixed sash sensors with take up reels is also permitted. Sash interface boxes with interface cards shall be mounted in an accessible location. Sidewall sensors are not acceptable for use to control the fume hood valves. If sidewall sensors are installed for monitoring purposes or drift alarm, follow manufacturer installation instructions and reference control wiring details for connection to valve controllers.

.2 The building management system contractor shall install all room controllers and room integrators in an accessible location in or around the designated laboratory room.

.3 The building management system contractor shall install an appropriately sized and fused 24 VAC transformer suitable for NEC Class II wiring.

.4 All cable shall be furnished and installed by the building management system contractor. The building management system contractor shall terminate and connect all cables as required. The building management system contractor shall utilize cables specifically recommended by the laboratory airflow controls supplier.

.5 The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.

.6 The mechanical contractor shall provide and install all reheat coils, neutralizers, silencers, and transitions.

.7 The mechanical contractor shall provide and install insulation as required.

.8 Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.4 SYSTEM START UP

.1 System start-up shall be provided by a factory-authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to the building management system (when applicable).

.2 The balancing contractor shall be responsible for final verification and reporting of all airflows. For all field flow measurement devices the balancer shall produce a flow report that documents field flows vs device flow and associated error. This to be tabulated for each device location at several flows including min and max. Cost and responsibility to meet the specified performance to be carried by the laboratory airflow control system.

3.5 WARRANTY

.1 The Warranty shall commence upon the date of substantial completion and extend for a period of 12 months for all airflow control devices and for all other control system components. Shall include parts and labour.

3.6 CLOSEOUT ACTIVITIES

.1 Training:

.1 The laboratory airflow control system supplier shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.

.2 Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

END OF SECTION

1 General

1.1 RELATED SECTIONS

.1 Section 01 33 00 Submittal Procedures.

.2 Section 21 05 01 Mechanical General Requirements.

1.2 PRODUCT DATA

.1 Submit product data in accordance with Section 01 33 00 Submittal Procedures.

.2 Indicate the following:
- .1 Capacity.
- .2 Throw and terminal velocity.
- .3 Noise criteria.
- .4 Pressure drop.
- .5 Neck velocity.
- .6 Finish.
- .7 Sizes.

2 Products

2.1 GENERAL

.1 Standard product to meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity as indicated.

.2 Where grilles and registers penetrate fire walls and fire partitions, provide approved steel sleeve secured to structure in accordance with NFPA 90A and NBC.

.3 Frames:
1. Full perimeter gaskets.
2. Plaster frames where set into plaster or gypsum board and as specified.
3. Concealed fasteners.
4. Mitred corners

.4 Concealed manual volume control damper operators where applicable.

.5 Colour: off-white baked enamel.

2.2 EXHAUST GRILLES AND REGISTERS

.1 General: opposed blade dampers only if balancing damper cannot be installed on the branch duct.

.2 As indicated.

3 Execution

3.1 INSTALLATION

.1 Install in accordance with manufacturers instructions.

.2 Install with flat head screws in countersunk holes where fastenings are visible.

.3 Provide dedicated support for each diffuser and grille. To be separate from the ductwork distribution system.

END OF SECTION