230540 LABORATORY VENTILATION

Cornell's Design and Construction Standards provide mandatory design constraints and acceptable or required products for all construction at Cornell University. These standards are provided to aid the design professional in the development of contract documents and are not intended to be used verbatim as a contract specification nor replace the work and best judgement of the design professional. Any deviation from the Design and Construction standards shall only be permitted with approval of the University Engineer.

PART 1 GENERAL

1.01 SCOPE

A. This Standard applies to construction of new facilities and renovations to existing facilities/spaces where laboratory-scale teaching, research, diagnostic or clinical testing is being proposed or conducted. To ensure appropriate engineering controls are implemented, specifics shall be reviewed with Facilities Engineering (FE), Environment, Health and Safety (EHS) and appropriate stakeholders early in the design process. Designs will strive to balance the sustainability goals of the University while maintaining the safety and health of laboratory occupants and the general public.

B. Laboratories outside the scope of this Standard:

1. Facilities in which chemical work is expected beyond lab-scale, or for which other hazards, such as high chemical hazard, radiological or biological hazards drive the design. These are regulated by other standards and require specific design permitting and certification.
2. Facilities intending to use animals in research, teaching, and testing. These are subject to Cornell Policy 1.4, Care and Use of Animals in Research and Testing. All plans and specifications shall be reviewed and approved by the Institutional Animal Care and Use Committee (IACUC). See https://www.iacuc.cornell.edu/ for additional information.
3. Facilities intending to incorporate housing for animals. The Cornell Center for Animal Resources and Education at CARE@Cornell.edu shall be contacted for information on animal facilities and housing.

1.02 RELATED CORNELL DESIGN AND CONSTRUCTION STANDARDS

A. Section 013010 – Accessibility for People with Disabilities

B. Section 018130 – Energy Modeling Guidelines

C. Section 098000 – Acoustics

D. Section 115000 – Laboratory Equipment

E. Section 220500 – Plumbing Basic Materials and Methods

F. Section 224500 – Safety Showers and Eyewashes

G. Section 230900 – Building Automation and Control System Guidelines

H. Section 263213 – Emergency Power Systems

1.03 REFERENCE CODES, STANDARDS AND RESOURCES

A. New York State Building Codes. This Code may bring in additional requirements via reference pertaining to Laboratories as follows:

1. ANSI/AIHA Z9.5: Laboratory Ventilation
2. NFPA 30: Flammable and Combustible Liquids Code
3. NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals, most specifically Chapter 7 when evaluating requirements for Higher Education Laboratories
4. NFPA 55: Compressed Gases and Cryogenic Fluids Code

B. ANSI/ASHRAE 110: Methods of Testing Performance of Laboratory Fume Hoods

C. ASHRAE Classification of Laboratory Ventilation Design Levels

D. ACGIH Industrial Ventilation: A Manual of Recommended Practice

E. International Code Council (ICC) / American National Standards Institute (ANSI) A117.1: Accessible and Usable Buildings and Facilities

F. ADA Standards for Accessible Design

G. Cornell University Environment, Health, and Safety Laboratory Ventilation Management Program
https://ehs.cornell.edu/research-safety/general-laboratory-safety/laboratory-ventilation

H. OSHA Technical Manual, Ventilation Investigation, Section III, Chapter 3, http://www.osha.gov/dts/osta/otm/otm_toc.html

I. NYSDEC DAR-1: Guidelines for the Control of Toxic Ambient Air Contaminants

J. NYSDEC DAR-10: Guidelines on Dispersion Modeling Procedures for Air Quality Impact Analysis.

K. NYSDEC 6NYCRR Chapter III:

1. Part 201: Permits and Registrations
2. Part 211: General Prohibitions
3. Part 212: General Process Emission Sources

L. NYSDEC 6NYCRR Chapter IV, Part 380: Prevention and Control of Environmental Pollution by Radioactive Materials

M. Be mindful of the version (year) of referenced Codes/Standards/Resources; the version referenced may not necessarily be the most current version.

1.04 DEFINITIONS

A. Laboratory – Code defined: A facility/space where the use of chemicals is related to testing, analysis, teaching, research or developmental activities. Chemicals are used or synthesized on a nonproduction bases, rather than in a manufacturing process. Laboratories generally have the following features:

1. Once-through ventilation: Recirculation within the space is allowed (for example, fan coil units providing supplemental cooling), but prohibited from recirculating to adjacent areas.
2. Local devices to capture fumes, vapors, mists, dusts or heat such as fume hoods, capture hoods, dust collectors, snorkel arms, etc.
3. Negatively pressurized relative to the corridor.

B. Higher Education Laboratory – Code defined: Laboratories in Group B occupancies used for educational purposes above the 12th grade. Storage, use and handling of chemicals are limited to purposes related to testing, analysis, teaching, research of developmental activities on a nonproduction basis. These laboratories are permitted to exceed the maximum allowable quantities of hazardous materials in control areas without requiring classification as a Group H occupancy; however, additional Code requirements must be met to take advantage of these increases. Higher Education Laboratories must comply with the Fire Code of NYS Chapter 38.

C. Laboratory Suite – Code defined: A fire-rated enclosed laboratory area that has one or more laboratory spaces within a Group B occupancy. A laboratory suite is permitted to include ancillary uses such as offices, bathrooms and corridors that are continuous within the laboratory suite boundary. A Laboratory Suite must comply with the Fire Code of NYS Chapter 38, in particular Section 3804. An NFPA 45

Laboratory Unit is considered a Laboratory Suite. Additional features of laboratory suites include but are not limited to the following:

1. Must be located in fully sprinklered buildings
2. The exhaust system must be configured to comply with Chapter 7 of NFPA 45.
3. Flooring where hazardous materials are present must have liquid-tight floors.

D. Control Area – Code defined: Spaces within a building where quantities of hazardous materials *not exceeding maximum allowable* are stored, dispensed, used or handled. Control areas are not required to be contiguous. A control area is not considered a fire area.

E. General Exhaust: Room exhaust from a laboratory that is not defined as process or fume hood exhaust; the air may have a moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors.

F. Laboratory Ventilation: A combination of fume hood exhaust, process exhaust, general exhaust and make-up air that:

1. Maintains minimum air change rates in a laboratory
2. Reduces the concentration of contaminants within the lab.

G. Process Exhaust: Exhaust ventilation designed to capture an emitted contaminant at or near its source, before the contaminant has a chance to disperse into the workplace air.

H. Hazardous Exhaust – Code defined: An exhaust system serving an area where operations involving the handling or processing of hazardous materials, in the absence of such exhaust systems and under normal operating conditions have the potential to create one of the following conditions:

1. A flammable vapor, gas mist or duct is present in concentrations exceeding 25% of the lower flammability limit of the substance for the expected room temperature.
2. A vapor, gas, fume, mist or dust with an NFPA 704 health-hazard rating of 4 is present in any concentration.
3. A vapor, gas, fume mist or dust with an NFPA 704 health-hazard rating of 1, 2, 3 is present in concentrations exceeding 1% of the LC50 of the substance for acute inhalation toxicity.

I. Laboratory Exhaust – Code defined: A subset of a hazardous exhaust system serving a Laboratory in which operations involving the handling or processing of hazardous materials, in the absence of such exhaust systems and under normal operating conditions have the potential to create one of the following conditions:

1. A flammable vapor, gas mist or dust is present in concentrations less than 25% of the lower flammability limit of the substance for the expected room temperature.
2. A vapor, gas, fume, mist or dust with an NFPA 704 health-hazard rating of 4 is present in any concentration.
3. A vapor, gas, fume mist or dust with an NFPA 704 health-hazard rating of 1, 2, 3 or 4 is present in concentrations less than 1% of the LC50 of the substance for acute inhalation toxicity.

J. Common Chemical Fume Hood Exhaust Duct System: A facility wide fume hood exhaust system that manifolds multiple fire areas, control areas, or laboratory suites (units). This system can be considered compliant with NFPA 45 Chapter 7 under certain circumstances.

K. Computational Fluid Dynamics (CFD): The use of numerical methods to calculate and visualize air flow patterns or particulate migration.

L. Vacant Laboratory: A laboratory space with a fume hood that is not assigned to an occupant or is otherwise unoccupied for an extended period of time. The general ventilation and fume hoods are turned off or down to levels needed only for minimum ventilation or temperature control.

M. Occupied Laboratory: A laboratory space where the building control system occupancy sensors recognize that a person is physically within the room; the ventilation increases to the occupied set point to control the accumulation of contaminants.

N. Unoccupied Laboratory: A laboratory space where the building control system occupancy sensors do not recognize that a person is physically within the room; the ventilation is allowed to decrease to the unoccupied set point.

O. Fume Hood Hibernation: In a laboratory space with a fume hood that is assigned to an occupant that has no need for a fume hood, the fume hood can be temporarily shut down. Signage and mechanical features are installed to prevent the storage or use of chemicals within the fume hood. The general ventilation is turned down to levels needed only for minimum ventilation or temperature.

1.05 GENERAL

A. Laboratory project specifics shall be reviewed with Facilities Engineering (FE), Environment Health, and Safety (EHS) and Energy and Sustainability (ES) before determining the ventilation basis of design.

1. The types and quantities of chemicals must be known and classified in order to establish air change rates and the ventilation design.
2. EHS is responsible for establishing the minimum ventilation rates for laboratories based on the chemical inventory. The ASHRAE Classification of Laboratory Ventilation Design Levels document will be used as a resource in determining the minimum ventilation basis of design.

B. Each laboratory shall have at least one sink, workstation, and fume hood that are accessible to people with disabilities in accordance with Chapters 3 of the ICC/ANSI A117.1-2009 and 2010 ADA Standards for Accessible Design.

C. When determining appropriate locations for laboratories within a building it is strongly encouraged to locate laboratories adjacent to a shaft or utility corridor.

D. Contact the Cornell Project Manager to discuss options in the event the heat load is expected to result in airflow requirements that exceed what is offset by the minimum required ventilation rate. It is preferred that a supplemental cooling unit connected to the facility chilled water system be provided in lieu of increasing the ventilation air. This decision needs to consider the long-term operating costs vs first time costs.

E. The Consultant shall provide a Basis of Design narrative that clearly defines all system criteria and assumptions made during the design process. Documentation shall include, but not be limited to, the following:

1. Minimum air change rates; identify where minimum air change rates are exceeded for cooling purposes.
2. Description of the lab ventilation control system
4. Temperature, humidity, cleanliness design criteria
5. Major equipment and expected heat loading
6 Occupancy
7. Diversities

F. CFD Modeling:

1. Projects with a total project cost exceeding 5 million dollars: The ventilation effectiveness of the proposed design shall be verified using CFD Modeling. The laboratory spaces studied shall be a representative sampling, and shall include spaces where the air change rate exceeds 8 air changes per hour. The CFD model will validate the effectiveness of diffuser types and placement on the fume hood's ability to properly capture contaminants, and will be used as a means to provide lower ventilation rates where appropriate.
2. On projects with total project costs between $500K and $5M: Contact Facilities Engineering to discuss if CFD modeling will be required.

G. Emergency considerations:

1. Exhaust fans serving fume hoods, gas cabinets and other exhausted enclosures, along with their associated controls shall be connected to emergency power.
2. The laboratory ventilation system shall be designed to prevent a pressure differential that would impede egress during an emergency (loss of power or fire scenario). The exhaust fans serving laboratory fume hoods are expected to continue to operate at reduced capacity during such an emergency.
3. Typically, zone laboratory controls shall be connected to normal power.
4. For manifolded systems, provision of multiple exhaust fans with N+1 redundancy is required.

H. The final mechanical system selection shall be supported by a life cycle cost analysis of the options. The Consultant shall submit an economic analysis no later than schematic design; with updates provided at each subsequent design submission.

I. The Fire Code of New York State Sections 5307.2, 5504.2.1.3, 5504.2.2.3, 5505.4.1.1; and Mechanical Code of New York State Section 502.9.3 refer to a requirement to provide ventilation in laboratory spaces with the storage, use, handling and dispensing of compressed gases not otherwise classified and cryogenic fluids. Although these paragraphs point to Code Sections that list requirements applicable to spaces when Maximum Allowable Quantities are exceeded, the local AHJs have interpreted that the ventilation requirements must be met REGARDLESS of quantity. Due to varying research needs and the desire for labs to be designed with flexibility in mind, it cannot always be predicted where compressed gases not otherwise classified and/or cryogenic fluids will be introduced into the laboratory environment. Therefore, the ventilation system to laboratories and laboratory service areas subject to an air change requirement shall be provided with airflow control devices with full shut-off capability and a break-glass type manual shutoff control devices labeled "VENTILATION SYSTEM EMERGENCY SHUTOFF". Please keep in mind that these switches are intended to be activated at the discretion of the Fire Department during an emergency. Cornell has not experienced any issues with unintended activation or vandalism associated with the ventilation system shutoff switches.

1.06 LABORATORY EXHAUST SYSTEM ANALYSIS

A. All laboratory exhaust systems must comply with the NYS Building Codes, ANSI/AIHA Z9.5, and NYSDEC requirements including, but not limited to 6NYCRR Parts 201, 211, 212, and 380.

1. Effluent discharge: Provide a minimum of ten feet above the roof surface with a velocity of 3,000 feet per minute (fpm) velocity.

2. Exhaust System Classification: The consultant shall perform an analysis of the airborne concentrations of flammable vapors, gases, fumes, mists or dusts, and volatile or airborne materials posing a health hazard, such as toxic or corrosive materials expected to be conveyed within the exhaust system.
3. Dispersion Analysis: A dispersion analysis shall be performed on all new buildings and major renovations that include laboratory facilities with a total project cost exceeding 5 million dollars. On projects with total project costs between $500K and $5M, contact Facilities Engineering to discuss if modeling will be required.
4. Consultants shall also consider the requirements of NYSDEC Guidelines DAR-1 and DAR-10 when performing the exhaust analysis.

1.07 LABORATORY DESIGN CRITERIA

A. Ventilation Rates:

1. When the laboratory process is not well defined (i.e the expected chemical use is not known or the lab is being designed for an unknown future research group), laboratories shall be designed to operate at the following default ventilation rates:

   a. Occupied Mode: 8 air changes per hour (ACH)
   b. Unoccupied Mode: 4 ACH

2. The mechanical system shall be adjustable and capable of operating at lower flow rates once the process is well defined. This will be determined by an Environment, Health, and Safety review of operations in the laboratory and potential reduction as follows:

   a. Occupied Mode: 6 ACH
   b. Unoccupied Mode 3 ACH

3. Higher ventilation rates may be required based on the hazard assessment conducted for the laboratory or process.
4. In consideration for the ability to add laboratories to the system in future, the central air handling systems, main ductwork, duct risers and shafts shall be designed using the 8 ACH requirement. Only individual laboratories can be designed with the lower air change rate when the operations are well defined.

B. Laboratory Ventilation supply outlets and exhaust inlets shall be located to allow for the sweeping of the general ventilation from supply diffusers to exhaust points without creating areas where there may be accumulation of chemical vapors or fumes.

C. Acoustics: Proper acoustic design should be accomplished by providing appropriate duct design, fan size and type. The use of interior duct lining is prohibited. When

used, sound attenuators must be packless and constructed of materials suitable for the materials being conveyed.

D. Hood placement: Refer to Section 115000 – Laboratory Equipment for locating fume hoods, placement of laboratory furniture, and designing pedestrian traffic patterns to optimize ventilation effectiveness within the lab.

E. Ventilation System Design Criteria:

1. Chemical use shall not be allowed in spaces with return air to other spaces. Spaces with chemical use shall have once-through ventilation.

2. Fume hoods which have highly hazardous materials or unique use, such as perchloric acid use, acid digestive systems, and radio-iodination shall not be installed in a manifolded exhaust system. These must be separately exhausted.

3. Localized exhaust of dust generating operations, instruments, gas cabinets, storage cabinets or other special operations (for example valve manifold boxes) not requiring the use of a fume hood that have the potential to introduce hazardous vapors, gases, fumes, mists, dusts or significant heat into the lab environment shall be provided.

4. Fume Hood Airflow:

   a. The fume hood maximum exhaust airflow rate shall be designed to provide an average face velocity of 100 FPM at an 18-inch sash opening. The final operational airflow may ultimately be set as low as 80 fpm by EHS based on results of commissioning activities.

   b. The fume hood sash closed minimum exhaust airflow rate shall be designed to provide 30% of the sash open at 18-inch, 100 FPM face velocity airflow rate. The final operational airflow may ultimately be set higher based on results of commissioning activities.

   c. For laboratories where minimum air change rates are exceeded due to high hood density or small footprint, a VAV hood shall be used. A high performance (low velocity) fume hood can also be considered, but will require final approval from EHS.

5. Laboratory (chemical fume hood) exhaust:

   a. Pay special consideration to ductwork routing and manifolding, especially if the project is to take advantage of the increased allowable hazardous material storage and use in Higher Education Laboratories. The duct system shall be designed to allow a minimal level of alteration to add additional features in the future.

   b. Fume hood exhaust ducts shall not contain fire or smoke dampers.

   c. Systems and ductwork serving fume hoods or other hazardous exhaust systems shall be negatively pressurized. It is prohibited to place fume

hood exhaust fans within mechanical penthouses or rooms that would result in positively pressurized ductwork sections to be located within the building confines.

6. General exhaust:
   a. It is generally preferred that a fume hood not serve as the only source of exhaust from a laboratory space.
   b. The design of the general exhaust shall consider the density of vapors expected.
7. Supply air:
   a. Delivery must be designed to ensure hood performance and maintain pressurization requirements. Supply diffuser type and location within the room shall be such that the effectiveness of the ventilation to remove contaminants is enhanced; and that the exhaust systems, fire protection or extinguishing systems are not adversely affected.
   b. Diffusers shall be located at least 4 feet from the face of a fume hood.
   c. Perforated duct or fabric diffusers may be used. Discharge velocities shall not exceed 200 FPM at the diffuser outlets or anywhere else within the lab.
   d. Air velocity caused by supply outlets, window drafts, traffic, etc. shall not exceed 30-50 FPM at the hood face.
   e. Supply diffusers shall provide throw patterns that sweep air across work surfaces and away from occupant breathing zones.
   f. Consideration should be made for make-up air system reliability by cross-connecting multiple air handling units or providing multiple fans and stacked coils within a single air handling unit.
8. Manifolding of chemical fume hood and ducts:
   a. Chemical fume hood and general exhaust shall be manifolded together within the lab. This will provide dilution of the fume hood exhaust airstream and flexibility to divert air from general exhaust to additional fume hood(s) in future.
   b. Each laboratory suite shall have an independent riser to a mechanical room or the roof before it is connected to a common manifold. Connection to a common riser located in a shaft enclosure or the use of subducts is prohibited.
   c. Independent exhaust risers to a mechanical room or the roof are also desired for control areas; this will allow the potential to re-classify as a laboratory suite in future renovation projects with minimal disruption.

d. It is preferred to locate shafts containing laboratory exhaust risers adjacent to the established control area / laboratory suite. This will avoid having to enclose the exhaust duct within fire-rated construction or provide fire wrap between the control area / lab suite boundary penetration and the shaft enclosure.

F. Control System Design Criteria:

1. VAV control systems are preferred. Two-position control systems shall be full analog with setpoints established via programming.

   EXCEPTION: Hoods used for volatile radioactive material discharge must maintain a relatively steady flow rate. The use of occupancy based variable volume air systems that change the hood flow rate are not allowed.

2. Pressurization shall be established by initial balance and maintained by supply tracking the exhaust. Use of through-the-wall pressurization controllers shall be avoided. Special care should be made during renovations to seal windows and corridor wall penetrations. Monitoring of exhaust shall be reported to the building dashboard.

3. Demonstrate that the airflow design meets minimum requirements by including an airflow schedule that specifies the airflow requirements (setpoints) and resultant air change rate for each laboratory airflow control device for the following modes:

   a. Air valve manufacturer's device full range

   b. Cooling mode (if air is provided for cooling above the minimum required)

   c. Occupied fume hood sash open position at both 100-fpm and 80 fpm

   d. Occupied fume hood sash closed position

   e. Unoccupied fume hood sash full position

   f. Unoccupied fume hood sash open position

   g. Unoccupied fume hood sash closed position

4. Single mode infrared sensors, with a minimum of two sensors per laboratory area, shall be used to establish occupancy/unoccupancy intervals. Schemes that utilize Time-of-Day (TOD), light switches and/or manual switches to establish lab occupancy shall be avoided.

5. Please refer to Cornell Design and Construction Standard 230900, Building Automation and Control System Guidelines and Cornell Standard Details 3.7.1, 3.7.2, and 3.7.3 for additional information on laboratory controls.

G. Maintainability: Indicate the recommended space and access features required to replace, maintain, inspect and calibrate all equipment, devices and controls on the

Contract drawings. Ensure throughout the construction process that this space has not been encroached upon; demonstrate ability to access and maintain these features prior to substantial completion.

PART 2 MATERIALS AND EQUIPMENT

2.01 EXHAUST DUCTS

A. Duct materials shall be compatible with vapors to be exhausted, and in conformance with applicable Codes.

1. Type 316 welded stainless steel shall be used on all horizontal branch ducts from the fume hood connection to the point where the duct connects to a main or riser.
2. Galvanized duct is acceptable for use on laboratory general exhaust ducts and risers.
3. For systems using corrosive vapors and perchloric acid, FRP or plastic ducts shall be considered. Review FM Global Data Sheets to incorporate additional features that may be required for the use of combustible plastic materials.
4. For ADA hoods designed to be adjustable by the space occupants, the use of flexible stainless-steel duct or flexible hose meeting UL 94V0 for flame retardance shall be used.

2.02 EXHAUST FANS

A. All fans used for fume exhaust shall be AMCA Type B spark-resistant construction.

B. Fans shall be sized to operate below 2,000 RPM.

C. All components exposed to the air stream shall have a corrosion resistant coating.

D. Fans constructed of PVC or FRP shall be used where high concentrations of corrosives are anticipated.

2.03 FUME HOODS

A. See Section 115000 Laboratory Equipment.

2.04 CONTROLS AND ALARMS

A. It is preferred to use active face velocity controls and fume hoods suitable for VAV operation.

B. All new fume hoods must be equipped with a device providing the following minimum control and alarm points:

1. Face velocity display.
2. Visible and audible alarms for high and low face velocity (+/- 20% of set-point value) for both occupied and unoccupied modes.
3. Local alarm reset.
4. Standby velocity setting (for unoccupied face mode).
5. Sash position input (vertical and horizontal).
6. Hood exhaust feedback.
7. A manual means to attain hood maximum airflow regardless of sash position (purge).
8. Dry contact for alarming status to the BACS.

C. Please refer to Cornell Design and Construction Standard 230900, Building Automation and Control System Guidelines for additional material specifications for Laboratory Control Systems.

PART 3 EXECUTION

3.01 COMMISSIONING

A. Proper commissioning of laboratory ventilation systems, especially the fume hoods is critical to maintaining a safe working environment while minimizing energy use. Refer to Section 115000 – Laboratory Equipment for "As-Installed (AI) commissioning of laboratory fume hoods. This work can be contracted through the HVAC Test and Balance Contractor or through the Casework/Fume Hood vendor.