NC State University Design and Construction Guidelines
Division 23 Laboratory and Industrial Ventilation Systems

1.0 Purpose

A. The following guidelines provide information on laboratory fume hood and laboratory exhaust construction, materials, installation and certification requirements.

2.0 General Requirements

A. Codes, Standards, References

1. ACGIH Ventilation Manual
2. ANSI/AIHA Z9.5
3. ANSI/ASHRAE 55
4. ASHRAE 110
5. NSF 49
6. ASTM E84
7. NC State Biological Safety Manual
8. SEFA

B. General

1. Specific Applications not covered in this document shall follow the requirements listed in the latest version of the *ACGIH Ventilation Manual*.
2. When considering equipment for which specific design references do not exist, design parameters shall be approved by NC State.
3. The ANSI/AIHA Z9.5 guidelines do not apply to lab ventilation for the following conditions:
    a) Laminar Flow Chemical Hoods: Contact NC State for requirements
    b) Biological Safety Cabinets shall meet NSF 49 requirements. Contact NC State for additional requirements.
4. Design must result in a laboratory noise level of NC 50 or lower. Proper acoustic design should be accomplished by appropriate fan size and type. Sound attenuators must be approved by NC State. Sound attenuators must be constructed of 304 stainless steel.
5. Laboratories and offices shall be configured to be served by separate supply air systems to allow individualized scheduling of occupied periods.
6. For manifolded systems, there shall be at least two exhaust fans for redundancy, and at least one fan shall be connected to emergency power.

C. Lab Ventilation Rates

1. Wet Lab: Between six and eight (6-8) air changes per hour (ACH) based on the lab/building application and NC State hazard evaluation. Rates lower than 6 ACH may be appropriate for lower hazard (non chemistry) labs. Safety controls or temperature demands may dictate a design, which results in air change rates in excess of 8 ACH. Where air change rates lower than 6 ACH or greater than 8 ACH are proposed, NC State approval shall be obtained at the SD stage of design.
2. Off-hour/night setback: Typically 4 ACH and requires NC State Approval.

D. Supply Air System

1. The supply air system shall be equipped to control humidity.
2. Supply air diffusers in laboratories shall be low velocity. Air velocity caused by supply diffusers shall be less than ½ and preferably $^1/_3$ of the chemical hood average face velocity, measured as specified in ASHRAE 110.
3. Laboratories shall be maintained negative with respect to the surrounding spaces at a minimum differential pressure between 0.01" and 0.02" w.g. The laboratory envelope control shall be maintained by volumetric differential controls with respect to exhaust and supply. Adequate makeup air from adjacent spaces shall be considered to facilitate laboratory pressurization control.
4. Through the wall differential pressurization controllers are not allowed (exceptions may be made for specific applications such as clean rooms and BSL-3/BSL-4 laboratories).
5. Variable Air Volume (VAV) and Constant Air Volume (CAV) systems shall maintain laboratories negative regardless of laboratory hoods sash position and/or other exhaust devices flow adjustment damper position.
6. The minimum horizontal distance from a diffuser to the face of the hood is 4'.
7. The minimum distance from lab entrance door and/or operable windows to the hood is 10'.
8. Supply Flow Monitors: Workstations used for the control/exhaust of hazardous materials and which also contain HEPA filtered air supply system, shall include a differential pressure gauge visible to the operator to measure the static pressure drop across the filter.
9. Maximum supply air velocity at any laboratory work station shall meet the ANSI/ASHRAE 55 requirements for comfort conditioning.
10. When adding one or more exhaust devices to an existing space, equivalent supply of outside makeup air shall be provided to the space to offset laboratory exhaust load increases.

E. Chemical Hood Design Requirements

1. Bypass hoods are required for CAV applications. The bypass shall be able to maintain the exhaust volume unchanged (<5%) when the sash is in the fully closed position. Bypass is not required for VAV hoods.
2. The diversity factor for VAV systems shall be approved by NC State.
3. Auxiliary air hoods and ductless hoods are not allowed. Should the designer propose low flow hoods as design alternative, proposed hardware and design assumptions for energy savings shall be provided to NC State for review and approval at the programming stage of design.
4. A mechanical sash stop is required to limit the maximum vertical sash height at 18".
5. Non-combination vertical sashes are required.
6. For a 5-foot hood, vertical sash opening shall not require more than 5 lbs force. For larger hoods, an additional one lb of force may be required for each additional linear foot of fume hood width, and sash should remain stationary when force is removed.
7. Hoods shall be equipped with front edge air foils.
8. All utility valves and switches shall be located outside the hood. Non-electrical utilities may be installed inside the hood provided they have outside cutoffs. Fume hoods shall be UL listed.
9. The finished installation for all hood working surfaces shall be 33"-34" above the finished floor.
10. The hood work surface shall be recessed at least 1/8 in. with a seamless vertical lip. If the hood is provided with a recessed sink, the perimeter of the sink shall also contain a 1/8 in. lip.
11. Corrosive storage cabinets beneath the hood shall be vented. Flammable storage cabinets beneath the hood shall not be vented.
12. The hood light shall be in a vapor resistant panel accessible from outside the hood. The light shall provide a minimum of 80 foot-candles on any part of the bench level.
13. Chemical hoods shall be designed to provide a continuous face velocity of 110 fpm at a sash height of 18". Final balance shall indicate 100 fpm at 18" sash height.
14. VAV chemical hoods shall draw a minimum rate of 25 cubic feet per square foot of hood surface area with the hood sash in the closed position.
15. VAV room balance response time shall not be more than 10 seconds for laboratories.

16. Fume hood VAV response time shall not be more than 3-5 seconds.
17. Iodination and biological hoods shall be filtered prior to connection to a centralized exhaust system.
18. Flammable storage cabinets located under hoods shall be NFPA-30 approved.

F. Chemical Hood Material

1. Liner material shall be flame retardant, self-extinguishing and have a flame rating of 25 or less in accordance with ASTM E84.
2. The chemical hood sash shall be constructed of shatter- proof transparent material.

G. Chemical Hood Selection

1. NCSU pre-qualified fume hoods and alarms
   a) Pre-approved ADA fume hoods
      (1) Thermo Scientific SafeAire II
   b) Pre-approved fume hoods
      (1) Thermo Scientific SafeAire II
      (2) Fisher Hamilton Concept
      (3) LABCONCO Protector XStream
      (4) Kewaunee Supreme Air
   c) Pre-approved perchloric acid and acid digestion hoods
      (1) TFI Inline Design Corp Polypropylene counter top fume hood flame retardant
      (2) NuAire Fumegard 156 Polypropylene hood
      (3) LABCONCO Protector Stainless Steel Perchloric Acid Laboratory Hood
   d) Pre-approved fume hood flow monitor /alarms
      (1) AFA 1000 Alarm
      (2) TSI FHM-10-01 Fume Hood Face Velocity Meter
2. Reuse or relocation of existing laboratory hoods shall require approval by NC State.

H. Exhaust Flow/Velocity Monitor and Alarm

1. All chemical hoods shall be equipped with an exhaust flow/velocity monitor with digital readout and alarm which shall sound whenever average face velocity drops below 80 fpm at 18” sash height.

I. Exhaust System

1. A manifolded exhaust plenum on the roof is required, except in the case of high hazard or unique use hoods, such as perchloric acid, acid digestion and radio iodination hoods. High hazard hoods shall not be installed in plenum-type systems and shall be separately exhausted.
2. Provisions shall be made for local exhaust of instruments. Equipment emitting hazardous gases or vapors, including but not limited to gas cabinets and gas chromatographs, shall be exhausted via point of use exhaust ventilation. Refer to *ACGIH Ventilation Manual*.
3. Exhaust discharges from vacuum pumps shall be hard piped to local exhaust systems.
4. Exhaust systems for gas cabinets and other exhaust devices housing high hazard materials shall be equipped with an exhaust flow monitor which includes an auxiliary relay for process control.
5. Gas cabinets for gas cylinders shall have an average face velocity of 200 fpm at the inspection door when the inspection door is fully opened.
6. Balancing dampers or control valves shall be installed in each exhaust duct branch connected to exhaust devices.

J. Exhaust Duct

1. General-purpose chemical hood ductwork shall be butt-welded 304 stainless steel with 304 stainless steel fillet material.
2. Iodination hood ductwork shall be butt-welded stainless steel.
3. Flanged joints may be used only where field conditions prevent welded joints.

K. Exhaust Fans

1. Exhaust stacks shall have a minimum discharge velocity of 3000 fpm with preferable velocities approaching 4000 fpm.
2. The fan set for manifolded exhaust systems shall be of the radial, direct drive, high plume, induced air type.
3. Fans shall be direct drive. Air induction shall take place upstream of the fan impeller.
4. For manifolded systems, 100% redundancy shall be provided and at least one fan shall be connected to emergency power.
5. Fans shall have stainless, motorized isolation dampers.

L. Individual Exhaust Hood

1. Exhaust stacks shall extend a minimum of 10 ft. above adjacent roof lines and air intakes.
2. Exhaust stacks may be supported by bolting to a flanged fan discharge or by extending support steel from the fan support curb or steel frame. Guy wire supports are not allowed.
3. Exhaust stacks shall have a coned discharge to achieve discharge velocity. Fans shall be provided with a zero-loss style exhaust discharge. Fans shall be provided with a drain and ball valve in the bottom of the scroll.
4. Each fan shall be connected to emergency power.

M. Perchloric Acid Hoods and Exhaust Systems

1. A perchloric acid hood and exhaust system is a dedicated hood/system for use only with perchloric acid applications.
2. With NC State approval, some limited perchloric acid applications/concentrations may not require a dedicated perchloric acid hood.
3. Provide a placard that complies with NC State's Interior Signage Manual stating: (first line) "PERCHLORIC ACID HOOD"; (second line) "Do NOT Use or Store Other Chemicals, Specifically Organic Compounds in This Hood"; (third line) "Wash Down Before and After Each Use to prevent shock-sensitive explosives build up".
4. Perchloric acid hoods and exhaust systems shall be constructed of specialized stainless steel or flame retardant, self-extinguishing materials and shall have non-reactive/acid resistant duct, exhaust fan, gaskets and other components, and built-in water wash-down system.
5. Perchloric acid hoods and exhaust systems shall meet the ANSI Z9.5 and NFPA 45 requirements.
6. Hood baffles shall be removable and accessible.
7. Ductwork shall take the most direct and straightest path to the exterior. Positive drainage shall be provided back to the hood.
8. A water spray system shall be provided to wash down the entire exhaust system from the hood interior behind the baffle, through the fan, up to the roofline. The hood work surface shall be watertight with a minimum depression of ½" at the front and sides. An integral trough shall be provided at the rear of the hood to collect wash down water and direct it to a building-wide laboratory waste system. A hose bib shall be provided within 40 feet of the discharge stack to allow for manual wash down.

9. Provide controls to initiate wash down. Provide an automatic wash down cycle with manual override.

N. Acid Hoods (non-perchloric)

1. Acid digestions and certain large volume/high temperature (e.g. boiling) acid applications shall require acid hoods.
2. Connecting ductwork from acid hoods to other exhaust equipment is prohibited.
3. Ductwork shall take the straightest most direct path to the outside. Positive drainage shall be provided back to the hood.
4. Hoods, exhaust ductwork, fans, gaskets, and other material/components shall be constructed of acid resistant, non-reactive, compatible, and impervious materials.

O. Other local exhaust ventilation systems

1. Canopy hoods may only be used for non-hazardous odor or heat control at the source and shall not be used to control exposure against hazardous materials in laboratories. Canopy hood design shall meet the *ACGIH Industrial Ventilation* Guidelines and shall require NC State approval.
2. Slot hoods, snorkels, and special design/purpose hoods shall not be used as the primary engineering protection or as a replacement for chemical laboratory hoods.
3. Glove boxes shall meet the requirements of ANSI Z9.5.
4. Exhausted balance enclosures shall meet all fume hood requirements listed/referenced in this document. Balance enclosures shall not return air back into the laboratory after filtration.
5. Downdraft tables are required for anatomy lab dissection.

P. Testing/Commissioning

1. Airflows in hoods must be certified. The exhaust air flow quantity of each hood shall be tested and certified by an independent testing agency, and submitted to NC State. The results shall be certified by the contractor and engineer and submitted to NC State.
2. Balancing is required for chemical hoods, gas cabinets, laminar flow chemical hoods, and other exhausted devices where hazardous materials are stored or used.
3. Balancing shall be performed by persons certified by the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).
4. A white sticker containing exhaust device identification information shall be applied by the balancing contractor to the face panel of the exhaust device. Where this is not practical, the sticker can be applied to the duct that is measured.

The sticker shall contain the following: face velocity at 18-inch sash height, fan serving the hood, hoods served by same fan, date, signature of tester and company name.

5. Every fan shall have a list readily available listing the hoods served, furnished to NC State.
6. Duct traverse pilot holes shall be capped with a removable plug to allow for future readings at the same location.
7. The Designer shall incorporate the NC State New and Renovated Fume Hood Construction Form (FH-1) in its entirety and unmodified in the project specifications.
8. Balancing shall be performed by persons certified by the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).
9. All newly installed laboratory chemical hoods shall be third party tested to As Installed test criteria (per NC State University modified ASHRAE 110 test requirements). All readings/data recordings shall be directly downloaded from the instruments. Unless otherwise stated, test results shall meet both AHRAE 110 and ANSI Z9.5 requirements. This test shall include the following:
   a) Exhaust flow measurement
   b) Hood static pressure measurement
   c) Hood monitor and alarm calibration
      (1) Minimum flow alarm set at 80 fpm
      (2) Sash position alarm set at 20”
   d) Room pressurization check (differential pressure measurement)
   e) Face velocity test - Average face velocity shall be between 95-110 fpm range (with 100 fpm as target face velocity)
   f) Cross draft evaluation per ASHRAE 110 - Corrections required if more than 50% of the average hood face velocity
   g) Airflow visualization (both small and large volume smoke tests)
   h) Tracer gas containment test
      (1) Static test
      (2) Dynamic/sash movement affect test
   i) Additional commissioning tests for VAV systems
      (1) Flow/face velocity measurements with sash at full open, 18” and 12”. VAV systems shall prevent flow variations in excess of 10% from design at each sash location.
      (2) VAV response time measurement of 3-5 sec shall be measured at the baffle slot or exhaust duct.

10. The contractor shall be financially responsible for all testing, repairs, modifications and replacements necessary to pass the full ASHRAE 110 Test. If As-Installed test reveals any hood design/installation deficiency, the contractor shall remediate the deficiency and repeat the full ASHRAE 110 test. The contractor shall be financially responsible for all additional tests required after modifications/repairs are made. If the remediated hood can not pass the ASHRAE 110 Test, then it can not be used.