VANDERBILT UNIVERSITY

# VANDERBILT LABORATORY SAFETY DESIGN GUIDELINES

**Vanderbilt Laboratory Safety Design Guidelines (LSDG)**

1. **Purpose**
   As an internationally recognized institution of higher education, Vanderbilt is optimized to inspire and nurture cross-disciplinary research that fosters discoveries with global impact. The Built Environment (BE) organization supports this mission by creating, operating, maintaining, and enhancing the University's campus infrastructure. The Laboratory Safety Design Guideline (LSDG) is performance-based and developed to foster safe, efficient, high performance, flexible and collaborative research and teaching environments.

2. **Scope**
   The LSDG is primarily relevant to renovation and construction of "wet" laboratories and provides design recommendations on issues that may directly affect the health and safety of laboratory occupants and operations. "Wet" labs are typically those rooms where teaching or research is conducted using hazardous materials and equipment such as chemicals, compressed gases, biological materials, toxins, radioactive materials, lasers, high voltage, physical hazards, etc.

   It is the responsibility of design professionals to use these guidelines to complement their own design knowledge and experience by providing "state-of-the-art", flexible, efficient and collaborative laboratory facilities. Lab Planners and Design Professionals should also keep in mind that laboratory design is a highly specialized, ever-changing field, and comprehensive research, programmatic development, and due diligence are essential to the successful development of these facilities. It is incumbent upon the Design Professionals to properly investigate the specific requirements of the researchers within the lab to ensure compliance with all local, state and national codes and regulations, Vanderbilt's Architectural and Engineering Design Standards, High-Performance and Resilient Infrastructure Guidelines, and Research Safety best practices.

3. **Coordination**
   All laboratory design teams must consult with Vanderbilt University's Resiliency and Research Safety (RRS) team throughout the project.

4. **Desirable Characteristics**
   The following are desirable characteristics of Vanderbilt laboratory facilities:
   - Protects occupants from hazards and supports occupant health and wellbeing.
   - Designed to efficiently use and conserve resources such as energy, water, materials, equipment, etc.
   - Oriented to take advantage of natural lighting while controlling sunlight, heat, and glare.
   - Metered for primary utility services with submetering as approved by VU Built Environment.
   - Designed to be usable and accessible by all people to the greatest extent possible without need for adaptation or accommodation.
   - Provides a secure environment to protect our people, property, and research.
   - Provides a collaborative, flexible and easily adaptable facility that can quickly and easily respond to changes in research focus, funding, technology, methods, equipment, staffing and maintenance.

5. **General Lab Design Requirements**
   Laboratory space should be designed to:
   - Separate offices, common space, break space, and equipment room space from lab space. Locate administrative workstations outside of the laboratory but in close proximity to the lab.
   - Allow occupants to exit non-lab areas without passing through a lab space.
   - Minimize foot traffic in areas where air flow sensitive devices are used, such as biological safety cabinets (BSCs) and chemical fume hoods.
   - Use modular casework, services, and lighting with moveable and adjustable height lab bench systems and services with quick disconnects delivered from above whenever possible.
   - Provide meeting, eating and drinking spaces external to the lab space.
   - Provide at least one bench, sink, and eyewash in compliance with ADA accessibility requirements.

- Have chemically resistant, non-slip flooring and doors with fire-rated vision panels for safety, self-closing hardware, and kick plates.
- Have work surfaces that are chemical resistant, smooth, readily cleanable, non-porous, with back and side splashes.
- Provide standard 8.5 x 11-inch clear plastic sign holders outside door, to accommodate lab door sign on the latch side of all doors.
- Have enough electrical outlets to eliminate the need for extension cords and multi-plug adapters.
- Monitor as part of the building automation system critical equipment, environmental rooms, laboratory compressed air and vacuum, along with other types of equipment as needed.
- Be secure and have controlled access with self-closing and lockable doors separating lab areas from public areas. Card readers tied to VU's central card access system are preferred.
- Allow safe and compliant space, access and logistics for the following:
    - lab gas tank storage and changeovers.
    - mechanical equipment maintenance and repairs.
    - shared equipment such as freezers, refrigerators, autoclaves, and centrifuges.
    - storage of hazardous materials and gases.
    - Collection, storage and movement of trash, recycling, and hazardous chemical, radioactive, and biological/infectious waste in a manner that minimizes transport through public areas or event venues.

**6. General Laboratory Ventilation Design**

Lab ventilation design should meet the requirements of the latest version of ANSI Z9.5 for Laboratory Ventilation. Variations should be approved by the RRS team. Laboratory ventilation systems shall be designed to:

- Always operate with 100% outside air and exhausted to the outside with no recirculation to other areas of the building.
- Maintain negative pressure relative to adjacent non-lab areas.
- Occupied air exchange rate set to a minimum of six (6) air changes per hour.
- Unoccupied air change rate setbacks for energy savings are allowed based on a combination of time-of-day and occupancy sensor
- Emergency exhaust purge wall button is advisable for labs using volatile hazardous chemicals.

This could vary for specialty labs such as cleanrooms, BSL3 or BSL4 and other special scenarios. HVAC equipment should be designed to meet at least 20% increases in exhaust or supply air demand over lab design conditions to account for future growth.

**Energy Recovery Systems:**

Enthalpy wheels are not permitted to be installed in any exhaust streams that include exhaust from laboratory fume hoods, gas cabinets or other types of ventilated enclosures (based on the potential to off-gas absorbed materials back into the air supply). Other types of energy recovery systems are recommended for laboratory ventilation systems.

**7. Hazardous Chemicals**

The use of hazardous materials has direct bearing on the design of the laboratory so research operations and materials should be well understood in the planning phases of design. Laboratory design for the use of hazardous chemicals must meet the requirements of the university's Chemical Hygiene Plan, Federal and state regulations, and current local code requirements including Maximum Allowable Quantities (MAQs).

Additionally, overall building design must meet the requirements of Metro Nashville's current Plumbing Code including requirements for monitoring through the building automation system and assurance that building effluent always meet Metro's required pH range.

### 7.1. Hazardous Liquid Storage Cabinets

All flammable liquid storage cabinets must be UL listed, steel, self-closing, and meet relevant fire code requirements. One or more flammable liquid storage cabinets are required for all labs that store, use or handle more than 10 gallons of flammable or combustible materials. Cabinets should not be located near exits, doorways, stairways, in locations that would impede egress, or near open flames or ignition sources and are not required to be vented except for odor control of noxious materials.

Corrosive cabinets should be provided in sufficient numbers for the amount of corrosive materials in the lab, made of non-corroding materials, have a single-piece, leakproof floor pan, and vented to fume hood or lab exhaust system as appropriate.

### 7.2. Local Laboratory Exhaust Ventilation

#### 7.2.1. Chemical Fume Hoods

All fume hood installations shall be tested in accordance with the latest version of ANSI/ASHRAE 110: Laboratory Fume Hoods Performance Testing by an independent testing agency prior to acceptance by Vanderbilt University. After acceptance of test results, RRS will certify and label fume hoods for use.

- For standard fume hoods, design to provide 100 feet per minute (fpm) linear air velocity into hood face (acceptable working range = 80 - 120 fpm, with sash height of 18" – not full open). Non-occupancy setpoints to 80fpm if applicable.
- For hoods rated by the manufacturer to run at lower face velocities, such as high-performance fume hoods, design to 80 fpm +/- 20%. Non-occupancy setpoints to 60fpm if applicable. All hoods that are designed to operate at <100fpm face velocity must be approved by RRS.
- Hoods must have permanently installed visual flow indicators and alarms for off-normal conditions.
- Fume hoods should be appropriate for the control system being used. Bypass sash design required for constant air volume (CAV) systems, and hoods that are designed for variable air volume (VAV) systems should be selected when VAV systems drive the hood ventilation.
- Sash style should be either vertical or horizontal for constant volume systems but can be combination vertical/horizontal operating sash with variable volume systems only. For horizontal sliding sashes, 12” panels are preferred to enable users to work behind it by wrapping their arms around the panel.
- Hoods should have chemically resistant surfaces and finishes.
- Locate hoods at least 6 ft from doors, pedestrian traffic ways, and overhead supply air diffusers to minimize deleterious effects of turbulence; front-to-front placement within the same room should be avoided.
- Most hood installations will require electricity, house vacuum, and compressed air. If required by user, also install gas service connection.
- Electrical outlets needed for equipment should be located on the hood exterior and must not be placed inside the hood.
- Lights must be easily accessible from outside of hood to facilitate timely replacement
- Code and label fume hoods with consistent, standardized system (e.g., building code-room number-hood number).
- Hood cabinetry/casework should include flammable cabinets and possibly corrosive storage cabinets below, depending on chemicals used in the laboratory. Refer to the Chemical Storage information in Section 7.2.7 for specific cabinet requirements.
- Cup sinks are not allowed unless approved by RRS. If absolutely necessary, they must be installed with an elevated lip from the remaining fume hood countertop surface.

#### 7.2.2.Radioisotope Fume Hoods

Radioisotope fume hoods should be constructed with internal surfaces impermeable to radioactive materials and include radioactive material filters if required by RSS.

#### 7.2.3. Perchloric Acid Hoods

- Any laboratories that will use heated perchloric acid in a process where perchloric acid vapors are not condensed (or otherwise trapped or scrubbed) as part of the process, or those that use concentrated perchloric acid (>72%) shall be equipped with a perchloric acid hood with wash-down system. Contact RSS for guidance.
- Perchloric acid hoods shall not be manifolded with non-perchloric acid hoods.

#### 7.2.4. Gas Cabinets and Exhausted Enclosures

- Any laboratory where toxic or corrosive gases are present must be equipped with a gas cabinet or exhausted enclosure that meets the requirements of current code.
- Any laboratory where flammable gases are present in excess of the MAQ per code must be equipped with a gas cabinet that meets the requirement of current code.

#### 7.2.5. Snorkels (Extraction Arms)

- Extraction arms for typical laboratory use can be either 3" or 4" depending on application.
- Hoods should be made of clear plastic unless there is need for additional chemical resistance. They can be either dome or square style, depending on application.
- Note: snorkels used in welding applications should be 6" and have spark protection and a compatible hood.

#### 7.2.6. Ductless Fume Hoods

- Only permitted with RSS approval for specific applications in temporary or swing space applications only
- If allowed, the ductless hood must meet the following criteria:
  - The manufacturer shall meet and provide documentation indicating that the unit can be used with the chemicals in the anticipated concentrations used in the lab.
  - The unit must include a reliable monitoring system that indicates breakthrough at 25% the threshold limit value.

#### 7.2.7. Chemical Storage

The laboratory design must include dedicated space for chemical storage. This can include below-hood and/or free-standing flammable and corrosive chemical storage cabinets as well as shelving.

##### 7.2.7.1. Flammable Storage Cabinets

- Must have self-closing and self-latching doors.
- Must be labeled "Flammable"
- Must be labeled to identify if they are/are not connected to exhaust.
- Must have door sill raised at least two inches above the cabinet bottom to retain spilled liquid within the cabinet.
- Venting/exhausting of flammable storage cabinets is only required where there will be storage of toxic by inhalation/acutely toxic or noxious chemicals.
  - If flammable cabinets are vented, they must comply with current code and be directly connected to exhaust.
- Metal flammable storage cabinets must be designed to meet current fire code and OSHA requirements, which includes:
  - Bottom, top and sides of cabinet must be at least No. 18-gauge sheet iron.
  - Cabinet must be double walled with one and one-half inch airspace.
  - Joints must be riveted, welded or made tight by some equally effective means.
  - Door must have a three-point latch.
- Wood flammable storage cabinets must be designed to meet current fire code and OSHA requirements, which includes:

- Bottom, top and sides of cabinet must be constructed of exterior-grade plywood at least one inch thick.
- Plywood must not break down or delaminate under fire conditions.
- Joints shall be rabbeted and fastened in two directions with flathead wood screws.
- When more than one door is used, they must have a rabbeted overlap of not less than one inch.
- Hinges must be mounted in such a manner as not to lose their holding capacity due to loosening or burning out of the screws when subjected to the fire test.

**7.2.7.2. Corrosive Storage Cabinets**

- Must have self-closing and self-latching doors.
- Must be labeled "Corrosive."
- Must have door sill raised at least two inches above the cabinet bottom to retain spilled liquid within the cabinet.
- Venting/exhausting of corrosive storage cabinets may be required. Consult with RSS.

### 7.3. Gas Cylinders

When compressed gas cylinders are required inside a laboratory, the following conditions shall apply:

- Meets all NFPA and applicable current local fire codes.
- Storage site is at least 20 feet from highly combustible materials, 5 feet from any doorway or opening that has two means of egress, and at least 10 feet from any doorway or opening with only one means of egress.
- The storage site shall be protected from heat and ignition sources. The site shall be in area that minimizes that opportunity for accidental contact with the cylinders. The site shall be in a well-ventilated, dry location, with easy accessibility for periodic exchange of cylinders.
- Gas cylinders shall not be stored unprotected in public corridors. Cylinders may be stored in properly constructed corridor storage closets with proper wall ratings, ventilation and monitor equipment.
- Ensure materials are appropriate and rated for the gas being used such as oxygen, hydrogen, corrosive gases, etc.
- For flammable gas cylinders stored indoors, ensure storage is in accordance with NFPA 55 or prevailing local building and fire codes.
- Flammable gases must be stored separately from oxidizing gases by a distance of 20 feet or a 5-foot high, one-hour fire-rated barrier.
- Adequate storage space is provided and located to allow for segregation of gases by hazard classes.
- Provide adequate access for cylinder handling and material handling carts.
- Provide strapping and anchoring devices to a permanent building member. The number of devices shall be adequate for the number of cylinders, bearing in mind that local regulations may restrict the number of cylinders of an individual gas permitted to be stored in a laboratory.
- Confirm oxygen sensor requirements with RSS.
- Confirm with the researcher how/when cylinders will be replaced. An automatic/manual manifold system may be required.
- Rooms with large volumes of cryogens should have effective ventilation to mitigate risk in a spill or release. If not practical, then oxygen monitoring and alarms should be provided.

Labs using highly toxic, toxic, flammable or pyrophoric gas may require a gas monitoring system and/or lower explosive limit (LEL) monitoring. If these gases are to be used, gas monitoring design must have approval by the RSS team.

## 8. Eyewashes and Safety Showers

Eyewash and safety shower installations should meet the requirements in the latest version of ANSI Z358.1: Emergency Eyewash and Shower Equipment. A plumbed emergency shower or safety center with integrated

safety service such as face wash/eye wash, fire extinguishers, and spill kits should be considered for all work areas where areas of the body may come into contact with hazardous substances, particularly those that are corrosive or severely irritating to skin or mucous membranes. Careful consideration should be given to not only current but future use of lab spaces as research needs change. Without an emergency safety shower, future research or hazardous materials use in the space will be restricted or require costly retrofitting.

Install emergency eyewash and shower equipment in accessible locations that meet these criteria:

- Equipment is reachable within 10 seconds or less
- Equipment is on the same floor level as the hazard with travel paths free of obstructions that could inhibit immediate use of the equipment.
- If the hazard is not corrosive, one intervening door can be present so long as it opens in the same direction of travel as the person attempting to reach the eyewash and shower equipment and the door is equipped with a closing mechanism that cannot be locked to impede access.
- In areas where highly corrosive chemicals are used, you may need to shorten the distance to 10-20 ft from the hazard.
- Eyewashes should flush both eyes at the same time, be able to be used hands-free, deliver tepid water, and controls aren't blocked by casework or other obstructions.
- Eyewashes must be plumbed directly to a drain or located at a sink to promote regular testing.
- Each shower installation must have a secondary shut-off (ball) valve just upstream from unit. It should be located out-of-view where possible and installed with a lock-out mechanism. Shut-off valve must be in "open" position at time of lab commissioning.
- Consider flow alarm on showers tied with the building automation system.
- Modesty curtains should be considered for emergency showers. When installed, a minimum unobstructed area of 34 inches should be provided.
- No obstructions shall be located within 16 inches from the center of the spray pattern of the emergency shower facility. Note: The eyewash is not considered an obstruction.
- No electrical apparatus or receptacles (electrical outlets) shall be located within a zone measured 3 feet horizontally and 8 feet vertically of eyewash stations or showers. If a 120-volt outlet or receptacle is present within 6 feet of an eyewash or shower, it shall be equipped with a Ground Fault Circuit Interrupter (GFCI).
- Emergency eyewash and shower locations must be identified with a highly visible sign positioned so the sign is visible within the area served by eyewash and shower equipment
- The areas around the eyewash or shower must be well lit including in an emergency (proper locating of emergency light fixtures near units).

**9. Biological Safety**

All VU wet labs should be designed to BSL-2 standards following the latest edition of the Centers for Disease Control and Prevention (CDC)/National Institutes of Health (NIH) Biosafety in Microbiological and Biomedical Labs (BMBL). A BSL-2 lab includes the following features:

- Newly constructed labs are under negative pressure with net directional inward airflow from public spaces into the lab towards the most contaminated/high-risk areas for exposure control.
- Self-closing and lockable doors.
- Handwashing sink located in the lab
- Eyewash located in the lab
- Chairs, walls, floors, and working surfaces must be constructed of non-porous materials and be easily cleaned. Carpet rugs, and porous fabric chairs are not permitted.
- Spaces between benches, cabinets, and equipment should be accessible for cleaning.
- Biosafety cabinets must be located/positioned in accordance with the clearance requirements specified in the latest National Sanitation Foundation (NSF) Standard 49 (see attached for summary from latest Standard).

Any potential BSL-3 laboratory design must include close consultation with the RSS team.

### 9.1. Cell Culture Rooms

These rooms must be designed to maintain contaminant-free conditions through proper placement and use of biological safety cabinets, easily cleanable finishes and services, lensed and gasketed light fixtures. These rooms should be located internally in lab spaces rather than off public corridors or in other places where negative space pressurization is required. A handwashing sink and eyewash are located inside the room, preferably near the door.

### 9.2. Biological Safety Cabinets (BSCs)

Biological safety cabinets (BSC) should be installed in such a manner that fluctuations of the room supply and exhaust air do not cause the BSCs to operate outside their parameters for containment. Locate BSCs away from doors, windows that can be opened, heavily traveled laboratory areas, chemical fume hoods, room air supply or return, and other possible airflow disruptions.

- HEPA filtered exhaust air from a Class II Biological Safety Cabinet may be recirculated back into the laboratory environment. Connection to the laboratory's exhaust system must be approved by RSS and should be a thimble/canopy connection.
- The BSC class and type should be confirmed with RSS before purchase.
- Provide vacuum and electrical service to units. Use flexible connections where possible to permit limited re-positioning of BSC.
- Do not install plumbing for gas lines in new BSCs without approval by RSS.
- Biosafety Cabinet location and installation must conform to the latest version of NSF/ANSI 49 including being away from traffic patterns, doors, fans, ventilation registers, fume hoods, and any other air-handling device that could disrupt its airflow and located on wall furthest from and facing the entry door. If not possible, locate on the side wall perpendicular to the hinge side of the door.

## 10. Laser Areas

These rooms may be similar to microscopy/imaging rooms but may contain complex non-standard assemblies and instruments including laser arrays. The design team shall obtain from the principal investigator space requirements, temperature and humidity range and stability, electromagnetic and vibration requirements, necessary electrical, data and other piped services (e.g., vacuum), etc. These criteria must be vetted through RSS and with the School/Department. Laser rooms shall be designed in accordance with the latest version of ANSI Z136.1: Safe Use of Lasers.

### 10.1. Black-out/Laser Curtains

RSS should be consulted to confirm the need for black-out/laser curtains, the type that should be specified, and other requirements. Curtains are required to be made of an inherently flame-resistant material (IFR).

### 10.2. Signage and Emergency Power Shutoff

The A/E shall review safety requirements with the Principal Investigator, Project Manager and RSS team. "Laser in Operation" signage and emergency power off (EPO) pushbutton(s) may be required.

## 11. Regulated Laboratory Waste

- Sufficient space must be provided in lab spaces for the collection and storage of regulated waste streams including dry and liquid radioactive waste, hazardous chemical waste, and biomedical waste containers.
- Space much be allocated in each laboratory area as all chemical hazardous waste must be kept in the room at or near the point of generation. This should also include space for secondary containment, as it is required to separate hazard classes.
- Fume hoods are not intended as waste accumulation locations and should not be considered such unless approved by RSS.
- Space is needed either on or below bench tops for medical waste and sharps containers for easy access.
- Each laboratory should have space for normal trash and recycling, if applicable.

- If the building is not connected to the tunnel system which allows safe and efficient hazardous waste transport to central accumulation areas, then a hazardous waste storage room must be built into the building with design and size approved by RSS.

**12. Special Operations**

The following types of facilities and operations carry higher or unusual hazards, and must be designed in conjunction with RSS and other applicable departments:

- Radioactive material or radiation-producing machine areas or strong electric and magnetic field labs
    - The A/E shall review safety requirements with the Principal Investigator, Project Manager and RSS. Additional security, signage, area detectors, and structural shielding may be required.
- Clean Rooms
    - Spaces where particulate matter would compromise the work product (semiconductors, etc.) and achieve their "cleanliness" through circulation of large quantities of usually HEPA-filtered air.
    - Positively pressurized airlocks may be provided at entrances.
    - Clean rooms may be small, purchased package units, or custom-built assemblies requiring extensive HVAC infrastructure.
    - Semiconductor fabrication requires highly specialized equipment and highly hazardous chemicals and toxic gases.
    - Design of clean rooms should take place in very close coordination with the Principal Investigator and their School/Department, RSS, and the BE Maintenance and Operations team.
- Animal Facilities
    - Animal facilities will need to be designed in close collaboration with VUMC's Animal Care and Use Program (ACUP) and approved by the Institutional Animal Care and Use Committee (IACUC) as well as the Office of Laboratory Animal Welfare (OLAW).

**13. Commissioning**

All laboratory projects will be commissioned in accordance with a plan developed by either in-house BE staff or a third-party provider. The design team will develop the "owner's project requirements", "design intent", and "basis of design" portions of the commissioning plan with support from BE Planning, Design, and Construction, RSS, and Maintenance and Operations teams, commissioning provider and the University client. The commissioning provider will develop verification and functional performance testing requirements and operation and maintenance criteria. It is very important that sufficient time be allocated for commissioning at the end of construction and prior to project acceptance and occupancy.

All fume hood installations shall be tested in accordance with the latest version of ANSI/ASHRAE 110: Laboratory Fume Hoods Performance Testing by an independent testing agency prior to acceptance by Vanderbilt University. After acceptance of test results, RSS will certify and label fume hoods for use. Ductless fume hoods are not allowed unless specifically approved by RSS.