THE UNIVERSITY OF
MEMPHIS

Laboratory Design Standards

Prepared by
Environmental Health and Safety
Physical Plant

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Approved by:

Environmental Health and Safety

Physical Plant

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Laboratory Design Standards

This design guide shall apply to all laboratories where hazardous chemicals, biological agents, and radioactive materials are stored, handled, used, or produced.

All such laboratories shall be designed to comply with NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, edition corresponding with that recognized by the State of Tennessee Fire Marshall; University of Memphis' *Laboratory Chemical Hygiene Program*, *Biological Safety Program*, *Radiation Safety Manual*; CDC's *Biosafety in Microbiological and Biomedical Laboratories*, latest edition; and related laws, regulations, and standards applicable to each laboratory.

These requirements shall apply to both renovations and new construction.

Fume Hoods

Containment
Fume hoods shall meet the following performance ratings at a face velocity of 100 fpm (0.51 m/s) and a tracer gas release rate of 4.0 L/min when tested according to ASHRAE 110-1995:

- As Manufactured Rating: 4.0 AM 0.05 (0.05 ppm)
- As Used Rating: 4.0 AU 0.10 (0.10 ppm)

Cross Drafts
Cross draft velocities should be less than 30 fpm near the hood face opening. In no case shall cross draft velocities exceed 50 fpm near the hood face.

Face Velocity
Average face velocity shall be 100 fpm at any sash opening size for VAV hoods, and 100 fpm at 18 inches sash opening for CAV hoods. Variations in face velocity across hood face shall be no more than 20%. (Variations exceeding 20% can be acceptable where containment is verified by tracer gas and smoke visualization test.)

Fume Hood Type

- Hoods intended to be installed as part of a VAV system shall be restricted bypass type.
- Hoods intended to be installed as part of a CAV system shall be open bypass type.
- Auxiliary air hoods are not permitted.
- Ductless hoods are not permitted for use with hazardous chemicals

Manufacturers
Subject to compliance with all technical and aesthetic requirements, fume hoods shall be provided by one of the following:

- Mott Manufacturing
- Labconco Corporation

- Others as approved by the University

Materials of Construction
Steel Sheet: commercial-quality, cold-rolled, carbon-steel sheet, complying with ASTM A 366; matte finish; suitable for exposed applications; and stretcher leveled or roller leveled to stretcher-leveled flatness
Stainless-Steel Sheet: ASTM A 666, Type 302 or 304, stretcher leveled, No.4 finish.
Glass-fiber Reinforced Polyester: Polyester laminate complying with ASTM 04357, with a chemical-resistant gel coat on the exposed face, and having a flame-spread index of 25 or less when tested according to ASTM E 84.
Epoxy: Factory-molded, modified, epoxy-resin formulation, uniform mixture throughout, full thickness with smooth, nonspecular finish.

Physical Properties shall comply with the following minimum requirements:

- Flexural strength: 15,000 psi (100 MPa)
- Compressive strength: 30,000 psi (200 MPa)
- Hardness (Rockwell M): 100
- Water absorption (24 hours): 0.02 percent (maximum)
- Heat distortion point: 350 deg F (177 deg C)
- Thermal-shock resistance: Highly resistant.

Flame Spread: 25 or less per ASTM E 84.

Chemical Resistance: Epoxy-resin material shall have the following ratings when tested with indicated reagents according to NEMA LD 3, test procedure 3.9.5:

- Acetone: Moderate effect.
- Acetic acid (98 percent): No effect.
- Hydrochloric acid (37 percent): No effect.
- Nitric acid (70 percent): No effect.
- Phosphoric acid (85 percent): No effect.
- Sulfuric acid (33 percent): No effect.
- Benzene: No effect.
- Butyl alcohol: No effect.
- Carbon tetrachloride: No effect.
- Ethyl acetate: No effect.
- Ethyl ether: No effect.
- Formaldehyde: No effect.
- Phenol (85 percent): No effect.
- Xylene: No effect.
- Ammonium hydroxide (28 percent): No effect.
- Sodium hydroxide (50 percent): Moderate effect.
- Zinc chloride: No effect.

Phenolic Composite: Factory formed under high temperature and pressure from cellulose-fiber-reinforced phenolic resins with a pigmented, chemical-resistant, melamine-resin surface.

Physical Properties shall comply with the following minimum requirements:

- Flexural strength: 14,500 psi (100 MPa)
- Compressive strength: 24,000 psi (160 MPa).
- Hardness (Rockwell M): 95.
- Water absorption (24 hours): 1 percent (maximum).
- Heat distortion point: 350 deg F (177 deg C).
- Thermal-shock resistance: Highly resistant.

Flame Spread: 25 or less per ASTM E 84.

Chemical Resistance: Composite material shall have the following ratings when tested with indicated reagents according to NEMA LD 3, test procedure 3.9.5:

- Acetone: No effect.
- Hydrochloric acid (37 percent): No effect.
- Hydrofluoric acid (50 percent): No effect.
- Nitric acid (70 percent): No effect.
- Perchloric acid (70 percent): No effect.
- Phosphoric acid (B5 percent): No effect.
- Sulfuric acid (33 percent): No effect.
- Carbon tetrachloride: No effect.
- Ethyl ether: No effect.
- Furfural: No effect.
- Naphtha: No effect.
- Toluene: No effect.
- Ammonium hydroxide (28 percent): No effect.
- Sodium hydroxide (20 percent): No effect.
- Zinc chloride: No effect.
- Gentian violet: No effect.

Glass-Fiber Cement Board: 1/4-inch- (6.35-mm-) thick, glass-fiber cement board complying with ASTM C 1186.

Tempered Glass: ASTM C 1048, Kind FT, Condition A, Type I, Class 1, Quality q3.

Laminated Safety Glass: ASTM C 1172, Kind LT; Kind FT, Condition A. Type I, Class I, Quality q3 lites with clear, polyvinyl butyral interlayer

Fabrication

Steel Exterior: Fabricate from steel sheet, 0.0478 inch (1.2 mm) thick, with component parts screwed together to allow removal of end panels, front fascia, and airfoil, and to allow access to plumbing lines and service fittings. Apply finish to interior and exterior surface of component parts before final assembly.

Ends: Double-wall end panels without projecting corner posts or other obstructions to interfere with smooth, even airflow. Close area between double walls at front of fume hood and as needed to house sash counterbalance weights, utility lines. and remote-control valves.

Provide airfoil vane at bottom, top, and sides of opening to direct airflow across work surface with 1 inch (25-mm) open space between foil and front edge of countertop. Extend airfoil under sash so sash closes on top of foil.

Interior Lining: Provide fume hoods with linings of the following material appropriate for fume hood type:

General Purpose Hood:

- Glass-Fiber reinforced polyester not less than 1/4 inch (6.35mm) thick.
- Epoxy, 1/4 inch (6.35 mm) thick.
- Phenolic composite, 1/4 inch (6.35 mm) thick.

Radioisotope Hood:

- Stainless steel, 0.0500 inch (1.3mm) thick.

Lining Assembly: Unless otherwise indicated, assemble with stainless-steel fasteners or epoxy adhesive, concealed where possible. Provide end panels, back panel, and top fastened together with cleats or steel angles to form a rigid assembly to which exterior is attached.

- Seal joints with chemical-resistant sealant before assembly to prevent open joints or spaces. Use stainless-steel, truss-head screws or rivets (not countersunk) for assembly of panels and to provide maximum strength joints.
- Punch fume hood lining side panels to receive remote controls and service fittings as indicated. Furnish removable plug buttons for holes not used for indicated fittings.

Stainless-Steel Lining Assembly: Welded unit consisting of end panels, back panel, top, and countertop; reinforced to form a rigid assembly to which exterior is attached.

- For radioisotope fume hood linings, cove corners and weld seams completely, grind smooth, and polish surfaces to produce uniform, directional textured, polished finish indicated, free of cross scratches. When polishing is completed, passivate and rinse surfaces, and remove foreign matter leaving surfaces chemically clean.

Exhaust Plenum: Full width of fume hood and with adequate volume to provide uniform airflow from hood, of same material as hood lining.

- Provide stainless-steel or glass-fiber-reinforced polyester duct stub for exhaust connection.

Sash: Provide operable sashes of type indicated. Fabricate from 0.0500-inch- l1.3-mm-} thick stainless steel into 4-sided frame with bottom corners welded and finished smooth. Make top member removable for glazing replacement. Set glazing in chemical-resistant, U-shaped gaskets.

- Glaze with 5-mm-thick tempered safety glass.
- Counterbalance vertical sliding sash with sash weight and stainless-steel cable system. Provide ball-bearing sheaves, plastic glides in stainless-steel guides, and stainless-steel lift handles. Provide rubber bumpers at top and bottom of each sash unit.
- Provide automatic sash stop at 18".
- Provide sash stops at 50% opening position of sash.

Lights: Provide a vapor proof, 2-tube, rapid-start, fluorescent light fixture, of longest practicable length, complete with tubes at each fume hood. Shield tubes from hood interior by 1 /4-inch- (6.35-mm-) thick laminated glass or 3-mm-thick tempered glass, sealed into hood with chemical-resistant rubber gaskets. Set units so that fluorescent tubes are easily replaceable from outside of hood.

- Provide fluorescent tubes with a color temperature of 3500 K and a minimum color rendering index of 85.
- Provide vapor proof, acid-resistant, incandescent light fixtures, complete with 100-W bulbs, instead of fluorescent fixtures at radioisotope fume hoods. Provide 2 fixtures for hoods up to 60 inches (1524 mm) long and 1 fixture for each 24 inches (610 mm) of length for longer hoods.

Countertops and Cup Sinks: Unless otherwise indicated, provide countertops and cup sinks as follows:

Epoxy Tops: Fabricate with front overhang of 1 inch (25 mm) over base cabinets, formed with continuous drip groove on underside 1/2 inch (13 mm) from edge and with factory cutouts for sinks.

- Top Configuration: Raised marine edges
- Top Thickness: 1 inch (25 mm).

Stainless-Steel Tops: Form tops from O.0625-inch- (1.6-mm) thick sheet with raised marine edge turned down to provide a 1-inch (25-mm) thickness and a Y2-inch (13-mm) return flange. Apply reinforcing channels to underside of top where necessary to insure rigidity without deflection. Sound deaden entire undersurface with heavy-build mastic coating.

- Where cup sinks are indicated, provide stainless-steel cup sinks continuously welded into top with welds ground smooth and polished.

Cup Sinks: 3-by-6-inch (75-by-150-mm) nominal size with 1-1/2-inch NPS (DN40) outlets with strainers and tailpieces a minimum of 6 inches (150 mm) of the same material as sink, or as otherwise approved by University.

Filler Strips: Wood or metal, as applicable to match adjoining surfaces. Provide as necessary to close openings between fume hood base cabinet or hood exterior and adjacent building construction.

Fasteners: Provide stainless-steel fasteners where exposed to fumes in hood.

Service Fittings: Comply with the following:

- Provide service fittings that comply with SEFA7, "Laboratory and Hospital Fixtures" recommended practices
- Provide service fittings complete with washers, locknuts, nipple and other installation accessories.
- Include wall flanges, escutcheons, handle extension rods, and similar items.
- Materials: Fabricated from cast or forged rod brass, unless otherwise indicated.
- Finish: Corrosion resistant.
  Provide corrosion-resistant finish in fume hood manufacturer's standard metallic brown, aluminum, or other color as approved by Architect.

Water Valves and Faucets: Provide units complying with ASME A 112.18.1, with renewable seats, designed for working pressure up to 80 psig (550 kPa).

- Vacuum Breakers: Provide ASSE 1001 atmospheric vacuum breakers on water fittings with serrated outlets.

Ground Key Cocks: Tapered core and handle of one-piece forged brass, ground and lapped, and held in place under constant spring pressure. Provide units designed for working pressure up to 40 psig (280 kPa), with serrated outlets.

Ball Valves: Handle requires no more than 5 Ibf (22N) to operate. Provide units designed for working pressure up to 75 psig (520 kPa), with serrated outlets.

- Provide units designed for working pressure up to 125 psig (860 kPa).

Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by “L”

Remote-Control Valves: Provide needle valves, straight-through or angle type as indicated for fume hoods and where indicated.

Handles: Provide three- or four-arm, forged-brass handles for valves, unless otherwise indicated.

- Provide lever-type handles for ground-key cocks.
- Provide lever-type handles for ball valves.
- Provide heat-resistant plastic handles for steam valves.
- Provide knurled nylon handles for needle valves.

Service-Outlet Identification: Provide color-coded plastic discs with embossed identification, secured to each service-fitting handle to be tamper resistant.

Electrical Service Fittings

Electrical Service Fittings, General: Provide units complete with metal housings, receptacles, terminals, switches, pilot lights, device plates, accessories, and gaskets required for mounting on laboratory casework.

Receptacles: Comply with NEMA WD 1, NEMA WD 6, FS W-C-596, and UL 498. Duplex type, Configuration 5 20R.

- Receptacle Grade: Hospital grade, unless otherwise indicated.
- GFCI Receptacles: Provide in accordance with NEC requirements. Comply with UL 943, Hospital Grade.
- TVSS Receptacles: Units with integral TVSS in line to ground, line to neutral, and neutral to ground.
    - TVSS Components: Multiple metal-oxide varistors; with a nominal clamp level rating of 500 V and minimum single transient pulse energy dissipation of 140 J line to neutral, and 70 J line to ground and neutral to ground.
    - Active TVSS Indication: Visual only with light visible in face of device to indicate device is "active" or "no longer in service."
    - Receptacle Type: Hospital grade, with isolated-ground terminal.
    - Identification: Distinctive marking on face of device to denote TVSS-type unit

Switches: Comply with FS W-C-896 and UL 20. Provide single-pole, double-pole, or 3-way switches as required; rated 120 to 277-V ac; and in amperage capacities to suit units served.

- Provide pilot lights adjacent to toggle switches where noted as "PL" next to switch identification.
- Provide thermal-overload switches, single or double pole, as required, with maximum overcurrent trip setting to suit particular motor controlled

Recessed-Type Fittings: Provide with galvanized steel boxes.

Finishes for Service-Fitting Components: Provide housings or boxes for pedestal- and line-type fittings with manufacturer's standard baked-on, chemical-resistant enamel in color as selected by Architect from manufacturer's full range.

- Color of Receptacles and Switches: As selected by Architect, unless otherwise indicated or required by NFPA 70.
- Color of TVSS Receptacles: Blue.

Cover Plates: Provide satin finish, Type 304, stainless-steel cover plates with formed, beveled edges.

Cover-Plate Identification: Use 1/4-inch- (6-mm-) high letters, unless otherwise indicated. On stainless steel or chrome-plated metal, stamp or etch plate and fill in letters with black enamel. Provide on all cover plates.

- Receptacles other than standard 125-V duplex, grounding type. Indicate voltage and phase.
- Switches and thermal-overload switches. Indicate equipment being controlled.
- Pilot lights when located remotely from associated equipment or switch, where function is not obvious. Indicate equipment being controlled.
- Receptacles, switches, and other locations indicated

Service-fitting Schedule

Water Service-Fitting:

- Type of Fitting: Remote control. Swivel gooseneck, in-line vacuum breaker, mixing valve where hot and cold water scheduled.
- Outlet: Removable serrated outlet.
- Mounting: Wall mounted.

Laboratory Gas Service-Fitting:

- Service: Air, Gas, Vacuum.
- Type of Fitting: Remote-control flange type.
- Where more fittings are scheduled than will fit on hood, the remainder shall be deck mounted turrets.
- Outlets: Removable serrated.
- Outlet Type: Angled. (Straight at deck mount).
- Valve Type: Remote control type shall be needle valve, deck mount to be ground-key cock.

Electrical Service-Fitting:

- Type of Fitting: recessed.
- Device: See schedule.
- Additional Requirements: GFCI receptacles.

Air Flow Indicator

Air flow Indicator shall be provided only for CAV fume hoods.

- Indicator Type: Thermal anemometer that measures fume hood face velocity and displays as digital readout.
- Airflow Alarm: Provide fume hoods with audible and visual alarm that activates when airflow sensor reading is outside of preset range.
- Provide with thermal-anemometer airflow sensor.
- Provide with reset and test switches.
- Provide with switch that silences audible alarm and automatically resets when airflow returns to within preset range.
- Sash Alarm: Provide fume hoods with audible and visual alarm that activates when sash is opened beyond preset position.
    - Provide with silence and test switches.

Commissioning

All new fume hoods and existing hoods present in laboratories undergoing renovations that impact air flow or HVAC systems shall be commissioned prior to acceptance. Such areas shall be appropriately balanced by an AABC certified professional prior to commissioning. Acceptable operation of hoods shall be indicated by conformance to ASHRAE 110-1995, 4.0 AU 0.10. Where several fume hoods require commissioning as part of the same project, commissioning shall be performed by an EH&S approved third-party; EH&S personnel shall have the right to be present during the commissioning. When the number of fume hoods requiring commissioning is not large enough to justify the cost of third-party commissioning, EH&S may perform the commissioning; however, contractor representatives and a laboratory representative shall have the right to be present during such commissioning.

Under Hood Cabinets

All fume hoods shall be placed atop at least a fire rated, ventilated cabinet for storage of flammable materials. Where hood width is adequate, an additional ventilated cabinet for storage of corrosives shall be placed to the left of the flammables cabinet. Vents from the flammables cabinet shall be connected directly to the exhaust duct.

Corrosives cabinets shall be lined with ¼ inch (6 mm) thick polyethylene or polypropylene. Vents from corrosive cabinets may be connected into the fume hood at the rear, if done so in a manner that will exclude spilled materials within the hood from entering the vent connection.

Radioisotope Hood base cabinets shall be capable of withstanding the following loads without permanent deformation, excessive deformation, excessive deflection, or binding of cabinet drawers and doors:

- 75 lb/ft (112 kg.m) within cabinets,
- 50 lb/ft (74 kg/m) countertop,
- 200 lb/ft (297 kg.m) on countertop, plus
- Weight of hood

Laboratory Environmental Control

Building mechanical systems shall be capable of maintaining temperature and humidity within acceptable limits for the work and materials being used in the laboratory. At a minimum temperature and humidity shall be maintained within comfort ranges established by ASHRAE.

Laboratory Air Flow Control

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 precisely controlled to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator being present 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). All controllers and actuators shall be Direct Digital Control (DDC).

Acceptable Manufacturers

- Phoenix
- TriaTech

Airflow Control System Description

Each individual laboratory shall have a dedicated laboratory airflow control system.

- The laboratory airflow control system shall employ individual average face velocity controllers that directly ensure the area of the fume hood sash opening and proportionally control the hoods 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.
- 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 between 1.0 to 1.5 feet per second.
- The hood exhaust airflow control device shall be automatically switched between in-use and standby levels based on operator 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 moment of detection with no more than a 5% overshoot or undershoot.
- 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 (within 0.6" to 3.0" we), airflow change or quantity of airflow control devices on the manifold.
- 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.
- The laboratory airflow control system shall maintain specific airflow (± 5% of signal) with a minimum 15 to1turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

- In areas such as animal care facilities, cleanrooms, and facilities where high hazard substances are present, a visual indicator or indicators of acceptable and unacceptable pressurization shall be provided. The location of the indicator(s) shall be approved by EH&S and users of the facilities.

Adaptive Face Velocity Control Equipment
VAV 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 for horizontal overlapping sashes. Control systems employing velocity sensors shall be unacceptable.

A presence and motion sensor shall be provided to determine an operators 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 of 100 fpm to a standby face velocity of 60 fpm, and vice versa.

- The sensor shall define a detection zone of two feet directly in front of the face of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within five 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.
- The sensor shall have a control circuit that adapts to its specific surroundings and automatically adjusts for inanimate objects placed within its detection zone. It shall map the area into memory and, after a period of five minutes, nullify the image of the inanimate object and return to a standby mode. Operators shall enter and leave the zone with the unit automatically adjusting between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall automatically re-map the area.
- Wide area motion detectors (on the hood or room level) shall be unacceptable.
- Hood controls shall maintain containment at 4.0 AU 0.10 during the standby mode.

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 totally closed.

A fume hood monitor shall be provided to receive the sash sensor output and presence and/or motion signal. This same monitor shall generate an exhaust airflow control signal for the appropriate volume control device in order to provide a constant average face velocity. Audible and separate visual alarms shall be provided for both flow alarm and emergency exhaust conditions.

Airflow Control Device – General

The airflow control device shall be a venturi valve.

The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.

The airflow control device shall maintain accuracy (± 5%) of signal over an airflow turndown range of no less than 15 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

The airflow control device shall be constructed of one of the following three types:

- Class A - The airflow control device for non-corrosive airstreams such as supply shall be constructed of 16 gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring grade stainless steel. All shaft bearing surfaces shall be made of a Teflon or Celenex composite. All supply devices will be externally pre-insulated at the factory, except for constant volume devices which have stand-offs for field insulation.
- 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.
- 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 baked-on, corrosion resistant phenolic coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting 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 a Teflon or Celenex composite.
- Class C - The airflow control device for highly corrosive airstreams shall be constructed as defined in paragraph D.2 and in addition, shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked-on corrosion resistant phenolic coating in addition to the materials defined in paragraph 0.2. The internal nuts, bolts, and rivets shall be phenolic coated stainless steel and/or titanium. Only devices clearly defined as "Class C" on project drawings will require this construction.

For two-position or VAV operation, an electric actuator shall be factory mounted to the valve. Loss of control power shall cause exhaust valves to fail to controlled maximum pressure independent flow, and supply valves to fail to controlled minimum pressure independent flow. Electric actuators that fail in last position are not acceptable. Constant volume valves do not require actuators. No pneumatic actuator will be acceptable.

Certification

- Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least ± 1 % of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ± 5% of signal at a minimum of eight different airflows across the full operating range of the device.
- All airflow control devices shall be individually marked with device specific, factory calibration data. As a minimum, it should include: tag number, serial number, model number, eight point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

Airflow control devices that are not venturi valves shall not be acceptable.

Exhaust and Supply Airflow Control Device
The control device shall use electronic-based, closed loop control to linearly regulate airflow based on a 0 to 10 volt control signal. The device shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.

Two-Position Airflow Control Device
The airflow control device shall maintain a factory calibrated pressure independent fixed maximum and minimum flow set-point based on a switched 0 to 20 psi pneumatic signal. Two-position devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.

Laboratory Lab Supply and General Purpose Airflow Control Device
The control device shall regulate flow based on varying 0 to 10 volt electronic signal, a varying 8 to 13 psi pneumatic signal. The lab supply or general purpose devices requiring flow feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.

Constant Volume Airflow Control Device

- The airflow control device shall maintain a pressure independent constant flow set-point. It shall be factory calibrated and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow. Devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.
- Laboratory airflow control systems suppliers not employing constant volume venturi air flow control valves shall be DDC.

Laboratory Control Unit

- A laboratory control unit shall control the supply and/or general exhaust airflow control devices to maintain proper room pressurization (positive or negative). Each individual laboratory shall have a dedicated laboratory control unit.

    - For specialized applications (e.g., clean rooms, animal care facilties) and high hazard areas, visual differential pressure indicators shall be provided.
- The control unit shall be electronic. The inputs shall accept linear feedback signals from fume hood, canopy, snorkel, biosafety cabinet, and lab supply airflow control devices. The output signals shall control supply, general exhaust/return airflow control devices and/or variable frequency drives with signals that are linearly proportional to the desired supply or exhaust airflows.
- The control unit shall maintain a constant design offset between the sum of the room’s total exhaust and make-up/supply airflows. 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 control unit shall generate linear signals that are proportional to all airflow sources, sash sensors, and flow alarms. The signals shall be available for hard wired connection to the facilities direct digital control (DOC) system, or through an integrated control unit that interfaces directly into the facilities DOC system.
- The laboratory control unit may be either panel or valve mounted.
- Refer to the DOC Control specification for the required input/output summary for the necessary points to be monitored and or controlled.
- Each laboratory shall have a dedicated 120 Vac line connection to power the laboratory's airflow control system power supply.

Sequence of Operations

VAV Laboratory with multiple Fume Hoods: As the static pressure in the exhaust and supply duct systems fluctuate, the pressure independent cone/spring assembly of each venturi valve shall modulate to maintain a fixed set-point volume within one second.

As each fume hood's sash opening increases or decreases, the sash sensor signal to the related fume hood monitor shall change proportionally. (A sash sensor and monitor are mounted on each fume hood.)

With an operator at the fume hood, each Zone Presence Sensor (also mounted on the fume hood) shalt detect the operator and shall send a 0 Vdc (operator present) user status signal to its associated fume hood monitor. This 0 Vdc user status signal shall switch the monitor into its standard operation mode. Based on the combination of user status and sash position inputs, the fume hood monitor shall apply a multiplier of "1 U to the sash signal to generate a 0-10 Vdc standard operation command signal. This 0-10 Vdc linear, calibrated command signal shall control its associated hood exhaust valve, thus maintaining a constant average, standard operation, face velocity at the fume hood opening. During standard operation, each fume hood shall operate as a conventional variable air volume hood with a conventional face velocity (i.e., 100 fpm).

When the operator walks away from the fume hood and out of the ZPS detection zone, each Zone Presence Sensor shall detect the absence of the operator and shall send a + 12 Vdc (operator absent) user status signal to its associated fume hood monitor. This + 12 Vdc user status signal shall switch the monitor into its standby operation mode.

Based on the combination of user status and sash position inputs, the fume hood monitor shall apply a multiplier equal to "(standby face velocity)/(standard face velocity)" to the sash signal to generate a 0-10 Vdc setback command signal. This 0-10 Vdc linear, calibrated command signal shall control its associated hood exhaust valve, thus maintaining a constant average, standby operation, face velocity at the fume hood opening. During standby operation, each fume hood shall operate with a lower, yet safe, face velocity (i.e., 60 fpm).

Each hood exhaust valve shall generate a 0-10 Vdc feedback signal, proportional to the valve's airflow in cfm, and shall send this signal to the make-up air controller (mounted on the master make-up air valve).

The make-up air controller shall calculate the total hood exhaust volume by summing the feedback signals from both hood exhaust valves, and shall generate a 0-10 Vdc total hood exhaust signal.

The make-up air controller shall maintain a constant, adjustable net negative offset between the zone's total exhaust and make-up air volumes. This offset shall not vary with changes in exhaust volume magnitude and represents the volume of air that enters the zone from the corridor or adjacent spaces.

To achieve a negative room offset volume, the make-up air controller shall subtract the quantity of offset from the total hood exhaust signal. The resultant 0-10 Vdc signal is the make-up air for hood demand signal and represents the volume of make-up air required to satisfy the total hood exhaust demand with respect to the desired room offset volume

The override clamp (on the make-up air controller) shall clamp the make-up air valves to a minimum volume that is large enough to maintain the minimum ventilation volume.

On a rise in zone temperature, the electronic thermostat shall send signal to the make-up air controller. This signal shall be proportionate to the supply air volume required to condition the zone. The PTI option (mounted on the make-up air controller) consists of a transducer and a scaling function module. The scaling function module shall scale the thermal demand signal into a 0-10 Vdc signal at the supply cfm/volt scale factor of the make-up air controller.

The make-up air command signal shall be generated by comparing the override minimum clamp, the make-up air for hood demand and the scaled thermal demand signals, and selecting the higher of these three.

The make-up air controller shall generate a 0-10 Vdc signal to control the zone's general exhaust valve. This command signal shall equal the algebraic difference between the make-up air and total hood exhaust volumes, pius the desired room offset volume. The make-up air controller shall command the general exhaust valve to open when additional exhaust volume is required to maintain zone pressurization. Should the total hood exhaust volume increase, the make-up air controller shall decrease the command to the Gex valve accordingly, thereby providing pressurization control of the zone.

Independently, the zone thermostat shall control the reheat coil.

When the differential static pressure across each hood exhaust valve drops below the valve's minimum operating differential static pressure, the differential pressure switch (mounted on each hood exhaust valve) shall open, causing its associated fume hood monitor to generate an audible and visual flow alarm, indicating that the valve is outside of its control range. Upon a valve jam condition (i.e., feedback signal does not equal command signal) the fume hood monitor shall also generate a flow alarm. A mute button shall silence the audible portion of the alarm. When system conditions return to normal, all alarms shall automatically clear.

Fail-safe Condition

The valves in this application have been configured to fail in the following manner. Under loss of pneumatic air or power, each hood exhaust valve and the general exhaust valve will fail to their maximum mechanical limits, and each make-up air valve will fail to its minimum scheduled position. This zone fails in a negative pressurization mode with an increased offset volume.

On a rise in lab temperature, the electronic thermostat shall send a thermal demand signal to the lab supply valve that is within a 0 to 10 Vdc range. This thermal demand signal shall be proportionate to the supply air volume required to condition the lab. [Alternatively, if a DDC sensor is used, the DDC sensor shall send a signal to the DDC controller which generates a 0-10 Vdc thermal demand signal which is then dent to the lab supply valve.] The M option (a scaling function module mounted on the lab supply valve) shall scale the thermal demand signal into a 0-10 Vdc signal at the efm/volt scale factor of the lab supply valve. The lab supply valve shall then increase the airflow into the lab. The lab supply valve shall generate a 0-10 Vdc feedback signal, proportional to the valve's airflow in cfm, and shall send this signal to the make-up air controller.

Installation

The 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 devices 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. Sash interface boxes with interface cards shall be mounted in an accessible location.

The Contractor shall install the laboratory control unit (if panel-mounted) and wall-mounted power supply (as required) in an accessible location in the designated laboratory room.

The Contractor shall terminate and connect all cables as required. All cable shall be furnished and installed by the ATC contractor. In addition, integrated laboratory control unit connectors shall be furnished by the ATC.

The Contractor shall install all airflow control devices in the ductwork. The mechanical contractor shall provide and install all reheat coils and transitions.

The Contractor shall connect all airflow control valve linkages. The Contractor shall provide and install insulation as required (except for pre-insulated devices).

Fume Hood Exhaust Fans

Fume hood exhaust fans intended to be used in VAV systems shall be Strobic or equivalent. Where fume hood exhausts are manifolded in new construction, there should be sufficient fan redundancy to allow continued ventilation in the event of a fan failure or fan maintenance.

Exhaust fans shall be located outside the laboratory building, preferably at the highest-level of the roof, or located in a roof-top penthouse or mechanical equipment room that is always maintained at a negative pressure with respect to the rest of the building. Exhaust fans shall discharge directly into the exhaust stacks.

Fans equipped to operate from emergency power during an electrical outage shall automatically restart when transferred to emergency power and upon return to normal power.

Fans incorporated into VAV systems shall operate continuously, with no user controlled on/off switch. Fans in CAV systems may have a user controlled on/off switch provided that clearly visible indicators are present to communicate hood operational status.

Ducts

Unless contraindicated due to incompatibility with materials to be exhausted, fume hood exhaust ducts shall be constructed of welded 316 stainless steel designed to maintain adequate effluent transport velocities (minimum duct velocities of 1000-2000 fpm are recommended).

Exhaust ducts for laboratory equipment (e.g., vacuum pumps, analytical instruments) shall be compatible with the gases, vapors, fumes, or dusts to be exhausted and shall meet equipment manufacturers' recommended design specifications.

Dedicated radioisotope hood exhaust ducts, and those from biosafety cabinets, perchloric acid hoods, and other devices for handing high hazard materials shall not be manifolded into exhaust ducts serving other labs. A radioisotope hood may be manifolded with other fume hoods in the same lab when approved by EH&S. Hoods with exhaust requiring filtration shall not be manifolded with other hoods.

Internal insulation is prohibited for all supply and exhaust ducts serving laboratories.

Exhaust ducting shall be grounded to dissipate static electricity. Lengths of electrically conductive ductwork on either side of a flexible connection or other electrically insulating section in the airflow path shall be electrically bonded and grounded.

Ventilation Stations

Structural frame shall be constructed of extruded aluminum. All exterior surfaces shall be electrostatically epoxy-coated for superior resistance to both solvents and corrosive acids. Aluminum shall be properly prepared for epoxy coating.

Enclosures must contain a rear baffle, plenum, and airfoil for maximum containment. These features shall be constructed of polycarbonate and tempered safety glass.

Sides, top, and sash shall be 3/16" tempered safety glass for superior corrosion and heat resistance. Sash shall limit exhaust demand when closed and be hinged to provide maximum opening for access to interior when opened. Materials such as acrylic or various forms of plastics are unacceptable.

Enclosures shall be able to accept 6" round duct from the top, rear or bottom of the unit.

Enclosure shall contain two utility ports for electrical cords or tubing access. Ports shall be located at the lower rear of the unit and shall be furnished with removable plugs to seal ports when not in use.

Work surfaces to be of solid epoxy for maximum chemical resistance and dished to contain spills.

Enclosure shall incorporate a by-pass feature for efficient removal of contaminates located in the upper portion of the unit.

Perchloric Acid Hoods

Hoods intended for use of perchloric acid at temperatures above ambient and/or in quantities greater than 100 mL shall be of the dedicated, wash-down type dedicated for safe use of perchloric acid.

Emergency Showers and Eyewashes

All newly constructed and renovated laboratories where hazardous chemicals may be used shall be equipped with an emergency shower, eyewash, and drench hose meeting

ANSI Z358.1-2009. Emergency showers and eyewashes shall be located to give unimpeded emergency access to laboratory personnel within ten (10) seconds. Locate these units at or near the exit door unless approved by EH&S.

Appropriate mixing valves, or other approved methods, shall be provided to assure delivery of tepid water to showers and eyewashes at appropriate rates of flow.

Unless approved otherwise by Environmental Health and Safety and Campus Planning and Design, shower/eyewash units shall be free-standing, ADA compliant combo units. In addition to the drench hose connected to the shower/eyewash combo, additional drench hoses may be specified at sinks as needed. Units shall be Haws Model 8309WC, barrier-free, combination shower and eye/face wash with AXION MSR™ eye/face wash and showerhead, with Model 8901RFK, body spray unit (drench hose), or equivalent.

Compressed Gases and Delivery Systems

Approved storage racks shall be provided to adequately secure gas cylinders by chains, metal straps, or other approved materials, to prevent cylinders from falling or being knocked over. Use of chains is preferred over straps; however, when straps are used, straps shall be noncombustible. Racks shall be secured to a permanent building member or fixture with sufficient mass and structural integrity to resist toppling of the rack. Gasses that are considered particularly hazardous may require ventilated storage cabinets.

Where compressed gases, except air, are delivered via permanently installed tubing, all tubing shall be stainless steel with Swagelok fittings and associated devices. (Where gases are incompatible with stainless steel, other materials may be substituted when specifically authorized.) Tubing diameter shall be either ¼ inch O.D. or 3/8 inch I.D. Gauges associated with such delivery systems, including those for air, shall be part of a system that emits an alarm to indicate low gas supply; alarm set point shall be adjustable as appropriate for the gases to be delivered.

Flooring

Floor penetrations for electrical, plumbing, and mechanical services shall be completely and permanently sealed prior to applying finish flooring.

All newly constructed and renovated labs shall, unless alternative material is approved by Environmental Health and Safety, have floors covered by resilient epoxy coating that shall extend continuously up walls a minimum of 6 inches and shall extend around floor penetrations so as to prevent spilled liquids from exiting the spill area via such penetrations.

Where epoxy coating is unfeasible or not cost effective, sheet goods may be used. Sheet goods shall be installed in continuous sheets or multiple sheets sealed so as to form a seamless, continuous barrier. Materials shall be resistant to slipping and resistant to deterioration from chemicals.

Unless otherwise approved by Campus Planning and Design and Environmental Health and Safety, all laboratory flooring materials shall have the following ratings when tested with indicated reagents:

- Acetone: Moderate effect.
- Acetic acid (98 percent): No effect.
- Hydrochloric acid (37 percent): No effect.
- Nitric acid (70 percent): No effect.
- Phosphoric acid (85 percent): No effect.
- Sulfuric acid (33 percent): No effect.
- Benzene: No effect.
- Butyl alcohol: No effect.
- Carbon tetrachloride: No effect.
- Ethyl acetate: No effect.
- Ethyl ether: No effect.
- Ethyl Alcohol: Moderate effect.
- Formaldehyde: No effect.
- Phenol (85 percent): No effect.
- Xylene: No effect.
- Ammonium hydroxide (28 percent): No effect.
- Sodium hydroxide (50 percent): Moderate effect.
- Zinc chloride: No effect.

Shelving and Cabinets

All laboratory shelving shall be securely attached to walls or other supporting surface, not extend higher than 6 feet above the floor, and shall have lips, doors, or other means to prevent materials from inadvertently falling off. Materials of construction shall be compatible with any chemicals intended to be stored on the shelves, and shall exhibit appropriate strength to safely support materials intended to be stored on such shelves.

Laboratories shall, when applicable, be provided with sufficient lockable cabinets for storage of specifically regulated materials, such as DEA Controlled Substances, radioisotopes, particularly hazardous chemicals, and Select Agents.

Sinks and Faucets

Laboratories intended for use of biological materials shall be provided with at least one sink for hand washing; sink shall be provided with both hot and cold water supplies.

Faucets in labs intended for Biosafety Level 2 work shall be operable by means other than use of the hands.

Windows

Natural lighting from windows is desirable and encouraged; however, labs should not be equipped with operable windows. Where operable windows must be utilized, each window shall be equipped with screens of sufficient construction to prevent entry of insects, birds, and other animals.

Electrical Power

Emergency Power

Backup power by means of UPS system(s) shall be considered for inclusion in the scope of work where vital research equipment and power sensitive research equipment must be protected from fractional power interruptions. If determined necessary to the project, UPS systems shall protect equipment from power fluctuations that originate from both natural and man-made conditions.

If emergency power is available in any building housing a laboratory, and the system is capable of handling the current load, contractor shall ensure that critical laboratory equipment (e.g., incubators, low temperature freezers) is provided with emergency powered electrical outlets for these devices as needed. These outlets shall be on a separate automatic transfer switch (ATS) dedicated to non-life safety equipment.

Fans serving fume hoods shall be supplied with emergency power in new construction to ensure continued operation during power failure. In existing labs without emergency power to fume hood fans, consideration shall be given to the feasibility of installing emergency power to the fans.

In situations where new emergency power is to be installed as part of a laboratory construction or renovation project, current capacity shall be sufficient to handle critical laboratory equipment via a non-life safety ATS.

Shunt Breakers

Shunt breaker requirements for critical equipment shall be identified by lab users and the University in the design phase of all projects. Shunt breakers shall be resettable by laboratory personnel.

Electrical Panel Labeling

Electrical panels serving critical laboratory equipment, especially equipment that can be damaged or will require recalibration or servicing due to power loss, shall be labeled appropriately to warn against unscheduled power shut-off. Laboratory personnel are responsible for providing Contractor with the identity of all such equipment prior to substantial completion. Wording for electrical panel labels shall be approved by EH&S and Physical Plant.