SECTION 15980

Non-Proprietary LEED™ Vortex II™ Fume Safety Cabinets (FSC)

A. General

A.1. Summary – The following performance specifications is for a high performance chemical laboratory Fume Safety Cabinet (herein referred to as FSC) with the intent to achieve the maximum affordable and available control technology. The FSC is expected to operate at the highest level of fume containment over a broad range of operation. The FSC shall be a non-barrier ergonomically design FSC for all size workers which requires a full 27 ½" sash opening. The specification is to provide the safest possible FSC for credit in the Leadership In Energy and Environmental Design Program (LEED™) sponsored by the U.S. Green Building Council which:

a. Provides containment of chemical fumes for the safety of personnel working within laboratory areas, including lab workers, maintenance staff, visitors and others whether or not that they are trained in lab safety.

b. Operates at constant volume control for the least complicated engineered system to enhance laboratory commissioning and re-commissioning LEED required program.

c. Provides the maximum first cost mechanical equipment and operational energy savings with proven containment that also supports OSHA's required Chemical Hygiene Plan (CHP) via an enhanced ASHRAE 110 Test (2.10) that will include a safety factor to achieve added robustness even when operating in less than ideal conditions at a full 27 ½" sash opening.

d. The basis of the FSC specification is on the principles of a Bi-Stable Vortex to maintain memory and momentum under multiple upset variables occurring simultaneously. Other FSC products not based on a Bi-Stable Vortex design must provide technical documentation on its theory of operation including Computational Fluid Dynamic (CFD) modeling for all conditions of operation at time of bid.

e. Construction quality control – the manufacturing facility shall be currently ISO-9000 registered facility.

f. Design Requirements – The system shall be designed, manufactured, tested and installed in compliance with the current versions or issuance of:

g. The United States, UL Classified 1805 for Fire, Electrical and Mechanical Hazards, for Canada, CAN/CSAZ316.5-94

h. OSHA 29 CFR Part 1910

i. ASHRAE 62 & 110

j. AIHA Z9.5

k. NFPA 45

l. Americans with Disabilities Act

m. LEED™

A.2. Submittals required at time of bid for non pre-approved FSC's – Submittals shall include documentation of:

a. Performance characteristics for each of the criteria specified herein. Submittal shall include a copy of these specifications with each section marked with either a "C" for comply or "D" for the deviation. A written explanation shall be provided for each deviation from the specification considered for acceptance. To do otherwise is immediate grounds to reject total bid "Not Acceptable".

b. Testing Documentation Certifying Hoods meet the "Factory As Manufactured (AM) Quality Control Testing of Fume Safety Cabinets" 2.10 section of this specification. To do otherwise is immediate grounds to reject total bid " Not acceptable".

c. Dimensions and weights

d. Features

e. Technical discussion on the mechanical principals the FSC is based on including Renolds numbers (Re) for each size FSC.

f. Warranty Statement.

A.3. Approved Manufacturers – This specification is intended as a performance specification. Manufacturers which provide equipment meeting the performance specified herein shall be acceptable with the provisions that:

a. Manufacturer has been making and has installations of the identical FSC offered in the bid for a minimum of the last 5 years.

b. There are no projects where the submitted manufacturer's equipment has performed unacceptably as known by the engineer or owner.

c. Manufacturer shall not take exception to the factory testing provisions herein.

d. Naming of a manufacturer herein or on the drawings shall not relieve manufacturer of meeting all performance criteria herein and complying to 1.2.1.

e. Bidders.

1. Flow Safe, Denville, NJ 973-627-8553

A.4. Alternate FSC Types not meeting LEED airflow levels but designed non barrier and ergonomically correct and tested to 2.10 section will only be considered based upon the following.

a. Safety - Alternate systems shall be required to meet all the safety performance criteria listed in this specification for a vertical sash opening of 27 ½" for both testing performance ratings and exhaust airflow calculations. Alternate FSC types which have a potential sash opening exceeding 27 ½" shall be tested and analyzed at their higher actual maximum potential opening. Alternate FSC types shall be considered and tested for safety at only full sash opening at a minimum 27 ½" vertical and 26 ½" horizontal opening. Safety performance at full sash positions shall be proven by factory tests per 2.10 of this specification. Alternate FSC exhaust airflow shall not be considered based upon lowered (less than fully open) sash design points, to do otherwise becomes immediate grounds to reject total bid.

b. Energy Cost Payment - If the alternate exhaust airflow exceeds LEED's specified exhaust airflow by more than 5%, the contractor or FSC supplier (as applicable for whichever entity has the contract with the owner) shall provide compensation to the owner for the additional energy costs covering a fifteen year operating period. Payment shall be calculated as per the formula below based upon increased HVAC load at $3 per additional CFM per year for cooling, $2.82 per additional CFM per year for reheat, energy cost equivalent of 6 cents per kw-hr and 3%/year energy cost increase:

1. Energy Cost Payment in dollars = (Total increase in FSC exhaust CFM based upon all FSC operating at full open sash less design FSC exhaust CFM) x (66.72 $/CFM)

2. Support Systems Cost Payment - If the alternate exhaust airflow exceeds specified exhaust airflow values by more than 5%, the contractor or FSC supplier (as above) shall be financially responsible for all supporting system cost increases associated with changes resulting from the alternate FSC type. These shall include changes in fans, ducts, air handling devices, air conditioning systems, chiller costs, reheat coils, boilers, floor to floor heights, electrical distribution system, electrical utility service size, re-engineering design costs and all other related costs. Actual costs shall be used for this calculation as determined by the architect/engineer and owner. Costs of $3,000 to $4,000 or higher per ton of increased supporting system equipment should be anticipated. When existing central plant chillers are supplying the facility, the contractor or supplier (as above) shall be responsible for a payment covering loss of chiller margin, which may ultimately result in an earlier requirement to expand the central plant. This shall be calculated at $2,500 per ton and is additional to any other actual supporting systems cost increases.

3. CFM to Tons Conversion Factor – Each additional CFM of FSC exhaust CFM shall be considered as requiring 0.005 tons of additional HVAC supporting equipment.

4. Payment Timing - Payment of both the Energy Cost Payment and Support Systems Cost Payment shall be made to the owner prior to payment by the owner for the FSC units. A final adjustment of the actual supporting systems increase cost shall be made at project completion.

B. Product

B.1. The maximum allowable air flow exhaust for any high performance FSC will be based on the U.S. Green Building Council LEED Rating of no greater than 50 CFM per square foot of work surface area as performance tested to 2.10 of this specification at full 27 ½" sash opening.

B.2. Services Codes are:

a. C_2H_2 Acetylene

b. A Air

c. A_R Argon

d. $C0_2$ Carbon Dioxide

e. C Cold Water

f. D De-ionized Water

g. He Helium

h. H Hydrogen

i. E 515R-2 Receptacle

j. G Natural Gas

k. N_2 Nitrogen

l. $N0_2$ Nitrous Oxide

m. 0_2 Oxygen

n. S Steam

o. V Vacuum

B.3. Liner Codes types are:

PR Poly Resin

P Phenolic Resin

FP Fiberglass Reinforced Polyester

S304 Stainless Steel 304

S316 Stainless Steel 316

B.4. Construction: FSC shall be constructed as follows subject to exceptions noted in the schedule or on the project drawings:

a. Standard bench-type fume FSC superstructure shall be designed for installation on 30-3/4 inch deep work surface.

b. Walk-in type FSC superstructure shall be floor mounted.

c. Superstructure: For safety related to physical structural containment, superstructures shall be double wall type with outer wall of -coated steel with sufficient powder coat material (no solvent base material LEEDTM requirements) to achieve an average 1.5 mil film thickness with a minimum 1.2 mil film thickness and shall have smooth luster and the inner galvanized wall, covered with minimum 3/16" thick chemically resistant white liner or stainless steel per schedule. The exterior shall be constructed of 18 gauge C.R.S. complying with ASTM A366 (ASTM A366M) finished per UL 1805 for following chemical resistance, color selected from manufacture's standard color chart by architect/engineer. The interior wall shall be securely held in place with stainless steel threaded fastenings with corrosion protection. Chemical Resistance: rating when tested with indicated reagents according to NEMA LD 3, test procedure 3.9.5:

1. External Metal Parts

   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 (95 percent): No effect

   Xylene: No effect.

   Ammonium hydroxide (28 percent): No effect.

   Sodium hydroxide (50 percent): Moderate effect.

   Zinc chloride: No effect.

2. Internal Metal Parts

   Amyl Acetate: Moderate effect.

   Ethyl Acetate: Moderate effect.

Acetic Acid, 98%: Moderate effect.

Acetone: Moderate effect.

Acid Dichromate, 5%: Moderate effect.

Alcohol, Butyl: No effect.

Alcohol, Ethyl: Moderate effect.

Alcohol, Methyl: Moderate effect.

Ammonium Hydroxide, 28%: No effect.

Benzene: No effect.

Carbon Tetrachloride: No effect.

Chloroform: Moderate effect.

Chromic Acid, 60%: Moderate effect.

Cresol: Moderate effect.

Ethyl Ether: Moderate effect.

Formaldehyde, 37%: No effect.

Formic Acid, 90%: Moderate effect.

Gasoline: No effect.

Hydrochloric Acid, 37%: No effect.

Hydrofluoric Acid, 48%: Moderate effect.

Hydrogen Peroxide, 3%: No effect.

Iodine, Tincture of: No effect.

Methyl Ethyl Ketone: Moderate effect.

Methyl Chloride: Moderate effect.

Monochlorobenze: Moderate effect.

Naphthalene: No effect.

Nitric Acid, 20%: No effect.

Nitric Acid, 30%: No effect.

Nitric Acid, 70%: Moderate effect.

Phenol, 90%: Moderate effect.

Phosphoric Acid, 85%: No effect.

Silver Nitrate, Saturated: No effect.

Sodium Hydroxide, 10%: No effect.

Sodium Hydroxide, 20%: No effect.

Sodium Hydroxide, 40%: No effect.

Sodium Hydroxide, Flake: No effect.

Sodium Sulfide, Saturated: No effect.

Sulfuric Acid, 33%: No effect.

Sulfuric Acid, 77%: No effect.

d. Baffle: adjustable baffle with slots at top, center and bottom. The baffle's design concept, slot velocity, and its impact on the hoods performance under various conditions must be stated.

e. The base specified Bi-Stable Vortex FSC requires auto baffle control (see specification 15981). The baffle control actuators shall be mounted on top of FSC with remote jack shaft control, direct actuator mounting is not acceptable.

f. Alternate FSC's using alternate controls, fans or techniques provide details on life cycle testing and component guarantees.

g. Countertops: Counter top material, thickness, and color per schedule, with 3/8" dished design to avoid spillage.

h. FSC front to include posts, tracks, sash with weight, pulleys, cable, foil, pre-piped plumbing fixtures and pre-wired electrical fixtures. FSC front with sash and pre-wired electrical components, including the light box, are to be removable from hood body as a complete assembled one piece unit without disconnecting cable components or electrical components.

i. Sash: Sash shall be metal construction (finish per 2.2.3) with combination style with both vertical and horizontal moving glass panels. Vertical movement to allow hood loading and horizontal movement to provide a safety body shield when needed. No more than a 1/8" air gap above sash in any vertical position or a sash pocket must be provided. Horizontal sliding sashes are on two tracks. Horizontal sash shall be ¼" laminated safety plate glass ASTM C 1172, Kind LT; Kind FT, Condition A. Type T, Class I, Quality q3 lites with clear, polyvinyl butyral interlayer with finger pulls on each panel. Each panel must ride on rollers supported from top rail only. Sash frame shall be constructed and reinforced to support added weight. The sash mechanism shall be so designed to allow it to move below the counter top. All glass panels to have plastic edge guard on all vertical surfaces. Maximum sash opening to be 27-1/2”. An additional 7” high, clear glass panel integrated as part of FSC lintel shall maintain a clear vision height of 34” above countertop.

j. The walk-in type FSC shall have double hung combination horizontal/vertical sashes each with a vertical height of 33-1/2 inches.

k. Sash Height Limiting Hardware: The FSC maximum sash height opening of 27 1/2” will be measured from leading edge of bypass, dynamic turning vane airfoil to the bottom of sash handle. The 27 1/2” vertical top cannot be defeated. Provide a key lock preventing intermediate vertical sash movement as required per schedule. Each FSC to have integral sash height limiting hardware were required per schedule, mounted on the exterior of the hood, which prevents unintentionally raising the vertical sash above a set point with auto reset. Note, the hood exhaust air volume is specified to maintain containment even if sash is raised above sash limiting hardware.

l. Air Entry Transitions: The following requirements are to prevent reverse eddy airflow. Area surrounding sash opening to be rounded to create an aerodynamic configuration with side posts maximum 4.5" in width. Side posts to incorporate an airfoil design. A multi-vector airfoil bypass and dynamic turning vane shall be mounted behind the sash. Hood post to be flat radius edge design and extend a minimum beyond the sash.

m. Hood Depth: Interior dimensions and vortex chamber to be mathematically sized to support a Bi-Stable vortex. These calculations must be part of the FSC submission.

1. Electrical Access: Electrical components shall be accessible from the front of hood. Pre-wiring of all electrical components to junction box must be removable with hood front section without disconnecting components. Front panel must be removable without screw fasteners for access to all wiring at junction box and re-lamping of (2) tube High Performance LEEDTM required fluorescent fixtures.

n. Counterweight system shall include weights, stainless steel cables (with minimum safety factor of 10, and not to exposed to exhaust vapors) and sash guides, steel pulleys with cable retaining device. Counterweight system shall be balanced to provide smooth operation of the sash at any point along the full width of the bottom pull and prevent sash creep at any position. Only single front counterweight system is acceptable for ease of maintenance. No rear or dual weight system are allowed.

o. Spill Trough: Hood shall incorporate a trough to collect spills. Trough shall be designed at the front of the countertop and normally hidden by the multi-vector bypass dynamic turning vane airfoil under the sash. This airfoil shall be coated (see 2.2.3) steel, permanently attached via spring loaded pins to hood allowing swing-up for clearing of trough, and cord access.

p. The walk-in type FSC shall have a removable multi-vector bottom airfoil dynamic turning vane mounted along the threshold of the fume hood opening. The airfoil shall be coated (see 2.2.3) steel, 2 inch high and tapered to the floor level on the inside and outside of the hood along the entire length of the airfoil to allow equipment to be rolled into the fume hood.

q. Interior Access: Provide removable flush access panels on inside for ease of maintenance of valves and remote control stem attachments shall be provided. Inside panels shall be held in place using stainless steel, threaded fasteners which are protected from corrosion. Rubber held access panels are susceptible to fire and are not acceptable.

r. Round Duct Collars: 4" high parabolic connection, sized to support linear trim trunnion valves as specified in Specification 15981. Rectangular or sharp edge connection not acceptable.

s. Rear Panel: A Finished rear panel is required even if rear of hood is not exposed to view. Panel shall match material and color of the hood's main exterior skin.

t. Fume Hood Sound Level Certification: Provide certification of fume hood compliance with design criteria for maximum allowable noise as tested at manufactures test facility, which includes all valves and controls as specified in Div. 15981 as required for a complete system operating with air flows specified in 2.6. Maximum allowable decibel level of 65 dBA measured 36 inches away from, and perpendicular to, face of fume hood.

C.1. Laboratory FSC services, fixtures and accessories

a. All switches, outlets, fixture handles, and controls per Specification 15981 shall be on the front posts of the superstructure at a height that is accessible when the FSC is used while seated.

b. References FSC hood details and schedule on drawings for service rough-in locations, fixture quantities and fixture mounting locations.

c. Factory pre-piping shall extend beyond the top of the FSC per rough-in locations and shall be capped until final connection is made by division 15A and 15B contractors.

d. Water Service: 3/8 inch, type L copper water tube, H (drawn temper, ASTM B88; wrought copper pressure fittings, ANSI B16.22 lead free (<.2%)solder, ASTM B32 flux, ASTM B813 copper phosphorous brazing alloy, AWS A5.8 Bcup or swagelok flareless fittings.

e. Cold water piping, fittings and valve bodies shall be factory insulated with ½" thick closed cell elastomeric insulation. Slip insulation over piping where possible. Seal joints and seams with full bed of adhesive on both surfaces. Taped joints and seams are not acceptable.

f. Vacuum Service: 3/8 inch, type L copper water tube, cleaned, washed and capped, H drawn temper, ASTM B88; wrought copper pressure fittings, ANSI B16.22 lead free (<.2%) solder, ASTM B32 flux, ASTM B813 copper phosphorous brazing alloy, AWS A5.8 Bcup or swagelok flareless fittings

g. Natural Gas, Compressed Air and Steam Service: ASTM A 53, type E or S, standard weight (schedule 40) black steel pipe with ASTM A 197/ANSI B16.3 class 150 black malleable iron threaded fittings using thread lubricant or teflon tape.

h. Plumbing Fixtures: Oval cup sinks material (per schedule), nominal 3 inch x 6 inch or 3 x 9 inch per schedule, 1-1/2 inch IPS outlet, color: black.

i. Provide sidewall panel mounted cup sink for walk-in type fume hood with interior access panel.

j. Single service cold water fixtures: forged brass valve bodies, 80 psi working pressure, renewable type neoprene valve disc and a replaceable stainless steel seat. Valve body shall be remote mounted inside superstructure wall.

k. Fixture outlets shall be brass, stem type with 90 degree tip - DI water 30 degree tip, panel mounted in sidewall liner of FSC above cup sink. Fixture outlet shall have removable serrated tips, acid and solvent resistant epoxy finish. Fixture outlet shall have a color-coded mounting washer. Fixture control handle mounted in exterior superstructure post shall be chrome four arm handle with plastic color-coded center index button that matches color of serrated tip mounting washer.

l. Water fixtures shall be factory pre-piped with a laboratory vacuum breaker mounted not within hood chamber towards top corner of FSC superstructure post.

m. Vacuum, Natural Gas, Compressed Air Fixtures: forged brass valve bodies, 125 psi working pressure, needle valve construction with renewable type stainless steel floating cone and replaceable stainless steel seat. Valve body shall be remote mounted inside superstructure wall.

n. Fixture outlets shall be brass, stem type, panel mounted in sidewall liner of FSC above cup sink. Fixture outlet shall have a 30 degree angle removable serrated tips, acid and solvent resistant epoxy finish. DI water fixtures will be tin lined. Fixture outlet shall have a color-coded mounting washer. Fixture control handle mounted in exterior superstructure post shall be chrome four arm handle with plastic color-coded center index button that matches color of serrated tip mounting washer.

o. Steam Fixtures: forged brass valve bodies, 20 psi working pressure, renewable type teflon valve disc and replaceable stainless steel seat. Valve body shall be remote mounted inside superstructure wall. Fixture outlets shall be brass, stem type, panel mounted in sidewall liner of FSC above cup sink. Fixture outlet shall have 30 degree angle removable serrated tips, acid and solvent resistant epoxy finish. Fixture outlet shall have a color-coded mounting washer. Fixture control handle mounted in exterior superstructure post shall be chrome four-arm handle with plastic-color coded center index button that matches color of serrated tip mounting washer.

C.2. Electrical Services: The following specifications are for factory pre-wired 120 VAC electrical services within the laboratory FSC. All materials and installation methods shall meet the requirements of the National Electric Code.

a. Wiring: minimum #12 copper, type THHN/THWN insulation. Wire color coding shall be black for current carrying conductors, white for neutral conductors and green for ground conductors.

b. Conduit: Unless noted or required otherwise, ½ inch, flexible PVC conduit. Secure conduit to superstructure framework with conduit clamps. Conduit to light fixture to have pigtail for ease of lamp maintenance.

c. Junction Boxes: 4 inch square by 2-1/8 inch deep, code gauge galvanized steel, screw covers.

d. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for splices and taps.

e. Electrical Fixtures: All electrical devices shall be UL listed.

f. FSC light fixtures shall have two lamps, fluorescent type with electronic ballasts, rapid start. Average illumination of work surface shall be 80 foot-candles minimum. Fixture shall be mounted in roof liner and vapor proof sealed behind a laminated safety glass panel to isolate light fixture from FSC interior.

g. Light fixture switch shall be toggle type mounted in front post of superstructure. Switch plate shall be stainless steel with a brushed finish.

h. Receptacles duplex, 20 amp, 120 VAC, GFCI, grounding type, hospital grade receptacle shall be provided. Receptacles shall be mounted on front superstructure post. Location per schedule.

i. FSC light fixture, switch and receptacle shall be pre-wired by FSC manufacturer to a junction box for a single point power connection by the electrical contractor. Locations per schedule.

j. Explosion Proof Electrical Fixtures: All electrical wiring, conduit and devices installed in FSCs, in rated areas per schedule shall meet the NEC class and division control explosion proof requirements as noted per schedule.

C.3. Controls: FSC manufacturer shall provide complete factory installed controls, per control manufacturer’s directions, from one manufacturer for single source responsibility, as supplied to FSC manufacturer per Specification 15981.

C.4. Containment as specified herein per LEED's requirement must be maintained. It is a requirement of the hood manufacturer to ensure containment when these volumes (2.1) of air are utilized. Higher airflows are not acceptable due to their increased requirements for support equipment including chiller capacity, fan capacity, duct sizing, reheat capacity and related energy costs. See 1.4 to calculate first cost and energy cost for non-complying FSC's.

a. Maximum 380 CFM for 4' hood at 27 ½" sash opening

b. Maximum 490 CFM for 5' hood at 27 ½" sash opening

c. Maximum 600 CFM for 6' hood at 27 ½" sash opening

d. Maximum 720 CFM for 7' hood at 27 ½" sash opening

e. Maximum 850 CFM for 8' hood at 27 ½" sash opening

C.5. FSC pressure drop: The maximum hood pressure drop from inlet to discharge collar shall not exceed 0.10" H2O based upon the airflows listed.

C.6. The FSC's bypass air configuration will provide full sash closure without more than a 5% CFM deviation from LEED's design airflow without added exhaust volume controls.

C.7. Ergonomic Compliance: FSC design and bench height shall be designed to be ergonomically correct for both taller and shorter workers. FSC supplier must provide a study on how it's design addresses these issues as well as any recommendations on bench height.

C.8. Factory As Manufactured (AM) Quality Control of Fume Safety Cabinets

a. General: Positive assurance of FSC performance Testing to achieve the maximum affordable and available control technology is the most critical aspect of this specification for personnel safety for those who will be in proximity to the working hood. As such the factory testing section of this specification is specifically noted as critical. Evaluation of manufacturer's standard product shall take place in manufacturer's own test facility, with testing personnel, samples, apparatus, instruments, and test materials supplied by the manufacturer at no cost to the owner. The testing procedure and reporting shall be strictly adhered to.

b. Submit detailed written review of quality control specification (2.10) per numerical reference item by number if the bid complies or does not comply at time of bid. No exceptions to these requirements will be allowed unless product was prequalified by the engineer before time of bid. To do otherwise becomes immediate grounds to reject the total bid. During bid review, it is determine false or misleading information was submitted, it becomes immediate grounds to reject the total bid. Tendering a bid becomes admission and a legal agreement that the bidding FSC or contractor supplier fully understood their responsibility in this process and the engineer will have final determination in the bid review process. Submit test report or reports as specified at time of bid by non pre-approved bidders consisting of all the following test parameters and equipment for each hood width and configuration specified.

1. FSC testing goal is to achieve the maximum available and affordable control technology to (0.00) zero spillage at 8.0 liter/min. tracer gas release rate under less than ideal conditions at the lowest airflow volume exhaust. The minimum leakage exhaust volume becomes the minimum airflow to which a 30% safety factor is then applied. It will be at this airflow rate the FSC will be rated for use. Tests shall be both static and dynamic using an enhanced version of ANSI / ASHRAE - 110-1995 method of testing performance of laboratory FSCs. The engineer has final determination in all test procedures. The object is to test for both tall (5-'9" or taller) and height challenged (5'2" or shorter) workers. Shorter workers are expected to be seated. The 8-liter/min. release rate is to simulate boiling activity within the hood. Calculate all FPM face velocity based on 27 ½" sash opening

2. Test Facility: Facility shall be of sufficient size to provide similar conditions FSC will experience in normal operating conditions. Provide make-up air and general exhaust system controls so that space pressure may be fluctuated between +0.015"WC to -0.15" WC. Introduce make-up air in a manner that can produce adjustable cross drafts and down drafts up to 100 FPM. The engineer will direct the methods to introduce drafts that best support the laboratory design. Adjustment in exhaust blower shall vary face velocity from a maximum 100 FPM down to minimum 30 FPM, with sash at 27 ½ " vertical opening, and 100 FPM down to 30 FPM minimum, with sash at 26-1/2" horizontal opening.

3. Witnesses: During testing up to three witnesses as determined by owner/architect/engineer shall be allowed present in test room to simulate as used activity conditions and for observation.

4. The minimum CFM the FSC can be tested to is a volume of 50 CFM/foot of FSC length, for a 24 inch deep hood or 25 CFM per ft^2 of FSC work surface for deeper FSC.

5. Every test FSC shall be challenged only at 27 ½" vertical sash face opening, over a range of airflows. This is to establish the lowest CFM at which the test FSC could achieve its maximum available control. To this CFM will be added 30% (safety factor) to establish the lowest CFM at which the test FSC may be operated at regardless if the sash may be positioned at less than 27 ½" opening. Reducing vertical sash opening from 27 ½" to evaluate FSC's maximum achievable control, automatically becomes grounds to reject total bid. Test FSC shall be challenged at its maximum horizontal face opening at different airflows in order to establish the lowest CFM at which the test FSC could achieve its maximum available control. To this CFM will be added 30% (safety factor) to establish the lowest CFM at which the test FSC may be operated at horizontal sash face opening.

6. High performance hoods may require face velocity controls, motorized baffles, and integral auxiliary make-up or push pull supply fans. All these devices are subject to failure. After the series of as manufactured (AM) tests are performed with these elements in operation, another series of tests will be re-run with controls in there failure mode and all FSC supply fans off and all testing at maximum vertical 27 ½" sash openings. This testing will enter into the maximum achievable control results.

7. Probe Height During Tests: To simulate varied personnel height test shall be done at the ASHRAE standard gas pick-up height measured from the work surface of 26" and at 19" from the work surface for both vertical and horizontal tests. Testing and

confirmation of containment performance at both heights is critical to ensure safe operating conditions for tall, shorter and seated lab workers.

c. Testing Equipment

1. Recently factory calibrated (within six months) hot wire thermal anemometer or calibrated by ISA Certified Level III CCIT Technologist. Readings to be taken per ANSI recommendation of 12 or more equal areas.

2. During testing FSC exhaust airflow volume to be continuously monitored using a NIST traceable velocity pressure-measuring device.

3. Multiple Point Equal Averaging Airflow Probe: Number of multiple points and number of probes determined by Reynolds number calculations as detailed in latest Chemical Engineering Handbook (Pitot tube). Calculation required for 10:1 turndown for each specific airflow condition. Required straight run upstream and downstream for each application shall be provided and confirmed. Probe multiple sensor positions to be based of the 7th power law for airflow profiling. Detail drawing indicating probe-sensing positions is required for each application.

4. Accuracy, +2% testing confirmation by independent AMCA DS610-7/92 run test.

5. Each Flow element shall have its individual flow coefficients supplied at the time of testing.

6. Airflow volume signal to be displayed on a 3 1/2 digital LCD.

7. Tracer gas: Industrial grade Sulfur hexa-fluoride (SF_6) supplied from a cylinder.

8. Ejector system: Tracer gas ejector shall be the same as outlined in ANSI / ASHRAE 110-1995 standard. For six foot and longer FSC a second ejector must be added. Submit sufficient proof of ejector system calibration.

9. Critical orifice: Sized to provide tracer gas at eight liters per minute at an upstream pressure of 30 PSIG. Orifice sizes shall be verified by engineer and recorded.

10. Detection Instruments: Analyzer using infrared technique. Calibration check of analyzer must be witnessed by the engineer before and after testing. Analyzer shall be calibrated linear to 0 to 0.15 PPM full scale using analyzer real time 0-1 VDC output. Calibration must be performed by ISA Certified Level III CCIT Technologist. Analyzer shall have a sample rate representative of human breathing rate at 15 liters/min (15,000cc) sampling. Analyzers or leak detectors with sampling below 10 liters/min or above 20 liters/min are not acceptable.

11. An ink pen strip recorder with an accuracy better than plus or minus .05% of full scale, will be synchronized directly to analyzer output. Data loggers can only be used in conjunction with real time ink strip recorder.

12. Three-dimensional mannequin, clothed in a smock, overall height adjustable to allow testing as specified herein for taller, shorter and seated workers.

13. Theatrical smoke machine, or equal titanium tetrachloride glass modules. Caution: Titanium tetrachloride is hazardous and skin contact or inhalation must be avoided.

14. The duration of the test will be a minimum 5 minutes per test configuration. The witness engineer can lengthen the test duration anytime during testing. To eliminate the possibility of background wash spills into test space, FSC's using auxiliary air or push/pull air systems must run all tests a minimum 20 minutes.

d. Factory Preliminary Test Procedure:

1. Provide sketch of room indicating room layout, location of significant equipment, including test and other hoods. Unusually large volume space (maximum 2000 cubic feet) beyond the smallest lab module is not permitted. Provide sketch of air supply system indicating type of supply fixtures.

2. Reverse airflows and dead space test:

2.1. Swab smoke along both walls and floor of hood in a line 6" behind and parallel to the hood face, and along the top of the face opening. Swab an 8" diameter circle on the back of the hood. All smoke should be carried to the back of the hood and exhausted.

2.2. Test the operation of the bottom air bypass airfoil by running smoke at the airfoil.

2.3. If visible smoke flows out of the front of the hood, the hood fails the test and receives no rating.

e. Face Velocity Measurements: Face velocity shall be determined by averaging minimum of 12 readings at the hood face. Take readings at center of grid made up of sections of equal area across the top, center and bottom of the full sash opening. Each reading to be recorded after a minimum 10-second duration at each point.

1. Test Procedure:

2.1. Check sash operation by moving sash through its' full travel. Verify that sash operation is smooth and easy, and that vertical rising sash shall hold at any height without creeping up or down. Position sash in full open position.

2.2. Monitor exhaust airflow with various vertical and horizontal sash positions to completely closed. Airflow must not vary more than 3% in any position. Hoods exceeding this fail the test and receive no rating.

2.3. Hood Static pressure shall be measured per ANSI / ASHRAE 41.3-1989 standard of pressure measurement, in the center of exit plane at the top plane of collar(s). Static pressure loss shall not exceed values given under design requirements.

2.4. To ensure safe performance when the hood is used, i.e. non-empty state, as required by OSHA, the following tests shall be conducted with the FSC loaded with 12"L x 9" W x 8" D (or similar) boxes blocking 33% of the vertical sash area opening. Boxes shall be within one inch of the airfoil and one inch to the back of the gas injector. All boxes shall be flush to the work surface. Witness engineer shall set up boxes at their discretion and can change configuration during any testing. All tests will also be repeated with FSC empty.

2.5. Install ejector in test positions per ANSI / ASHRAE 110-1995 guideline. For a typical bench-type hood, three positions are required: left, center, and right as seen looking into the hood. In the left position the ejector centerline is 12" from the left inside wall of the hood; center position is equal distance from the inside sidewalls; and the right position is 12" from the right inside wall. The ejector body is located to the closest possible experiment position up next to the airfoil. The position cannot exceed 6" from the face of the fume hood. The test position in inches to the sash plane will be noted in bid documents.

2.6. Perimeter test required for all FSC's to evaluate leakage with all auxiliary air or push/pull style FSC's with all supply fans on and then off.

2.7. Install mannequin positioned in front of the hood, centered on the ejector.

2.8. Fix detector probe in the region of the nose and mouth of the mannequin. Take care that the method of attachment of the probe does not interfere with the flow patterns around the mannequin. For first series of tests, locate nose of mannequin in front of the ejector 3" in front of sash. For second series of tests, locate nose of mannequin in front of the ejector right at the sash plane.

2.9. All FSC's will be tested over maximum to minimum airflow volumes. The AM YYY value will be rated at both average and peak values, and becomes the basis for the FSC's maximum achievable control evaluation.

2.10. ANSI / ASHRAE 110-1995 incorporates a sash movement effect (SME) procedure which shall be utilized to simulate actual hood usage conditions. After testing FSC statically in the three positions and the results recorded, the mannequin shall be placed in the most vulnerable center position and the following test proceedings followed:

a. The mannequin shall be located at the appropriate center test position with the sash at 27 ½" full vertical opening. The block valve shall be opened releasing SF6 gas (perform at 8-liters/min. rates) and the sash closed. After two minutes, a background level with the sash closed shall be determined. The sash shall be fully opened in a smooth motion at a velocity between 1.0 ft/s (0.3 m/s) and 1.5 ft/s (.05 m/s) while tracer gas is released and the tracer gas concentration is recorded. The peak levels shall be noted. After the system has stabilized for a maximum of one minute after opening the sash, the sash shall be closed at a rate between 1.0 ft/s (0.3 m/s) and 1.5 ft/s (0.5 m/s) while continuing to record the tracer gas concentration. From a minimum 5 min to 20 min test run determined by the engineer at time of testing.

b. The sash movement effect (SME) is the maximum peak tracer gas concentration determined in above test. The sash movement performance of the hood shall be recorded as SME-AM yyy, where yyy equals sash movement effect, ppm.

2.11. FSCs performance is affected by fluctuations in space pressure. The following test procedure shall be followed.

a. The mannequin shall be located at the appropriate center test position with the sash at a full 27 1/2” vertical opening. The block valve shall be opened releasing SF6 gas (8-liters/min. rate) for two minutes. The test chamber room shall be set for negative 0.05" WC pressure with test room door closed. The test chamber door shall be abruptly opened in less than one second, pause for 15 seconds and then abruptly shut in less than one second while the tracer gas is released and the tracer gas concentration is recorded. The peak levels shall be noted. This sequence is to be repeated three times, with a maximum of one minute between tests.

b. The "Space Pressure Effect" (SPE) is the maximum peak tracer gas concentration determined in above test. The space pressure performance of the hood shall be recorded as SPE-AM yyy, where yyy equals space pressure, ppm.

2.12. All data on the above test conditions including instrumentation and equipment, test conditions, preliminary test data information shall be provided via written report, at the time of bid for non pre-approved bidders, including a printout of the average face velocities, and a separate graph recorded performance data from analyzer results of all above tests. Hoods not meeting the listed requirements shall be determined “Not Acceptable” and becomes immediate grounds to reject bid.

C.9. Quality Assurance

a. Factory Witness Test Report: The witnessed approved factory test report for non pre-approved FSC supplies shall be provided to the owner and engineer prior to any placement of FSC order with either general or mechanical contractor.

b. If the results of the FSC installed field testing show any deviation from specified owner or engineer performance and operating characteristics, the FSC manufacturer shall replace FSC as required by the owner or engineer to provide a properly operating FSC including, but not limited to, complete removal of the non-conforming FSC and replacement with another manufacturer’s FSC.

c. One day is allotted for factory witness testing for each different style and size FSC. Should, for any reason, the testing described above prove that the FSC’s do not perform as specified or manufacturer must delay testing, the FSC manufacturer, mechanical contractor or general contractor shall be responsible for all subsequent labor, travel expenses, and incidental expenses, penalties, or other costs required to demonstrate the FSC performs as specified within specified time restraints. This shall include, but not be limited to, labor, travel and incidental expenses of not only contractor and owner’s consultants, but also those incurred by the owner as may be specifically required for this purpose. The expense to be at $1,000 per diem rate per person plus all out of pocket expenses.

C.10. Execution

a. Installation: FSCs shall be installed as indicated on the project drawings and schedules.