CONSIDERATIONS FOR LABORATORY DESIGN

Table of Contents

Purpose

These considerations are available to provide information that will help principal investigators make informed decisions as laboratories are designed and organized. This guide focuses on the equipment, furnishings and layout of a laboratory; it considers safety, regulatory requirements, and recommendations made by associated safety organizations. Some of the regulatory agencies include: the Occupational Safety & Health Administration, the Environmental Protection Agency, the Nuclear Regulatory Commission, the National Fire Protection Association, and the Americans with Disabilities Act. Associated safety organizations include: Underwriters Laboratory, American National Standards Institute, and the International Electro-Technical Commission. This document is not all encompassing, therefore; the Architect / Engineer is responsible for the overall design of the project.

Not all laboratories are the same, so this design guide includes the most common items purchased for or used in a laboratory. Those putting a laboratory together should include the same considerations or criteria as other items are purchased and placed in a laboratory.

In addition, the university has its own requirements found in the "Building Design Standards of The Ohio State University" http://fod.osu.edu/bds/index.htm. These standards also reflect safety and regulatory requirements which are incorporated in new laboratory construction and renovations. The Building Design Standards apply to permanent structure such as utilities, room ventilation, flooring, windows and fire suppression sprinklers, as well as safety equipment, such as safety showers, eyewashes, and chemical fume hoods. Where Building Design Standards apply in this design guide, links are provided to the specific standard for your convenience.

Laboratory Layout

1. Keep office space separate from research areas.

2. Segregate hazardous operations from other laboratory activities. Use fume hoods or walls if possible. Other safe means include barriers, enclosures and blast shields.

3. Furniture, casework and equipment should be arranged so that means of access to an exit can be reached easily from any point. (NFPA 45 3.5)

4. Reasonable accommodations and provisions should be made for employees with disabilities. (ADA A4.2.1) Consider a 32" egress clearance for a wheelchair, 34"

maximum height for counters, sinks and equipment, 30” or less for reach, and 60” turning space for wheelchairs. Also consider adjustable tables, benches and biological safety cabinets. For more information, go to - Requirements to Assure Access for Individuals with Disabilities – Building Design Standards, Appendix B: http://fod.osu.edu/bds/app_b.pdf

5. Equipment and activities that require local ventilation should be kept away from doors, foot traffic and windows (if opened).

6. Compressed gas cylinders should be kept out of public hallways, high foot traffic areas, areas where damage could occur, and out of direct sunlight. Compressed gas cylinders that contain oxidizers should be segregated from flammable compressed gases, unless they are in use.

7. Compressed gas cylinders should be stored away from electrical arc welding and stored grease and oils.

8. Equipment sensitive to vibration should be kept away from high foot traffic areas, strong local ventilation and ceiling supply air vents.

9. Equipment and furniture should not obstruct a safety shower or eyewash. A minimum clearance of 16” is required. (ANSI Z358.1)

10. Large equipment like freezers, refrigerators or incubators should not be stored or located in public corridors, hallways and high foot traffic areas.

Safety Equipment

Laboratory Chemical Fume Hoods

1. Building Design Standards, Appendix W: http://fod.osu.edu/bds/app_w.pdf

2. For information on chemical fume hood use and safety practices, go to: http://ehs.osu.edu/ResBioSafety/ChemFH.aspx

Biological Safety Cabinets (BSCs)

1. Class II Biological Safety Cabinets should meet the performance requirements outlined in NSF/ANSI Standard 49 (laminar flow) biosafety cabinetry. See the NSF website for more information: http://nsf.org/business/biosafety_cabinetry/index.asp?program=BiosafetyCab

2. Always use the correct type of BSC for the type of work being conducted. There are four types of Class II BSCs.
    a. Type A1 – maintain a minimum average inflow velocity of 75 fpm through the work access opening; have HEPA filtered downflow air that is a portion of the mixed downflow and inflow air from a common plenum; may exhaust HEPA filtered air back into the laboratory or to the environment through an exhaust canopy; and may have positive pressure contaminate ducts and plenums that are not surrounded by negative pressure plenums. **Type A1 cabinets are not suitable for work with volatile toxic chemicals and volatile radionuclides.**
    b. Type A2 – maintain a minimum average inflow velocity of 100 fpm through the work access opening; have HEPA filtered downflow air that is a portion of the mixed downflow and inflow air from a common plenum; may exhaust HEPA filtered air back into the laboratory or to the environment through an exhaust canopy; and have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums. **Type 2 cabinets used for work with minute quantities of volatile toxic chemicals and tracer amounts of radionuclides required as an adjunct to microbiological studies must be exhausted through properly functioning exhaust canopies.**
    c. Type B1 – maintain a minimum average inflow velocity of 100 fpm through the work access opening; have HEPA filtered downflow air composed largely of uncontaminated recirculated inflow air; exhaust most of the contaminated downflow air through a dedicated duct exhausted to the atmosphere after passing through a HEPA filter; and have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums. **Type B1 cabinets may be used for work treated with minute quantities of volatile toxic chemicals and tracer amounts of radionuclides required as an adjunct to microbiological studies if work is done in the**

direct exhausted portion of the cabinet, or if the chemicals or radionuclides will not interfere with the work when recirculated in the downflow air.

d. Type B2 – maintain a minimum average inflow velocity of 100 fpm through the work access opening; have HEPA filtered downflow air drawn from the laboratory or the outside air (i.e. downflow air is not recirculated from the cabinet exhaust air); exhaust all inflow and downflow air to the atmosphere after filtration through a HEPA filter without recirculation in the cabinet or return to the laboratory; and have all contaminated ducts and plenums under negative pressure or surrounded by directly exhausted (non-recirculated through the work area) negative pressure ducts and plenums. **Type B2 cabinets may be used for work with volatile toxic chemicals and radionuclides required as adjuncts to microbiological studies.**

3. The recommended exhaust system connection for type A1 and A2 BSCs is an exhaust canopy connection. No type A cabinet should ever be hard connected to a building exhaust system. (NSF/ANSI Standard 49; Annex E).

   Type B1 and B2 cabinets are to be vented outside the building without recirculation. The venting system should include a leak-tight duct, a damper in the duct near the cabinet to permit flow adjustment closure and decontamination and an external exhaust fan as the final component. The exhaust fan should be sized to deliver the required exhaust airflow (as specified by the cabinet manufacturer), considering pressure losses in the duct and allowing at least 2" w.g. for a dirty HEPA filter. (NSF/ANSI Standard 49; Annex E)

4. For information on biological safety cabinet use and safety practices, go to: http://ehs.osu.edu/ResBioSafety/BiosafetyCabinets.aspx

Auxiliary Air Units

1. Auxiliary Air Units – Building Design Standards, Appendix W: http://fod.osu.edu/bds/app_w.pdf

Fire Extinguishers

1. Building Design Standards, Division 10 Section 44 16: http://fod.osu.edu/bds/div_10.pdf

Eye Wash and Safety Showers

1. Building Design Standards, Division 10 Section 40: http://fod.osu.edu/bds/div_10.pdf

Electronic Safety and Security

1. Electronic Safety and Security – Building Design Standards, Division 28: http://fod.osu.edu/bds/div_28.pdf

Other

1. All laboratories should have a telephone and a list of emergency contacts and numbers posted.

2. All laboratories should have a chemical or biological spill kit designed to handle the specific hazardous materials used in each laboratory. More information can be found on the EHS website www.ehs.osu.edu.

Laboratory Room Ventilation and Openings

Laboratory Room Ventilation

1. Laboratory Room Ventilation – Building Design Standards, Appendix W: http://fod.osu.edu/bds/app_w.pdf

Windows and Doors

1. Windows and Doors – Building Design Standards, Division 8 Section 50: http://fod.osu.edu/bds/div_08.pdf

2. Windows that open, must be fitted with fly screens.

Furnishings

General Information

1. Furnishings should be designed and constructed for long-term use, reuse and relocation.

2. Furnishings should incorporate adjustability.

3. Furnishings should be made of materials that are easy to clean and repair.

4. Ergonomics should be taken into consideration when purchasing equipment and setting it up. Consider knee room for lab bench areas where prolonged operations are performed.

5. Determine if operations would require elbow, foot or electronic controls for sinks.

Work Surfaces

1. For clean areas – polypropylene or stainless steel is a good choice.

2. Lab benches should be chemical resistant, smooth and easy to clean – epoxy resin or phenolic resin, are a good choice. Benches should also be seamless with sealed penetrations. There should be a backsplash that meets the wall.

Storage

1. Consider storage needs before furnishings are purchased.

2. Shelves used to store chemicals should have lips on the edge surfaces and should be resistant to chemicals.

3. Consider the height of shelves for reaching chemicals (1 liter or larger bottles should be at or below shoulder height).

Chairs

1. Chairs and stools will have non-fabric coverings and should be easy to clean and disinfect.

2. Select chairs and stools that are adjustable and incorporate pneumatic features.

Special Storage

Flammable Liquid Storage Cabinets

1. Flammable liquid storage cabinets shall meet the design requirements of NFPA 30, NFPA 45 and the Ohio Fire Code.

2. Flammable liquid storage cabinets must be UL rated.

3. Flammable liquid storage cabinets do not need to be vented. If not vented, vent openings must be sealed with the bungs supplied with the cabinet or bungs specified by the manufacturer.

4. If Flammable liquid storage cabinets are vented, they must be vented outdoors in a manner that will not compromise the performance of the cabinet.

5. The NFPA does not recommend venting.

6. Flammable liquid storage cabinets must meet one of the NFPA 30-35 4.3.3 requirements: (a) A flammable liquid storage cabinet must be designed and constructed to limit the internal temperature to no more than 325^{o} F / 162.8^{o} C when subjected to a 10 minute NFPA fire test.

(b) A flammable storage cabinet must be constructed so the bottom, top, sides, and door are made of at least #18 gauge sheet steel and shall be double-walled with a 1.5 inch / 28 mm air space. Joints shall be riveted, welded, or made tight by equally effective means. The door shall be provided with a three-point latch arrangement and shall be raised at least 2 inches / 50 mm above the bottom of the cabinet to retain spilled liquid.

(c) Wooden cabinets – the bottom, sides, and top shall be constructed of exterior grade plywood that is at least 1 inch / 25 mm thick and of a type that will not break down or delaminate under fire conditions. Joints shall be riveted and fastened in two directions with wood screws. Where more than one door is used, there shall be a rabbeted overlap of not less than 1 inch / 25 mm. Doors shall be equipped with a means of latching and hinges shall be constructed and mounted so not to lose their holding capacity when subjected to fire exposure. A raised sill or pan capable of containing a 2 inch / 50 mm depth of liquid shall be provided at the bottom of the cabinet.

7. Flammable liquid storage cabinets shall be labeled "FLAMMABLE Keep Away From Fire".

8. Flammable liquid storage cabinets cannot be mounted to a wall.

9. No more than 120 gallons of class I, class II, and class IIIA liquids may be stored in a cabinet. Of this total, not more than 60 gallons may be class I and class II (NFPA 30 4-3-1).

10. Flammable liquid storage cabinets cannot be located near an exit doorway, stairwell or a location that would impede egress. They cannot be stored near an open flame.

Corrosive Cabinets

1. Cabinets designed for the storage of non-flammable corrosives should be constructed of a corrosive resistant material such as polypropylene or polyethylene.

2. Cabinets used for the storage of non-flammable corrosives should have venting and a lockable door.

3. Cabinets used for the storage of non-flammable corrosives, made of metal or wood, should be painted with a corrosive resistant, epoxy coating.

4. Cabinets used for the storage of non-flammable corrosives should have a polypropylene or polyethylene pan on each shelf and the bottom of the cabinet should have a catch pan or reservoir made of the same material.

5. Cabinets used for the storage of non-flammable corrosives should be labeled with "Caution Corrosives".

Compressed Gas Cylinders (OSHA CFR 1910.101 and CGA P-1-1965)

1. Compressed gas cylinders should be stored in an upright position (never lay acetylene tanks on their side).

2. Compressed oxygen cylinders should not be exposed to temperatures of 125^{o} F or higher.

3. Compressed cylinders of oxidizers and flammables should be segregated by at least 20 feet or by a 5 foot or taller (30 minute) fire rated wall.

4. Compressed gas cylinders should be secured to walls or other permanent structures using chains, plastic coated wire cable, commercial straps, clamps, or cylinder stands.

5. Compressed gas cylinders should by strapped between the waste and shoulder.

6. Compressed gas cylinders should be transported with an approved cylinder cart.

7. Only use the correct regulator and tools recommended or provided by the manufacturer.

8. All compressed gas cylinders should be labeled for content and have a full or empty tag.

9. Unused compressed gas cylinders should be capped.

Refrigerators and Freezers

1. Use "Flammable-Safe" refrigerators and freezers for storing flammable liquids.

2. Flammable-Safe refrigerators and freezers must have all electrical components located outside of the storage area.

3. Flammable-Safe refrigerators and freezers must be prominently marked “Safe Storage of Flammable Liquids”.

4. Flammable-Safe refrigerators and freezers must be UL labeled.

5. Explosion-Proof refrigerators and freezers must meet NFPA 45 9.2.2 requirements and 501 NFPA 70 for class I, division I and II locations and conditions.

6. Explosion-Proof refrigerators and freezers must be intrinsically safe and hard-wired.

7. Explosion-Proof refrigerators and freezers must be UL labeled and posted as “Explosion Proof”.

8. Consider purchasing refrigerators and freezers with alarms that will sound when temperatures drop below desired levels.

9. Consider purchasing refrigerators and freezers with corrosive resistant interiors and adjustable shelves.

Laboratory Equipment

In general, look for equipment that is UL approved and/or meets IEC standards (International Electro-technical Commission). Consider the size of equipment in proportion to your available space and needs. Look for equipment that includes safety features and data recording. Purchase equipment from reputable vendors and when possible, vendors that provide on-site training. Consider maintenance requirements before purchases and consider maintenance packages. If conditions warrant, consider intrinsically safe equipment.

Radionuclide Use

1. Radiation Protection and Instrumentation – Building Design Standard, Division 13 Section 49 00: http://fod.osu.edu/bds/div_13.pdf

2. Non-portable monitoring equipment and shielding (gamma or liquid scintillation counter). Both are dependent upon the type(s) of radionuclides used.

3. For information on non-medical X-ray devices and electron microscopes, go to: http://ehs.osu.edu/RadSafety/Xray.aspx

Centrifuges

1. A centrifuge should be UL approved and meet IEC standards (International Electro-technical Commission).

2. A centrifuge should have these basic features:
   (a) Lid with a latch
   (b) Interlock to prevent opening while spinning
   (c) Out of balance-automatic off switch
   (d) Over speed protection
   (e) Compatible rotor
   (f) The motor should have an overheat shut off feature

3. A centrifuge should be tested for containment in case of catastrophic failure.

4. A centrifuge should have a transparent lid.

5. A centrifuge should be made of an easy to clean material.

6. The drive shaft should be flexible and made of a carbon fiber for less fatigue and corrosion.

7. Remember that a brushless motor requires less maintenance.

8. When using biological materials, a centrifuge should have bio containment rotors and accessories certified by the Centre for Applied Microbiology and Research (CAMP). Accessories include safety cups or closed removal rotors.

9. When using biological materials, consider a centrifuge with a HEPA-filter.

10. Consider capacity, ease of use and startup time before a purchase.

11. Consider how much noise the centrifuge will make.

12. Consider the risk when using flammable materials in the centrifuge.

13. Consider electronic identification and controlled access software or traceable software.

14. Consider using disposable or single use consumables.

15. Consider using manufacturers that provide an inspection clinic by a technician along with initial training.

16. Be aware of rotor life management for the centrifuge.

Lasers

1. For information on lasers and laser safety, go to: http://ehs.osu.edu/RadSafety/LaserSP.aspx

Signage

University Signage Requirements

1. Interior Signs - Building Design Standards, Appendix S page 4: http://fod.osu.edu/bds/app_s.pdf

2. Ordering non-laboratory door signs – http://fod.osu.edu/services/index.htm

Laboratory Door Signs

1. All laboratories require door signs that include contact information and pertinent safety information. There should be one sign at each laboratory entrance. The signs should be located on the door or next to the door.

2. Order laboratory door signs: http://ehs.osu.edu/ServiceRequest/RoomSignRequest.aspx