

ENVIRONMENTAL HEALTH & SAFETY

UNIVERSITY *of* WASHINGTON

LABORATORY SAFETY DESIGN GUIDE

2014



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INTRODUCTION

The construction of laboratory facilities requires oversight. Regulatory requirements must be addressed and good practice must be considered. Laboratory facilities have architectural, space planning, HVAC, environmental control, and fire/life safety requirements not generally found in most types of construction.

UW Environmental Health & Safety Department (EH&S) has prepared and will maintain this guide to aid the campus community and project design teams with planning and design issues. The intent of this guide is to improve design efficiency and minimize changes in conjunction with EH&S plan review and consultation services.

The guide is a resource document to be used by design professionals during the planning, design and commissioning phases of a project. It is applicable to all facilities occupied by UW employees with an emphasis on those facilities that will be used as laboratory buildings, laboratory units, and laboratory work areas in which hazardous materials are used, handled and stored. The criterion in this guide represents the minimum requirement; more stringent requirements may be necessary depending on the specific laboratory and the type of research being completed.

This guide applies to both leased and owned buildings. Supplemental requirements for UW owned and operated buildings are also noted herein and in the UW Facilities Services Design Information Guide maintained by Campus Engineering and Operations.

SECTION 1: GENERAL REQUIREMENTS FOR LABORATORIES

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- A. Scope
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A. Scope

The primary objective in laboratory design should be to provide a safe, accessible environment for laboratory personnel to conduct their work. A secondary objective is to allow for maximum flexibility for safe research and teaching use. Therefore, health and safety hazards shall be anticipated and carefully evaluated so that protective measures can be incorporated into the design wherever possible. The requirements listed below illustrate some of the basic health and safety design features required for new and remodeled laboratories. Variations from these guidelines require approval from the Environmental Health & Safety Department (EH&S).

B. Building Design Issues

Because the handling and storage of hazardous materials inherently carries a high risk of exposure and injury, segregate laboratory and non-laboratory activities to the extent possible.

1. Noncombustible construction is preferred.
2. Offices should be separated from laboratories.
3. An automatically triggered main gas shutoff valve for the building should be provided to cut off the natural gas service in a seismic event.

C. Laboratory Design Considerations

1. The laboratory shall be bound by four walls and a roof or ceiling.
2. Design for adjacent spaces for storage and consumption of food and drink as needed.
3. Design laboratory workstations to accommodate the range of body dimensions that may be using the workstations. For example, computer and microscopes workstations may require height-adjustable work surfaces and chairs.
4. Each laboratory using hazardous materials, whether chemical, biological, or radioactive, should contain a sink for hand washing.
5. All work surfaces (e.g., bench tops, counters, etc.) should be impervious to the chemicals and materials used in the laboratory.
6. The laboratory shall be designed so that it can be easily cleaned. Bench tops should be of a seamless one-piece design to prevent contamination. Penetrations for

electrical, plumbing, and other considerations should be completely and permanently sealed. If the bench top abuts a wall, it should be covered or have a backsplash against the wall.

7. The walls shall be non-porous and painted with a durable, impervious finish to facilitate decontamination and cleaning. High gloss paint is recommended.
8. Provide shelf lips for seismic restraint. Lips should be $\frac{3}{4}$ inch above the shelf surface for bookshelves and 1 $\frac{1}{2}$ " inches above the shelf surface for shelves used to store breakable containers, chemicals, or other hazardous materials.
9. Refer to Chapter 11 of the Guide for design considerations for spaces containing Class 3B or 4 Lasers. Design consideration for spaces containing other sources of non-ionizing radiation (radio-frequency, microwave, ultraviolet, etc.) and large magnetic fields can also be found in Chapter 11 of the Guide.

D. Building Requirements

1. Building Occupancy Classification and Control Areas— Occupancy classification and control areas should be based upon an assessment of the projected chemical inventory of the building. Most teaching and research buildings should not require an H occupancy classification; however, individual H occupancy rooms may be necessary.
2. Facilities using radioactive materials may need to be approved by the State of Washington Department of Health and a Notice of Construction (NOC) may need to be filed with the DOH, depending on what air emission calculations reveal. Please contact the UW Radiation Safety Office to determine if this will be required.

E. Hazardous Materials Design Issues

1. Facilities shall be designed so that use of a respirator is not required for normal operations.
2. There must be adequate in-laboratory storage cabinets to store reagents and chemicals and to provide segregation of incompatible materials. Storage design should be based on projected quantities and waste management practices.
3. The laboratory shall have a means of securing specifically regulated materials such as controlled substances regulated by the Drug Enforcement Administration and radioactive materials, select agents, etc. (i.e., lockable doors, lockable cabinets etc.), where applicable.
4. See Chapters 5 and 6 of the Guide for additional requirements for compressed gas storage and hazardous materials cabinets.

5. Please see Chapter 9 of the Guide for additional requirements for laboratories using radioactive material. Please see Chapter 10 of the Guide for additional requirements for spaces containing large sources of radiation.

F. Entries, Exits, and Aisle Width

1. Self-closing laboratory doors should be operable with a minimum of effort to allow access and egress for physically challenged individuals. A minimum of a 36-inch-wide door should be provided to facilitate equipment movement.
2. Laboratory benches, laboratory equipment and other furniture or obstacles shall not be placed so that there is less than five feet of clear egress within the laboratory.
3. Laboratory doors that separate laboratory areas from non-laboratory areas are to be automatically self-closing.
4. Corridors should not be less than 6 feet wide to allow for movement of large equipment and allow for circulation of materials on carts, etc.
5. Common corridors shall not be programmed for laboratory operations. For more information on use of corridors see the [Corridor Policy Focus Sheet](#).
6. Equipment corridors shall be provided with a system designed to allow for securing equipment to prevent movement during an earthquake.

G. Electrical and Utility Issues

1. Electrical receptacles above counter tops within six feet of sinks, safety showers, or other sources of water, should have GFCI circuit protection
2. Laboratories shall be provided with light fixture on emergency power at the entrance/exit door. Hallway and corridor emergency light shall be provided based on the local code requirements.
3. New requirements found in the International Fuel Gas Code (IFGC) state emergency shutoff valves for natural gas lines shall be located INSIDE the lab, adjacent to the egress door. The valve shall be located behind an access panel (similar to a medical gas system) and labeled "GAS SHUTOFF". Consideration should be given to locating valves at a height that allows easy access and operation without becoming blocked.
4. Flexible connections shall be used for connecting gas and other plumbed utilities to any freestanding device where rupture of the supply, return, exhaust or vent line could pose a hazard.

SECTION 2: ENVIRONMENTAL REQUIREMENTS

Contents

- A. Scope
- B. General Environmental Design Criteria
- C. Demolition
- D. Regulated Building Materials

A. Scope

This section presents general guidance to ensure a consistent approach to meeting environmental regulations associated with construction and renovation projects (UW owned and Non-UW owned).

EH&S maintains more specific criteria and updated requirements on its website at www.ehs.washington.edu. Please visit the website to ensure all requirements have been met.

It should be noted that under certain circumstances issues may not apply to non-UW owned properties and should be evaluated on a case-by-case basis through consultation with EH&S.

B. General Environmental Design Criteria

1. Air pollution: Installation of fuel-burning equipment and air-pollution-control equipment (spray paint booths, baghouses, etc.) may require an air permit prior to installation. EH&S and the Puget Sound Clean Air Agency web site at <http://www.pscleanair.org> should be consulted.
2. Laboratories that will be completely or partially vacated due to construction/renovation activities must be adequately cleaned during the process of decommissioning to ensure worker safety.
3. All sources of ionizing radiation are subject to state and federal regulations. The proper management of radioactive materials is required to ensure continued worker safety.
4. Storm water management: Storm water runoff generated by construction and/or renovation activities can degrade surface water quality. Storm water management requirements that are applicable to projects discharging into the City of Seattle storm water system may differ from those associated with projects discharging into the UW storm water system. More information is available on the [EH&S website](#).
5. Underground storage tanks: Underground storage tank systems can threaten the environment and pose a long-term liability for the UW.
6. Other environmental issues: Additional environmental issues will be incorporated into the EH&S website as they are identified.

C. Demolition

1. Hazardous wastes must be handled, stored, and disposed of in accordance with all applicable University, state, and federal environmental requirements. The EH&S Environmental Programs Office will determine proper waste disposal procedures on behalf of the UW and arrange for disposal. Waste determination may require sampling and analysis, and may take several weeks for receipt of the necessary analytical data

and final disposal facility approval for shipment offsite. The Project Manager is responsible to ensure waste is properly stored during this time. Hazardous wastes cannot be transported off UW property without a Uniform Hazardous Waste Manifest signed by a UW EH&S Environmental Programs Office representative.

2. Site contamination: Performing construction in areas of known site contamination is likely to increase project costs significantly. The discovery of suspected environmental contamination during construction activities may require follow-up environmental investigation and reporting. The EH&S website should be consulted for a listing of all UW-owned sites known to be or suspected to be contaminated, and for other requirements associated with site contamination. Documents applicable to construction/renovation projects in the vicinity of the former Montlake landfill include: "The Montlake Landfill Management Plan"; "The UW Maintenance Plan for Sports Fields, Roads and Parking Areas in East Campus"; and "The Montlake Landfill Information Summary", dated January 1999. These documents, available via UW EH&S, should also be consulted prior to project design.

D. Regulated Building Materials

1. All construction/renovation projects, including those occurring within new buildings or newly renovated areas, must be inspected to identify asbestos-containing materials (ACM), which could be impacted during construction/renovation. With limited exceptions, contract documents shall include abatement of all ACM, since there is a reasonable expectation that they will to be disturbed by construction/renovation activities. When inspecting for asbestos or preparing abatement contract documents, specific consideration shall be given to areas which may be impacted outside the immediate renovation/construction area, nearby restricted access areas, and abatement phasing requirements. The EH&S website should be consulted for these and other asbestos-related requirements and guidance.
2. EH&S maintains restricted access reports identifying areas of asbestos contamination. Construction/renovation within or adjacent to these areas may require the implementation of enhanced safety precautions. Restricted access reports are available on the [EH&S website](#).
3. Historical asbestos survey reports have been compiled on some University buildings. These survey reports are available for review via the Facilities Services Records Department.
4. Depending on work practices, lead-containing materials have the potential to adversely impact the health of construction workers and others located adjacent to the work area. Depending on lead concentrations and final waste streams, lead-containing materials may be designated as a hazardous waste when disposed.

5. The production, use, and handling of ozone-depleting substances (e.g., CFC-refrigerants and HCFC-refrigerants) are regulated by federal regulation 40 of the CFR Part 82. Pursuant to this regulation, CFC-refrigerants are no longer being manufactured, thereby encouraging the production and use of refrigerants that have a lower tendency to deplete atmospheric ozone. In addition, US Environmental Protection Agency (EPA) regulations prohibit individuals from knowingly venting ozone-depleting compounds used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of refrigeration equipment. More information is available on the EH&S website.

6. PCB-containing materials: Oil-filled electrical equipment (transformers, bushings, capacitors, cooling and insulating fluids, contaminated soil, etc.) poses a long-term liability to the UW due to Washington State Department of Ecology and EPA regulation. These agencies have extensive requirements for waste labeling, handling, marking, storage, contingency planning, staff training, manifesting, transportation and disposal. The EH&S Environmental Programs Office will determine proper waste disposal procedures on behalf of the UW and arrange for disposal through the appropriate agencies. More information can be found on the EH&S website.

SECTION 3: LABORATORY VENTILATION

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- A. Scope
- B. General Laboratory Ventilation
- C. Fume Hood Exhaust System Design Criteria (FHES)
- D. Fume Hood Exhaust System Testing
- E. Local Exhaust Ventilation
- F. Laboratory Design References

A. Scope

The purpose of laboratory ventilation is to help provide a safe and comfortable environment that facilitates scientific research and teaching. The expectation is that the design team will provide a combination of general laboratory ventilation, fume hoods, and other local exhaust ventilation (LEV), to contain emissions within the laboratory, depending on the specific needs of the laboratory. This guide provides minimum requirements; more stringent requirements may be necessary depending on the specific laboratory function or contaminants generated.

B. General Laboratory Ventilation

1. All laboratories shall have mechanical ventilation.
2. All laboratory rooms shall use 100% outside air and exhaust to the outside.
 - a. Using Class I air, as defined by ASHRAE 62.1, as make up air for laboratories will be considered as an exception on a case by case basis.
3. Design the air change rate for each laboratory room to provide the following:
 - a. Adequate make-up air for LEV including fume hoods and bio-safety cabinets.
 - b. Adequate tempering for personal comfort and laboratory requirements
4. Document designed air change rate (ACH) for each laboratory space.
5. Document how the design, including location of supply diffusers, exhaust grilles, and LEV optimizes ventilation effectiveness, including the capture and removal of emissions and mixing of air. Refer to "Determination of Laboratory Airflow Rates" to better understand the University's expectations.
6. Combined general and fume hood exhaust systems are preferred where their application can provide reduced cost and energy use without compromising safety or system integrity. The following should be included unless alternate design strategies are approved:
 - a. Use 316 stainless steel duct material except for general exhaust branch upstream of the combined duct
 - b. Use pressure independent air terminal units for balancing as needed

*For clarification, see RWDI/ECT paper "Combined General and Fume Hood Exhaust and Duct Velocities"
7. Fume hoods should not be the sole means of room air exhaust.
8. Provide excess capacity for equipment aging and future expansion.

9. Design for noise levels of 55 dBA or less.
10. Do not provide operable windows.
11. Direction of airflow should be from low hazard to high hazard areas.
12. Design to maintain negative pressure relative to adjacent non-lab areas. Provide an offset of 10% or 100 cfm per door to the corridor – whichever is greater.
13. Provide adequate makeup air (90% of the exhaust).
14. Locate casework and equipment so as not to interfere with ventilation.
15. Choose location, type, and number of supply air diffusers so as not to compromise performance of fume hoods or other LEV. See RWDI/ECT paper: Laboratory Airflow Distribution. Do not line duct with insulation.
16. Ventilate and alarm cold rooms meant for human occupancy.

C. Fume Hood Exhaust System Design Criteria (FHES)

1. Design to incorporate user needs, room configuration and general ventilation.
2. The FHES shall contain and remove fumes generated within the hood.
3. Design with adequate space for hood service and utility connections.
4. Constant volume and variable volume systems are acceptable.
5. Design VAV diversity, typically 80%, around needs and practices of facility.
6. Locate hoods per guidelines provided in RWDI/ECT paper including:
 - a. At the back of labs or in alcoves
 - b. At least 3 feet from obstructions such as large equipment or columns
 - c. At least 4 feet from adjacent doorways and main traffic aisles
 - d. At least 5 feet between fume hoods that face each other
 - e. At an adequate distance from diffusers to prevent significant cross-drafts
7. For perchloric FHES, provide dedicated fan, duct and wash-down system.
8. Locate perchloric hood on building's top floor to minimize duct.
9. For radioisotope FEHS, provide a dedicated fan and duct.

10. For acid digestion, FEHS must be made of fiberglass reinforced plastic or material with similar acid resistance.
11. FHES for research shall not have local on/off or high/low control.
12. Under hood storage units shall comply with Chapter 6 of this Design Guide.
13. Ductless hoods are not permitted. Exceptions may be granted for single-process applications if approved by EH&S.
14. Design face velocities for a target sash height of 18 inches
15. For standard FHES, provide a face velocity of 100 fpm +/- 10%.
16. For low velocity FHES, provide a face velocity of 70 fpm +/- 10%
17. Design for noise levels of 65 dBA or less measured per ANSI S1.4-1971 at a point three foot in front of the sash at a height of five feet from the floor.
18. Provide constant volume (CV) hoods with an air bypass that limits the maximum face velocity to 300 lfm at a sash height of 6 inches.
19. Provide variable air volume (VAV) hoods with an exhaust minimum of 25 cfm/ft² of work surface area through air bypass.
20. Locate controls for hood utilities outside the hood
21. Hood lighting and other fixed electrical equipment within the hood shall be explosion proof.
22. Light fixture lamps shall be accessible from outside the hood.
23. For cup sinks, choose model with lip at least ¼ inch above the work surface.
24. Provide each fume hood with an audible and visible alarm that activate whenever the face velocity drops below 80 lfm for standard hoods and 56 fpm for low velocity hoods.
25. Equip water faucets with a vacuum breaker located outside the hood.
26. If this is not a University owned facility, see Appendix A for further design details of the FHES. If it is a University owned facility, refer to the Facilities Services Design Guide (FSDG).

D. Fume Hood Exhaust System Testing

1. Measure FHES face velocities per ASHRAE 110 part 6.
2. Provide information on instrumentation including calibration dates and results.
3. Measure the velocity of cross drafts.
4. Calibrate monitor, set and test low alarm, verify monitor is tracking correctly.
5. Once criteria above are met, provide test results to EH&S.
6. After review of test results, EH&S will test the hood to confirm adequate performance, label it appropriately, and approve for use.
7. If this is not a University owned facility, see Appendix A for testing details of the FHES ducts. If it is a University owned facility, refer to the FSDG.

E. Local Exhaust Ventilation

1. Design local exhaust ventilation (LEV) systems per ACGIH Industrial Ventilation Manual or other professionally recognized design criteria.

F. Laboratory Design References

1. [Determination of Laboratory Airflow Rates](#) (PDF)
2. [Combined General and Fume Hood Exhaust](#) (PDF)
3. [Laboratory Airflow Distribution](#) (PDF)
4. [Modeling for External Exhaust Systems](#) (PDF)
5. [Use of Computational Fluid Dynamics for Laboratory Airflows](#) (PDF)
6. [Ventilation Noise](#) (PDF)

SECTION 4: EMERGENCY EYEWASH AND SAFETY SHOWER EQUIPMENT

Contents

- A. Scope
- B. Applications
- C. Equipment Requirements
- D. Testing and Commissioning
- E. References

A. Scope

This guide presents the minimum performance requirements for emergency washing equipment. It covers the following types of equipment: emergency showers, eyewash equipment, and combination shower and eyewash or eye/face wash. Most of the requirements were taken directly from the Washington Administrative Code (WAC) 296-800-150 with supporting information from American National Standards Institute (ANSI) Z358.1-2009 and a directive from the Washington State Department of Labor & Industries (L&I); these references are provided at the end of this chapter.

B. Applications

1. Emergency washing equipment (EWE) is required to provide an immediate and local method of decontamination following an exposure to exposure to a hazardous chemical. Emergency showers can also be used to effectively extinguish clothing fires and flush contaminants off clothing.
2. EWE is required in areas where the following types of chemicals are used:
 - a. Corrosives, including acids and caustics, with a pH less than 2.5 or greater than 11.
 - b. Strong irritants that cause inflammatory effects at point of contact.
 - c. Toxic chemicals that can be absorbed through the skin and cause ill health effects.
3. EWE is also required in BSL-2 and BSL-3 biological laboratories per the CDC/NIH publication Biosafety in Microbiological and Biomedical Laboratories (BMBL), 5th edition.
4. EWE should also be installed where particulate is common that can injure the eyes.
5. Eyewash equipment is required wherever eyes may be exposed to the agents noted above. Use of personal protective equipment (PPE) such as safety glasses or face shields, though an important safeguard, does not substitute for the eyewash requirement.
6. Emergency showers are required if there is a potential for substantial portions of the body to come into contact with the types of chemicals noted above. UW EH&S interprets this to mean areas where the container size is greater than 1 gallon and chemical transfer, mixing, or spraying takes place. PPE such as aprons and gloves, though an important safeguard, does not substitute for the shower requirement.
7. Typical areas on the University campus where EWE is needed include the following:

- a. Laboratories where chemicals or infectious biological agents are used.
 - b. Areas where chemical transfer or mixing take place, including laboratory support spaces, shops, janitor's closets, the power plant, and mechanical rooms
 - c. Areas with closed systems, particularly those under pressure, that can catastrophically fail and cause the chemicals to leak including the power plant, shops, and mechanical rooms.
 - d. Waste accumulation areas.
 - e. Areas where there is a potential for the eyes to be exposed to physical hazards such as chips or dust from sanding or grinding processes including shops and mechanical spaces.
8. Location requirements of EWE
- a. The travel time required from potential exposure sites to EWE must be within 10 seconds. UW EH&S uses a requirement of not more than 50 feet walking distance for design review purposes.
 - b. The pathway from potential exposure sites to EWE must be free from obstructions. UW EH&S interprets this to be a clear path without physical obstacles; the need to pass through one door that does not require a key to pass through, swings in the direction of travel, and is equipped with a panic bar is acceptable.
 - c. Locating showers in the hallway has the advantage of serving multiple labs as long as the requirements of 8b are met.
 - d. If there is a potential for showers to be activated maliciously, locate them within the security of a laboratory room or, if located in the hallway, provide shower stall units complete with sloped floor or pan, plumbed drain and privacy curtain.
 - e. Avoid installing telephones, thermostats, or power receptacles within six feet of the shower. If receptacles are necessary within six feet, they should be equipped with ground fault circuit interruption (GFCI).

C. Equipment Requirements

1. A plumbed eyewash, shower, or combination unit, meeting the specifications of the most recent edition of ANSI Z358.1-2004 shall be provided. Drench hoses may be useful in some applications but do not substitute for showers or eyewashes. A portable non-plumbed eyewash unit may be approved if the location does not have plumbing.
2. Eyewashes shall be equipped with a drain to facilitate use during an emergency and complying with the weekly testing requirement.
3. EWE should be connected to potable water. Verify through the choice of the unit that the water supply cannot be contaminated through back pressure. For purposes of this

chapter, the water source is considered to be potable water if it is served by the building domestic water or by a separate line connected directly to the city supply into the building. This is in contrast to lab water or industrial water that serves the laboratory sinks or utility equipment.

4. Showers and eyewash units must be plumbed with tempered water per Section 416.2 of the 2012 Uniform Plumbing Code. Choose mixing valves specifically designed for EWE and set them to 90°F. Minimize the length of tempered water lines where reasonable to do so.
5. To encourage shower use and prevent flooding, EH&S strongly recommends selecting showers with stalls equipped with sloped floor or shower pan, plumbed drain, and privacy curtain; this is particularly critical in corridors or other public or common areas where malicious activation of the shower has caused significant flood damage.
6. Consider installing opaque modesty curtains for all safety showers to facilitate removal of contaminated clothing during the shower.
7. Swing-down or swing-over eyewashes that drain into a sink are preferred. Hose units are allowed but the pedestal location must be within 12 inches of the front edge of the bench or sink to facilitate hands-free use while the eyewash remains in the pedestal, AND contamination through back pressure must be prevented if connected to PW.
8. If the eyewash is mounted near a sink, detail the eyewash placement and connection to verify that it will drain into the sink. This is not an issue if specifying a faucet that has an integrated eyewash unit, but be aware that some of these units do not meet ANSI Z358.1-2004 requirements and will not be approved; the Speakman SEF-1800 Eyesaver Faucet is one unit that does meet the ANSI requirements.
9. For BSL-3 applications, locate the eyewash in the BSL-3 laboratory.
10. Specify equipment that meets ANSI Z358.1-2004
11. Specify performance requirements, including those in ANSI Z38.1-2009 pertaining to flow rate etc., as necessary to ensure that the contractor understands the requirements for conditions they will be responsible to provide.

D. Testing and Commissioning

1. The contractor to confirm units perform per ANSI A358.1-2009 for conditions they are responsible to provide. Most manufacturers can provide a checklist of these requirements.

2. Provide a report to the owner as a condition of substantial completion that documents all units have been tested and perform per ANSI A358.1-2009.
3. Provide a service label on all units for use by University Facilities when completing scheduled testing and service.

E. References

1. WAC 296-800-15030: Make sure emergency washing facilities are functional and readily accessible
2. ANSI Z358.1-2009: American National Standard for Emergency Eyewash and Shower Equipment
3. DOSH Directive 13.00: Emergency Washing Facilities, July 15, 2011. Washington State Department of Labor and Industries (L&I) Division of Occupational Safety and Health.

SECTION 5: COMPRESSED GAS & CRYOGENIC COMPONENTS AND SYSTEMS

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- A. Scope
- B. Compressed Gas Cylinder in Laboratories
- C. Compressed Gas Storage Areas
- D. Compressed Gas Manifolds
- E. Compressed Gas Cylinder Restraint
- F. Requirements for Gas Cabinets storing Toxic and Highly Toxic Gases

A. Scope

This Design Guide applies to all facilities, including leased properties. It covers all unfired pressure vessels (i.e., storage tanks, compressed-gas cylinders) that have been designed to operate at pressures above 15 psi, including the storage and use of compressed-gas cylinders and cryogenic fluids. This does not cover utilities (i.e., “house air”). Most of the requirements were taken directly from the International Fire Code, as adopted by Seattle/Washington State, with supporting information from the National Fire Protection Association.

B. Compressed Gas Cylinder in Laboratories

1. Cylinders in laboratories should generally be limited to those in use. Cylinders connected through a regulator or manifold to deliver gas to a laboratory operation, and a single cylinder located alongside, are considered to be in use. Other cylinders should be located in compressed gas storage areas.
2. Provisions should be made for segregation of cylinders of incompatible gases as outlined in the International Fire Code.
3. See requirements for highly toxic gases below in Section F.

C. Compressed Gas Storage Areas

1. A compressed gas storage area(s) meeting the requirements of applicable codes and standards for fire separation, ventilation, restraint and separation of incompatibles should be provided in the building or an appropriate outdoor location to provide sufficient back up supply and empty cylinder storage for users. Separate space for full and empty cylinders is preferred.
2. Emergency power shall be provided for “H” occupancy gas storage rooms, gas-cabinet exhaust ventilation, gas-detection systems, emergency alarm systems, and temperature control systems.
3. Storage areas shall be secured against unauthorized entry.
4. Rooms with large volumes of cryogenics shall be provided with effective ventilation to mitigate risk in the event of a spill or release. If not practical oxygen alarms should be provided if determined necessary through a risk assessment. The EH&S website has additional information on Liquid Nitrogen and Low Oxygen Alarms.

D. Compressed Gas Manifolds

1. Where a laboratory operation is projected to use a significant amount of compressed gas and it is not feasible to provide through a fixed tank, a compressed gas storage area and manifold system should be provided at dedicated room such as a ventilated closet, separate from the laboratory and accessible from common space such as a hallway. Depending upon the material the room may need to be classified as an “H” occupancy.

E. Compressed Gas Cylinder Restraint

1. Approved storage racks (e.g., Unistrut, pipe racks) shall be provided that adequately secure gas cylinders by chains, metal straps, or other approved materials, to prevent cylinders from falling or being knocked over. Chains are preferable to straps. Straps shall be non-combustible.
2. In laboratories, cylinder restraints shall be sufficient to prevent cylinders from tipping over using double chains/straps one-third and two-thirds the height of the cylinder.
3. Chain/strap restraints shall be used to restrain a maximum of three cylinders per chain/strap or per set of chains/straps (if double-chained/strapped).
4. Gas-cylinder securing systems should be anchored to a permanent building member or fixture. This connection is needed to prevent movement during a seismic event.

F. Requirements for Gas Cabinets storing Toxic and Highly Toxic Gases

1. Storage and use of toxic and highly toxic compressed-gas cylinders shall be within exhaust-ventilated gas storage cabinets, laboratory fume hoods, exhausted enclosures, or separate ventilated gas storage rooms without other occupancy or use. It is acceptable to mount lecture bottles connected to a manifold in a fume hood.
2. Gas cabinets shall be connected to a dedicated or fume hood exhaust system.
3. Gas cabinets shall be approved and constructed to meet the requirements of the International Fire Code.
4. Gas cabinets should be fitted with an airflow monitor.

SECTION 6: HAZARDOUS MATERIALS STORAGE CABINETS

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- A. Scope
- B. Approvals and Listings
- C. Design
- D. Venting Hazardous Materials Storage Cabinets
- E. General Installation Requirements

A. Scope

This section of the Design Guide applies to the design, construction, and installation of hazardous materials storage cabinets. Most of the requirements were taken directly from the International Fire Code, as adopted by Seattle/Washington State, with supporting information from the National Fire Protection Association.

B. Approvals and Listings

1. Storage cabinets shall be UL listed for their intended use.

C. Design

1. Laboratories that store, use or handle more than five gallons of flammable or combustible liquids shall have one or more flammable liquid storage cabinets so that the code provision for doubling the maximum allowable quantity may be applied.
2. Provide corrosive and other listed cabinets as necessary to allow for segregation of incompatibles. Information on incompatible materials may be found here.
3. Total hazardous material storage capacities in a control area must consider fire code maximum allowable quantities.

D. Venting Hazardous Materials Storage Cabinets

1. Corrosive material storage cabinets, including those built into laboratory casework, should be vented. If built into laboratory casework, they should vent directly into the fume-hood plenum behind the baffle.
2. Flammable liquid cabinets should not be vented as doing so may compromise the cabinet's fire-resistance performance during a fire. If a flammable liquid storage cabinet is ventilated, then it shall be connected through the lower bung opening to an exterior exhaust in such a manner that the specified performance or UL listing of the cabinet is not compromised. A flash arrester screen provided by the manufacturer with the cabinet shall replace the other bung. Exhaust vent materials for hazardous materials cabinets shall be compatible with cabinet contents. Vent materials for flammable liquid storage cabinets shall be resistant to high temperatures generated in a fire. Stainless steel, hard-soldered copper, and carbon-steel are all appropriate vent materials for flammable storage cabinets, provided the chosen material is compatible with the intended service. Non-metallic duct shall not be used to vent flammable storage cabinets.
3. Compatible non-metallic duct material, such as PVC, can be used for acid- or corrosive-material storage cabinet service. Polypropylene is not appropriate vent duct material, since it is combustible.

4. Flammable cabinets built into laboratory casework are not to be vented into the fume-hood exhaust system. No acceptable method of doing this has been identified.
5. Class 1 flammable liquids stored in basements must be kept in vented flammable liquid cabinets. Please consult with EH&S to ensure conformance with this Administrative Rule.
6. If the cabinet is not vented, then it shall be sealed with the bungs supplied by the manufacturer.
7. Toxic material storage cabinets, when used to store highly toxic materials in excess of an exempt amount, shall be vented in a manner similar to flammable liquid storage cabinets.

E. General Installation Requirements

1. Flammable liquid storage cabinets shall not be located near exit doorways, stairways, or in locations that would impede leaving the area.
2. Flammable liquid storage cabinets shall not be wall-mounted. Wall-mounted cabinets are not UL listed or FM approved. The mounting could breach the fire-resistant integrity of the cabinet.
3. Flammable and toxic/corrosive liquid storage cabinets shall be seismically anchored to prevent spillage of contents.

SECTION 7: BIO-SAFETY LABORATORIES

Contents

- A. Scope
- B. Basic Laboratory Design for Bio-Safety Level 1
- C. Basic Laboratory Design for Bio-Safety Level 2
- D. Basic Laboratory Design for Bio-Safety Level 3
- E. Biological Safety Cabinets
- F. Bag In/Bag Out Unit Detail
- G. Bio Safety Cabinet Duct Connection Detail

A. Scope

The majority of the criteria presented in this chapter are taken from Biosafety in Microbiological and Biomedical Laboratories (BMBL), 5th Edition authored by the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH). The criteria presented in this chapter are for general-use Biosafety Containment Levels 1, 2, and 3 for biological research laboratories. If vertebrate animals are involved in research with bio-hazardous materials, requirements of animal biosafety laboratories (ABSL), also provided in the BMBL, will apply as well. Furthermore, this chapter does not include Appendix G and Q of the NIH Guidelines for Recombinant DNA research which apply if recombinant DNA research will be performed in the laboratory.

B. Basic Laboratory Design for Bio-Safety Level 1

1. Each laboratory should have doors to control access.
2. Each laboratory must have a sink for hand washing.
3. The laboratories should be designed for easy cleaning.
 - a. Carpets and rugs shall not be used.
 - b. Spaces between furniture and equipment should be accessible for cleaning.
 - c. Furniture must be covered with a non-porous material for easy cleaning.
4. Laboratory Furniture must be capable of supporting anticipated loads and uses.
5. Bench tops shall be impervious to water, and resistant to acids, alkalis, organic solvents and moderate heat.
6. Approved methods for decontamination of infectious or regulated laboratory wastes shall be available (e.g., autoclave, chemical disinfection or other decontamination procedure approved by the University Biosafety Officer (BSO) or designee).
7. Windows shall be fixed and not operable unless existing condition requires them to open for ventilation. If operable, they must be fitted with screens.

C. Basic Laboratory Design for Bio-Safety Level 2

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

1. Doors should be self-closing and have locks in accordance with institutional policies.
2. The sink for hand washing should be located near the exit door.

3. Vacuum lines should be protected with High Efficiency Particulate Air (HEPA) filters. The preferred location of the HEPA filter is in the lab so as to minimize contamination of vacuum lines. If managed by lab ensure system design supports this approach.
4. An eyewash station must be readily available. See Chapter 4 for design details.
5. An approved method for decontaminating all laboratory wastes should be available in the facility. Optimize location to minimize travel distance for users.

D. Basic Laboratory Design for Bio-Safety Level 3

In addition to the requirements for a BSL 2 laboratory, the following are required.

1. The lab must be separated from areas that are open to unrestricted traffic flow within the building.
2. Doors must be self-closing and have locks in accordance with institutional policies.
3. Security systems shall be used to control access to the laboratory.
4. Access is restricted to entry by a series of two self-closing doors. The space between the two sets of doors can be used as an anteroom.
5. The sink for hand washing must be hands-free or automatically operated, and should be located near exit door.
6. Floors must be slip resistant, impervious to liquids, and resistant to chemicals. Consider the installation of seamless, sealed, resilient or poured floors, with integral cove base.
7. Walls should be constructed to produce a sealed smooth finish that can be easily cleaned and decontaminated.
8. Ceilings should be constructed, sealed, and finished in the same manner as walls.
9. All windows must be sealed.
10. Vacuum lines must be protected with High Efficiency Particulate Air (HEPA) filters. The preferred location of the HEPA filter is in the lab so as to minimize contamination of vacuum lines. If managed by lab ensure system design supports this approach.
11. An eyewash station must be readily available in the laboratory.

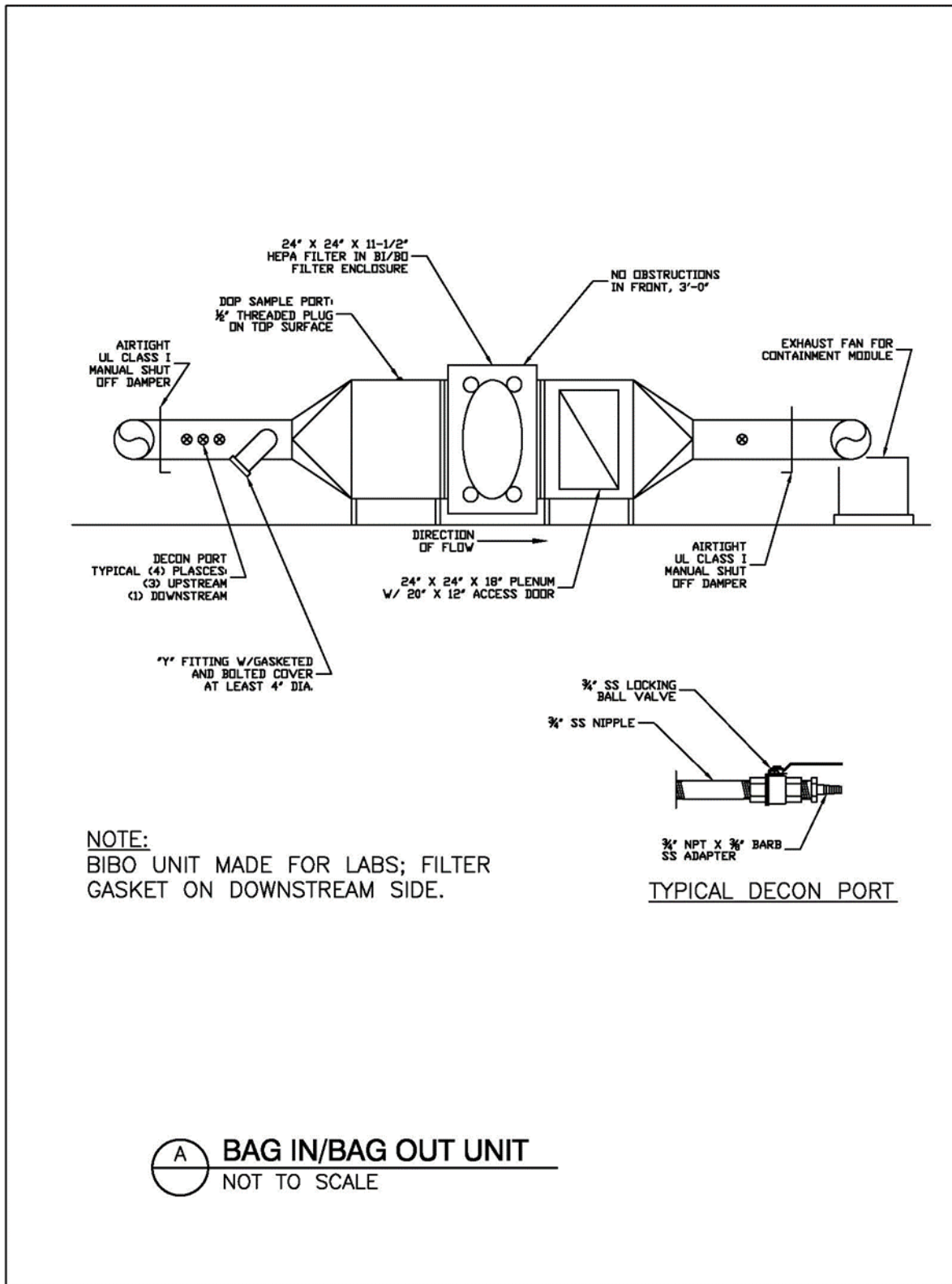
12. A fully ducted supply and exhaust air ventilation system is required. This system must provide sustained directional airflow from “clean” areas toward potentially contaminated areas. The system shall be designed so that under failure conditions, the airflow will not be reversed. In addition, the system must provide the following:
 - a. Laboratory personnel must be able to verify direction of air flow by means of a visual monitoring device at the laboratory entry. Audible alarms should be considered to notify personnel of air flow disruption.
 - b. Exhaust air must not re-circulate to any other areas of the building and the exhaust system should be dedicated to serve only the BSL-3.
 - c. Exhaust air including that of the anteroom must be HEPA filtered through a BIBO.
 - i. BIBO unit must be designed to facilitate decontamination with our in-house unit. For a schematic drawing of port locations and details see Figure A at the end of this chapter.
 - ii. Access to BIBO filter housings must be designed to allow scanning of the filters. If the BIBO unit is designed to have 2 banks of filters, side by side, access to both sides must be provided. A scanning rack should be included on larger models.
13. All Class II A2 BSCs shall have a thimble connection.
14. An approved method for decontaminating all laboratory wastes should be available in the facility, preferably within the laboratory.
15. Equipment that may produce infectious aerosols must be contained in devices that exhaust air through HEPA filtration before discharge into the laboratory. The HEPA filters should be tested and/or replaced annually.
16. Consider means of decontaminating large pieces of equipment before removal from the laboratory.
17. Enhanced design features may be required based upon specific research planned or funding conditions for the BSL3 in question. The enhancements may include one or more of the following; an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas tight dampers to facilitate laboratory isolation; laboratory effluent decontamination; advanced access control devices such as biometrics, fan redundancy, emergency power for HVAC, and specific room finishes.
18. The BSL-3 facility must be commissioned to include visual inspection and performance testing to verify that design and operational parameters have been met before research may begin. Facility performance must be re-verified and documented at least annually.

E. Biological Safety Cabinets

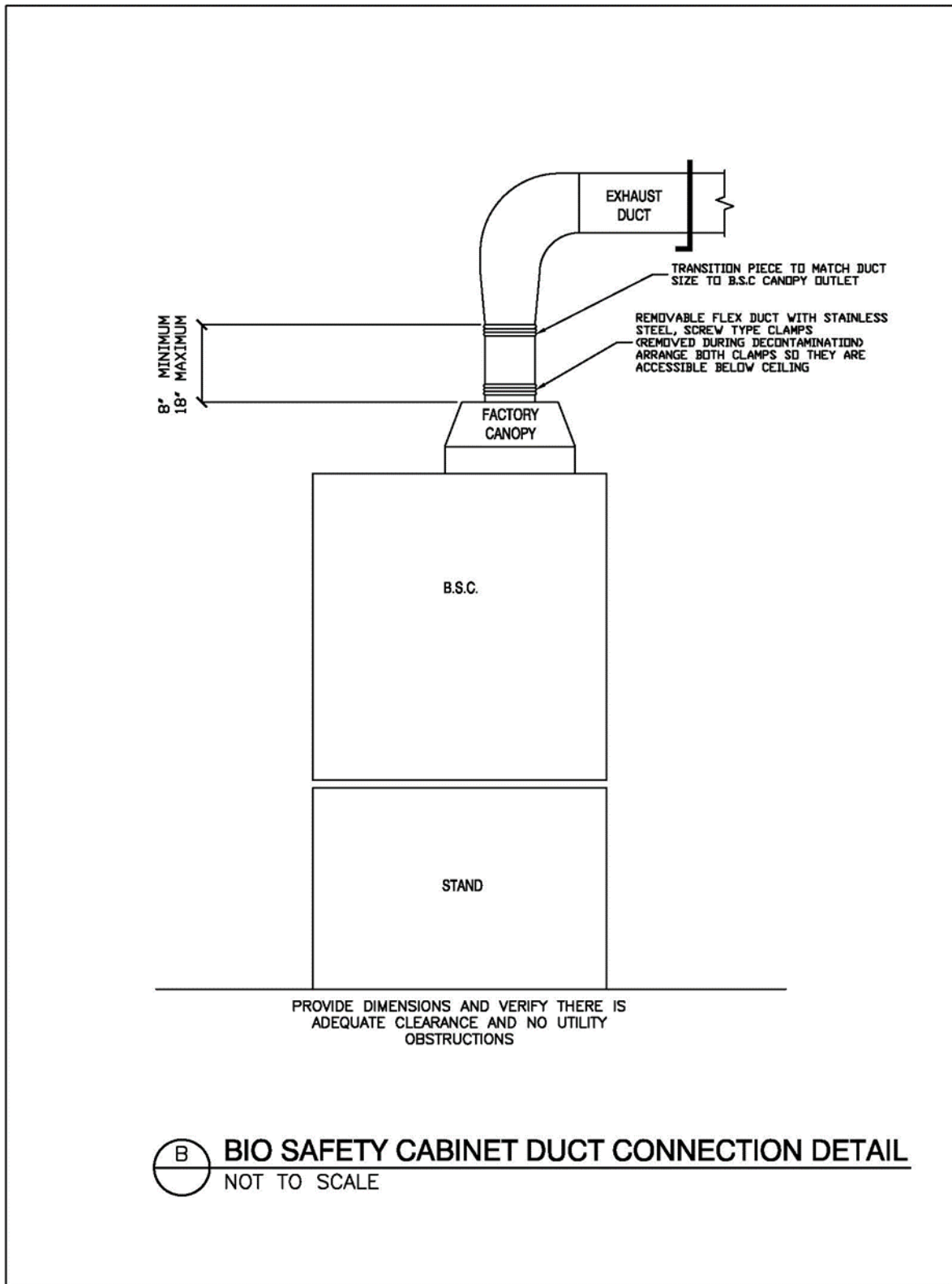
1. See the [Biological Safety Cabinets](#) webpage for information concerning BSC selection, location, procurement and certification.
2. Locate the biological safety cabinets (BSC) away from doors, operable windows, high-traffic, ventilation diffusers and other possible airflow disruptions; use a guideline of six feet of separation.
3. Provide a minimum of six feet of clearance between BSCs installed directly opposite another.
4. Do NOT plumb the BSCs with natural gas.
5. Design Biological Safety Cabinets (BSC) to be installed as follows:
 - a. Class II, Type A2 BSC may need to be connected to the general exhaust system via a thimble connection depending on chemical use. This determination is best made through discussions with EH&S early in the design process. If required, the thimble will be provided by the BSC manufacturer and installed per manufacturer's instructions and exhausted per Figure B at the end of this chapter.
 - b. Class II Type B2 BSC shall be directly (hard) connected to a dedicated exhaust system.
 - c. Class II Type B BSCs shall be interlocked with the exhaust fan so they shut down and alarm in the event of an exhaust fan/system failure.
 - d. Class II Type B BSC exhaust shall be provided with a gas-tight valve that is accessible from the front or side of the cabinet; the purpose of this valve is to facilitate decontamination of the BSC.
6. Provide each Class II Type B BSC with a dedicated exhaust system unless an alternative design is demonstrated to provide the precise control necessary for cabinets to stay in tight tolerance limits.
7. Provide each Class II Type B BSC with a bypass system for exhausting the room when the BCS fan is turned off; turning the BSC fan off saves filter life and the bypass facilitates decontamination of the BSC.
8. Thimble connection exhaust airflow shall be 120-125% of the BSC manufacturer's exhaust specification.
9. Provide at least ten inches of clearance above a recirculating Class II A2 BSC; this is to facilitate decontamination of the exhaust HEPA filter.

10. Provide at least four inches of clearance behind and on the non-utility side, and six inches clearance on the utility side of the cabinet.
11. Provide a NEMA 5-20 (20-amp) receptacle located high so that unit may be easily unplugged for servicing.
12. Specify BSC to be seismically anchored per manufacturer recommendations and include seismic braces and other necessary components in the purchase.
13. Biosafety cabinets must be certified by University EH&S technicians prior to substantial completion and use. This should be scheduled directly with the EH&S technician at least 2 weeks prior to required certification date.

F. Bag In/Bag Out Unit Detail



G. Bio Safety Cabinet Duct Connection Detail



SECTION 8: FIRE SAFETY

Contents

- A. Scope
- B. Fire Extinguishers
- C. Building Fire Service/Utilities
- D. Fire Sprinklers/Standpipes
- E. Fire Alarm Systems
- F. Fire/Smoke Dampers
- G. Environmental Control Systems/Smoke Control

A. Scope

This guide presents the minimum performance requirements for fire safety building features provided for laboratory buildings. It includes fire extinguishers, fire sprinklers, fire alarms, fire/smoke dampers, and environmental control systems/smoke control. This section is written primarily for leased buildings and other facilities not maintained by UW Facilities Services. For UW owned and operated buildings, see the UW Facilities Services Design Guide for fire safety requirements. Most of the requirements were taken directly from the International Fire Code, as adopted by Seattle/Washington State, with supporting information from the National Fire Protection Association. These references are provided at the end of this chapter.

B. Fire Extinguishers

1. Fire extinguisher shall be conspicuously located and within required travel distances as outlined in codes and standards. Travel distance and extinguisher capacity requirements vary significantly with occupancy. Below are common placement and design criteria specific to laboratory buildings.
2. Wet laboratories, hazardous material storage, dispensing, and mixing rooms require a UL rated 3A:40BC extinguisher within thirty (30) feet of travel distance from any point, but not necessarily in each room. Where extinguishers are provided inside wet laboratories, the extinguisher should be located near the egress door. Wet laboratories are considered laboratories with significant amounts (greater than five gallons) of hazardous and flammable materials such as chemical research laboratories, semiconductor fabrication facilities, biological laboratories, and other laboratories using hazardous materials.
3. An UL-rated 3A:40BC extinguisher shall be required in ordinary-hazard occupancies within a travel distance of fifty (50) feet from any point, but not necessarily in each room. Ordinary-hazard occupancies are considered to be: dry laboratories, computer laboratories, laundry rooms, library stacks, low combustible warehousing/storage mechanical rooms, fuel-fired equipment rooms, parking garages, and workshop-service-repair areas. Dry laboratories have five gallons or less of hazardous and flammable materials such as microscope rooms, physics laboratories, astronomy laboratories, electronics laboratories, and geology laboratories.
4. An UL-rated 2A:10BC extinguisher shall be required in light-hazard occupancies within (75) seventy-five feet of travel distance from any point, but not necessarily in each room. Light-hazard occupancies are considered to be: assembly rooms, auditoriums, meeting/conference rooms, classrooms, common areas, corridors, hallways, dining and lunch or break rooms, electrical vaults, kitchenettes, locker rooms, mechanical rooms without fuel-fired equipment, medical/hospital In-patient/clinic and treatment rooms, offices, reception areas, waiting rooms, and lounges.

5. An UL-rated 2A:10BC extinguisher shall be required in elevator machine rooms or just outside the rooms no further than fifteen feet from the access to the elevator machine room. Should this be included in this section? Not really within scope
6. Carbon dioxide or other clean agent (UL-rated 10BC) extinguishers shall be provided in dedicated computer rooms and clean rooms.
7. A UL Class D extinguisher shall be required in areas where combustible metals are used or stored.

C. Building Fire Service/Utilities

1. A six-inch minimum fire service shall be provided. Engineering calculations shall be generated for lead-in pipe sizing to document pipe sizing.
2. Water piping shall not be installed below slabs on grade.
3. Drains should parallel combination standpipes within stair enclosures and discharge to a minimum six-inch sewer drain with a short standpipe (e.g., eight-inch pipe to approximately thirty inches above finished floor) to prevent flooding.

D. Fire Sprinklers/Standpipes

1. Fire sprinklers shall be provided throughout laboratory buildings. Although not required by code in all cases, the UW believes that providing fire sprinklers is a proven investment and provides related code benefits and increased flexibility for hazardous material storage and use.
2. Laboratories are Ordinary-Hazard Group II for fire sprinkler design purposes. Floors not occupied by laboratories shall be designed based on their specific occupancies.
3. Concealed sprinkler heads shall not be used in laboratories unless specifically listed for the laboratory environment being installed.
4. Quick-response fire sprinkler heads shall be used to satisfy accessibility standards instead of providing areas of evacuation assistance. Quick-response heads shall be install in all areas allowed by governing standards.
5. System layouts with a branch-and-tree configuration shall be provided, with identifiable and accessible cross-mains. A looped cross-main design with dead-end branch lines may substitute for a branch-and-tree layout provided, the cross main only uses a single loop (no grid) and the looped main is minimum 2.5 inches. This performance criterion is given to ensure the fire sprinkler system can be easily modified over the life of the building to address changes in building function and configuration.

6. Where partial ceilings are provided for architectural reasons, special attention should be paid to the design of the sprinkler system. Heads both above and below the ceiling may be required where the ceiling is not continuous.

E. Fire Alarm Systems

1. The fire alarm control panel shall be addressable with analog sensor and PNIS proprietary station monitoring capability. .
2. Service personnel must be able to perform comprehensive tests on the fire alarm system with minimum disruption to occupants.
 - a. Fire alarm system control must originate from the control panel and/or programmable field devices.
 - b. Individual bypass switches located at the main control panel must provide system-wide bypass for each type of output to accommodate testing with minimal disruption.
3. Fire alarm systems should provide voice capability for UW Seattle Campus buildings for mass notification by University Police. A local microphone is not necessary for small buildings.
4. The system shall include complete smoke detection throughout public corridors and hallways. Detection shall be spaced thirty-five (35) to forty (40) feet on center. Detector locations shall be coordinated with ceiling diffusers; none may be closer than three (3) feet.
5. Smoke detectors shall not be provided in exit stairs or dirty environments that would be prone to false alarm unless required by code.
6. Manual fire alarm pull stations shall be provided at all building exits in the direct path of egress, regardless of code requirements. Pull stations shall be provided on individual floors at the entrance to the exit stair.
7. Fire alarm audibility is required throughout the building. The following guidelines are provided to ensure audibility is provided per code and occupant sensitivity to alarms is addressed.
 - a. Typically, fire alarm speaker audibility can only be achieved through a single door. Therefore, an office inside a suite would require an audible device within the suite to ensure sufficient audibility in the office. Audible device placement in individual offices should be avoided where possible.

- b. Audible/visual alarms shall be provided in each laboratory to overcome ambient laboratory noise.
 - c. Audible devices are typically required in acoustic (sound) rooms, coolers, environmental rooms, and other regularly occupied sound-transmission-resistant areas. Environmental rooms may require weatherproof devices.
 - d. Audible devices located in restrooms should set at a reduced level.
8. Visual alarms (strobe lights) are required throughout all public spaces and common areas as defined by the applicable codes and standards. Visual alarm design must include the candela rating on the individual device, and a template should be used to ensure sufficient intensity to provide coverage of all required areas. Synchronization of visual notification devices is required when multiple devices are in the line of sight. Providing synchronization for the entire building should be considered. When visual alarms are provided as part of a combination device (horn/strobe or speaker/strobe) in a non-public space (i.e., research laboratory), the visual alarm need not achieve the minimal candela rating throughout the room or area. Public spaces include but are not limited to hallways, corridors, classrooms, meeting rooms, conference rooms, copy rooms, lounges, break rooms, and restrooms.

F. Fire/Smoke Dampers

1. The number of smoke/fire dampers should be minimized through:
 - a. Coordination of duct layout with suite configurations.
 - b. Close attention to code “exceptions” to standard smoke/fire damper placement requirements.
2. The UW prefers the use of pneumatic dampers due to their reliability. If the building is connected to a reliable air supply, pneumatic dampers should be considered.
3. The manufacturer shall stand behind the reliability of the actuators even if they are to be closed only once a year. The manufacturer shall not limit the warranty of the damper due to closure only once a year. Electric actuators shall have an end-switch or clutch to reduce force on the damper when it is being held open. Electric actuators shall not use stall-motors.
4. Provide access panels associated with each fire/smoke damper.

G. Environmental Control Systems/Smoke Control

1. Engineered smoke control systems should be provided only as value-added for the project or specifically required by code. The specific requirements of a smoke control system shall be reviewed to ensure a smoke control system will be value-added. The UW’s history with engineered smoke control systems is not favorable. Unless the systems are designed in detail and based on good engineering principles, these systems often increase project costs and are not reliable.

2. Only the fire alarm system should control life safety fans such as atriums, elevator shafts, and dedicated smoke control systems. Likewise, only the fire alarm system should control the smoke dampers at air-handler inlet and discharge. Shut down authority should be effective for all positions of the local HOA or VFD controls. The environmental control system shall not control fans after shutdown by the fire alarm system until after resetting the fire alarm system. Toilet and other non-recirculating exhaust fans shall remain on unless this creates a problem with air quality or excessive pressure on exit doors.
3. In buildings where mechanical systems operate under direct digital control in emergency power conditions, the environmental control system shall monitor the fire alarm panel to determine when the building is under a fire alarm condition. The environmental control system shall monitor the emergency power transfer switch to determine when there is loss of normal power and restoration of normal power.

SECTION 9: ADDITIONAL REQUIREMENTS FOR RADIOACTIVE MATERIALS LABORATORIES

Contents

- A. Scope
- B. Basic Laboratory Design
- C. Ventilation Considerations
- D. Radioactive Waste Management
- E. References

A. Scope

All radioactive materials and their uses are governed by the terms and conditions of the UW Radioactive Materials License, issued by the State of Washington Department of Health, Division of Radiation Protection (DOH). Most of the requirements were taken directly from the Washington Administrative Code (WAC) 296-800-150 with supporting information from American National Standards Institute (ANSI) Z358.1-2009 and a directive from the Washington State Department of Labor & Industries (L&I); these references are provided at the end of this chapter.

B. Basic Laboratory Design

1. A facility for handling radioactive material shall be located and designed so that the radiation doses to persons outside the facility can be maintained below applicable limits and are As Low As Reasonably Achievable (ALARA).
2. Sinks shall be constructed of impervious material such as stainless steel. Faucets should be foot-, elbow- or knee-operated. Plumbing should be smooth and easily cleaned.
3. When required, radiation shielding shall be approved by the UW Radiation Safety Office (RSO). This applies to high-energy gamma and x-ray emitters. Facility-designed shielding is not usually needed for alpha- or beta-emitters.
4. The UW RSO shall determine whether High, Very High or Airborne radiation areas exist and specify requirements that may result from these unusual levels of radioactive materials.
5. Floors should be smooth, nonporous, easily cleaned surfaces. Appropriate floor materials include sheet vinyl and sealed concrete.
6. Laboratory benches must have nonporous, easily decontaminated surfaces. Surfaces of high-quality plastic laminate or stainless steel are preferable.

C. Ventilation Considerations

1. The UW RSO shall evaluate facilities performing procedures that involve any unsealed radioactive materials having the potential to emit airborne radionuclides for compliance with State of Washington Air Emission Standards. Calculations may reveal that the facility needs to be equipped with ventilation that will limit air concentrations to levels that are ALARA and are lower than allowed limits. Ventilation systems shall prevent the escape of the airborne contaminants to adjacent non-use areas to assure that air concentrations in those areas do not exceed allowed limits. Facilities using radioactive materials may need to be approved by the State of Washington

Department of Health and a Notice of Construction (NOC) may need to be filed with the DOH, depending on what air emission calculations reveal.

2. Hood inserts are only permitted for iodination procedures specifically approved by the UW RSO.
3. Radioactive air cleaning (filtration) systems on major installations shall be designed in accordance with ASME N509 or AG-1, and should be designed in accordance with N509 and AG-1 whenever possible for all installations. The radiation exposure of individuals from the radioactive materials retained on the filter(s) shall be evaluated. Each filter stage shall be designed and located to facilitate independent testing in accordance with ASME N510 or AG-1. HEPA filters used in the last stage of a system just prior to discharge into occupied locations or the environment shall comply with DOE-STD-3020-97 (be "nuclear grade").
4. Each filter stage should be designed and located to facilitate independent testing according to applicable standards. Proper design will allow the filters to be changed easily while minimizing the potential for release of radioactivity and worker exposure. Push-through bag-in/bag-out systems are preferable. While closed-face filters appear to be convenient to use, proper in-place testing is virtually impossible, so they should not be used whenever the filter will be subjected to in-place testing. Higher efficiency filters, such as ULPA filters, are available, but they are not as rugged as a nuclear-grade HEPA filters and they should not be used for radioactive air cleaning.
5. In order to construct a new or modify an existing radionuclide air emission facility, a notice of construction (NOC) is required to be submitted to the Washington State Department of Health (DOH) early in the design phase. Within thirty days of receipt, the DOH will inform the applicant if additional information is required. Within sixty days of receipt of all required information, the DOH will issue an approval or denial to construct. When the new construction or modification is complete, the DOH will issue a license, or amend an existing license, authorizing operation of the emission units(s).

D. Radioactive Waste Management

1. Piping systems should be designed to minimize connections between sanitary and laboratory drains.
2. To reduce unnecessary exposure, radioactive waste should be stored in areas separate from work places. However, it is recommended that the transfer route of radionuclide to waste areas be over as short a distance as possible.

E. References

1. UW Radiation Safety Manual

2. Washington Administrative Code (WAC) 246
3. 10 Code of Federal Regulations (CFR) 20
4. 10 Code of Federal Regulations (CFR) 51
5. National Council on Radiation Protection and Measurements (NCRP) Report No. 127
6. Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities," 1993
7. NUREG 1556 Vol. 7
8. UW Type A License of Broad Scope
9. Regulatory Guide 8.25, Revision 1, "Air Sampling in the Workplace," 1992
10. Regulatory Guide 4.20, "Constraints on Release of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors," 1996
11. DOE Specification for HEPA Filters Used by DOE Contractors, DOE-STD-3020-2005
12. ASME Code on Nuclear Air and Gas Treatment AG-1-2010
13. ASME Nuclear Power Plant Air-Cleaning Units and Components ASME N509-2002
14. ASME "Testing of Nuclear Air Treatment Systems" ASME N510-2007
15. ASME Code on Nuclear Air and Gas Treatment AG-1-2010
16. ASME Nuclear Power Plant Air-Cleaning Units and Components ASME N509-2002
17. NCRP Report No. 127 Section 4.6
18. Laboratory Design References at www.ehs.washington.edu/facilities-projects-support

SECTION 10: ADDITIONAL REQUIREMENTS FOR LABORATORIES WITH IRRADIATORS AND/OR RADIATION PRODUCING MACHINES

Contents

- A. Scope
- B. Introduction
- C. General Requirements/Considerations
- D. Considerations for Radiation Producing Machines
- E. Considerations for Radioactive Materials
- F. Considerations for Facilities/Sources used for the Healing Arts
- G. References

A. Scope

This Design Guide applies to all facilities, including leased properties. The purpose of this chapter is to identify common irradiators, sources, and machines that produce external ionizing radiation at research facilities and to give general guidelines regarding the planning, installation, storage and use of these sources. For details, always refer to the UW RSO or a “qualified expert”. Though these recommendations deal mostly with radiation sources found in research facilities, most campuses have medical x-ray facilities as well (e.g., hospitals, medical and dental clinics); therefore, limited comments regarding these facilities have been included. References are provided at the end of this chapter.

B. Introduction

Machine irradiators, and high activity non-sealed sources that produce ionizing radiation are common in research laboratories. These devices can include high-energy accelerators that require special shielding and control as well as devices that produce x-rays of such low energy and intensity that minimal shielding and controls is required. This wide variation in sources makes it difficult to write detailed guidelines for all radiation sources. It is important to involve the UW Radiation Safety Office (RSO) early on in the processes related to design, installation, acceptance testing, and operations of all such sources. Additionally, a State of Washington Department of Health (Division of Radiation Protection) approved “qualified expert” may assist in the shielding calculations and room design criteria for x-ray systems. Typical sources include:

1. Radiation Producing Machines:
 - a. X-ray radiographic and/or irradiation facilities
 - b. Accelerator facilities
 - c. Analytical x-ray machines (e.g., x-ray diffraction, electron microscopes)
 - d. Cabinet radiography units
 - e. Accelerators used for radioisotope production

2. Devices Containing Radioactive Materials:
 - a. Sealed sources
 - b. Irradiators
 - c. Moisture/density gauges
 - d. High activity non-sealed sources (i.e., sources which can produce high external radiation exposures, but do not satisfy the requirements to be considered sealed sources)

C. General Requirements/Considerations

Early in the planning stages when an irradiator or x-ray producing device is planned for installation in a building, UW RSO shall be consulted. There are numerous regulatory and

design requirements that shall be addressed (e.g., registration, licensing and shielding). Some general considerations that apply to both radiation producing machines and devices containing radioactive material are:

1. Exhaust ducts and collectors shall be located and/or shielded such that personnel exposures along its route of travel and at the collector are ALARA and do not exceed regulatory limits. Collectors shall be equipped with bag-in/bag-out capability and located such that there is adequate space to change out collectors without contaminating uncontrolled areas and with minimum disruption of uncontrolled operations. Since such ducting and associated collectors are often located in uncontrolled areas occupied by individuals who are unfamiliar with radiation, even small exposures may be alarming to the occupants. Therefore, it may be advisable to design shielding in order to reduce exposures far below regulatory limits or to provide additional training to the occupants regarding the effects of radiation.
2. Shielding required to protect people from radiation is often inadequate to protect unexposed film or emulsions stored near radiation sources. Shielding required to protect unexposed film or emulsions stored in areas near radiation sources shall be evaluated on an individual basis.
3. The structure of the facility shall be designed (evaluated and updated for renovated facilities) to physically support required shielding (e.g., weight “cold flow”). It is important to recognize that some shielding materials (e.g., lead) can “cold flow” with time, particularly for tall and thick sections. It is necessary to support shielding in a way that will address this problem or to use an alternative shielding material (e.g., iron or concrete).
4. Hazards associated with moving heavy shields, high voltage, and high magnetic fields are often present around radiation sources. Often, special administrative and engineering controls are required to deal with these hazards safely.
5. Exhaust systems for hazardous materials (e.g., ozone, cryogen, and gaseous activation products) produced or present around radiation sources need to be designed to maintain exposure levels for hazardous materials below the respective occupational exposure limits (OEL). Care shall be exercised in selecting the discharge points for these exhaust systems.
6. Interlocks may be required on movable shielding components or access doors to rooms containing high energy radiation producing machines or large sources of radioactive material. The interlocks must disable the production of radiation or shield the radioactive source if doors are not closed or if shielding is not positioned as required to provide adequate protection to controlled or uncontrolled areas. Such interlocks shall be failsafe and tamper resistant.

7. Emergency “Off” (mushroom) switches are typically required in areas where exposures to individuals could exceed the limits established by the RSO and/or RSC if administrative or engineering controls should fail. Such switches shall be centrally located and in sufficient number so each potential user has convenient access.
8. Warning lights, audible signals and signs shall be in compliance with the requirements in WAC 246-225, 227, 228, and 229. Signage shall be in compliance with the requirements in WAC 246-221, 225, 227, and 228.
9. Radiation area monitors are typically required when exposure rates are such that the exposure of an individual in the area could exceed institutional administrative controls specified by the UW RSO and/or the RSC.

D. Considerations for Radiation Producing Machines

1. Machine Registration
 - a. The State of Washington Department of Health, Division of Radiation Protection (WA DOH), requires registration of x-ray machines.
 - b. When constructing or remodeling a room that will house a radiation machine, the registrant shall notify WA DOH prior to the possession of the machine or commencement of the construction. This includes re-installing a machine in a previously constructed facility.
 - c. All machine registrations are recorded through UW RSO.
2. Shielding
 - a. Shielding specified for controlled and uncontrolled areas must be based on the shielding design goals specified in the applicable NCRP report or on the dose limits specified in the regulations, whichever is lower.
 - b. The shielding design shall be prepared by a “qualified expert” as defined in National Council on Radiation Protection and Measurements Reports No. 147 (NCRP 147) and No. 151 (NCRP 151). WA DOH keeps a list of qualified experts approved to perform this type of work within the state. Additional requirements for shielding design and selection of qualified experts is described below in the section on facilities used for the healing arts.
 - c. All shielding designs, floor plans, and equipment arrangements, including final construction drawings, shall be reviewed and approved by the UW RSO and/or RSC. These plans must also be submitted to and approved by WA DOH.
 - d. The UW RSO or State of Washington Department of Health approved “qualified expert” shall inspect shielding during construction to assure that it is installed according to specifications. Deficiencies shall be corrected prior to operation of the facility. After construction, the attenuation of shielding can sometimes be verified using a radiation source, however this is not an optimum method. Attenuation measurements can help determine the overall effectiveness of shielding, but cannot easily find small voids in the shielding.

- e. A radiation survey of adjacent controlled and uncontrolled areas before use of a radiation source shall be conducted at the discretion of the UW Radiation Safety Office. The RSO usually finds it necessary to make measurements to assure that shielding is adequate to meet regulatory exposure limits and/or limits specified in the shielding design. The radiation survey should be conducted under conditions that are representative of actual operating conditions at the facility. Deficiencies shall be corrected prior to operation of the facility.
 - f. For most single-floor facilities with energies less than 200 kVp (kilovoltage peak), shielding shall be extended from the floor to no less than seven feet high. In multi-floor/multi-level facilities, shielding walls may need to be higher than exactly seven feet. For single floor facilities with high-energy sources that can produce “skyshine,” ceilings may require shielding and the shielding in walls may need to extend from floor to ceiling. In multi-level facilities, particular attention must be paid to floor shielding, since the useful radiation beam is often predominantly pointed downward.
 - g. Nails/screws penetrating shielding material are not required to be capped with lead in walls that require less than four pounds of lead per square foot.
 - h. For operator protection, source controls shall be located such that no first-scattered radiation reaches the control area. These controls shall also be located such that exposures from primary and secondary radiation do not exceed regulatory limits when use and occupancy factors are taken into account. The operator shall be allotted 7.5 sq. ft. or more of unobstructed floor space in control booths to allow ease of movement behind barriers. No dimension of this space shall be less than 2 ft. An extension of a straight line drawn between any point on the edge of the booth shielding and the nearest vertical edge of a cassette holder, corner of the examination table, or any part of the tube housing assembly shall not impinge on this unobstructed space. The operator switch must be mounted so that the operator can avoid first-scattered radiation while energizing the machine. The requirement is for the switch to be permanently mounted 40 inches inside the protected control booth. A control booth-viewing window is required and shall have at least one square foot of viewing area. The viewing window must be equal or greater in lead equivalence to the shielding installed in the control booth walls.
 - i. Shielding and equipment shall be designed and installed to meet seismic restraint requirements.
3. Other Considerations
- a. In facilities with high-energy radiation producing machines, walls, shielding and source components may become radioactive by the process of neutron activation. The extent and magnitude of the activation is dependent on many factors including source “energy” and “on time”. In many cases activation occurs but is not a significant concern since the radioactive materials produced have a very short half-life. The extent and magnitude of activation should be evaluated for machines with energies greater than fifteen million electron volts (MeV).

When appropriate such facilities should be designed such that activation is reduced or activated materials may be removed easily.

- b. Conventional electron microscopes operating at less than 40 kVp must be registered with the UW Radiation Safety Office, but may be exempt from shielding requirements. UW RSO should be consulted for details.
- c. If a radiation producing machine is totally surrounded by a shielded enclosure with “failsafe” interlocks on all access doors (i.e. cabinet x-ray system), no additional shielding is usually required. UW RSO should be consulted for details.

E. Considerations for Radioactive Materials

1. Authorization to Possess
2. Sealed and unsealed sources of radioactive materials must be licensed by the appropriate regulatory agency. Licensing is through WA DOH, as a representative of the Nuclear Regulatory Commission. The UW RSO and/or Radiation Safety Committee (RSC) approve all used of radioactive materials.
3. Shielding
 - a. Facilities shall be designed such that the exposure limits specified in WAC 246-221 for controlled and uncontrolled areas are not exceeded when use and occupancy factors are taken into account. In addition, Washington Department of Health requires that shielding shall be designed to limit the dose equivalent in controlled areas to 10% of the regulatory limits. That is, 500 millirem/year. This requirement is in accordance with the intent of ALARA (keeping doses “As Low As Reasonably Achievable”).
 - b. Most devices containing radioactive material already contain shielding and normally do not require additional shielding. However, UW RSO must be consulted to perform an evaluation and make a determination as to whether additional shielding is required. If additional shielding is required, many of the considerations for radiation producing machines will apply.
4. Other Considerations
 - a. If certain thresholds of radioactivity are exceeded, there may be additional regulatory requirements to ensure security of the radioactive material. Contact UW RSO to determine if these additional security measures are required.
 - b. Radiation source transport systems (“rabbits”) shall be routed and/or shielded such that exposure limits are not exceeded in controlled or uncontrolled areas during routine operations or emergency situations (e.g., stuck sources). To plan for emergency situations, an accident analysis shall be conducted and an emergency response plan prepared that will deal with any hazardous conditions that were identified.

- c. Special consideration should be given to the storage location for moisture/density gauges. Storage locations may need to be shielded or in remote locations where the exposure limits for controlled and uncontrolled areas are not exceeded. The RSO should be consulted for details. Adequate security measures for the storage area need to be provided to prevent unauthorized removal.

F. Considerations for Facilities/Sources used for the Healing Arts

Some facilities/sources are not covered specifically by these recommendations; however, most of the requirements and considerations found in section B and C apply. It is important to remember that all facilities with radioactive materials and/or machines shall be reviewed and approved by the UW Radiation Safety Officer and/or Radiation Safety Committee prior to installation/operation. Due to the many safety and regulatory aspects related to the design, installation, commissioning and operation of such facilities, early involvement of the facility RSO is advisable. Unanticipated corrective actions can result in unpleasant, unnecessary, costly delays. Clinical and Veterinary facilities/sources are as follows:

Diagnostic Medical:

- Radiographic (e.g., fixed, portable, mammography)
- Fluoroscopic (e.g., fixed, portable)
- Cine
- CT
- Bone density
- Nuclear medicine imaging
- PET imaging

Diagnostic Dental:

- Radiographic
- Cephalometric
- Panoramic, CT

Therapy:

- Accelerators
- Brachytherapy sources
- HDR
- Gamma Knife
- Ortho-voltage units
- Grenz rays
- Intravascular brachytherapy devices

Some important considerations for facilities/sources used for the healing arts are as follows:

1. Clinical Facilities shall include:
 - a. Equipment for human use which meets FDA requirements
 - b. Equipment, all of which has been checked for compliance with regulatory requirements prior to commissioning for use on patients. Equipment at TJC accredited facilities shall be commissioned by a qualified expert prior to use.
 - c. Facilities and/or equipment, which provide the operator with the ability to communicate with and view the patient continuously from an area protected from primary, secondary and first-scatter radiation (i.e., a controlled area) when patients are being exposed/irradiated. Exceptions to this general rule are operators of portable diagnostic x-ray equipment used at non-fixed locations, and most nuclear medicine imaging equipment. For most of these exceptions, the operator shall be at least six feet from the source of radiation and out of the primary beam.
2. Before construction, the floor plans and equipment arrangement of medical installations utilizing x-rays for diagnostic or therapeutic purposes shall be submitted to a “qualified expert” for shielding design plan review. The “qualified expert” shall be approved by the State of Washington DOH Division of Radiation Protection and shall adhere to shielding methodologies in the “National Council on Radiation Protection and Measurements Report No. 49” (NCRP 49), or equivalent (NCRP 147 or NCRP 151). Completed shielding designs shall be submitted to the DOH for subsequent “plan review”. Diagnostic veterinary, podiatric, and dental facilities are exempt from plan review by the DOH. A copy of the DOH submittal and any approval documents or other communication from/to the DOH must also be forwarded to the UW RSO.
3. For dental radiographic facilities, the ordinary walls in a building (two layers of 5/8 inch drywall) often provide adequate shielding to protect surrounding areas. It should be noted that one of the common layouts for dental equipment puts the head of the dental chair adjacent to central work or patient areas. Unless modified, this common layout can result in the unacceptable practice of exposing the central work or patient areas to unshielded primary radiation. For general stationary dental intraoral equipment, the control switch shall be permanently mounted in a protected area no less than 36 inches from access to the direct scatter radiation field. Because of the many variables involved, the UW RSO or designee shall evaluate the shielding in each dental x-ray room.
4. The UW RSO or designee shall evaluate the shielding (design and testing) for each veterinary radiographic facility or room. NOTE: Operator control booths are not always required for these facilities.
5. Provisions should be made for storage of leaded aprons in medical fluoroscopic and cine facilities.

6. Medical bone density units seldom require operator control booths or additional shielding. However, the UW RSO or designee should evaluate each unit.
7. Each control booth shall have at least one viewing device so the operator can view the patient during exposure, and have a full view of entries into the room when using medical diagnostic and therapeutic equipment. If electronic viewing equipment is used, an alternate viewing system shall be available as a backup in the case of electronic failure.

G. References

1. NCRP 72 "Radiation Protection and Measurement for Low-Voltage Neutron Generators"
2. NCRP 79 "Neutron Contamination from Medical Electron Accelerators"
3. NCRP 116 "Limitation of Exposure to Ionizing Radiation"
4. NCRP 144 "Radiation Protection for Particle Accelerator Facilities"
5. NCRP 145 "Radiation Protection in Dentistry"
6. NCRP 147 "Structural Shielding Design for Medical X-Ray Imaging Facilities"
7. NCRP 151 "Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities"
8. Washington Administrative Code 246-225
9. State of Washington DOH Division of Radiation Protection advisory documents
10. State and local building requirements
11. The Joint Commission (TJC) recommendations

SECTION 11: ADDITIONAL REQUIREMENTS FOR LABORATORIES USING NON-IONIZING RADIATION SOURCES

Contents

- A. Scope
- B. Non-Ionizing Radiation (NIR) Basic Safety Requirements
- C. Controlling Access to Laser Areas
- D. Beam Path Management
- E. Fire Safety for Lasers
- F. Electrical Safety for Lasers
- G. Class 4 Laser Laboratories
- H. Optical Bench Safety
- I. Excimer Lasers
- J. Laser-Generated Air Contaminants (LGAC)
- K. Radio Frequency and Microwave Devices (30 kHz to 300 GHz)
- L. Sub-radio Frequency Fields (<30 kHz)
- M. Static (Zero Hz) Magnetic Fields
- N. Ultraviolet Radiation
- O. References

A. Scope

This Design Guide applies to all facilities, including leased properties. References are provided at the end of this chapter.

B. Non-Ionizing Radiation (NIR) Basic Safety Requirements

1. Laboratories using non-ionizing radiation sources (such as: lasers, ultraviolet lights, and large magnets) should be designed to minimize radiation exposure to personnel and the environment.
2. Laboratory designs shall utilize appropriate engineering and administrative controls to prevent radiation exposure in excess of the applicable regulations, standards, and guidelines.
3. Laboratory designs should be forwarded to the UW Radiation Safety Office (RSO) for NIR safety review and approval prior to being released for bid or beginning construction (for internal projects that are not put up for bid).

C. Controlling Access to Laser Areas

1. Doors providing access to spaces containing open-beam Class 4 lasers shall be fitted with interlocks to prevent emission from the lasers if the door is opened or to deny outside-to-inside entry during laser emission. Design of interlocks should favor the use of shutters or laser beam dumps to limit emission. Laser power supply shutoffs should not be used except where no other alternative exists. In certain situations (such as medical or surgical applications), interlocks may not be feasible or appropriate. For these applications, the EH&S RSO should be consulted regarding approval for alternatives to interlocks.
2. All doors to Class 3b and Class 4 laser areas shall have ANSI Z136.1 (2007) specification laser warning signs. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs should not be mounted above doorways. Lighted laser warning signs (or status) panels that indicate the room access status) shall be used for Class lasers and are suggested for class 3b lasers.
3. Partitions, dogleg entrances or other provisions shall be made to allow persons to don laser protective eyewear and other required PPE before entering spaces where beam hazards exist or could exist. Preferably, this provision should be made before the entry to the laboratory.
4. Appropriate barriers shall be provided to prevent Class 3b or 4 laser beams from leaving the confines of a laser laboratory through doorways, windows, etc.

D. Beam Path Management

1. Provisions shall be made to enclose Class 3b or 4 laser beams whenever possible. Class 3b or 4 laser beam paths that cross between optical tables/equipment benches or pass through barriers shall be properly enclosed and marked identifying the hazard. All enclosures shall be compatible with the laser wavelength and beam power. All laser beam paths shall be maintained at a height either above or below the eye level of standing/sitting persons who may be exposed.
2. Laser enclosures, beam stops, beam barriers and other exposed surfaces shall be diffusely reflective at the laser wavelength used. Surfaces that may create a specular reflection at the laser wavelength shall not be used.

E. Fire Safety for Lasers

1. Flammable/combustible construction materials shall be avoided in spaces housing Class 4 lasers. Materials used for beam stops or beam barriers shall not off-gas or be combustible at the beam power used. Curtains used as laser barriers shall not off-gas and shall be flame-retardant or, preferably, flameproof or laser-rated.
2. Provisions shall be made for the safe storage of laser dye solutions, solvents, and other flammable materials.

F. Electrical Safety for Lasers

1. Appropriate grounding connections shall be provided for laser power supplies and other electrical components. All optical tables shall be properly grounded. To facilitate use, all grounding connections should be properly marked.
2. Electrical systems shall be marked to show voltage, frequency, and power output. All high voltage sources shall be properly marked and secured to prevent accidental access.

G. Class 4 Laser Laboratories

1. Red mushroom-type room/area emergency shutoffs (to deactivate or reduce laser power below the Maximum Permissible Exposure, or MPE) shall be installed in a conspicuous location that is easily accessible from the laboratory entrances. The switch shall be clearly and conspicuously marked with the words "Notice – In emergency, push button to shut down laser".
2. All laser laboratories shall be provided with easy egress. Crash-bar hardware can be used on outward-swinging doors.

H. Optical Bench Safety

Optical benches shall be secured to prevent severe movements in an earthquake. This requires anchoring a sturdy frame to the laboratory floor that surrounds and is close to (within one-half inch), but not touching, the optical bench.

I. Excimer Lasers

1. Halogen gas mixtures shall normally be stored in gas storage cabinets. All transfer lines and components in contact with halogens shall be of compatible (non-reactive) materials. Institutional toxic gas program requirements will designate the specific storage quantities allowed (depending on toxicity and other factors).
2. Conventional gas storage cabinets will effectively contain the dilute halogen and hydrogen halide in inert gas mixtures used in excimer lasers if the delivery lines are kept bone-dry. Gas storage cabinet hardware allows this to be done using bone-dry nitrogen purge gas.
3. The gas discharge from both the excimer laser and the associated halogen gas storage cabinet shall be connected to an appropriate exhaust ventilation system capable of maintaining an average face velocity of 200 fpm at the cabinet's window opening when the window is fully opened. An alarming airflow meter should be used to monitor and indicate low-flow conditions in the gas cabinet.
4. Halogen scrubber devices used on closed (non-ventilated) excimer laser systems shall meet appropriate safety standards and shall be pre-approved by the UW RSO prior to installation.

J. Laser-Generated Air Contaminants (LGAC)

Lens on laser conditions (or any place where the beam irradiance exceeds 1000 watts/cm²) should be jointly evaluated by an Industrial Hygienist and Health Physicist to identify engineering controls for laser generated air contaminants. Places where irradiances exceed 10,000 watts/cm² shall be enclosed to the maximum extent practical and properly ventilated. Exposure to LGAC shall not be managed with the use of PPE.

K. Radio Frequency and Microwave Devices (30 kHz to 300 GHz)

1. Provisions shall be made to protect people from exposures at or above the Maximum Permissible Exposure (MPE) limits. Engineering controls shall be used in lieu of PPE or other administrative controls whenever possible. Shielding shall be designed by or be reviewed by an electronic engineer experienced in radio frequency/microwave design.
2. Provisions shall be made to restrict access and post appropriate warnings for locations where field strengths could exceed the MPE. Appropriate ANSI specification warning signs shall be provided to identify such areas. Signs should be mounted so as to be

visible both at the doorway and at some distance from the doorway. Signs should not be mounted above doorways.

3. To prevent exposures exceeding the MPE for radio frequency electrical currents, barriers and/or cages shall be provided to protect persons from contact with or close proximity to such currents. These provisions shall be designed or reviewed by an Electronic Engineer experienced in radio frequency/microwave design.

L. Sub-radio Frequency Fields (<30 kHz)

1. Magnetic Fields: Overexposures at these frequencies are very unlikely. The most likely situation will entail a frequency of 60Hz. The exposure limit for 60 Hz is 0.2 mT (2 G or 160 A/m). This is a partial and whole body ceiling limit, although limbs can receive 5 times this amount, and hands and feet 10 times.
2. Electric Fields: Overexposures are unlikely if electric sources are insulated and grounded. The exposure limits vary according to the frequency range. For a 60 Hz field, the limit is 25 kV/m. However, the worst-case situation would be at 30 kHz, where the limit is 625 V/m.
3. There are a few types of cardiac pacemaker that are very sensitive. Some models are susceptible to interference by a power-frequency (50/60 Hz) as low as 2 kV/m. It is recommended, therefore, lacking specific information that exposure to pacemaker wearers be maintained at or below 1 kV/m.

M. Static (Zero Hz) Magnetic Fields

1. As part of the design process, the magnetic field in the facility shall be mathematically modeled to identify where pacemaker hazards (>5 G) and kinetic energy hazards (>30 G) exist. Places where excessive whole-body exposures (>600 G) could occur shall also be identified. If it is determined that shielding is required, an experienced consulting firm should be hired to design all electric or magnetic field shielding.
2. Provisions shall be made to prevent access to places where whole-body magnetic fields exceed 600 G. Areas such as hallways, stairways, and offices shall be located where fields are <5 G to allow completely unrestricted access.
3. The University of Washington enforces ACGIH TLV guidelines for static magnetic fields, which is somewhat more restrictive than ICNIRP.
4. Provisions shall be made to secure and restrict access to places where whole-body fields exceed 5 G. This is based solely on the possible effect that 5 gauss fields can have on some pacemakers.

5. A variety of prosthetic devices, medical equipment, makeup, and personal articles can also behave in a hazardous manner in stronger fields.
6. Appropriate ANSI Z535 specification warning signs shall be provided to identify such areas. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs should not be mounted above doorways.
7. Provisions should be made for persons to securely store their wallets, magnetic media, keys, and other ferrous-alloy tools and articles for safekeeping before entering places where fields exceed 5 G.
8. Appropriate discharge shall be made to direct cryogenic gases from a quenched superconducting magnet to a safe, unoccupied location to avoid exposing persons to an oxygen-deficient atmosphere. The issue of preventing oxygen deficiency during a quench condition shall be addressed in the design of locations for superconducting magnets. Doors to locations that may be subjected to gases during a quench shall open outwards to assure they can be opened should the laboratory become pressurized.
9. It is estimated that eighty liters of liquid helium (56,000 liters of gas at the 1:700 expansion ratio) can be ejected from the magnet Dewar in fifteen to thirty seconds.

N. Ultraviolet Radiation

1. Provisions shall be made to protect people from exposures at or above the Maximum Permissible Exposure Levels (MPE) defined for Actinic UV Radiation Effective Irradiances. Engineering controls may be used in place of PPE or other administrative controls but are not required. Proper UW rated plastics, glass and/or shielding design should be evaluated by the Radiation Safety Office.
2. Engineering controls such as automatic shut off switches and locked doors provide superior protection over measures such as signage. Time limits for exposure are based on a person not using proper PPE.
3. Provision should be made to restrict access and post appropriate warnings for location where irradiance could exceed the MPE. Appropriate warning or caution signs shall be provided to identify such areas. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs shall be placed on the UV source if the source is portable or moveable. Signs should not be mounted above the doorway.
4. To prevent exposures exceeding the MPE for Ultraviolet Radiation, care should be taken to ensure that all glass, windows, or visible access to the area is covered with UV

rated material for the wavelength of the UV source. These materials should be reviewed by the RSO prior to installation.

5. All overhead UV uses for germicidal purposes should be reviewed by the RSO prior to construction. Many portable and pre-constructed devices exist that would meet or exceed most requirements for overhead UV.
6. UV used for sterilization of water or other materials or solutions should be properly shielded. Devices of this type can put out significant amounts of UV above the MPEs and should be reviewed by the RSO prior to permanent installation.

O. References

1. ACGIH – TLV/BEI 2013
2. ANSI C95.1-1999
3. ANSI C95.1-2005
4. ANSI Z136.1-2007
5. NFPA 115
6. ICNIRP “Guidelines on Limits of Exposure to Static Magnetic Fields” 2009

APPENDIX A:

ADDITIONAL FUME HOOD EXHAUST CRITERIA FOR FACILITIES NOT OWNED BY THE UNIVERSITY OF WASHINGTON

This appendix applies to buildings that are not owned by the University. For buildings that are owned by the University, the University's Facilities Services Design Guide (FSDG), should be referred to for this criteria instead of this appendix.

Contents

- A. Fume Hood Exhaust System (FHES)
- B. Fume Hood Exhaust System Testing

A. Fume Hood Exhaust System (FHES)

1. Provide FHES fans with the following:
 - a. Outboard “split” bearings
 - b. Shaft Seal
 - c. An access door
 - d. Multiple 150 percent rated belts, or direct drive. In designing for explosion and fire control, the fan shall be of the non-sparking construction and the V-belt drive shall be non -conductive.
2. Provide a chemical resistant fan system.
3. Weld or permanently seal fan housing to avoid air leakage from the wheel shaft and discharge.
4. Choose fan type as follows:
 - a. Use straight-radial fan for systems handling moderate to heavy quantities of particulate matter in air.
 - b. Use backward-curved fans for systems handling relatively clean (low particulate) air.
 - c. Provide perchloric acid hoods with a separate stainless steel bifurcated straight flow-through with motor outside the air stream of the fume exhaust fan and completely independent from any other exhaust.
5. Manifold fume exhaust systems shall use constant volume fans with make-up air/outside air bypass.
6. Mount the fan with vibration isolators.
7. Provide weather protected fans installed near the building roof. Fan installation in naturally ventilated penthouses is preferred. The fan shall be the last element of the system to assure that the ductwork throughout the building is under negative pressure.
8. Fans shall be installed so that they are readily accessible for maintenance and inspection without entering the plenum. If exhaust fans are located inside a penthouse, the ventilation needs of maintenance workers shall be considered.
9. Provide ducts that are round, non-combustible, inert to agents to be used, non-absorbent, and free of any organic impregnation.
10. Choose duct material based on the compatibility with the materials handled in the hood. Basic characteristics of preferred hood and duct materials are as follows:

- a. Provide new installations to be round 18 gauge minimum thickness Type 316L stainless steel. Exceptions: Use 16 gauge stainless steel for perchloric hood systems.
 - b. Use fiberglass reinforced plastic or material with similar acid resistant material for acid digestion systems. However, A/E must confirm design acceptability with both the University Fire Engineer and the local fire authority having jurisdiction prior to Design Development Phase.
 - c. Leave glazed ceramic ducts and vitrified clay tile ducts in place if possible.
11. Exhaust duct must have liquid and airtight joints with smooth interior surfaces free of cracks, joints, or ledges.
 12. Provide smooth, non-porous lining surfaces free of cracks, joints, or ledges.
 13. Use flexible connection sections of duct, such as hypalon or neoprene-coated glass fiber cloth, between the fan and its intake duct if compatible with chemicals used in hood. Provide the transition joint from duct to fan of a seamless, constant diameter, inert, corrosion and UV-resistant materials as approved by owner. Provide the duct alignment within ½ inch at the hood collar and fan.
 14. Continuously "butt" weld (use appropriate filler rod for type of stainless) for stainless steel joint construction. Provide a weld sample for A/E and UW inspection. A VanStone flange can be used if the quality of the weld may be compromised because of inaccessibility to the area.
 15. Provide a flanged removable spool piece (minimum of 24 inches long) at each fume hood connection. Use spool sections for leak tests, inspection, and to facilitate removal of equipment. Install acceptable gaskets at flanged joint connections.
 16. All horizontal ducting shall be sloped down towards the fume hood (a recommended guideline is that the slope should equal to 1/8 inch per foot).
 17. Automatic fire dampers shall not be used in laboratory hood exhaust systems. Fire detection and alarm systems shall not be interlocked to automatically shut down laboratory hood exhaust fans.
 18. Exhaust fans serving chemical fume hoods should be connected to emergency standby power. The ventilation system shall supply and exhaust at least half of the normal airflow during an electrical power failure. The design must also account for pressure differentials resulting from this condition with regard to egress from the laboratory and building.
 19. Provide adequate space and easy access to facilitate inspection, repair, or replacement of exhaust ducts.

20. Provide perchloric acid FHES with a dedicated fan and duct and wash-down system that meets the following requirements.
 - a. Design to provide as complete a wash down as possible with all duct at 45° or less from vertical.
 - b. Provide fan casings and hood bottoms with continuous gravity drainage to the sanitary sewer.
 - c. Design wash down to be activated by a manual valve located at the fume hood.
 - d. Prior to acceptance, testing of the wash down system must be witnessed and approved by appropriate University representatives.
21. The target design velocity in each duct shall be in the range of 1200 to 1500 fpm to prevent condensed fumes or particulate from adhering to the walls of the ducts or settling out onto horizontal surfaces and to address acoustical issues. The actual value needs to consider noise and prevention of product deposition in the ducts.
22. To overcome aesthetic objection, design the exhaust stacks in the conceptual stage by incorporating an exhaust tower or a cluster of exhaust stacks as an architectural element of the building.
23. Fume hood exhaust through roofs should have vertical stacks that terminate at least ten feet above the roof or two feet above the top of any parapet wall, whichever is greater, unless higher stacks are found to be necessary according to “The ASHRAE Handbook of Fundamentals” or based on modeling.
24. Design the discharge velocity from the stack to be at least 3000 feet per minute.
25. Do not provide exhaust stacks with weather protection, such as rain caps, bird screens and goosenecks, which require the air to change direction or cause turbulence upon discharge.

B. Fume Hood Exhaust System Testing

1. Test FHES duct as follows:
 - a. Connect a blower to the duct specimen through a shutoff valve. Provide a magnehelic gauge or inclined manometer with 0 to 10 inch W.G. range on the duct side of the shutoff valve.
 - b. Provide temporary seals at all open ends of the duct.
 - c. Average test pressure shall be 6 inches W.G. Initial pressure shall be 7 inches W.G.
 - d. All fume duct joints from the fume hood collar to the fan inlet flex connection, not inclusive, shall be tested.

- e. To prevent over-pressurizing the ducts, start the blower with the variable inlet damper closed. Controlling pressure carefully, pressurize the duct section to the required level. When the pressure of the duct reaches 7 inches W.G., close the shutoff valve.
- f. Using a stopwatch, measure the time elapsed from when the duct is at 7 inches W.G. to 5 inches W.G. Use the formula $t=6.23D$ to determine if the duct passes the test. (“D” is the nominal duct diameter, measured in inches; “t” is the MINIMUM allowable elapsed time, measured in seconds.)
- g. If the test fails to meet the allowable rate, make necessary repairs and retest until satisfactory results are obtained. Contact the Owner’s Representative to witness the test.
- h. Complete test reports.
- i. Comply with precautions listed in the current SMACNA HVAC Air Duct Leakage Test Manual.

APPENDIX B:

GENERAL HAZARDOUS MATERIALS PROVISIONS

Contents

- A. Scope
- B. Hazardous Materials Inventory Statement
- C. Occupancy Classification
- D. Control Areas
- E. Maximum Allowable Quantity (MAQ)
- F. Equipment and Egress Corridors
- G. Increases to the Maximum Allowable Quantity
- H. Control Area Design Alternatives

A. Scope

This guide provides information to assist the designer plan, program, and design teaching and research laboratory facilities. It also provide information on permit application. It applies to all University facilities including leased facilities.

B. Hazardous Materials Inventory Statement

1. A Hazardous Materials Inventory Statement (HMIS) is typically required to confirm the occupancy classification of the building or area. Depending on jurisdiction, an HMIS might be requested at building permit application and again at final inspection prior to issuance of the certificate of occupancy for new buildings.
2. In Seattle, to obtain a building permit the city usually requires an inventory statement and a summary report for each control area, but they do not typically require a hazardous materials management plan.
3. Data for developing an HMIS for a new facility where its use has not been determined, or when researchers are not yet assigned, can be developed with the assistance of EH&S. EH&S will copy data from other similar university laboratories and scale and modify it to fit the planned facility. If speculative data is provided to the building official or fire official for a permit the source of the data and assumptions need to be disclosed.
4. The fire official or building official will usually require a statement to include space beyond the boundary of the project, potentially the entire control area or building.
5. For University projects the HMIS and summary reports should be developed using MyChem, the EH&S proprietary chemical management program. For assistance contact EH&S.
6. When a project is nearing substantial completion, EH&S can assist the prospective tenant with permit application; often a condition for the certificate of occupancy for new buildings. Ideally a single application is made for a building or for each department occupying the building. In Seattle the fire official will often issue a permit and allow teaching and research to proceed and give us 3 to 6 months to develop an accurate inventory statement and summary report.

C. Occupancy Classification

1. Almost all of the existing research buildings at the UW Seattle campus are classified as B occupancies. While uncommon, some building have small centrally managed accessory rooms classified as H occupancies. These spaces, if effectively managed, can be a way to reduce material quantity in the control area.

2. In rare cases it may be necessary to consider an alternate occupancy classification if it is not possible to stay within MAQs. If this case an H occupancy classification may be necessary. Potentially, with approval of the AHJ, a code alternate based upon other precedent such as California's L occupancy may be considered. EH&S must be included in these discussions.
3. EH&S discourages the provision of shared accessory storage rooms for hazardous materials due to the administrative challenge to effectively manage the space and keep them compliant, organized and safe.
4. Centralized compressed gas storage areas located outside or near the loading dock can be a very effective way to reduce excess storage in control areas. This allows vendors to drop off and pickup cylinders on a regular basis. Labs should be designed so that no more than one backup cylinder is stored in each laboratory.
5. Waste pickup on the Seattle campus is conducted at the laboratory where it was generated. However, satellite facilities may need to be provided with a chemical waste bulking room that is located near the loading dock or other convenient, safe and secure location. This room is typically provided with a fume hood and spill containment so the EH&S staff may bulk materials into drums. Depending upon waste stream volume, it may be possible to classify the space as a B occupancy control area rather than an H occupancy accessory room. For more information on this topic and requirements for the bulking room contact EH&S.

D. Control Areas

1. Control areas should be established early in design when the general layout and ventilation shaft locations are being considered so that the ventilation design may be optimized. Preliminary HMIS and control zone reports can be helpful in determining control areas.
2. When two control areas are needed on a floor more advance planning is required. Ideally ventilation ducts should not pass through control area walls; a shaft is needed in or adjacent to each control area. Confer with EH&S during schematic design for control area layout.
3. Buildings with an atrium or other floor opening require special attention to control area layout. The code requires a 2 hour separation in some cases which can be onerous and limit architectural design.
4. For the Seattle campus, an agreement was reached with SFD and DPD to allow buildings constructed prior to the adoption of the IFC to continue to use 1997 UFC (Uniform Fire Code) requirements to manage control areas. This code allows up to four

control areas without reduction for above or below grade floors. For specific information on this agreement contact EH&S.

E. Maximum Allowable Quantity (MAQ)

1. The MAQ for a control area is reduced on floors above and below grade. The University often finds it difficult to conform to quantity limitations in some hazard classes when this reduction in MAQ occurs. Building design should consider the following options to address this constraint especially for upper stories.
 - a. Here are some recommendations for floors four through six:
 - i. Locate labs with more chemicals and high chemical density on lower floors
 - ii. Limit the total space of labs on these floors; less than 3500 square feet is advised as a starting point for planning purposes.
 - iii. Provide a second control zone
 - iv. Consider a code alternate (Seattle has one code alternate published to address this issue for biomedical and other research laboratories)
 - b. For floors above seven through nine:
 - i. Limit these floors to labs using minimal chemicals
 - ii. Limit the total space of labs on these floors; less than 1500 square feet is advised as a starting point for planning purposes.
 - iii. Provide a second control zone but also limit space for labs in each area
 - iv. Consider a code alternate
 - v. Program the space for other use such as vivarium or office space
 - c. Floors nine or more stories above grade can only have one control area and hazardous materials are very strictly limited.
 - d. For floors more than two levels below grade, hazardous materials are not allowed.
2. The code also limits the quantity of hazardous materials in use. If buildings are designed appropriately to accommodate materials in storage, the conditions that apply for materials in use can usually be met, but there are exceptions. The following procedures and operations are examples that require special consideration:
 - a. Dispensing and handling flammable liquids especially in containers larger than 1 gallon
 - b. Solvent distillation stills
 - c. Scintillation units
3. Hazard categories most likely to present an issue with respect to MAQs include flammable liquids, flammable gases, oxidizing gases, pyrophoric, water reactive, and highly toxic materials. Accurate estimates for these materials are critical.

4. Compressed gas and cryogen storage is also regulated under the same section of the code. Bulk storage and storage in laboratories must be carefully considered in order to comply with the MAQ limits.

F. Equipment and Egress Corridors

Hazardous materials should not be stored or used in equipment and exit corridors. For more specific guidance and exceptions refer the Use of Corridors and Unassigned Spaces policy on the EH&S web page, This policy represents a compliance plan with the Seattle Fire Department and applies to all Facilities in Seattle.

G. Increases to the Maximum Allowable Quantity

1. All laboratory buildings should be provided with fire protection which allows doubling of the MAQ for most hazard categories for every control area. Use of approved storage cabinets is much less common, except for flammable liquids. Do not assume a doubling will be allowed for cabinet use without conferring with EH&S and the occupants on the long term practicality of keeping all materials in cabinets.
2. Flammable liquid cabinets should be provided in all spaces with permit threshold quantities (> 5 gallons) so that the University may double the MAQ for this very common material.

H. Control Area Design Alternatives

1. Adding control areas can be an effective way to increase total storage amounts for a building. The nature of the teaching and research provide a significant variability and use changes regularly in research laboratories. For planning purposes, additional control areas should be considered when the lab portion of a control area exceeds:
 - a. 12,000 square feet if at grade level;
 - b. Smaller control areas above and below grade level.
2. A control area can be designed with spaces on more than a single floor. This was very common under the Uniform Codes since the total number of control areas per building was four. However, newly adopted codes limit the MAQs for control areas and require greater fire resistive construction based on how far above (or below) ground floor they are located. If designing a control area that will extend to two or more floors without rated construction, such as one that will include a convenience stair or atrium, the design criteria should use the most restrictive construction elements. For example, if extending from the second to fourth floors, the fire resistive rating for the fourth floor should be used.
3. Another strategy that might be proposed, subject to approval from the local jurisdiction, would be to request multiple "Ground Floors" for the purposes of designating control areas. If a facility is constructed on a slope, this could provide

some relief to the above grade/below grade quantity limitations. This could be shown to still meet the intent of the restrictions from a code standpoint, in that evacuation time and emergency response capabilities are not impacted.

4. Provide accessory H occupancy storage rooms on ground floors where research groups on upper floors can store larger quantities of reagents. If shared the rooms should be provided with cabinets assigned to each laboratory with no storage allowed outside of cabinets. Accessory occupancies are limited to 10% of the building area under the current Building Code.

APPENDIX C:

LABORATORY DECOMMISSIONING

Contents

- A. Overview
- B. Notice of Laboratory Move-out
- C. Chemical Fume Hood Duct Cleaning

A. Overview

Laboratory staff must leave the laboratory in a clean and safe condition for construction crews. Prior to vacating a laboratory, laboratory staff must remove all chemical, biological and radiological materials and they must decontaminate all work surfaces. They must also remove all equipment (unless arrangements have been otherwise) and any garbage or other items that will not be wanted by the new occupants or need to be out of the way of renovation.

B. Notice of Laboratory Move-out

Project Managers must verify that the laboratory is clean and decontaminated prior to demolition or construction of a lab to help prevent unexpected delays or unsafe conditions. In addition, the [Notice of Laboratory Moveout](#) (UoW 1800) must be completed, signed and posted on the inside of one of the laboratory doors.

If you can, consider a site visit with the Department Administrator or Building Coordinator to verify that the laboratory is clean before construction begins.

C. Chemical Fume Hood Duct Cleaning

A contractor should perform the cleaning of fume hood ducts because it requires working in restricted spaces and coordination with the project. Perchloric acid fume hood systems have the potential to form perchlorate deposits that are heat and shock sensitive. Arrange sampling for perchlorates through an environmental consultant prior to demolition of the hood or duct. If the testing results identify perchlorate deposits, the clean the duct thoroughly prior to demolition.