University of Toledo Laboratory Design Guidelines

For any new construction or renovation of laboratory areas, consider health, safety and regulatory compliance issues early in the design stage of the project. The following outlines some of these issues:

A. Layout

Laboratory space should be physically separate from personal desk space, meeting space and eating areas with a closable door. Workers should not have to go through a laboratory space where hazardous materials are used in order to exit from non-laboratory areas. Consider making visible separation between lab and non-lab space, for instance with different flooring.

Fire-rated hallway doors should have magnetic hold-open features, such that the door will close in the event of an alarm.

Doors to laboratories should not be fire-rated unless necessary.

Entryways should have provisions for mounting emergency information posters and other warning signage immediately outside the laboratory (e.g., on the door).

Each door from a hallway into a lab should have a view panel to prevent accidents from opening the door into a person on the other side and to allow individuals to see into the laboratory in case of an accident or injury.

Laboratory areas with autoclaves should have adequate room to allow access to the autoclave and clearance behind it for maintenance. There should also be adequate

room for temporary storage of materials before and after processing. Autoclave drainage should be designed to prevent or minimize flooding and damage to the floor.

For laboratories using radioactive materials: (Consult with Radiation Safety)

Eating and drinking areas should be physically separate (closable door) and conveniently located.

Allow for security of laboratory and materials.

Consider designing the lab to allow separation of radioactive materials use from other laboratory activities.

B. Furniture and Fixtures

Work surfaces should be chemical resistant, smooth, and readily cleanable, such as chemical-grade Formica.

Work surfaces, including computer areas, should incorporate ergonomic features, such as adjustability, appropriate lighting and equipment layout.

Benchwork areas should have knee space to allow room for chairs near fixed instruments, equipment or for procedures requiring prolonged operation.

Handwashing sinks for particularly hazardous chemicals or biological agents may need hands free operation

Wet chemical laboratories and darkrooms should have solvent resistant coved flooring using sheet goods rather than tile, particularly in areas where fume hoods are located.

Do not install more sinks or cupsinks than are necessary. Unused sinks may develop dry traps, resulting in odor complaints.

Sink faucets and hose bibs that are intended for use with attached hoses are provided with back siphon prevention (vacuum break) devices.

C. Storage

Cabinets for chemical storage should be of solid, sturdy construction. Hardwood or metal shelving is preferred. Some may require ventilation.

Materials of construction should be carefully considered where corrosive materials will be stored, e.g., corrosive-resistant liners or trays on shelves, location away from copper fittings, etc.

Allow space within the building for any central chemical and biological or radioactive waste storage needs.

Wall shelving should have heavy-duty brackets and standards and should be attached to studs or solid blocking. For office spaces, bookcases are preferable to wall-mounted shelving.

Flammable liquid storage needs should be defined in advance so that the laboratory may have space for a suitable number of flammable storage cabinets.

Flammable liquid storage (Class 1 Flammables) is not allowed below grade or near a means of egress, per the Uniform Fire Code.

Flammable storage cabinets should not be vented unless there is a significant odor or vapor control concern.

Laboratories using corrosive liquids should have ample storage space low to the floor, preferably in low cabinets, such as under fume hoods.

Allow space for the variety of waste collection containers needed. Depending on the laboratory, these may include laboratory trash, broken glass, sharps, recyclable containers, used oil, medical waste, and/or radioactive waste.

Laboratories using compressed gases should have recessed areas for cylinder storage and be equipped with devices to secure cylinders in place.

All laboratories should have storage space for supplies and combustible materials, e.g., boxes of gloves, spill kits, boxes of centrifuge tubes, etc.

D. Laboratory Ventilation

Laboratory ventilation rates should meet ASHRAE standards and ensure 8-10 air changes per hour minimum for occupied spaces and 6 air changes per hour minimum when unoccupied.

Bypass style fume hoods should be used. Auxiliary air hoods should not be used.

Fume hoods should have recessed work surfaces to control spills.

Canopy hoods should not be installed unless approved by Safety and Health and the use of snorkel hoods, or duct drops may be acceptable in some situations.

The location of fume hoods, supply air vents, operable windows, laboratory furniture and pedestrian traffic should encourage horizontal, laminar flow of air into the face of the hood, perpendicular to the hood opening. Hoods should be placed away from doors and not where they would face each other across a narrow isle.

Hoods may have a face velocity of ~100 linear feet per minute with the sash open to 18” or at its standard configuration (e.g., at the stopper height).

Each hood must have a continuous monitoring device, such as a magnehelic gauge. The device should display either air velocity or static pressure, rather than only an audible alarm.

Supply air vents should be placed away from or directed away from fume hoods and Biological Safety Cabinets to avoid interference. Air velocity caused by supply vents should not exceed 25 feet per minute at the face of the hood.

Noise from the fume hood should not exceed 65 dBA at the face of the hood.

Use hard ducting for the positive side of exhaust ducting for all internal (penthouse) fans to prevent contaminant leakage into work areas.

Fume hood exhaust ducts must not contain fire dampers.

Unless otherwise specified (e.g., clean rooms), air pressure in the laboratory should be negative with respect to the outer hallways and non-laboratory areas.

Consider the need for vented chemical storage areas or cabinets for chemicals with low odor thresholds.

Semi-conductor, Photovoltaic and other hazardous gases (e.g., silane, hydrogen fluoride, chlorine, etc.) must be placed in vented gas cabinets and utilize stainless steel or coated duct work when corrosive gasses are used.

Hoods for perchloric acid require stainless steel construction and a wash-down system and a dedicated, isolated fan.

Hoods requiring filters (such as those for some radioisotopes or biological materials) should be designed and located such that filters may be accessed and changed easily.

Provisions should be made for local exhaust of instruments, gas cabinets, vented storage cabinets or other operations requiring local ventilation.

Single vertical sliding sashes are preferred over horizontal or split sashes.

Debris screens should be placed in the ductwork leading from the hood.

E. Emergency Equipment

Laboratories using corrosive/caustic chemicals must have an eyewash and safety shower within 10 seconds travel time from the chemical use areas.

Drench hoses support, but do not replace, safety showers and eyewashes.

Eyewashes and safety showers should have plumbed drains and mixed/tepid water supplied through a rated thermostatic mixing valve

Eyewashes and safety showers should be standardized at least within a laboratory building.

Flooring under safety showers should be slip-resistant.

Safety showers may have privacy curtains, particularly in large laboratories or teaching laboratories.

Fire extinguishers, safety showers and eyewashes should be conspicuously labeled, particularly if recessed.

Fire extinguishers appropriate for the chemicals and equipment in use should be placed near the entrance of each laboratory, mechanical and electrical room.

Some chemical operations (e.g., distillation hoods) may benefit from hood fire suppression systems.

Windowless laboratories and environmental chambers should have emergency lighting.

Alarm enunciator panels should be descriptive of the area where the alarm has activated.

F. Materials Handling

Loading docks should be equipped with dockboards and should have enough room to maneuver pallets safely.

Cryogenic liquid tanks should be placed in such a manner that their controls could not accidentally be manipulated and such that they may be secured to prevent unauthorized access.

Cryogenic liquid tanks should be placed away from below grade areas where dense vapors may collect and away from glass doors or windows.

Avoid using flooring options that do not respond will to cold or hot temperature extremes.

A phone should be placed near any loading area.

G. Utilities

Utility shut-off controls should be located outside the laboratory.

Laboratories should have an abundant number of electrical supply outlets to eliminate the need for extension cords and multi-plug adapters.

Electrical panels should be placed in an accessible area not likely to be obstructed.

Ground fault circuit interrupters should be installed near sinks and wet areas.

Environmental chambers where evacuation or other alarms cannot be heard should be equipped with strobe lighting or additional alarms.

Central vacuum systems must be protected, since they are vulnerable to contamination.

All vacuum lines should have cold traps or filters to prevent contamination.

Chilled water loops should be available for equipment in need of cooling. Loops help to avoid excessive wastewater.

LASER laboratories should have an emergency cut-off switch installed near the entrance of the laboratory to turn off the LASER remotely. Many lasers require water-cooling systems requiring ground-fault circuit interrupters. Lighted signage that clearly indicates that a LASER is being operated should be present at all entrances to the lab.

H. Other

Laboratories using highly toxic gases should be equipped with alarmed vapor sensors, preferably with automatic shutdown systems.

Gas lines from highly toxic gases should use coaxial tubing for double containment. They should be welded in a continuous fashion and compression fittings only utilized inside of gas cabinets or other containment devices.

Animal care and use areas must meet Association for Assessment and Accreditation of Laboratory Animal Care International standards.

Biosafety or containment labs must be designed in coordination with the office of Research and the Biosafety Officer.

NMR laboratories should be equipped with Oxygen sensors and emergency exhaust features in the event of magnet quenching

Nano-scale laboratories must be evaluated by Safety and Health please call 419-530-3600

Contact Environmental Health and Radiation Safety with questions.

BIOSAFETY LABORATORIES

A. Scope

The design and construction of a facility that contributes to efficient and safe work with biohazardous materials is the goal. Before a proposed biosafety containment laboratory can be effectively planned, a risk assessment determines the containment conditions that are required. Risk assessments, conducted on a case-by case basis, consider the biohazardous materials, the nature of the work, procedures involved, equipment needs, regulatory requirements, national guidelines, and safety and health requirements. The guidelines presented here are for general-use Biosafety Containment Levels 1, 2, and 3 for biological research laboratories. Containment facilities for animals, large-scale (≥10 liters) operations, clean rooms, US Department of Agriculture containment requirements, Food and Drug Administration (FDA) containment requirements, greenhouse and Biosafety Level 4 work (BSL 4) are beyond the scope of this Guide.

If vertebrate animals are involved in research with biohazardous materials, special precautions are required. Requirements will be specified on a case-by-case basis by Environmental Health and Radiation Safety personnel.

Note: Each Biosafety Level builds to the next, so everything required for BSL1 labs is in turn required for BSL2 Labs as well.

B. Basic Laboratory Design for Biosafety Level 1

1. Each laboratory shall have a sink for hand washing.
2. The laboratories shall be designed for easy cleaning.
3. Carpets and rugs shall not be used.
4. Bench tops shall be impervious to water, and resistant to acids, alkalis, organic solvents and moderate heat.
5. Approved and accepted methods for decontamination of infectious or regulated laboratory wastes shall be available (e.g., autoclave, chemical disinfection or other decontamination system approved by the Biosafety Officer (BSO) or designee.
6. The autoclave need not be in the actual laboratory room. Autoclave installations need to be ASME stamped and UL Listed.
7. Laboratory furniture shall be:
   a) Sturdy.
   b) Capable of supporting anticipated loads and uses.
   c) Chairs should be covered with liquid-proof fabric and/or plastic and easily cleaned/decontaminated material.
8. Windows shall be fixed and not operable.
9. Doors shall be lockable.
10. Laboratories should be designed in order to incorporate proper ergonomic conditions for the tasks to be performed within the facility.
11. The lab should be negatively pressured to the hallway.

C. Basic Laboratory Design for Biosafety Level 2

In addition to the requirements for a BSL 1 laboratory, the following are required:

1. Floors shall:
   a) Have a slip-resistant, smooth, hard finish.
   b) Be liquid-tight, monolithic/seamless or have welded seams.
   c) Have recommended flooring material coved up wall four inches or have the cove-base installed to create a watertight seal to the floor.
2. Walls should be durable, washable, resistant to detergents/disinfectants, and use durable high-gloss acrylic or epoxy paint or equivalent.
3. Exposed corners and walls shall be protected from damage by carts.
4. Ceiling height shall provide a minimum of twelve inches of clearance above biological safety cabinets (BSC). The ceiling around the BSC shall be high enough to allow for thimble connection (or gas-tight valves for Class II Type B BSC). This also allows for certification and proper functioning of recirculating BSC's. If the laboratory has a sprinkler system, local fire codes may require eighteen inches or more clearance.
5. Doors shall:
   a) Be self-closing and locking.
   b) Have fire ratings as required.
   c) Not be provided with any kind of hold-open device.
6. Wall/ceiling penetrations shall be kept to a minimum and sealed with fire retardant material.
7. An emergency eyewash and shower shall be provided.
8. Floor drains shall be allowed for autoclaves.
9. An ASME-stamped UL-listed autoclave shall be provided in close proximity to the laboratory or other forms of waste decontamination such as an outside vendor.
10. Venting of the autoclave is recommended; use manufacturer's recommended and good industrial ventilation design principles.
11. Door signage signifying the level of biosafety work along with agents, PPE requirements and emergency contacts.

D. Basic Laboratory Design for Biosafety Level 3

The Biosafety Officer on behalf of and in accordance with the Institutional Biosafety Committee and their policies, must approve the location and design of any BSL 3 facility and has final authority to authorize commencement of BSL 3 work. The BSL 3 facility will need to meet requirements set forth by the CDC and NIH, and thus a thought out plan must be created and discussed with all appropriate staff before construction.

E. Biological Safety Cabinets and Other Containment Considerations

1. Biological safety cabinets shall be located away from doors, high-traffic, ventilation diffusers and other air current sources.
   NSF Standard 49, Annex E
   Air turbulence is generated (room air pressure is also affected) when doors are opened and when people walk in the vicinity of the biosafety cabinet. Currents of air can disrupt the protective capability of the cabinet. Installing biosafety cabinets in low traffic areas minimizes this problem.

2. Two biosafety cabinets should not be installed directly opposite each other when they are closer than six feet apart. Laminar airflow is greatly hindered by the concurrent operation of two biosafety cabinets situated across from each other. The potential for air turbulence also increases when two cabinet operators are working at the same time in the same immediate vicinity.
3. Do not design BSCs to be plumbed with natural gas; this is prohibited.
4. Biological Safety Cabinets (BSC) shall be installed as follows:
   a) Class II, Type A2 BSC for biohazard work not involving chemicals; shall be directly vented to the room (after HEPA filtration).
   b) With thimble connections as provided by the BSC manufacturer or as approved by the Biosafety Officer.
   c) Class II, Type B2 BSC for biohazardous work involving flammable, volatile, and toxic chemicals and radionuclides. Class II Type B2 BSC shall be directly (hard) connected to a dedicated exhaust system.
   d) Class II B BSC shall be interlocked with the exhaust fan so they shut down and alarm in the event of an exhaust fan/system failure.
   e) Class II B1 and B2 BSC shall be provided with a gas-tight valve for decontamination on the exhaust that is accessible from the front or side of the cabinet.
   f) Class II B1 and B2 BSC shall not share a common HVAC manifold or fan; separate ducts and fans shall be provided.
   g) Thimble connection exhaust airflow shall be 120-125% of the BSC manufacturer's exhaust specification.
   h) In addition, BSC in BSL 3 facilities should:
      - Have at least twelve inches of clearance is provided above it for testing and decontamination of HEPA filters.
      - Have at least four inches of clearance from the rear and six inches' clearance on the utility side of the cabinet.
      - Have the power receptacle located high on the wall so the unit may be easily unplugged for servicing.
      - Be ergonomically designed.
      - Be seismically anchored.
      - Have utilities lines installed behind it.
5. All cabinets shall be NSF listed, UL approved and installed in accordance with the manufacturer's requirements. The cabinet manufacturer has designed a unit which, when used and installed properly, will provide both product and personnel protection. However, if the cabinet is not installed properly (i.e., not ducting a Class II B2 cabinet), then it will not be serviceable. To install a cabinet and deviate from the listed NSF requirements will void the NSF Standard 49 approved listing.
6. When initially installed or when reinstalled, biosafety cabinets shall be provided with an appropriate means of seismic stabilization.The manufacturer should always be consulted to avoid possible damage to the pressurized cabinet volumes.
7. Biosafety cabinets shall be certified by approved technicians prior to building acceptance or, for installations not involving significance building modifications, before use with biohazards.
8. Class II Type A BSC shall be vented to the room unless specifically exempted by EHRS. Researchers must confer with the Biosafety Officer and provide information regarding materials and agents to be used in the cabinet. Exemptions will not be considered when information is not provided or unavailable

9. Where BSC are connected to external ducts, a flow monitoring system with audible and visual annunciations shall be used to alert the BSC of loss of external ventilation. Alternatively, thimble connections or canopy mini-enclosures in BSC shall be fitted with a ribbon streamer or equivalent attached at an edge through which air enters the device to indicate the airflow direction.
10. Security measures shall be designed and installed to meet or exceed the conditions set in Appendix F “Laboratory Security: an Emergency Response for Microbiological and Biomedical Laboratories.” *CDC-NIH Biosafety in Microbiological and Biomedical Laboratories*
11. The Biosafety Officer must approve The BSC make and model prior to procurement.

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The University of Toledo

Laboratory Planning and Design Quick Review Checklist

Fire protection	Yes	No	N/A	Required Actions
Have the requirements of NFPA 45 – Standard on Fire Protection for Laboratories Using Chemicals been followed?				If no or unsure, work with EHRS to identify which NFPA 45 requirements need to be followed.
Lab Separation and Security	**Yes**	**No**	**N/A**	**Required Actions**
Have provisions been made for the separation of laboratory space from non-laboratory space?				It is recommended to keep offices and employee support areas outside of laboratory spaces.
Are corridor configurations arranged to keep laboratory activities separate from non-laboratory activities and allow proper means of egress?				All corridors shall meet building codes pertaining to egress, and should limit traffic by non-lab staff.
Is access to shut-off valves, electrical equipment, gas cylinders supply, etc. maintained in designated closets or mechanical spaces?				It is important that there is unblocked access to these mechanical spaces or access panels.
Will the lab need additional security, such as door alarms, badge access, surveillance, or controlled key systems?				Ensure proper building security elements are in place.
Lab design	**Yes**	**No**	**N/A**	**Required Actions**
Will the lab consist of walls on all sides, a floor, and a ceiling?				All labs shall consist of walls on all sides, a floor and a ceiling. Building codes must be followed.
Will walls be painted with washable, hard, non-porous, cleanable material?				Walls should be painted with cleanable material, or other coverings that facilitate cleaning.
Are insect screens installed for windows that open?				It is not recommended that windows open, but if they do they should be fitted with insect screens.
Are floors constructed of non-pervious, cleanable, seamless, sheet vinyl, epoxy, or similar material?				Floors should be constructed to be cleanable and withstand chemical spills.

Are provisions in place for adequate illumination for sufficient visibility?				Provide sufficient illumination.
Are chemical resistant sinks installed for handwashing?				Hand washing sinks should be located within all BSL2 labs. There should also be a sink in close proximity to the laboratory door exiting the space.
Lab furniture	Yes	No	N/A	Required Actions
Are provisions made to construct all working surfaces such as bench tos and counters with sturdy and chemical resistant materials?				All furniture should be capable of supporting the anticipated loading.
Is the furniture designed to be cleanable and with basic ergonomic specifications				Fabric materials on furniture such as chairs shall not be used in laboratories.
Chemical Storage	Yes	No	N/A	Required Actions
Will flammable liquid storage cabinets be provided for storage of flammable liquids.				Cabinets must be UL listed and shall be limited in quantity. If large amounts of flammables will be stored, consult with EHRS.
Will storage cabinets be designed with partitions to separate incompatible chemicals?				Consult with EHRS to ensure proper chemical separation in cabinets.
Fume Hoods	Yes	No	N/A	Required Actions
Has an evaluation been completed to assess the appropriate type and number of fume hoods needed?				All appropriate lab ventilation requirements should be followed.
Has consideration been giving to the location of fume hoods with respect to open windows, doorways, traffic, and other items that influence the containment ability of the hood?				Fume hoods should not be located adjacent to a single means of egress exit or directly next to high traffic areas of a lab.
Are provisions in place for adequate supply of make-up air in the laboratory for fume hood exhausts?				The combined air supply and exhaust should still maintain a negative pressure for most labs.
Is there enough exhaust ventilation for the fume hood to properly work?				Fume hoods should maintain a ~100 fpm face velocity across the opening.

Biosafety Cabinets	Yes	No	N/A	Required Actions
Are Class II Type A biosafety cabinets installed in all BSL2 laboratories, away from high traffic areas and openings?				Consideration for BSL2 labs/Tissue culture labs should place Biosafety cabinets in proper locations with outlets.
Emergency Eyewashes and Safety Showers	**Yes**	**No**	**N/A**	**Required Actions**
Are provisions in place to install an emergency eyewash station in the areas where contamination of the eye by corrosive materials, severely irritating materials, and toxic materials is likely? If gross contamination of the body could occur a shower shall be installed.				ANSI z358.1 should be followed for emergency eyewash/shower installations.
Is an eyewash/shower installed within 10 seconds of the hazard and on the same level without any barriers? All BSL2/3 labs are required to have an eyewash.				The eyewash shall be identified with a highly visible sign and easily accessible.
Is the eyewash/shower installed with a drain to allow weekly testing?				It is best to install equipment with drain in order to facilitate weekly testing.
Is the water plumbed to the emergency eyewash/shower tepid?				Water temperatures must be maintained between 60-100 degrees F.
Electrical Safety	**Yes**	**No**	**N/A**	**Required Actions**
Are provisions in place to fit the laboratory with electrical outlets that can accommodate heavy equipment such as -80 freezers and incubators?				Power supply for heavy equipment should be considered.
Will electrical receptacles above countertops, on bench tops, and within six feet of any we areas such as a sink contain GFCI circuit protection?				Ensure all electrical installations and safety requirements are met.