HARVARD
Campus Services
ENVIRONMENTAL HEALTH & SAFETY

Harvard University Guidelines for Design

Table of Contents

1.0 Purpose

Harvard expects architects, engineers, and designers to construct campus buildings that meet building codes and regulatory standards and provide a safe and healthy environment for occupants and maintenance personnel.

As part of the hiring process, Harvard establishes a formal contractual agreement with architects, engineers, and designers by executing a standard form of agreement for applicable consulting, design, and construction services. As part of this agreement, the architect and their consultants must provide design services according to all current laws, statutes, ordinances, building codes, rules, and regulations applicable to the design of a project.

This manual provides information about certain environmental health and safety (EH&S) design requirements. It doesn't address and isn't intended to abrogate or assume responsibility for the architect's duty to know and understand all governing requirements according to their executed agreement with Harvard. This information is only provided to communicate certain EH&S design issues that may be overlooked by architects and their consultants during the design of Harvard projects.

There are also other Harvard design guidelines that should be used to help projects meet Harvard's goals for sustainability and climate resiliency.

Once baseline code and EH&S compliance requirements are met, EH&S encourages projects to work with other groups such as the Office for Sustainability to evaluate other opportunities to support healthy and sustainable buildings at Harvard.

This manual is divided into two sections:

- General design considerations highlight general EH&S issues about safety and installing building components like HVAC systems, air emission sources, and fuel storage tanks.
- All other sections highlight EH&S issues related to facilities like food service establishments and labs.

For certain projects, you may need to more specifically address other EH&S design issues.

Adequately managing these issues typically involves retaining specialized environmental consultants for stringent regulatory or permitting requirements. EH&S has tools and resources to help project managers and architects understand issues and incorporate them appropriately into the design process.

Our resources cover specific EH&S issues, including:

- Air emission source installation.
- Asbestos abatement.
- Geothermal well installation.
- Groundwater management.
- Lead paint abatement.
- Miscellaneous hazardous materials abatement.
- Soil management.
- Stormwater management.
- Underground storage tank removal.

For more information, visit EH&S or call at 617-495-2060.

2.0 General Design Considerations

2.1 Air Emission Sources

EH&S equipment services:

- Manage communications with regulatory agencies for issues like obtaining or modifying existing permits.
- Provide technical information, resources, and training during design, construction, and operation.

2.1.1 Air Emission Source Permitting and Installation

Before you install equipment that releases air pollutants, you typically need an air permit.

Examples of such equipment includes:

- Any equipment that burns fuel or emits air pollutants to outdoor air.
- Boilers, engines, and turbines.
- Cooling towers.
- Emergency generators.
- Refrigerant-containing devices with reservoirs of 5 lbs or more.
- Volatile organic compound (VOC) process equipment sources, such as solvents, paints, and degreasers, that potentially emit more than 1 ton of VOCs annually.

Before installing specific air emission sources that exceed specified regulatory thresholds, you must complete Massachusetts Department of Environmental Protection (MassDEP) permitting or a plan review. These thresholds are described in 2.1.3 Cooling Towers through 2.1.4 Emergency Generators.

If your project involves any of these permitted sources, you must:

- Retain a qualified air consultant.
- Send EH&S a copy of the engine permitting information to include in Harvard's permit.

Vendors should be prepared to supply technical information to help with permitting and recordkeeping.

You must ensure that all air emission sources installed at Harvard, including generators, boilers, and cooling towers, meet the minimum design criteria in 2.1.3 Cooling Towers through 2.1.4 Emergency Generators.

You must also ensure that equipment that burns fuel or emits air pollutants to outdoor air is installed and operated according to Environmental Protection Agency (EPA) and MassDEP requirements.

2.1.2 Boilers

- Ensure boilers comply with current American Boiler Manufacturer Association and American Society of

Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) design guidelines.

- Before purchasing and installing boilers with heat input capacity greater than 10 MMBtu/hour, get DEP approval.[1]
- For projects involving installing boiler groups within close proximity or using a single stack, boilers are typically considered one unit and require DEP approval if the aggregate heat input capacity exceeds 10 MMBtu/hour, even if the individual units don't exceed permitting threshold.
- Before installing boilers, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions that affect boiler performance, maintenance, and operations.
- Install all fuel gas piping systems, fuel gas utilization equipment, and related accessories servicing boilers according to National Fire Protection Agency (NFPA) 54.
- Install all full oil piping systems, fuel oil utilization equipment, and related accessories servicing boilers according to NFPA 31 and permit requirements.
- For boilers with heat input capacity of 3 MMBtu/hour or more but less than 10 MMBtu/hour, include these boilers in Harvard air permits and follow maintenance and recordkeeping requirements.

2.1.3 Cooling Towers

- Certify cooling tower thermal performance according to Cooling Technology Institute's STD-201.
- Ensure fill material and water distribution systems servicing cooling towers are made from corrosion-resistant and heat resistant materials.
- Ensure units with drift eliminators are made from corrosion- resistant, decay- resistant, and biological attack-resistant materials.
- Equip units with blowdown discharge flow meters.

[1] According to 310 CMR 7.02(1).

2.1.3.1 Cooling Tower Air Permits

Air permits are required when installing cooling towers that meet any of these criteria:

- Potentially emit 1 ton or more of particulate matter.
- Have a recirculation rate greater than 20,000 gpm.
- Have a total dissolved solids concentration in the blowdown greater than 1,800 mg/l of blowdown.

2.1.4 Emergency Generators

EH&S sources Harvard emergency generator design guidelines directly from the DEP Emergency Engine Environmental Certification Workbook and applicable regulations. This information includes requirements and expectations for installing generators at Massachusetts institutions, including emissions, stack heights, and emission dispersion.

2.1.4.1 Documentation Requirements by Generator Engine Type

Engine Type	Documentation Requirement
Emergency engines burning fuel oil	A statement that a certificate of conformity was obtained pursuant to the EPA Emission Standards for Nonroad Engines and Vehicles.
Emergency engines burning natural gas or propane	Supplier documentation stating that the engine, including any add-on catalytic emission control, meets the non-road compression ignition emission limitations for the engine power rating and model year.

2.1.4.2 Generator Engine Noise Reduction

To avoid creating noise nuisances:

- Choose unit locations thoughtfully.
- House units in enclosures specifically designed to attenuate sound.
- Avoid locations that affect people, like near windows, doors that open, or other sensitive receptors.

2.1.4.3 Generator Emission Limits

Both compression-ignition and spark-ignition engines must follow applicable EPA Emission Standards for Nonroad Engines and Vehicles that matches the engine model calendar year when they're installed.

- Only install fuel engines with ultra-low sulfur diesel (15 ppm sulfur).
- Equip emergency engines with a non-turn back hour counter to track hours of operation.
- Consider distancing generators with internal fuel storage tanks siting locations away from roadways and near fuel delivery vehicle access areas. Fuel delivery vehicles must typically park within 100 ft of the tank fill port.
- Where possible, design teams should consider evaluating alternatives to adding new fossil fuel burning equipment, such as leveraging an existing generator on a nearby building or using battery technology for emergency power.

2.1.5 Engine Exhaust Stacks

When designing exhaust engine stacks, engineers must:

- Ensure all engine exhausts, including those from engines or turbines, use an exhaust stack that discharges without causing a condition of air pollution.
- Design stacks to discharge vertically upward. Stack heads or devices that prevent precipitation from entering the stack must not restrict exhaust gas stream vertical flow.
- Don't use devices like "shanty caps" and "eggbeaters".

  While you can cone the top of a stack, consider making diameter changes of 1 in or less for every 5 in in length of cone to avoid serious backpressure that could affect air flow at the point of origin.

- Configure exhaust stacks to discharge combustion gases vertically, without any part or device that impedes emitted combustion gas vertical exhaust flow.
- Employ good air pollution control engineering practices to minimize the impact of exhaust stack emissions on sensitive receptors, such as people, windows, doors that open, and building fresh air intakes.

For example:

- Avoid locations that may be subject to exhaust downwash.
- Install a stack of sufficient height when doing so prevents and minimizes flue gas impacts upon sensitive receptors.

2.1.5.1 Exhaust Stack Air Dispersion Modeling

Projects with new emergency engines, including existing unit in-kind replacements, must use air dispersion modeling to demonstrate installation will satisfy all EPA and DEP requirements.

Contact EH&S for help making sure engine designs meet current regulatory requirements.

2.1.5.2 Exhaust Stack Good Engineering Practices

Engineers must employ EPA Good Engineering Practices (GEP) to ensure that exhaust emissions both:

- Don't adversely impact the air quality of nearby sensitive environmental receptors.
- Remain below Federal National Ambient Air Quality Standards (NAAQS) levels.

GEP requirements include:

- Place engines in areas where the exhaust stack won't impact air quality for nearby sensitive environmental receptors.

  The EPA GEP defines "nearby" as a building or solid structure within either five times the height or length of that structure from the stack, or one-half mile, whichever is less. For example, a building that is 10 ft tall, 20 ft wide, and 40 ft from an engine stack is considered nearby as it's less than 5 ft by 10 ft from the base of the proposed stack location.

- Design stacks to meet each pollutant's EPA GEP height, which are generally defined as 1.5 times either the height or the width of nearby structures, whichever is less.

  For all engines with a rated power output of 300 kW or greater, MassDEP recommends a minimum stack height of 10 ft above the facility rooftop, emergency engine, or turbine enclosure, whichever is lower.

MassDEP requirements don't supersede EPA GEP guidance. For example, a 10 ft stack next to an open window doesn't satisfy EPA and DEP regulatory compliance requirements unless it's proven through a modeling assessment of the air quality impacts to that window.

Learn more about [EPA Support Center for Regulatory Atmospheric Modeling GEP guidance].

2.1.5.3 Exhaust Stack Height Requirements

Type	Rated Power Output	Minimum Exhaust Stack Height
Emergency engine or emergency turbine	300 kW or greater.	10 ft above the rooftop, engine, or turbine enclosure, whichever is lower.
Engine	1 MW or greater.	1.5 times the height of the building where the stack is located.

For stacks lower than 1.5 times the building height or lower than the height of a structure within five times the lesser of the height or maximum projected width of the structure (5 L), the owner or operator must submit documentation demonstrating that the engine or turbine operation won't exceed NAAQS.

2.2 Heating Ventilation and Air Conditioning Systems

2.2.1 HVAC Ventilation

Architects must fully design and document proposed heating ventilation and air conditioning (HVAC) system design criteria as part of HVAC systems specification included in their overall design documents.

Ventilation requirements:

- Provide all occupied indoor spaces with either or a combination of both:
  - Natural ventilation that meets Massachusetts Building Code (9th Edition) 780 CMR 1203.4 and International Mechanical Code (2009) Section 402 requirements.
  - Mechanical ventilation that meets International Mechanical Code (2009) Section 403 requirements.

- Ensure recirculating variable air volume (VAV) system controls meet the minimum ventilation of International Mechanical Code (2009) Section 403.3 at all supply airflow rates.

2.2.2 HVAC Recirculation of Supply and Exhaust Air

- Ensure recirculation of return, transfer, and exhaust air meets Massachusetts Mechanical Code Section 403.2.1 requirements.
- Don't recirculate exhaust air from lab hoods or other exhausts that EH&S determines meet ASHRAE Standard 62.1 (2016) Section 5.16.1 Class 4.
- Don't use enthalpy wheels in any Class 4 exhaust.

2.2.3 HVAC Temperature Control and Thermal Comfort

- Ensure spaces intended for human occupancy have an active or passive heating system that maintains a minimum temperature of 68 °F (20 °C).[2] Don't install portable space heaters to meet this requirement.
- Design systems to meet Harvard's temperature policy of 68 °F to 71 °F in winter and 74 °F to 76 °F in summer unless specific applications require temperatures out of this range.
- In the design phase of HVAC systems, document performance criteria and verify them when commissioning HVAC systems.

2.2.4 HVAC Noise and Acoustical Insulation

- Ensure HVAC system noise levels meet room criteria noise levels specified in ASHRAE Handbook (2015) Applications Chapter 48 Noised and Vibration Control.
- Where appropriate, reduce fan and air noise with sound attenuators and vibration isolators. When feasible, use round or oval ducts instead of rectangular ducts and larger ducts and fans at lower revolutions per minute (RPM).

[2] Massachusetts Building Code Section 1204 and International Fire Code (2009) Section 309.

2.2.5 HVAC Duct Insulation

Ensure duct insulation meets Massachusetts Mechanical Code (IMC-2009) Section 604 requirements.

2.2.6 HVAC Air Intakes

- Ensure outdoor air intake locations meet Massachusetts Building Code Section 2801.2.2.1 requirements.
- Ensure design meets ASHRAE 62.1-2016 Section 5.5 Outdoor Air Intakes requirements.

2.2.7 HVAC Filtration

- Ensure filters meet Massachusetts Mechanical Code (IMC2009) Section 605 Air Filters requirements.
- Filter all outdoor air upstream of cooling coils or other wetted surfaces.
- Use filters with a minimum efficiency reporting value (MERV) of eight or more.[3]
- When specifying filters, consider potential outdoor air pollution sources and particulate levels required for intended indoor space use.

2.2.8 HVAC Fans

- Appropriately guard all moving parts like belts and drives per OSHA 1910, Subpart O, Machines and Machine Guarding.
- Designate and position fans for unencumbered inspection and maintenance access.

2.2.9 HVAC Drain Pans

- Provide drain pans beneath all dehumidifying cooling coil assemblies and all condensate producing heat exchangers.

---

[3] MERV of eight or more per Section ANSI/ASHRAE 62.1- 2016 Ventilation for Acceptable Indoor Air. See ASHRAE Handbook (2016) Chapter 29 Air Cleaners for Particular Contaminants for MERV values for typical applications.

- Ensure drain pans meet American National Standards Institute (ANSI)/ASHRAE 62.1-2016 Section 5.10 Drain Pans design requirements.

2.2.10 HVAC Exhaust Ventilation

- Provide minimum general mechanical exhaust ventilation recommended for select occupancies in Massachusetts Mechanical Code (IMC2009) Table 403.3 Minimum Ventilation Rates.

  See 4.2 Lab Local Exhaust Ventilation and Exposure Control Devices for specialized local exhaust ventilation like fume hoods and gas cabinets.

- Ensure exhaust outlet and vent locations meet Massachusetts Mechanical Code (IMC2009) Section 501.2.1 Location of Exhaust Outlets requirements.
- Ensure exhaust outlets aesthetic enclosure types are open louvered to let horizontal winds ventilate enclosures.
- Ensure exhaust outlets exhaust outside aesthetic enclosures and aren't in the same enclosure location as any air intakes.

2.2.11 HVAC Fin-Tube Coils and Heat Exchangers

Ensure fin-tube coils and heat exchangers providing dehumidification meet ANSI/ASHRAE 62.1-2016 Section 5.11 requirements.

2.2.12 HVAC Humidifiers and Water Spray Systems

Ensure humidifiers and water spray systems meet ANSI/ASHRAE 62.1-2016 Section 5.12 requirements.

2.3 Flammable and Combustible Liquid Storage

2.3.1 Liquid Storage Control Areas

Control areas are specific spaces within a building. They're enclosed and bounded by exterior walls, fire walls, fire separation assemblies and roofs, or a combination of these elements. In control areas, limited quantities of hazardous materials that don't exceed exempt amounts are stored, dispensed, used, or handled.

Design control areas to store flammable and combustible liquids so that projected work won't exceed exempt limits.

In Massachusetts, you must use control areas wherever hazardous materials are present.

You must read the Massachusetts Comprehensive Fire Safety Code in 527 CMR 1.00 based on the NFPA 1, 2021 Fire Code with state amendments which provide specific state requirements, including topics like control areas and emergency showers.

When designing, constructing, and determining the location and quantity of materials in a control area, you must meet these criteria:

- Apply Massachusetts Building Code 780 CMR requirements in conjunction with NFPA 45 requirements. If there's a conflict between the requirements, apply the most restrictive requirements.
- Comply with Massachusetts Building Code 780 CMR 417.2 requirements.
- Don't exceed allowable amounts of hazardous materials in each control area.[4]
- Ensure that the number of allowed control areas per floor, the percentage of allowable exempt quantities per control area, and the degree of vertical fire separation complies with 780 CMR Table 417.2 Permitted Control Areas requirements.
- Ensure that the floors and supporting structures for all floors within a control area have at least a two-hour fire separation. Ensure fire separation assemblies comply with 780 CMR 709.
- Locate control areas up to one level below grade. Control areas aren't permitted two levels below grade.
- Don't store Class 1 flammables below grade.

2.3.1.1 Maximum Liquid Storage Quantities

You may increase control area maximum storage quantities:

[4] As specified in 780 CMR Tables 307.8(1) and 307.8(2).

- When stored in buildings equipped throughout with automatic sprinklers.[5]
- If you store flammable materials in approved cabinets, gas cabinets, fume hoods, or ventilated cabinets.

2.3.2 Flammable Storage Cabinets

Design and construct approved flammable storage cabinets to:

- Meet 527 CMR 1.00 Massachusetts Comprehensive Fire Safety Code specifications.[6]
- Limit the internal temperature during fire testing, as specified in NFPA 251, Standard Methods of Tests of Fire Resistance of Building and Construction and Materials.

2.3.2.1 Metal Flammable Storage Cabinets

Metal flammable storage cabinet design and construction must meet these criteria:

- The cabinet's bottom, top, door, and sides must be double walled with a 38 mm (1.5 in) air space. They must be constructed using sheet steel that is at least 18 gauge or thicker.
- Joints must be riveted, welded, or made tight by equally effective means.
- The door must have a three-point latch arrangement, and the door sill must be raised at least 50 mm (2 in) above the bottom of the cabinet to retain spilled liquid within the cabinet.
- New cabinets must have self-closing doors.

2.3.2.2 Venting Flammable Storage Cabinets

You don't need to vent flammable storage cabinets for fire protection. In this case, you can seal vent openings with the bungs supplied with the cabinet or with bungs specified by the cabinet manufacturer.

---

[5] According to 780 CMR 906.2.1.

[6] Based on NFPA 1 2021 edition, Chapter 66 Flammables and Combustible Liquids, Section 66.9.9 Flammable Liquids Storage Cabinets: New cabinets must meet NFPA 30 2021 edition, Chapter 9, Section 9.5 Liquid Storage Cabinets.

For vented storage cabinets, ensure cabinets vent directly outdoors in a way that both:

- Doesn't compromise the cabinet's specified performance.
- Is acceptable by the authority having jurisdiction.

This includes thermally-actuated intake and exhaust vent dampers, flame arrestors on the cabinet vent openings, and exhaust through the vent opening closest to the cabinet bottom.

2.3.2.3 Wooden Flammable Storage Cabinets

Wooden flammable storage cabinet design and construction must meet these criteria:

- Ensure the bottom, sides, and top are made of exterior grade plywood at least 25 mm (1 in) thick.
- Ensure the plywood type won't break down or delaminate under fire conditions.
- Ensure all joints are rabbeted and fastened in two directions using wood screws.
- If multiple cabinet doors are used, provide a rabbeted overlap of not less than 25 mm (1 in).
- Equip doors with a means of latching. Ensure hinges are constructed and mounted to maintain their holding capacity during exposure to fire.
- Include a raised sill or pan at the bottom of the cabinet, capable of containing a 50 mm (2 in) depth of liquid to retain spilled liquid within the cabinet.
- Ensure new cabinets have self-closing doors.

2.3.3 Inside Liquid Storage Rooms

If you plan to store flammable and combustible liquids that exceed the allowed amounts per control area, you must have inside (indoor) liquid storage rooms or cut-off rooms.

2.3.3.1 Liquid Storage Room Design

Build inside storage rooms to meet applicable requirements:

- Comply with 780 CMR 417.5,
- Massachusetts Board of Fire Prevention Codes 527 CMR 14.03 (18)d, and

- NFPA 30 2003 Flammable and Combustible Liquids Code Section 6.4.
- Ensure inside storage areas don't exceed 500 sq ft.
- If cut-off rooms exceed 500 sq ft, ensure they have at least one exterior door approved for fire department access.
- Maintain an aisle at least 3 ft wide in flammable storage rooms.
- Inside liquid storage rooms and cut-off rooms must include one or two outside walls.
- Don't build inside liquid storage rooms in basements.

Inside liquid storage rooms are categorized as H-2 occupancy areas.

2.3.3.2 Liquid Storage Room Electrical Wiring

In inside rooms used for Class I liquids, ensure electrical wiring and equipment is suitable for Class I, Division 2 classified locations.

Learn about designing and installing electrical equipment from NFPA 70, National Electrical Code.

2.3.3.3 Liquid Storage Room Fire Safety Planning

- Ensure inside liquid storage room fire resistance ratings meet minimum NFPA 30 Section 6.4.2.2 requirements.
- In mixed use groups, ensure fire separation meets the four-hour separation in 780 CMR 313 for H-2 User Group.
- Install fire doors according to NFPA 80, Standard for Fire Doors and Fire Windows.
- Provide all inside flammable storage areas with fire detections system that comply with 780 CMR 417.5.3.
- Protect inside flammable liquid storage rooms with an automatic fire protection system installed according to 780 CMR 906.2.1.
- Place at least one portable fire extinguisher with a minimum rating of 20-B outside of, but not more than, 10 ft of the door opening into the room.

2.3.3.4 Liquid Storage Room Spill Controls

Provide flammable liquid storage rooms with spill control and drainage control.

2.3.3.5 Liquid Storage Room Storage for Containers

If you store containers over 30 gal and capable of storing Class I or Class II liquids, don't store them more than one container high.

2.3.3.6 Liquid Storage Room Ventilation

- Install continuous mechanical exhaust ventilation systems in all inside liquid storage rooms.
- Ensure they provide a minimum of 1 CFM of exhaust for each square foot of floor area, but not less than 150 CFM total. Equip these systems with an airflow switch or other reliable method interlocked to sound an audible alarm if the ventilation system fails.
- Depending on the density of the vapor produced, design systems to take exhaust ventilation from the ceiling and the floor. To prevent accumulating flammable vapors, arrange exhaust and inlet air opening locations to provide air movement across all portions of the floor as far as possible.
- Directly vent exhaust from the room to the exterior of the building without recirculation.
- Ensure all ducts comply with NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids.

2.4 Pest Control

- Ensure that new construction and renovation projects are consistent with current Harvard Construction Integrated Pest Management Standard requirements and guidelines.
- Schedule EH&S for a formal design review and a pest assessment during construction and before completion.
- Engage services from a Harvard-qualified pest management vendor.
- Keep all vegetation (except grass or clover) at least 18 away from building foundations. Place trees and bushes so that their mature crowns stay at least 6 ft away from the building's sides.

- Review proposals for interior or exterior green walls with EH&S.
- Review food waste handling, storage, security, and cleaning plans with EH&S.
- Design and install all exterior doors and utility penetrations to exclude rodents and pests from entering.
- Screen all chimney flues to prevent entry by wildlife, including birds and bats.
- For large openings like loading docks and garages, specify rapid roll-up doors designed to be pest-tight. If you use doors that can be activated by motion sensors or other means, ensure they close automatically after vehicles have passed.
- Install insect screening on all operable windows for protection. For louvers, use non-oxidizing metal mesh with 1/4 in holes.
- Modify landscaped or hardscaped areas to ensure efficient drainage, reducing mosquito developmental habitats. Ensure swales designed for stormwater retention and detention drain completely in fewer than three days.
- Avoid expanses of glass unless they specifically are designed to discourage bird strike incidents.
- Avoid installing bright lights on or around buildings, which can disorient birds and insects, potentially leading to impacts with the building or fouling of the façade.

2.5 Safety

2.5.1 Automated External Defibrillators

Automated external defibrillators (AED) are required in Massachusetts health clubs[7], nursing facilities[8], public schools[9], and dental offices.[10]

---

[7] Massachusetts General Laws (MGL), Part I, Title XV, Chapter 93, Section 78A.

[8] 105 CMR 150.000.

[9] MGL Part I, Title XII, Chapter71, Section 54C.

[10] 234 CMR 6.00.

Harvard supports fitting AEDs in targeted public areas where many people transit or gather to increase cardiac emergency survival rates.

Harvard's AED program meets Massachusetts AED requirements for Public Access Defibrillator Programs[11] and follows the American Heart Association's (AHA) Public Access to Defibrillation (PAD) guidelines.

By fitting AEDs into your facility, you agree to abide by the Harvard AED program administrated by EH&S. Harvard University Health Services (HUHS) provides required AED program medical oversight, defines roles and responsibilities, outlines routine inspections, and maintenance.

Schools and units are responsible for costs associated with AEDs, parts, accessories, inspections, and maintenance.

The AED program requires ZOLL AED Plus or AED3 units. Follow the AED Cabinet Standard, Division 10 43 13 when installing AED cabinets.

Learn more about Harvard AED program implementation.

2.5.1.1 AED Locations

You must install AEDs in childcare centers, health clubs, and athletic facilities.

Generally, you should install fixed AEDs in public areas where large numbers of people transit or gather, including:

- Classrooms (CLS).
- Commercial offices and retail (COM).
- Dry labs and studios (DLB).
- Undergraduate dorms (DOR).
- Healthcare (HLT).

[11] M.G.L. Part I, Title XVI, Chapter 112, Section 12V ½.

- Study and libraries (LIB).
- General assembly.
- Museum (MUS).
- Offices.
- Institutional (OFC).
- Residential graduate and affiliates (RES).
- Research office buildings and labs (ROB).

Consider AHA PAD recommendations when selecting AED locations in facilities:

- Install AEDs where people can reach them and deliver a shock to a victim within three to five minutes after the person collapses.
- Ensure AEDs are readily visible and always accessible.
- Include medical oversight provided by HUHS.
- Inspect and maintain AEDs follow manufacturer's recommendations.

2.5.1.2 AED Models

ZOLL Medical Corporation manufactures AEDs and offers Harvard a selection of AEDs, parts, and accessories.

For more information about current Harvard AED models and specifications, review the AED Program.

2.5.2 Confined Spaces

A confined space is an area that:

- Is large enough for an employee to enter and perform assigned work.
- Has limited or restricted means for entry or exit.
- Isn't designed for continuous employee occupancy.

A confined space's hazards can make it significantly more dangerous to enter.

Design all structures to minimize the number of confined spaces.

2.5.2.1 Permit-Required Confined Spaces

Confined spaces require permits if one or more characteristics exist:

- Contains or potentially contains a hazardous atmosphere.
- Contains a material that has the potential for engulfing an entrant.
- Has an internal configuration so that entrants can be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized serious safety or health hazards.

If you must create a permit required confined space, take at least one action to reduce the space's hazards:

- Install a remote monitoring and inspection system and automated cleaning system to eliminate or minimize the need for entry.
- Provide mechanical ventilation in confined spaces to avoid build-up of contaminants or combustible atmospheres.
- Design adequate means of entry and exit. Make provisions for people entering and exiting for those who may be required to wear personal protective equipment (PPE), a breathing apparatus, and protective clothing.
- Design suitable illumination for emergency power. Don't use timer switches. Ensure lighting is sufficient for safe entry, conducting work, and exiting.
- Eliminate fall hazards by providing:
    - Fixed ladders, guardrails, platforms, and anchor points for personal fall arrest systems.
    - Non-slip work surfaces (textured flooring).

2.5.3 Fall Hazards

Design structures to eliminate fall hazards during all activities, including routine and non-routine use, maintenance, and repairs.

Where you can't avoid exposure to fall hazards in your building's design, minimize hazards for working at heights above 6 ft:

- Install permanent fall arrest anchor points for personal fall protection equipment.[12]
- Install guardrails and toe boards where people are exposed to falls of six or more feet.[13]
- Provide fall protection when working over dangerous equipment and machinery, regardless of the fall distance.
- Protect rooftop equipment or drains within 15 feet of the leading edge of the rooftop with a passive or active fall protection system.

  Sometimes a combination of both systems applies. Corralling equipment with railing leading back to a safe walking path may be an alternative.
- Protect ladder and hatch access from the leading edge of the roof (within 15 feet) and use railing (passive fall protection system) or anchor points or lifelines (active fall protection system) to safeguard workers on rooftops or elevated workspaces.

2.5.4 First Aid Kits

First aid kit accessibility requirements:

- Locate the operable parts of the first aid kit (including parts like the latch or handle) no higher than 48 inches and no lower than 15 inches above the finished floor.

---

[12] Personal fall arrest equipment attachment anchorages should be capable of supporting at least 5,000 pounds (22.2 kN) per employee attached as required by the Occupational Health and Safety Administration (OSHA).

[13] Install standard railings with standard toe boards on all exposed sides except at the entrance to the opening. Construct railings and toe boards according to the American National Standards Institute (ANSI) standard A1264.1-2017.

- If the first aid kit protrudes more than 4 inches from the wall, locate the leading edge no higher than 27 inches from the floor. If the depth is less than 4 inches, there are no height restrictions.

  For an illustration of how to locate protruding objects and maintain accessibility, review the U.S. Access Board Guide to the Americans with Disabilities Act (ADA) Accessibility Standards: Limits of Protruding Objects.

- A 30 inch by 48 inch clear space in front of the first aid kit allows for a wheelchair to approach.

  For an illustration of a how to create a clear space in front of a first aid kit, review the U.S. Access Board Guide to the ADA Accessibility Standards: Accessible Features of Operable Parts.

2.5.5 Fixed Ladders

Fixed ladder requirements:

- Compliance with OSHA standard 29 CFR 1910.27.
- Construction according to ANSI standard A14.3-2008.

These standards establish minimum requirements for fixed ladder design, construction, and use, including safety features like cages, wells, and safety systems used with fixed ladders to minimize personal injuries.

2.5.6 Skylights

A skylight is considered a hatchway, which means it's an opening in the roof of a building through which people can potentially fall.[14] OSHA requires skylights to be guarded by a standard skylight screen or a fixed standard railing on all exposed sides.

Design skylights to prevent people from falling through them.

[14] OSHA regulation 29 CFR 1910.23(a)(4).

2.5.6.1 Skylight Screens

Skylight screens must be:[15]

- Constructed and mounted to withstand a load of at least 200 lbs applied perpendicularly at any single area on the screen.
- Constructed and mounted so that, under normal loads or impacts, they won't deflect downward enough to break the glass below them.
- Constructed with either:
  - Grillwork with openings no longer than 4 in.
  - Slat work with openings no wider than 2 in with the length unrestricted.

2.5.7 Window Washing

On all new buildings where windows must be washed by suspended systems, including suspended scaffolds, boatswain's chairs, or rope descent systems:

- Install roof anchors according to ANSI and International Window Cleaning Association standard I 14.1-2001.
- Construct all window cleaning powered platforms according to the American Society of Mechanical Engineers (ASME) standard A 120.1-2001 and ASME 120.1b-1999.

2.6 Solid Waste

2.6.1 Construction Waste Management Plans

- Develop construction waste management plans as specified by EH&S Standard Specification Section 017419 Construction and Demolition Waste. Include these plans in the design specifications.
- When sourcing materials, consider recycled content and material recyclability. Include locally sourced

[15] OSHA regulation 29 CFR 1910.23(e)(8).

materials, both extracted and manufactured locally.

- Verify that any excess building materials from construction are recycled or diverted locally.

2.6.2 Massachusetts Solid Waste Bans

Comply with Massachusetts waste bans, which prohibit certain items from disposal under 310 CMR 19.017. These waste bans apply to all solid waste destined for a Massachusetts landfill, incinerator, or transfer station.

Items banned from disposal:

- Asphalt pavement, brick, and concrete.
- Cathode-ray tubes (CRT).
- Clean gypsum wallboard.
- Food waste.
- Glass bottles and jars.
- Lead acid batteries.
- Leaves and yard waste,
- Mattresses.
- Metal beverage and food containers.
- Plastic bottles, jars, jugs, and tubs.
- Recyclable paper and cardboard.
- Scrap metal.
- Textiles.
- Whole tires.
- Wood waste (treated and untreated).

2.6.3 Solid Waste Pest-Proof Storage Containers

Comply with storage and disposal requirements to deter wildlife:

- Install rodent-proof and squirrel-proof trash and recycling containers in outdoor areas.

- Review Section 2.4 Pest Control for more pest management information.

2.6.4 Solid Waste Storage and Collection Space

When planning a project, consider waste system design for the facility from the earliest stages. Design adequate space to store and collect solid waste. Consider how indoor and outdoor bin needs may influence the building design, layout, and budget.

During design, follow these criteria to meet solid waste compliance requirements:

- Incorporate efficient strategies for estimating occupant-generated waste for implementation, including operations and maintenance.
- Ensure that each building can collect three separate waste streams – trash, mixed recyclables, and food waste.
- Evaluate path of travel requirements for waste and recyclables from the building to an outdoor enclosure or loading dock.
- Ensure that operational services are met for the access route, including turning radius and overhead space, for the bins and collection containers in the outdoor enclosure or loading dock for the collection vehicles.

2.7 Storage Tank Installation

Aboveground storage tanks (AST), underground storage tanks (UST), and all associated appurtenances to be installed on Harvard property must meet all these criteria:

- A Massachusetts licensed professional qualified by the state to design such items must complete the design.
- A professional engineer must review the design.
- Harvard EH&S and Engineering and Utilities departments must review design documents, including plans, schematics, notifications, and permit applications. These departments review submittals to ensure compliance with Harvard permits and policies.
- Compliance with all federal, state, and local regulations governing fuel storage tank permitting.

- The minimum design criteria outlined in Section 2.7.2 Aboveground Storage Tanks and Section 2.7.3 Underground Storage Tanks.

2.7.1 Tank Permitting

- Ensure contractors are properly licensed.
- Direct contractors to perform work and obtain the appropriate permits according to all applicable federal, state, and local regulations governing work involving permitting ASTs and USTs.

Specific notifications, registrations, licensing, and permitting may differ between jurisdictions.

2.7.1.1 Permitting Requirements by Tank Type

Tank Type	Permitting Requirements
AST	Properly install and permit tanks and associated piping according, but not limited, to 40 CFR 112, 310 CMR 7.00, and 502 CMR 9.00.
UST	Properly install and permit tanks and associated piping: • According to, but not limited to, 40 CFR 112, 310 CMR 7.00, and 310 CMR 80.00. • With the manufacturer's instructions. • With "Petroleum Equipment Institute Publication RP100-97, Recommended Practices for Installation of Underground Liquid Storage Systems."

2.7.1.2 Tank Installation Contractor Approvals and Documentation

Typical installation contractor approval process and documentation requirements:

Tank Characteristics	Requirements
Heating oil tanks associated with fuel burning equipment.	Ensure that a permit has been obtained from the Massachusetts Department of Public Safety and local fire department.[16]
Gasoline tanks and diesel fuel tanks.	Submit registration and permit to the Massachusetts Department of Fire Services and local fire department.
Tanks greater than 10,000 gal containing materials other than water, including pressurized gases like nitrogen.	Submit a registration application and license to: Massachusetts Department of Public Safety, Massachusetts Department of Fire Services, [17] local fire department, and license commission.[18]

2.7.2 Aboveground Storage Tanks

ASTs are installed in underground vaults. They aren't buried and are otherwise accessible for inspection. These storage tanks are subject to all applicable AST requirements.

When designing ASTs:

- When possible, employ on-tank suction-type pumps to prevent and minimize leaks by eliminating valve and fitting leaks.
- Don't place tanks directly under building eaves where falling snow or dripping water could increase external damage.
- Ensure tank systems have properly sized vents for emergency pressure relief.
- If you must place tanks outside buildings, protect them from vandalism, collision, and accidental damage

[16] 527 CMR 4.03 (1)(b), 527 CMR 4.03 (1)(d)

[17] 502 CMR 5.00.

[18] 502 CMR 9.03 (B).

using strategies like bollards or wire fences around the tank.

- Consider tanks made of less corrosive materials like polyethylene.
- To prevent tanks from floating, secure them in areas subject to flooding like basements.
- Consider the tank fill port's distance from the closest roadway or fuel delivery vehicle access point. Most delivery vehicles need to be within 100 ft of the fill port. Ensure the driver can see the fill port and delivery vehicle while filling.

2.7.2.1 AST Oil Spill and Overfill Controls

To prevent and minimize oil spills and overfills, tanks must have at least one of these controls:

- Audible high-level alarm activated by a float switch at a specified fill level.
- Valve located within fill-pipe access to close automatically at a specified fill level.
- Direct reading level gauge at the tank visible from fill pipe location.
- Secondary containment that can contain 110 percent capacity of the tank or the containment area's largest tank.

Learn more about Harvard's Spill Prevention, Control, and Countermeasure Plan.

2.7.3 Underground Storage Tanks

Properly design and protect USTs and associated piping from corrosion.

When designing USTs:

- Construct tanks from fiberglass-reinforced plastic in compliance with "Underwriters Labs Standard 1316-83-87; Standard for Glass-Fiber-Reinforced Plastic", "Underground Storage Tanks for Petroleum Products", or "American Society of Testing and Materials Standard D4021-86; Standard Specification for Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks".
- Install piping systems according to American Petroleum Institute-API Recommended Practice 1632.
- Consider the tank fill port's distance from the closest roadway or fuel delivery vehicle access point. Most delivery vehicles need to be within 100 ft of the fill port. Ensure the driver can see the fill port and delivery

vehicle while filling.

Tanks installed in underground vaults that aren't buried may be subject to AST requirements.

2.7.3.1 UST Oil Spill and Overfill Controls

Provide tanks with overfill and leak detection systems that can minimize the risk of oil spill risks, including:

- A device that automatically shuts flow into the tank when the tank is no more than 90 percent full.
- A device that alerts the individual delivering product when the tank is no more than 85 percent full by restricting the flow into the tank or triggering a high-level alarm.
- Continuous in-tank leak detection system installed according to the manufacturer's instructions. The system should detect leaks or discharges at a rate of 0.20 gal per hour with a 0.95 probability of detection and a 0.05 probability of false alarm. An independent testing lab must verify these capabilities using the EPA Standard Test Procedures for Evaluating Leak Detection Methods (EPA/530/UST-90/004 through 010) or other equivalent test procedures.
- Electronically transmitted leak detection alarms to the appropriate Operations Center.

2.8 Stormwater Management Systems

Stormwater management systems include:

- Bio-retention and vegetated swales.
- Catch basins.
- Leaching and dry-well systems.
- Particle separators.
- Porous asphalt and pavers.

Regulations governing stormwater management device installation operation, maintenance, and permitting vary by municipality. Before proposing a device for installation, you should verify these regulations:

- Boston stormwater systems.

- Cambridge stormwater management.

Before submittal: EH&S must review any documentation sent to a municipality that affects or dictates device maintenance and operations once ownership transitions to Harvard.

For devices that inject stormwater into the ground like leaching and dry-well systems, you must register these devices with the MassDEP under the Underground Injection Control Program.[19]

Contact EH&S before design to facilitate post-project permitting and learn about areas where stormwater reinjection could lead to groundwater contamination.

2.9 Workstation Design

You can properly design workplaces and workstations by considering ergonomic factors that can impact workers.

These design guidelines are based on past workstation performance.

2.9.1 Public Workstations

Ensure public workstations are easy to adjust and straightforward.

Aspect	Minimum Dimension	Preferred Dimension
Separation between people	48 in (122 cm).	96 in (244 cm).
Sitting wells (space under the desk)	32 in (81 cm) wide under the work surface.	At least minimum width and 39 in (100 cm) deep to let the user to stretch their legs while sitting.

2.9.2 Workstation Chair Criteria

Well-designed and appropriately adjusted chairs are an essential element of a safe and productive computer

[19] 310 CMR 27.00.

workstation.

Guidelines	Area
Five-legged stability	Not available.
Lumbar support location in lumbar region of the back	Lumbar support depth between 1.2 in and 2 in (3 cm and 5 cm).
Seat back height minimum	14 in (36 cm), width minimum .12 in (30 cm).
Seat back tilt minimum range	Between 0 degrees and 15 degrees.
Seat pan depth-adjustable	Between 15 in and 17 in (38 cm and 43 cm) with waterfall sloping front edge.
Seat pan height-adjustable	Between 16 in and 21 in (41 cm and 53 cm).
Seat pan width adjustable	Between 18 in and 22 in (46 cm and 56 cm).

2.9.3 Workstation Fixed Millwork

Use fixed millwork, like custom millwork and other non-systems installations, to account for future adaptations, individual worker variability, and changes in tasks.

Ideally, you should install fixed millwork to allow for adaptability without the need for significant changes or modifications.

2.9.4 Workstation Flat Panel Liquid-Crystal Display Monitors

Flat panel LCD monitors have several advantages over CRT monitors. Flat panel LCD monitors are lighter, use less desk space, are easier to adjust, and use less power which can lead to cost savings over time.

You can choose monitors with adjustable stands, but many stands offer less flexibility compared to monitor arms. Some monitors offer either or both height adjustability and swivel and rotation features.

2.9.5 Workstation Height Clearance

Add work surface thickness to the clearance dimensions.

Aspect	Clearance Range
Thighs and lower legs	Between 20 in and 27 in (51 cm and 69 cm).
Nonadjustable work surfaces at the front edge	28.5 in (72 cm).
Adjustable work surfaces (adjustable range)	Between 19.5 in and 28 in (50 cm and 71 cm).
Knee height (17 in from front edge)	Between 19.6 in and 25 in (50 cm and 63 cm) at 17 in (43 cm) from the front edge of the work surface.

2.9.6 Workstation Keyboard Trays

Consider choosing keyboard trays that meet these criteria:

- Not cumbersome.
- Fully adjustable with 5 in (12.5 cm) of height-adjustability, 20 degrees of side-to-side articulation, and +15-degree tilt.
- No knobs and other mechanisms underneath the tray.

Provide a stable surface that doesn’t bounce from normal keying motions.

To prevent obstructions from the keyboard tray’s mounting mechanisms and support arm, account for thigh and leg clearance as well as thigh width clearance.

Consider trays that are wide enough to support the keyboard and mouse or that include a separate mouse tray.

2.9.7 Workstation Sit-Stand Work Surfaces

Consider choosing sit-stand work surfaces that meet these criteria:

- Adjust to a height of 46 in.
- Work surface depth and width are both 30 in.
- Knee depth of 15 in.
- Separate surface for keyboard and input devices.

2.9.8 Workstation Standard Office Desks

Standard office desks are commonly 30 in (76 cm) deep and come in a variety of widths.

When selecting desks for writing tasks, consider choosing desks with:

- Area of 12 in (30 cm) wide and 16 in (41 cm) deep, preferably 30 in (76 cm) in both directions for adequate writing space.
- Rounded work surface edges and corners with a minimum radius of .01 in (3 mm).
- Work surfaces with a non-reflective surface.

2.9.9 Workstation Systems Furniture

Systems furniture works well because it’s adjustable and offers a wide range of configurations. You can mix and match the main components, including panels, work surfaces, and storage areas, to create virtually endless configurations.

3.0 Food Service and Retail Food Establishments

3.1 Boston Food Establishment Permitting

Before coordinating with Boston, provide project managers with all permit applications and relevant design documents for appropriate internal reviews.

To apply for a food service permit in Boston, applicants must:

1. Complete a permit application and plan review by submitting a plan review and permit application forms with a permit fee to the Boston Inspectional Services Health Division.

2. Provide four sets of proposed establishment plans (two if submitting electronically) to the Building Division. Ensure plans are drawn to scale, are a minimum size of 11 in by 17 in with a legend and come with a detailed proposed menu.
3. Schedule a plan review appointment in advance by calling the Boston Health Department at 617-635-5326 or emailing isdhealth@boston.gov. Plan review appointments are Monday through Friday between 10:00 am and 2:00 pm.

   Once the departments review and approve all sets of plans, they stamp them for approval. The Health Department keeps one set and you keep one set.

4. Deliver two sets of plans to the Building Department's Plans and Zoning office for review and approval.

   The Building Department's Fire Safety Plans Examiner reviews fire safety issues.

5. Determine the establishment's zoning for renovations in terms of occupancy and use. You may need to determine if the facility is zoned for purposes like eat-in only, take-out, outdoor seating, or retail only. Zoning may affect which renovation changes you consider.
6. Once the Building Department completes and approves your application and construction is complete with all necessary signoffs by the Building Department, bring copies of these documents to the Health Department:

   - Certificate of Occupancy and Certificate of Inspection required for the intended use.
   - Common Victualler License (if required per licensing board for the intended use).
   - Food protection manager's current certificate and Allergen Awareness Certificate.

7. After submitting all documentation, schedule a required pre-operation inspection. Once the establishment passes inspection, it will be granted a food service permit.

3.2 Cambridge Food Establishment Requirements

When opening a restaurant or food service establishment in Cambridge, you must:

- Ensure proposed locations comply with Cambridge zoning ordinances. To do so, schedule an appointment with the Zoning Specialist for proposed location approval.

- Submit a plan for review to the Inspectional Services Department to keep as the department's permanent record. Allow 30 days for plan review.[20]
- Obtain all applicable Cambridge permits and licenses.

Before coordinating with Cambridge, provide project managers with all permit applications and relevant design documents for appropriate internal reviews. Send copies to the Environmental Public Health (EPH) group (46 Blackstone Street, Cambridge, MA 02139).

3.2.1 Cambridge Food Permits and Licenses

To request more information about applying for a permit to build, renovate, or operate food service establishments, contact the Cambridge Health Department.

Cambridge Permit or License	Action
Building permits	Obtain necessary permits for any building, renovation, or repair work, including building, plumbing, electrical, or gas fitting.
Certificate of Inspection	If required, obtain according to the Massachusetts Building Code.
Certificate of Occupancy	If required, obtain according to the Massachusetts Building Code and the Cambridge Zoning Ordinance.
Common Victualer's License	Complete all necessary license applications from the License Commission.
Food Handler's Permit	Before opening a food establishment, obtain a permit from the Environmental Health Division.
Frozen Dessert License	Obtain if applicable.

[20] Per State Sanitary Code for Food Service Establishments Article X.

Cambridge Permit or License	Action
Milk License	Obtain if applicable.

The Inspectional Services Department, Environmental Health Division handles all plans and permit applications.[21]

The Environmental Health Division refers applicants to these additional information sources:

Source	Seller Location
Cambridge Zoning Ordinance	Cambridge City Clerk's Office
Massachusetts Architectural Access Board	Massachusetts State House Bookstore
Massachusetts Sanitary Code for Food Service Establishments	Massachusetts State House Bookstore
Massachusetts State Electrical Code	Massachusetts State House Bookstore
Massachusetts State Plumbing and Gas Code	Massachusetts State House Bookstore
Massachusetts Building Code	Massachusetts State House Bookstore

3.3 EH&S Proposed Food Service Establishment Review

You must submit relevant design documents for EPH to perform an appropriate proposed food service establishment review.

To ensure that comments from EPH can be incorporated into the final design documents, submit documents at least one month before construction bidding. EPH reviews submissions within 21 days of receiving them.

[21] Contact: Shawn Freund, Inspection, 831 Massachusetts Avenue, Cambridge, MA 02139, 617-349-6123.

Required Documentation	Description
Equipment plan	Show each piece of food equipment intended for use, in approximate scale, with its intended location on the plan. Indicate all sinks locations, including hand washing, ware-washing, food preparation, and mop sinks. Include an equipment schedule, numbering each piece of equipment and assigning a corresponding number on the plans.
Equipment specifications	Equipment specification packet with cut sheets for all equipment.
Floor plans	A complete paper hard copy of plans accurately drawn to a scale of 1/4 in to 1 ft. Ensure plans are at least 11 in by 14 in.
Inspectional Services contact	Name of city Inspectional Services contact.
Lighting level specifications	Specifications for lighting levels in all areas measured in footcandles or lux.
Meals per meal period	Establishment estimate of the number of meals served per meal period.
Menu	Establishment menu.
Permits	List of all permits you applied for or plan to apply for, including the date of submittal to the appropriate authority. Permits may include a food service permit, an electrical permit, a plumbing permit, and a general building permit.
Private well testing and authorization	For establishments serviced by private wells, current water quality test results and documentation that the required state and local regulatory authorities approved the well.
Schedule of operation	Establishment schedule of operation.

Required Documentation	Description
Seating plan	Establishment seating plan specifying the number of seats.
Surface materials	List of materials for all surfaces, including floors, walls, countertops, cabinets, paints, and finishes.

3.4 Food Establishment Design Considerations

3.4.1 Food Preparation Sinks

- Provide a designated food preparation sink in all food service establishments where food is prepared.
- Label sinks with the message "For food preparation only - No ware washing - No hand washing."
- Locate soap and paper towel dispensers away from food preparation sinks.

3.4.2 Food Service Back Flow Prevention Devices and Air Gaps

Provide back flow prevention devices and air gaps wherever required by any applicable Food Code (FC) section, including 5-202.13, 5-202.14, 5-203.14, 5-204.12 5-205.12, and 4-101.14.

3.4.3 Food Service Dressing Areas and Lockers

If employees routinely change their clothing in the establishment:

- Provide dressing rooms and lockers or other suitable, secure storage for employee belongings.
- Ensure all dressing areas and lockers follow FC 6-305.11.

3.4.4 Food Service Equipment Spacing and Elevation

Ensure equipment spacing and elevation conforms to the FC to facilitate cleaning and maintenance.

3.4.5 Food Service Floor Drains

Locate floor drains in areas so that drain lids can be removed for cleaning.

If condensate is directed into a floor drain, ensure the piping from the condensate doesn't prevent drain cover removal.

3.4.6 Food Service Hand Sinks

- Install hand sinks according to the requirements of all pertinent FC sections, including 5-204.11 and 5-203.11.[22]
- Install hand sinks in quantities and locations so employees can conveniently use them in food preparation, food dispensing, and ware washing areas.
- Place hand wash sinks so they don't potentially contribute to cross contaminating their clean surrounding areas.
- Fit sinks with stainless steel barriers on both sides. Ensure barriers have rounded edges and are high enough to mitigate splashing. Fit sinks with a low-profile faucet.

3.4.7 Food Service Lighting

- To protect objects below in case of breakage, implement coatings or shields over food preparation areas, food storage, utensil storage, equipment storage areas, and ware washing areas in accordance with FC 6-202.11.
- Ensure all food and food service establishment areas meet FC 6-303.11 minimum light intensity requirements.

3.4.7.1 Food Service Minimum Lighting Requirements

Certain minimum light intensity levels must be present in locations within food service establishments where various tasks are performed and equipment is located.[23]

Light intensity is measured at a point 30 in above the floor and is measured in footcandles or lux. Use a

[22] Massachusetts State Sanitary Code, Chapter 10, Minimum Sanitation Standards for Food Establishments.

[23] Emphasized by the Massachusetts State Sanitary Code for Food Service Establishments, 105 CMR 590.000.

standard light meter to determine if the proposed space meets guidelines.

Minimum Lighting Required	Location
10 footcandles (110 lux)	In walk-in refrigerators, walk-in freezers, dry food storage areas, and other areas and rooms while they're being cleaned.
20 footcandles (220 lux)	Surfaces where food is provided for customer self-service, like salad bars and buffets. Surfaces where fresh produce or packaged food is offered or sold.
20 footcandles (220 lux)	Inside equipment, like reach-in and under-counter refrigerators.
20 footcandles (220 lux)	In areas used for hand washing, ware washing, equipment and utensil storage, and toilet rooms.
50 footcandles (540 lux)	Surfaces where food employees work with food.
50 footcandles (540 lux)	Surfaces where food employees work with utensils or equipment where employee safety is a factor, such as knives, grinders, slicers, or saws.

3.4.8 Food Service Loading Dock Doors

- Ensure loading-dock doors fit tight against the ground.
- Construct bumpers with a hard material to prevent rodents from eating through rubber bumpers.

3.4.9 Food Service Mechanical Ware Washing Machines

Make sure to only install commercial dishwashers, as household dishwashers aren't approved for commercial application.

When choosing a dishwasher, ensure that:

- Dishwashers properly wash, rinse, and sanitize dishes.
- Commercial dishwashers meet all local codes for commercial use.

When choosing commercial dishwashing equipment, consider either:

- A high-temperature machine, using hot water to sanitize during washing and rinse cycles.
- A low-temperature machine, using a chemical rinse to sanitize or kill pathogens on dishware and equipment.
- Ensure that mechanical ware washing machines always display a manufacturer's data plate showing operating specifications.

3.4.9.1 Food Service High-Temperature Machines

High-temperature machines use water with a standard minimum temperature of 150 °F for wash cycles and 180 °F for rinse cycles. The water exits the manifold at the specified temperature and may safely drop to 160 °F at the dish or utensil. The high temperature effectively renders pathogens harmless, and hot water and detergent emulsify grease.

Consider using high-temperature machines because they don't require sanitizer, especially if you don't want chemical residue on dishes and equipment.

You must test high-temperature machines at regular intervals to verify the machine is reaching the proper rinse and wash temperatures.

You can conduct testing by either:

- Sending a temperature sensitive, disposable thermometer through a dish cycle. Use a thermometer that changes color when it reaches the proper temperature.
- Sending a maximum and minimum registering dishwasher thermometer through a dish cycle. Use a thermometer that registers the cycle's highest temperature.

To monitor temperatures with moderate accuracy, use a properly calibrating exterior machine temperature gauge to check the wash and rinse temperatures at every dish load.

For establishments where water doesn't enter the machines at a temperature high enough for the boosters to raise it to the required levels, provide a dedicated hot water heater for the dishwasher.

In exception to 160 °F temperature requirements at the dish or plate, stationary rack, single temperature machines must reach 165 °F for the final rinse cycle. Check the machine's data plate for the manufacturer's specification on proper operating temperatures.

3.4.9.2 Food Service Low-Temperature Sanitizing Machines

Low-temperature machines use a wash and rinse cycle temperature of approximately 120 °F as indicated by the manufacturer's specifications on the data plate. This temperature, in conjunction with the detergent in the wash cycle and the sanitizer in the final rinse, effectively renders pathogens harmless.

To help remove greasy food residues from dishes, effectively rinse dishes at a lower temperature before dishwashing. If recommended temperatures aren't reached, food residues may remain on plates or utensils.

While properly calibrated sanitizer in the final rinse of a low-temperature machine is food safe, some people, such as brewery personnel, believe that this sanitizer leaves a taste on glassware.

- Carefully monitor sanitizing solution strength. Typically, you should use a chlorine-based type sanitizer.
- Dip test strips into rinse residue on a dish after passing it through the machine. The sanitizer must register the proper concentration.

Ensure newly installed low-temperature machines have an audible or visible low-sanitizer level alarm. Jurisdictions interpret this requirement differently, and can either be:

- A sight-glass mounted in-line at the chlorine addition point.
- An audible alarm set up at the dispenser.
- A light alarm set-up somewhere on or above the machine.

Staff must regularly monitor these alarms because dishware that isn't sanitized can spread pathogens between customers.

3.4.10 Food Service Sneeze Guards

In areas where food is prepared, served, or displayed, use sneeze guards or other effective methods to protect food from contact with diners and other environmental contamination sources.[24]

3.4.11 Food Service Trash Receptacles

- When selecting large trash receptacles for handling food waste, choose self-contained compactors. These designs prevent rodents from feeding inside containers by squeezing past a fixed piston unit.
- For small trash receptacles, choose those constructed with hard lids and materials other than rubber. Consider designs with a sliding door that keeps the container rodent-tight when closed.

3.4.12 Food Service Unshielded Sewage Lines

- Don't allow food preparation activities, food or equipment storage, or ware-washing activities in areas beneath unshielded sewage lines.
- Locate food storage out of areas prohibited by FC 3-305.12, 4-401.11, including mechanical rooms.

3.4.13 Food Service Ventilation Hoods

Install ventilation hoods:

- Whenever required by the FC or building or fire codes.
- According to the requirements of all pertinent building or fire codes and FC sections, including 4-204.11, 6-501.14, and 6-304.11.
- Whenever necessary to remove excessive heat, steam, vapors, smoke, obnoxious odors, or fumes.

Design and install ventilation systems to prevent grease or condensation from collecting on walls and ceilings or from dripping onto other surfaces or equipment.

---

[24] FC 3-305.14, 3-306.11.

Ensure ventilation systems don't create a public health hazard, nuisance, or unlawful discharge.

3.4.14 Food Storage Rooms

- Design food storage rooms to prevent rodents and insects from gaining access.
- If you install drop ceilings, seal the ceiling space above the tile field from rodent entry.
- Seal all holes and penetrations with fire stop material.
- To make doors rodent tight when closed, install a hard door sweep rather than a rubber or brush sweep, which are easily chewed through.
- Use storage racks to keep food products off the floor.

4.0 Lab Design

These guidelines provide general and specific lab design recommendations that may directly affect health and safety in labs. They supplement other design information sources when developing project specifications. However, these guidelines shouldn't be used without appropriate regulatory and code reviews.

4.1 Lab General Ventilation Design

This information doesn't include special design requirements for non-standard labs, such as high containment Biosafety Level (BL) BL3 and BL4 labs, clean rooms, or labs requiring high hazard classification under the Massachusetts Building Code (780 Code of Massachusetts Regulations).

4.1.1 Lab Ventilation Design Process

Lab designers should consider following this design process when determining lab HVAC system general design features and making basic decisions about lab HVAC systems, including systems in BL1 and BL2 labs.

While there isn't an air change per hour (ACH) rate appropriate for all labs, contaminants, or operations, this process establishes an acceptable air exchange rate of between 6 ACH to 8 ACH for most labs when in they're in occupied mode.

During occupied periods, avoid air exchange rates less than 6 ACH unless the building is under a Lab

Ventilation Management Program (LVMP) where EH&S assesses inhalation risks on an ongoing basis. In rare cases, lab-specific conditions may require increased ventilation.

Review programming documents and lab operations to determine emission sources and corresponding equipment requirements.

4.1.1.1 Lab Local Exhaust Ventilation Evaluation

Determine the local exhaust ventilation required to control anticipated chemical or heat emissions.

Ensure you evaluate all opportunities to use local exhaust ventilation as it is the most effective method to reduce exposure risks and cooling requirements.

When evaluating local exhaust ventilation, consider:

- Canopy hoods for local heat or wet exhaust enclosures like autoclaves.
- Exhausted work benches.
- Gas cabinets.
- Number and size of chemical fume hoods.
- Special local exhaust, including exhaust lines for equipment exhaust discharge or snorkels.
- Vented equipment enclosures, considering two-speed where appropriate for open or closed conditions.

4.1.1.2 Lab Local Exhaust and Cooling Load Balance

Determine if local exhaust ventilation requirements match the cooling load or demand required for equipment (use plug loads if possible), people, and solar loads.

If cooling loads are the primary contributor to specifying higher air exchange rates, consider alternative strategies to meet cooling loads like:

- Using more terminal cooling units.
- Considering water-cooled lab equipment.
- Installing dedicated exhaust like canopy hoods for point heat sources, such as ovens or autoclaves.

4.1.1.3 Exhaust-Driven Labs

For exhaust-driven labs, calculate the air exchange rate of the given design using the expected net volume of the room. Determine the room volume and then subtract the space occupied by fixed structures, such as lab benches or ventilation equipment.

Consider these recommendations based on the calculated air exchange rate and lab-specific conditions.

Conditions	Recommendations
Air exchange rate greater than 8 ACH and lab-specific conditions don't require increased ventilation	VAV or high-performance fume hoods to reduce exhaust volumes without eliminating exhaust devices. Review fume hood design specifications and VAV hood minimum flow.
Occupied air-exchange rate less than 6 ACH or lab-specific conditions require additional exhaust	Increase general exhaust unless the building has an LVMP in place.

Design HVAC equipment to meet at least 20 percent increases in exhaust or supply air demand above lab design conditions (unnecessary for support spaces).

Consider diversity in large projects where appropriate.

Follow supply air, exhaust air, and ventilation load diversity specifications in ANSI/American Industrial Hygiene Association (AIHA) Z9.5 Laboratory Ventilation.

4.1.2 Unoccupied Lab Ventilation Modes

A lab is defined as unoccupied when it meets all these conditions:

- Dual-technology (a combination of passive infrared, microwave, or ultrasonic) occupancy sensors that provide adequate coverage and redundancy have not been activated for at least 15 minutes.
- Fume hoods maintain their minimum fume hood settings.

During unoccupied mode, you can reduce lab room air exchange rates to 4 ACH (or lower under an LVMP).

4.1.3 Lab Room Pressurization

Design room pressurization to minimize air movement from high potential contamination lab work areas to lower potential contamination areas, like corridors. Achieve this by either:

- Specifying supply and exhaust offsets (in most labs).
- Specifying room pressure differentials.

Design the pressurization system so that adequate transfer air is available when operational conditions are met, such as when all hallway doors are closed. This ensures there is enough makeup air for all exhaust equipment and doors can operate without excessive resistance.

To verify air flow direction or room pressure differentials, use fog generators or a micro-manometer. Specify these details on project documents, such as indicating them with arrows.

4.1.4 Lab Ventilation Enthalpy Wheels

To avoid potentially off-gassing absorbed materials back into the air supply, don’t install enthalpy wheels in exhaust streams that include exhaust from ventilated enclosures such as lab fume hoods or gas cabinets.

For lab ventilation systems, consider using other types of energy recovery system such as heat pipes or run-around loops.

If the general lab exhaust isn’t connected to fume hoods or other ventilated enclosures, you can use enthalpy wheels and air supplied back to labs.

4.1.5 Lab Demand-Controlled Ventilation Systems

Avoid using Aircuity or other demand-controlled ventilation (DCV) systems in lab work areas because:

- Contaminant concentrations at sensor locations don’t correlate well with exposures at the source and may be delayed.
- Some contaminants may remain undetected because materials and processes are constantly changing, and a single sensor can’t assure detection of significant potential contaminants.

To control exposures, preferably use local exhaust ventilation rather than DCV systems.

DCV systems may be appropriate for labs and support areas with a few specific measurable contaminants, such as ammonia and particles in animal containment areas, which drive ventilation rates. However, EH&S must review these applications on an individual basis.

DCV systems are recommended for offices, conference rooms, and meeting rooms, including those in a lab building.

4.1.6 Lab Exhaust

- When planning large installations or those close to fresh air intakes or community receptors, model installations to determine the best location and stack height for effective contaminant dispersion.
- Ensure lab exhaust ventilation meets [HVAC system requirements](#).
- Don't recirculate lab exhaust. Discharge lab exhaust directly outside the building. Perform any required air cleaning to meet applicable federal, state, or local air emission standards.
- Keep lab exhaust ducts in lab work areas at negative pressure by installing fans outside of buildings, preferably on the highest-level roof or in a rooftop penthouse or mechanical space designed for such use.
- During design, include lab exhaust connections for future lab ventilation, such as lab extraction arms or benchtop ventilated enclosures. Determine the number, locations, and duct sizes based on the project needs. Provide all connection points with dampers.
- Install isolation dampers at the inlet side of all exhaust fans discharging directly to the atmosphere.
- Install isolation dampers at both the inlet and outlet of all exhaust fans discharging to a common stack or exhaust plenum.
- Ensure lab exhaust minimum discharge velocities are 3000 fpm unless you demonstrate that the specific design can meet dilution criteria at all potential receptors.

4.1.7 Lab Ventilation Emergency Controls

For labs using volatile hazardous chemicals, provide a "Purge Ventilation" button.

4.2 Lab Local Exhaust Ventilation and Exposure Control Devices

4.2.1 Lab Biosafety Cabinets

Biosafety cabinets (BSC) are the main containment devices in labs to prevent airborne exposure to infectious materials and protect sterile products from contamination during manipulations.

When choosing which type of BSC to install, consult EH&S.

When selecting a BSC, consider:

- Risk group of agent to be used.
- Which protection level the work requires.
- How volatile chemicals will be used.
- Types of procedures performed.
- Type and size of equipment that will go inside the BSC.
- Handicap accessibility.

4.2.1.1 BSC Classes

Class or Type	Type	Personnel Protection	Product Protection	Application
Class I		Yes	No	Uncommon. Exhaust is often discharged to the outside. Exhaust is high efficiency particulate air (HEPA) filtered.
Class II	A1	Yes	Yes	HEPA filtered exhaust is recirculated into the room or discharged to the outside by a canopy connection. Don’t use for volatile toxic chemicals or radionuclides work.

Class or Type	Type	Personnel Protection	Product Protection	Application
Class II	A2	Yes	Yes	Harvard's most common BSC. HEPA filtered exhaust is recirculated into the room or discharged to the outside by canopy connection. Can use for small amounts of volatile toxic chemicals and trace amounts of radionuclides if exhausted to the outside by canopy connection. Don't hard duct cabinets to the exhaust system.
Class II	B1	Yes	Yes	HEPA filtered externally hard ducted exhaust with high energy demands. Can use for low levels of volatile toxic chemicals and trace amounts radionuclides.
Class II	B2	Yes	Yes	HEPA filtered externally hard ducted exhaust with energy demands. Can use for volatile toxic chemicals and radionuclides work.
Class III		Yes	Yes	Ducted closed system. Enclosed, gas-tight system. Manipulation of highly infectious pathogens.

4.2.1.2 BSC Accessories and Customization

BSCs offer options for purchase and customization from manufacturers, including installation with:

- Built-in containment for aspiration flask set-up.
- Inline gas and vacuum nozzles.
- Sash alarms.
- Ultraviolet (UV) lights.

For BSCs with energy efficiency monitors, install electrical outlets at or near the top of the BSC.

When working in BSCs, investigators shouldn't use heat sources or Bunsen burners, including "touch type" Bunsen burners.

Don't install plumbing for gas lines into new BSCs.

4.2.1.3 BSC Installation

- Install BSCs away from doors and high traffic patterns.
- Don't locate BSCs directly underneath the room's air supply air diffuser or return.
- Don't locate BSCs directly opposite chemical fume hoods or other BSCs.
- Install BSCs away from equipment that generates steam or moisture.
- Install BSCs away from operable and unlocked windows.
- Make sure the room has both mechanical exhaust ventilation and exhaust ventilation provided by a hard ducted BSC.
- Ducting installation may require hard or canopy connections. Follow manufacturer's installation specifications.
- Design BSCs with enough ceiling height clearance to stop exhaust from disrupting the barrier at the access opening of the BSC.
- Locate power receptacles high on walls for easy unplugging.

4.2.1.4 BSC Certification

- Before using a newly installed BSC or after any move or repair, test and certify the BSC.
- Ensure Class II BSC testing and certification meets current National Sanitation Foundation (NSF) 49 Standard for Class II Biosafety Cabinets.
- If a BSC fails certification, don't use it until it's fixed. Fixed BSCs must pass recertification testing before use.

4.2.1.5 BSC Ventilation and Ducting

Class II Type B1 and B2 BSC ventilation requirements are taxing on building HVAC systems, so only install these cabinets if they are supported by the research's risk assessment.

Consider cabinet replacement for older model BSCs that can't accept canopy connections and that are used for research involving volatile reagents.

BSC Type	Requirements
Class II Type A2	• Follow NSF/ANSI 49- 2010 design, construction, and performance requirements. • Vent outside by canopy or thimble connection. • Don't hard duct to building exhaust systems. • You can use cabinet canopy connections to use small volumes of volatile chemicals or radioactive materials, but not to use the same chemicals you can use in chemical fume hoods or hard ducted Class II Type B BSCs. • Only retrofit cabinets to a canopy connection with available manufacturer conversion kits or a custom fabricated canopy connection if necessary. Canopy connection exhaust volumes are slightly higher and canopy design is critical to performance. • Exhausting requires canopy (thimble) ducting and an airflow monitor in the exhaust duct with an audible and visual alarm.
Class II Type B1	Must be hard ducted.
Class II Type B2	Require total exhaust.

4.2.1.6 Lab Aerosol Generation Equipment

Common aerosol generation equipment in biological research labs include:[25]

- Fluorescence activated cell sorting.
- Madison aerosol chambers.

[25] Other lab equipment may also generate smaller aerosol amounts.

- Sonicators.

These equipment classes have significant aerosol generation risks and need special consideration for controlling aerosol releases during operation.

Examples of way to reduce aerosols from equipment:

- Place equipment in BSCs or specially designed HEPA filtered laminar airflow cabinets designed to contain aerosols.
- Design special containment equipment specific to the instrument.
- Buy aerosol containment devices for the machines (if available).

4.2.2 Lab Canopy Hoods

- Design canopy hoods with telescoping, articulate, or flexible exhaust arms. Choose materials like aluminum or stainless steel depending on the vented air temperature.
- Include steel flange extensions or other means to adjust the metal hood bottom. This adjustment should let users position the bottom to a height of no more than 3 in to 6 in above the specific heated source, such as an oven or furnace vent.
- Provide exhaust flow to achieve a capture velocity of 50 fpm at the source. For example, about 3 in to 6 in below the canopy hood.
- Project the edge of each canopy hood at least 3 in outside the heated source's boundaries on each side.

4.2.3 Lab Chemical Fume Hoods

When designing chemical fume hoods:

- Provide all fume hoods with a visual flow indicator and flow alarms.
- Unless specific factors require higher flow rates, only install high-performance fume hoods. These fume hoods have design improvements like baffles or slots, airfoils, and aerodynamic flow into and within the fume hood that enable adequate containment with reduced airflow into the fume hood.
- Ensure that manufacturers provide ASHRAE 110-2016 Methods of Testing Performance of Laboratory

Fume Hoods as manufactured test results. These results must meet a control level of As-Manufactured (AM) 0.05 as specified in ANSI/AIHA-Z 9.5 Laboratory Ventilation-2012 Section 6.1.2.7.

- For horizontally sliding sash panels, provide at least one panel no more than 14 inches wide. This feature lets fume hood users wrap their arms around the panel as a safety shield.[26]

4.2.3.1 Chemical Fume Hood Automatic Sash Closers

For VAV fume hoods, install automatic sash closers to improve sash management.

For all chemical fume hoods, disable automatic sash openers unless specifically requested by user. If you install automatic sash closers, inform lab representatives and notify them about any fume hood use limitations with this installation.

Automatic sash closers should be equipped with these features:

- A proximity sensor and a motion sensor to better evaluate fume hood status.
- A sensor on the sash that accurately detects obstacles, preferably with a recoil function that moves the sash away from obstacles when detected.
- Time-delays for sash closing that allow for delays up to 15 minutes.
- Allow manual override of positioning with a force of no more than 10 lb mechanical both when powered and during fault modes or power failures.

You can install occupancy sensors on VAV fume hoods to activate the unoccupied fume hood mode only if the sash is closed.

4.2.3.2 Chemical Fume Hood Cup Sinks

Avoid installing cup sinks in fume hoods. In the future, local sewer authorities may prohibit cup sinks and

[26] Per ANSI Z9.5 paragraph 3.1.1.3.

require capping existing cup sinks.[27]

Before installing new cup sinks in fume hoods, contact EH&S to confirm process requirements or explore alternatives.

If you must install cup sinks in fume hoods, equip sinks with a berm to prevent chemical spills from entering the municipal sewer system.

4.2.3.3 Chemical Fume Hood Performance Testing

You must conduct ASHRAE 110 As Installed (AI) testing on all high-performance fume hoods installed in new locations. Optionally, you can also conduct this testing on new or relocated standard fume hoods. All fume hoods must meet acceptable control of AI 0.1 ppm unless otherwise specified**.**

On large projects that install more than five fume hoods, you can reduce the number of fume hoods you test to a representative number.[28] For example, you could test at least one fume hood in each different layout, like alcove or open room and distance from doors or diffusers.

Conduct ASHRAE 110 testing by:

1. Challenging the fume hood with the exhaust flow at the alarm set point, which represents the lowest point of the full range of operating exhaust conditions.
2. Increasing the exhaust (after completing the testing) to the design set point, which corresponds with the middle of the range of operating conditions.

   During the testing process, also assess the sash movement containment.

For VAV fume hoods, confirm that:

---

[27] Based on instructions from local sewer authorities.

[28] Particularly fume hoods in identical room configurations on multiple floors with similar layouts, such as identical alcoves or environmental factors like diffuser and door locations.

- Face velocity control at standard operating sash position of 18 inches open and 50 percent and 25 percent of that standard sash position ensures flow stability within +/-10 percent of the tested face velocity.
- Response time (time to reach steady state) is about three seconds after sash movement completion.

4.2.3.4 Chemical Fume Hood Set Points

All measurements are taken under standard operating conditions (SOC), which are defined as either:

- Sashes open 18 in high for vertical-sliding or combination sashes.
- The sash position with maximum open width for horizontal sash.

Set points by fume hood type:

Fume Hood Type	**Average Face Velocities (AFV)[29] at SOC**	**Alarm AFV Set Points**
High-performance	70 fpm (+/- 5 fpm)	60 fpm
Standard	100 fpm (+/- 10 fpm)	80 fpm

Set point for VAV fume hood fan type (with sash closed):

Fume Hood Fan Type	**Minimum Flow**
VAV	15 CFM/sq ft

Program fume hoods to maintain their minimum settings when the sashes are in the closed position, or at the alarm or minimum face velocity at SOC of 60 fpm (for high-performance) or 80 fpm (for standard) in labs requiring controlled heating or chemical processes to run overnight.

[29] Calculate AFV by dividing the opening into a grid and taking the 20-second average readings in the center of each grid rectangle.

4.2.3.5 Environmental Factors

High-performance fume hoods operate at a reduced average face velocity. These fume hoods are more sensitive to environmental conditions and may require different diffuser designs and locations than standard fume hoods. Nonetheless, meet these requirements for all fume hoods:

- Ensure supply diffuser throw velocities aimed at a hood face don't exceed one-half (preferably one-third) of the fume hood's average face velocity. You can meet this requirement by ensuring supply diffusers are carefully located at least 6 ft away horizontally and designed with flow directed away from fume hoods.
- In small rooms where you can't maintain the desired supply air diffuser location or velocity at the face of fume hood, use radial flow diffusers. These high-capacity outlets have short throws and one-way or two-way discharge patterns.
- Keep fume hoods away from high-traffic areas.
- Don't install fume hoods within 6 ft of doors, except for emergency-only exit doors.

4.2.4 Lab Gas Cabinets

You must install gas cabinets to meet these gas storage requirements:

Gas Type	Storage Requirements
Any amount of highly toxic gas (Globally Harmonized System (GHS) Category 1 Acute Toxicity)	Store in a gas cabinet or exhausted enclosure following CMR 1 Massachusetts Comprehensive Fire Code, Massachusetts Building Code Table 307.1(2) Table 60.4.2.1.1.3, and Massachusetts Comprehensive Fire Code Table 63.2.3.1.1.

Gas Type	Storage Requirements
Any toxic, flammable, oxidizing, or pyrophoric gas more than Maximum Allowable Quantity (MAQ) Table 307.1(2)[30]	Store in a gas cabinet or vented enclosure.
Containers greater than 0.5 standard cu ft that contain silane gas at concentrations over 1.37 percent	Store in sprinklered gas cabinets.

Ensure gas cabinet design meets these criteria:

- Gas cabinets meet Massachusetts Fire Code (MFC) 62.2.16 requirements.
- Exhausted enclosures meet MFC 62.2.17 requirements.
- Gas cabinets containing silane or silane mixtures meet Compressed Gas Association (CGA) 13-2006 Storage and Handling of Silane and Silane Mixtures requirements.

4.2.5 Lab Perchloric Acid Hoods

For labs that use heated perchloric acid in a process where perchloric acid vapors aren't condensed or otherwise trapped or scrubbed as part of the process, equip labs with an acid scrubber or perchloric acid hood.

Ensure perchloric acid hoods:

- Meet lab chemical fume hood general design requirements.
- Meet additional design requirements in NFPA 45 -2015 Standard for Fire Protection for Labs Using Chemicals Section 87.112 and ANSI/AIHA Z9.5 Laboratory Ventilation-2012 Section 3.2.54.

[30] Massachusetts Comprehensive Fire Code - Table 63.2.3.1.1 MAQ Table 307.1(2)

- Aren't manifolded with non-perchloric acid hoods unless a scrubber is installed between the hood and manifold.

4.2.6 Lab Radiological Fume Hoods

Ensure radiological fume hoods:

- Meet lab fume hood general design requirements in Section 4.2.3 Lab Chemical Fume Hoods.
- Are made of type 304 stainless steel with coved seamless welded seams.
- For fume hoods used for Technetium-99 (with a half-life of 211,000 years), don't manifold these fume hoods with non-radioisotope hoods unless you provide an activated charcoal bed filter between the hood and manifold.

4.2.7 Lab Snorkel Exhaust Arms

Flexible ducts connected directly from equipment exhaust ports to the facility exhaust system aren't considered snorkel exhaust arms.

When choosing and installing snorkel exhaust arms:

- Choose Nederman FX Model snorkel exhaust arms or equivalent snorkel exhaust arm makes and models.

  You can use snorkel exhaust arms with aluminum articulating arms unless specific conditions require additional chemical resistance or preventing electrostatic discharge (ESD).

  You can use transparent plastic snorkel exhaust arm hoods, unless specific anticipated conditions require heat resistance, additional chemical resistance, or ESD prevention. Snorkel exhaust arm hood examples include:

  - Nederman Combi Original (Model 70500144).
  - Nederman Flange Hood (Model 70502844) for tight clearance on benchtops.
  - Nederman Metal Hood (Model 70500444) for use as canopy hood for oven vents.
- Ensure snorkel exhaust arms are 3 in (75 mm) in diameter unless special conditions require additional flow

capacity.

- Provide exhaust flow to achieve a capture velocity of 50 fpm at 5 in from the snorkel hood face.
- Only attach snorkel exhaust arms to benchtop ventilated enclosures if they're designed for this and provide the specified flow for the enclosures to achieve an average velocity of 80 fpm to 100 fpm across the face of the enclosure opening or openings.
- Equip articulating arms with a shutoff damper at an accessible point of use that can be engaged when you don't need exhaust flow.

4.3 BL1 and BL2 Biological Research Lab General Design

Harvard's most common biological research labs are BL1 and BL2 labs.

You can learn more about biosafety levels, biological agents, and lab design elements in the Centers for Disease Control and Prevention (CDC)/National Institutes of Health (NIH) Biosafety in Microbiological and Biomedical Labs, 5th Edition, 2009.

When designing biological research labs at Harvard, you must:

- Follow the NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules, 2013.
- Ensure mechanisms for controlling lab access are in place.

  Separate all labs from public areas using self-closing and lockable doors to control access to labs, research materials, and information.

  Door locking mechanisms may include one or a combination of these measures:

  - Card reader (preferred).
  - Punch-code lock.
  - Standard keyed entry.
- Design labs for easy cleaning and decontamination, including built-in components and furniture.
- Ensure benchtops are impervious to water and resistant to acids, alkalis, organic solvents, and moderate

heat.

- Ensure lab furniture is sturdy and easily cleanable. Hard, non-porous surfaces like plastic are easier to clean and decontaminate.

  Don't use upholstered furniture or furniture with cloth coverings.

  Make spaces between benches, cabinets, and desks easily accessible for cleaning.

- Don't install carpets, rugs, or fabric window coverings in labs.
- Ensure labs are under negative pressure and have net directional inward airflow with air moving from public spaces into the lab towards the most contaminated or high-risk areas for exposure control if there is a spill in the lab.

  Don't recirculate lab air to any other building spaces outside of the lab. Exhaust lab air to the outside.

- Don't eat or drink in labs. Design labs to incorporate areas outside the lab for food storage and to eat safely.
- Design labs to prevent insect and rodent penetration, including sealing holes. Fit lab windows that open with fly screens.

Depending on their research and safety needs, labs may also require this equipment:

- Autoclaves.
- Biosafety cabinets.

4.3.1 Biological Research Lab Sinks

Ensure each biological research lab includes hand washing sinks and eye wash stations.

When designing sinks:

- Consider installing hands-free sinks that are infrared sensors or foot-pedal operated, which reduce spreading contaminants from handles.

  If you can't install hands-free sinks, use paddle handles to reduce the need to touch handles when turning the water on and off.

- Consider using fine mesh sink screen strainers to stop sharps like needles, small pipette tips from going down the drain.
- Use sink materials that are compatible with chemical decontaminants commonly used in biological labs. Choose materials that are easy to clean and disinfect.

Higher containment labs have specific sink requirements.

4.4 Electric and Magnetic Field and Magnet Labs

When designing large electric and magnetic field (EMF) or magnetic field producing devices and labs that can produce fields greater than 5 gauss, you must:

- Contact the Radiation Safety Office. They will connect you with the EH&S LSO who will provide tailored EMF lab setup design guidance.
- Follow special design guidance to help ensure the safety and well-being of personnel working within these spaces.
- Register EMF magnet labs with Harvard's Radiation Safety Office.

4.4.1 EMF and Magnet Facility Layout and Safety Features

- Design the labs to keep the 5 gauss line entirely within a controlled area, such as within the access-controlled lab or room itself.
- Establish a single entry and exit point to effectively control and monitor access to the lab. Incorporate a system to indicate if there are people inside the lab.
- Install adequate signage at various points in the lab, including the entryway, to indicate the presence of strong magnetic fields and caution people with medical implants or devices that might be affected by magnetic fields against entering.
- Design electrical services to meet safety codes, including lockout-tagout procedures, considering that magnet systems often require high electrical services.

- Implement appropriate ventilation systems and safe handling methods for hazardous chemicals or materials that may be present in the lab. Ensure ventilation can adequately displace the evaporated helium gas during a magnet quench.
- In magnet labs, clearly demarcate the 5-gauss line within the room and ensure it is distinctly marked and visible to all personnel working within the lab. Maintain this marking and regularly check it for clarity.
- In nuclear magnetic resonance and magnetic resonance imaging labs, install oxygen monitors and calibrate them annually.

4.5 Lab Equipment and Processes

4.5.1 Lab Biological and Biomedical Waste Storage Facilities

Store and dispose of lab biological waste according to 105 CMR 480.000 Storage and Disposal of Infectious or Physically Dangerous Medical or Biological Waste State Sanitary Code Chapter VIII.

When designing biological waste temporary storage areas, consider:

- Locate storage facilities away from access areas.
- Base storage facility sizes on the number of labs and the amount of waste each lab will generate.
- Dedicate the facility for biological or biomedical waste storage.
- Make an exhaust system available to vent odor.
- Ensure wall, floor, and ceiling surfaces are easy to clean and decontaminate.
- Seal wall, floor, and ceiling penetrations rodent and bug tight.
- Store biological and biomedical waste boxes on top of pallets.
- Ensure the door can be locked.
- Post a biohazard door placard on the outside of the door.

Address these issues as necessary:

- Temperature control for animal parts and carcass storage.
- Install a berm to prevent liquid spill releases outside storage rooms.

- Accessible handwashing facility.
- Accessible closet to store storage facility routine cleaning and decontamination materials.

4.5.2 Lab Chemical and Hazardous Waste Main Accumulation Areas

Before setting up a main accumulation area (MAA), contact EH&S.

When setting up a hazardous waste MAA, you must follow the compliance and technical requirements of DEP 310 CMR 30 and the relevant fire code, including:

4.5.2.1 MAA Location

Equip all lab buildings with at least one MAA sized to store chemical waste from the building for the appropriate storage time frames based on the generator quantity.

Generator Quantity	Storage Time
Small quantity generator	180 days.
Large quantity generator	90 days.

If a loading dock isn't at the same level as the MAA, you must include elevator access to the loading dock.

Install a separate service elevator available in the building for moving hazardous waste between lab floors, the MAA, and the loading dock. This separate service elevator prevents lab staff and visitors from sharing the elevator with drums or carts of hazardous waste.

Generally, you can store flammable waste in the MAA at grade and load it at a loading dock below grade.

4.5.2.2 MAA Storage Type by Room Location

MAA Storage	Room Location
Ignitable or reactive hazardous waste	15 m from the property line.
Class 1 flammable materials	At grade (you must not store Class 1 flammables below grade).

4.5.2.3 MAA Containment

- Seal MAA room floors, typically with epoxy, to eliminate all cracks and gaps.
- Install a berm or other secondary containment method to prevent material spills from escaping the MAA room.
- Ensure MAA rooms don't have sewer floor drains.

4.5.2.4 MAA Desk Space

- Provide a suitable secure workspace near, but not inside, chemical waste storage rooms with separate access and egress.
- Locate this workspace in a room next to the storage room with a window to safely view the storage room. This enables personnel to use the window to assess potential hazards in the storage room without entering it.

4.5.2.5 MAA Emergency Equipment

Equip each MAA with:

- Spill equipment.
- Storage room for carts, drums, and emergency response spill supplies.
- Emergency shower and eye wash.
- Stable, heavy duty metal shelving applicable to the types and volumes of waste stored in the room.
- "No Smoking" signs.
- Exit signs at all exit ways from the area.

- Emergency egress map showing the locations of emergency equipment like spill kits and phones.[31]
- A phone to call outside emergency services like the fire department. Install the phone outside the area where the lab stores waste.
- Fire extinguisher, intrinsically safe lighting, and special fire control equipment (fire extinguishing system appropriate for wastes stored in area, typically inert gas.

4.5.2.6 MAA Fume Hoods

MAAs must include fume hoods where special high-hazard waste are stored that may present volatility hazards. Personnel can use fume hoods for fingerprint analysis of unknown waste streams.

If possible, also design MAA rooms with a consolidation area for 55 gal drums. Equip this area with ventilation, bonding, and grounding suitable for flammable waste consolidation.

4.5.2.7 MAA Security

When designing MAAs, follow these security considerations:

- Ensure all doors in MAAs are fire-rated and equipped with locks or keycard access to prevent unauthorized entry from untrained individuals.
- Don’t install windows on doors and walls that would allow the public to see hazardous waste.
- If a MAA room has windows, store waste in the room inside a cabinet or out of the public’s view.

4.5.2.8 MAA Segregation and Aisle Space

- Set up the MAA to make sure waste containers are adequately segregated with appropriate secondary containment.
- Design the MAA with enough space to ensure at least 3 ft of adequate aisle space for egress.
- Store virgin chemicals separately from hazardous waste.

---

[31] Required by the Hazardous Waste Contingency Plan.

MAA containment systems (floor and containment vault) must have the capacity to always hold either:

- 10 percent of the total liquid hazardous waste volume in the MAA.
- 110 percent of the largest container or the volume of water that would accumulate if the room's sprinkler system discharged within the room.

4.5.2.9 MAA Ventilation, Bonding, and Grounding

- Design MAA ventilation systems to adequately address potential volatile emissions within the MAA.
- Use stand-alone ventilation systems to prevent vapors or fumes from spills in the MAA from spreading to the rest of the building.
- Design and install floor-mounted (also known as "walk-in") drum hoods or other local ventilation with appropriate bonding and grounding for flammable waste consolidation.

4.5.3 Lab Compressed Gas Cylinder Storage

Don't store compressed gas cylinders in locations that meet any of these conditions:

- Where heavy moving objects could strike or fall on the cylinders.
- Where cylinders obstruct walkways, exit routes, or other areas normally used or intended for the safe exit of personnel.
- Near elevators.
- At unprotected platform edges.

When designing cylinder storage areas:

- Mark gas storage rooms in accordance with NFPA 704.Mark cylinder storage areas with proper precautionary signs, such as "Storage of flammable, oxidizer, or toxic materials."
- Mark cylinder storage areas with "full" and "empty" locations.
- Protect cylinders from objects that could cause harmful cuts or other abrasions to the cylinder's surface.
- Store cylinders upright and fasten them securely to a stationary building support using a strap or a chain. Position straps and chains at two thirds height level on the cylinder.

- Provide cylinders with engineered supports made of non-combustible material placed on non-combustible foundations.
- Always keep valve protection caps on cylinders except when a cylinder is actually being used or charged.

  In areas designed to store cylinders that accept valve protective caps, ensure users always keep these caps on the cylinders, except when the cylinders are empty, being processed, or connected for use.

- For all full or partially full cylinders in storage that contain toxic, highly toxic, pyrophoric, or unstable reactive Class 3 or Class 4 gases, provide gastight valve outlet caps or plugs.
- To prevent bottom corrosion, protect cylinders, containers, and tanks from direct contact with soil or surfaces where water might accumulate.
- Ensure portable carbon dioxide or dry chemical fire extinguishers, or other fire protection or suppression systems or devices, are available at storage installations for fire emergencies. Only allow trained personnel to operate fire extinguishers.
- Don't store cylinders in areas where they're exposed to flammable liquids, such as acetone.
- Keep the interior and the area surrounding the exterior of a storage building free of combustible materials.
- In areas where a flammable atmosphere could occur, use indirect heating means, like steam or hot water.
- Prevent possible explosions or fires by placing cylinders in a location where they won't be subject to mechanical or physical damage, heat, or electrical circuits.
- Keep combustible waste at least 10 ft away from compressed gas cylinders and systems.
- Store cylinders in a dry, well-ventilated area away from flames, sparks, or other sources of heat or ignition.
- Segregate full cylinders containing low hazard gases from "empty" cylinders awaiting return to the vendor.
- Don't expose cylinders to open flames or temperatures above 125 °F.
- Don't expose cylinders to continuous dampness or store them near salt or other corrosive chemicals or fumes. Corrosion can damage cylinders and make their valve protection caps stick.

4.5.3.1 Compressed Gas Cylinder Storage Distances by Hazard Class

Separate compressed gas cylinders from each other according to the hazard class of their contents.[32]

Gas Category	Other Gas	Unstable Reactive Class 2, Class 3, or Class 4	Corrosive	Oxidizing	Flammable	Pyrophoric	Toxic or Highly Toxic
Toxic or highly toxic	NR[33]	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	
Pyrophoric	NR	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)		20 feet (6.1 meters)
Flammable	NR	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)		20 feet (6.1 meters)	20 feet (6.1 meters)
Oxidizing	NR	20 feet (6.1 meters)	20 feet (6.1 meters)		20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)

[32] Compressed gas cylinder storage distances by hazard classes are based on the information in NFPA 55 Table 7.1.10.2 Separation of Gas Cylinders, Containers, and Tanks by Hazard Class.

[33] No separation required (NR).

Gas Category	Other Gas	Unstable Reactive Class 2, Class 3, or Class 4	Corrosive	Oxidizing	Flammable	Pyrophoric	Toxic or Highly Toxic
Corrosive	NR	20 feet (6.1 meters)		20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)
Unstable reactive Class 2, Class 3, or Class 4	NR		20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)	20 feet (6.1 meters)
Other gas		NR	NR	NR	NR	NR	NR

4.5.3.2 Reduced Compressed Gas Cylinder Storage Distances

You can reduce the required storage distances between gases without limit if the cylinders are separated by a non-combustible barrier with a fire resistance rating of at least 0.5 hours that interrupts the line of sight between the containers.

You can reduce the 20 ft (6.1 m) distance:

- To a distance of 5 ft (1.5 m) if one of the gases is enclosed in a gas cabinet.
- Without limit if both gases are enclosed in gas cabinets.

If barriers aren't feasible, you can follow 4.5.3.1 Compressed Gas Cylinder Storage Distances by Hazard Class

to store hazard classes.[34]

4.5.3.3 Compressed Gas Cylinder Storage Piping Systems

Mark piping systems in accordance with ASME A13.1 *Scheme for the Identification of Piping Systems* or other applicable approved standards, including:

- Ensure markings include the name of the gas and a direction-of-flow arrow.
- For piping that conveys multiple gases at various times, mark piping to clearly identify and provide warnings about the hazard.
- Provide markings for piping systems at these locations:
  - At each critical process control valve.
  - At wall, floor, or ceiling penetrations.
  - At each change of direction.
  - At a minimum of every 20 ft (6.1 m) or fraction thereof throughout the piping run.

4.5.3.4 Compressed Gas Cylinder Storage Security

- Design cylinder storage, use, and handling areas with security against unauthorized entry.
- You can use administrative controls to control access to individual storage, use, and handling areas within secure facilities that aren't accessible to the general public.
- For cylinders stored or used in public areas, protect cylinders from tampering and damage.

4.5.3.5 Hazardous Gas Storage Design

When designing areas to store hazardous gases, consider the following:

- Ensure that equipment used in oxygen service, including valves, piping, fittings, and regulators, are

[34] Based on the information in NFPA 1 63.3.1.11.2 Incompatible Materials and NFPA 1 Table 63.3.1.11.2 Separation of Gas Cylinders, Containers, and Tanks by Hazard Class.

constructed from materials and have pressure rating that are compatible with oxygen.

- For flammable gas containers stored indoors, ensure storage is in accordance with NFPA 55 or the prevailing local, provincial, and territorial building and fire prevention codes.

  Some occupancies apply special quantity limits or impose maximum quantities unless specified controls, construction, heights and area limits, and distances to exposures (separations) are in effect.

4.5.3.6 Nesting Compressed Gas Cylinders

You can nest cylinders if storage is compliant with the three-point method contact system.

The method you use to secure cylinders can depend on seismic risks and must follow local, provincial, and territorial building and fire prevention codes.

4.5.4 Lab Ductless Fume Hoods

Only install ductless fume hoods for highly repetitive processes conducted within the fume hood. For example, they're suitable for core facilities that use the same limited number of chemicals at the same concentrations with few anticipated changes over the fume hood's life.

Before specifying a ductless fume hood, ensure EH&S conducts a review.

When selecting and installing ductless fume hoods, ensure they meet these criteria:

- Ductless fume hoods must meet ANSI/ASHRAE Z9.5 Laboratory Ventilation Section 4.2 requirements.
- Manufacturers must compare a list of allowed contaminants and concentrations used in the specific lab to ensure that their fume hood filtration can handle the contaminants and to provide an estimate of how often their filters must be replaced (their service changeout schedule).
- Ductless fume hoods must have a reliable monitoring system that indicates breakthrough at no more than half the threshold limit value.
- Ductless fume hoods must pass ASHRAE 110 at specified velocities.

4.5.5 Lab Emergency Eyewashes and Showers

4.5.5.1 Eyewash and Shower Locations

Equip these locations with at least one emergency eyewash and shower placed no greater than 50 ft from where corrosive or flammable liquids are handled:[35]

- Every newly constructed or renovated lab.
- Any room used for similar purposes where either corrosive or flammable liquids are handled or open flame devices are used.

According to OSHA regulations, "where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use."[36]

Work areas and operations that may require these devices include:

- Battery charging areas.
- Biohazardous waste rooms.
- High dust areas.
- Mechanical rooms.
- pH neutralization system locations.
- Radioactive materials use and waste areas.
- Spraying operations.

4.5.5.2 Eyewash and Shower Installation

Install all emergency eyewashes and showers according to ANSI, Z358.1-2014.

[35] Commonwealth of Massachusetts Comprehensive Fire Safety Code - 527 CMR 1.00 Section 10.23.

[36] 29 CFR 1910.151(c).

Install emergency eyewash and shower equipment in accessible locations that meet these criteria:[37]

- The equipment is reachable within 10 seconds or less (this criteria may be changed depending on the chemical's potential effects).
- The equipment is on the same level as the hazard.
- With travel paths free of obstructions that could inhibit immediate use of the equipment.

In areas where highly corrosive chemicals are used, you may be required to install an emergency shower and eyewash station within a range of 3 m to 6 m (10 ft to 20 ft) from the hazard. Install these units to prevent contamination from corrosive chemicals or other contaminants used nearby.

For all fixed eyewash stations and showers, provide floor drains, sinks, or a means to collect water during flushing.

In lab buildings where floor drains must be connected to lab wastewater neutralization systems, equip floor drains with "U" type or primed P-traps. If the fixtures aren't connected to a floor drain, ensure there is sufficient space to place a bucket or other collection container for routine flushing of fixtures as required at least every six months for emergency showers.

Emergencies may impair your vision, so emergency equipment requires "highly visible signs" that meet these criteria:

- Use contrasting color (either red and white or green and white).[38]
- Have a minimum area of 70 sq in.
- Display the words "emergency wash station" or "safety shower" in uppercase letters.
- Positioned close to emergency equipment for quick identification.
- Supply adequate lighting in the area surrounding emergency equipment.

---

[37] ANSI.

[38] 527 CMR 1.00 Section 10.23.

4.5.5.3 Eyewash and Shower Selection

Ensure all emergency eyewashes and showers comply with ANSI, Z358.1-2014.

Don’t use drench hoses as primary emergency eyewashes or showers.

Emergency showers must meet these criteria:

- Provide a minimum spray volume of 75.7 L/minute (20 gal/minute) connected to an uninterruptible water supply.
- Design showers so they can be activated in 1 second or less, ensuring they remain operational without the need for operators to use their hands.

Eyewash stations must meet these criteria:

- Be easy to activate.
- Deliver fluid to both eyes simultaneously at a volume of at least 1.5 L/minute (0.4 gal/minute) for 15 minutes. Ensure volume velocity can’t injure eyes.
- Remain operational in a hands-free mode.
- Eyewashes and their actuators don’t conflict with other operating controls like hot, cold, or reverse osmosis water.
- Eyewashes and their actuators aren’t blocked by casework or other obstructions.

In areas where you handle relatively small quantities of injurious materials, consider installing combination eyewash drench hose units that are third-party certified to meet or exceed ANSI, Z358.1-2014 provisions.

4.5.5.4 Eyewash and Shower Water Temperature

Use equipment with tepid water temperatures.[39] Generally, suitable water temperatures are between 16 °C to 38 °C (about 60 °F to 100 °F). For extended periods of eye irrigation or showering, provide temperatures in the

[39] The ANSI water temperature standard specifies "tepid" water.

higher part of the range.

4.5.6 Lab Gas Detection and Alarms

If a lab uses highly toxic gases like GHS Category 1 Acute Toxic in quantities greater than MAQ, equip the lab with gas detection and alarms. See the Hazardous Gas Manual for more information.

4.5.7 Lab Fire Extinguishers for Sensitive Electronic Equipment

Provide a hydrofluorocarbon (HFC) clean agent portable fire extinguisher within the immediate vicinity of sensitive electronic equipment, including:

- Class 3B or Class 4 lasers.
- Clean room environments.
- Epitaxial reactors.
- Laser cutters.

Choose fire extinguishers like ANSUL CleanGuard HFC-236fa that contain at least 9.5 lb of extinguishing agent.

You can use a phased approach for equipment by implementing signage, instructions for lab personnel, and an extinguisher maintenance program:

- Provide a CO_2 (Class BC) fire extinguisher in the immediate vicinity of sensitive electronic equipment.
- Ensure a Class ABC fire extinguisher is accessible nearby as a secondary defense.

Typical Class ABC fire extinguishers are effective but could damage sensitive electronic equipment. HFC and CO_2 fire extinguishers leave less residue on such equipment.

Portable fire extinguishers containing CO_2 or less than 9.5 lb of ANSUL CleanGuard HFC-236fa extinguishing agent (both rated Class BC) aren't rated for combustibles like paper, wood, cloths, and some plastics (Class A).

CO_2 fire extinguishers sometimes don't displace enough oxygen to totally extinguish the flames and could elicit a mild static shock if their metal braid is damaged.

4.6 Lab Hazardous Materials

In addition to other equipment and hazard-specific guidelines, these design requirements apply to all lab settings where people will use hazardous materials.

- At benches and desks in labs use chairs and stools made of wipeable, impermeable, and non-porous materials.
- Separate kitchenettes and areas where people consume food or drinks from hazardous materials with a physical barrier, such as a wall or door.
- Design spaces to minimize the need to transport food or drinks through lab spaces.
- Install shelving outside of labs for items like cups.

  Consider installing shelving that is recessed or with curved edges, fluorescent, and no more than 4 in deep and more than 27 in above the floor.

  See accessibility standards for protruding objects.
- Dedicate space at the lab entrance for storing PPE, such as lab coats, gloves, and eye protection.
- Identify dedicated waste storage areas for chemical, biological, and radioactive waste collection.

4.8 Lab Industrial Wastewater Pretreatment Systems

Industrial wastewater pretreatment systems (IWPS) are designed to either remove pollutants below or otherwise treat industrial wastewater to a level where the wastewater discharged into the MWRA or applicable sewer authority collection system complies with Harvard's respective wastewater discharge permit.

These design guidelines only include pH neutralization for the purposes of the specifications referenced.

You only need specification amendments for systems that require additional treatment technologies to meet compliance, such as metals removal.

Ensure that IWPS capabilities meet these minimum criteria:

- Maintain effluent discharge between 5.5 pH and 12.0 pH per the MWRA or as required by local authorities.

- Maintain pH by automatic control using feedback from installed electronic pH sensors, ideally with all operations fully automated).
- Send pH and other critical alarm conditions to the building management system that can relay information to another location, like the Operations Center.
- Continuously measure and record effluent pH and flow on a circular pH chart recorder or approved equivalent method.

Learn more at the EH&S Wastewater Management program website.

4.9 Lab Laser Systems

When designing a Class 3B and Class 4 laser installation or laser facility, you must:

- Contact the Radiation Safety Office. They will connect you with the EH&S Laser Safety Officer (LSO) who will provide tailored design guidance.
- Throughout the design and construction phases, follow all relevant regulations and Harvard policies, including Commonwealth of Massachusetts Regulations 105 CMR 121: Laser Systems and the Laser Safety Manual.
- Register Class 3B and Class 4 laser systems with Harvard's Radiation Protection Office.

4.9.1 Class 3B Laser Facilities

When designing a Class 3B laser facility:

- Ensure Class 3B laser systems are only operated by personnel trained in the laser's operation, system, and safety protocols. Restrict access to unauthorized individuals and maintain positive access control in the laser-controlled area.
- Display suitable warning signs at the entryways of Class 3B laser-controlled areas. The LSO can supply the necessary self-adhesive label postings.

  Depending on the LSO's recommendations, Class 3B lasers might need audible or other visible warning devices (see Class 4 lasers).

- Prevent direct or scattered laser light from exceeding the maximum permissible exposure (MPE) outside the laser-controlled areas by removing or filtering windows or other transparent structures. Secure and label covers or filters to deter unauthorized removal.
- Avoid using construction materials that contribute to generating specular reflections. Encourage diffuse reflections by avoiding smooth, polished surfaces, especially on walls and other vertical surfaces.
- To prevent accidental exposure, position laser beam paths either above or below eye level whether sitting or standing.
- Ensure electrical services for lasers meet all electrical safety codes, including lockout-tagout procedures. Laser systems often require high voltage and high amperage electrical services.
- Because some laser systems use hazardous chemicals or generate hazardous air contaminants, provide appropriate hazardous chemical ventilation systems and safe liquid handling methods.

4.9.2 Class 4 Laser Facilities

When designing a Class 4 laser facility:

- Follow all Class 3B laser facility safety design criteria.
- Design Class 4 laser-controlled areas and entryways for rapid egress at all times, especially under emergency conditions.

  Install a prominently marked "Panic" button to either deactivate the laser or reduce its output to below the MPE during emergencies.

- Include a visible or audible signal indicating that the laser is energized and operating at the entryway to the Class 4 laser-controlled area. Ensure warning lights are discernible to personnel wearing laser safety glasses. Ensure warning signs only illuminate when the Class 4 laser is on and flash to make them easily visible.

  Contractors are responsible for procuring and installing these warning signs. Additional devices might be required within the laser-controlled area, as directed by the LSO.

- Consider including audible warning devices in areas with high ambient noise levels and ensuring accessibility for individuals with hearing or visual impairments.
- Because Class 4 lasers may ignite combustible materials, restrict combustible materials from direct beam or specular reflection exposure and only allow exposure to absolutely necessary materials.

Establish entryway safety controls in consultation with the LSO, which could include:

Entryway Safety Control Type	Description
Non-Defeatable	Safety mechanisms or interlocks that can't be bypassed, halting the laser or lowering its output to under the allowable MPE during unscheduled entries.
Defeatable	If non-defeatable controls hinder the laser or laser system's intended use, install defeatable safety mechanisms that can be bypassed, reducing the laser output to below the MPE during unscheduled entries.
Procedural	If non-defeatable or defeatable area or entryway safety controls limit the laser's or laser system's intended use, use procedural controls like a door, blocking barrier, screen, or curtain to block, screen, or attenuate the laser radiation at the entryway. Barriers must not support combustion or release toxic fumes following a laser exposure.

4.10 Lab Pest Control

- Design and construct labs to exclude entry and escape by pests, including rodents, birds, and insects.
- For labs that maintain or manipulate exotic, genetically modified organisms, design and construct labs following the CDC, United States Department of Agriculture, Harvard Committee on Microbiological Safety, and other applicable regulatory requirements.
- When practical, seal partitions above ceilings to exclude pests from passing through.
- Ensure that there are no gaps 1/4 in or wider beneath or between doors serving labs or animal room

doors.

- Avoid installing pocket doors unless the pockets are completely sealed within.
- Ensure that the bottom of hollow core doors is sealed to prevent mice from entering.
- Ensure that all floor drains or receptors are readily accessible for inspection and servicing.
- Ensure an auto-primer serves each drain.
- Appropriately secure each drain to prevent pests from passing through.
- Schedule a formal design review and on-site inspection conducted by EH&S Pest Control.

For research facilities, review Section 015716 Construction Integrated Pest Management Standard.

4.11 Lab Ultraviolet Light Systems

When designing UV light labs where UV lights are used in room-wide installations or where UV lights of significant power illuminate non-confined personnel-accessible spaces, you must:

- Follow special design guidance to ensure the safety and well-being of the personnel working within the lab.
- Contact the Radiation Safety Office. They will connect you with the EH&S LSO who will provide tailored UV light lab setup design guidance.
- Throughout the design and construction phases, follow all relevant regulations and policies.
- Register room-wide and personnel accessible UV light labs with Harvard's Radiation Safety Office.

4.11.1 UV Facility Layout and Safety Features

- Ensure that UV light labs have a clear indicator both outside and inside the UV room to signal when the UV lights are on.
- Employ an interlock system, such as motion sensors or magnetic door sensors, that triggers the UV lights to turn off automatically when someone enters the room. Many interlock systems are available commercially.
- Install UV protective glass on windows and doors to safeguard people outside the lab.

- To prevent accidental activation, install a safety enclosure like a locking cover around the UV light switch.
- Consider designing the lab with a single point of entry and exit to efficiently monitor and control access.
- Consider installing a designated locker area equipped with a tracking board for personnel to indicate their presence in the lab.

4.11.2 UV Signage

Place clear and prominent signs at various points in the lab, including:

- On doors, instructing personnel on what to do if the UV lights turn on unexpectedly.
- Inside the lab, reminding personnel to perform a sweep before leaving the lab and planning to activate the UV lights.
- On the UV light switch, displaying the complete policy for activating the UV lights.

4.12 X-Ray Labs

When designing X-ray labs, you must:

- Contact the Radiation Safety Office. They will connect you with the EH&S Radiation Safety Officer (RSO) who will provide tailored X-ray lab design guidance.
- Follow specialized design guidance to ensure the safety and well-being of personnel working in X-ray labs.
- Register all X-ray devices and labs with Harvard's Radiation Safety Office.

4.12.1 X-Ray Lab Facility Layout and Safety Features

- Design labs for a single point of entry and exit to facilitate effective monitoring and control access to the lab.
- Implement measures to restrict unauthorized access and maintain positive access control in the X-ray controlled area and X-ray equipment security.
- When designing lab layouts, consider preventing unintended X-ray exposure.

  For open beam X-rays, incorporate barriers or shielding materials that attenuate X-ray radiation, effectively protecting areas outside the controlled zone from exposure.

- Only allow trained personnel to operate X-ray labs. Ensure these personnel are trained in X-ray equipment operation, systems, and safety protocols.
- Implement electrical safety protocols, including lockout-tagout procedures, considering the high electrical demands often associated with X-ray systems.

Install safety features such as:

- Emergency stop buttons for emergency deactivation of X-ray sources.
- If not already provided by the manufacturer, interlocks for X-ray rooms that can be entered by personnel. Ensure interlocks disable the X-ray when the door opens.

4.12.2 X-Ray Lab Warnings and Signage

- Clearly show controlled areas where there is a risk of exposure to X-rays.

  Ensure that all necessary warning signs are visibly displayed at entry points, including a “Caution X-ray” sign. The RSO can give you guidance about appropriate signage and labels.

  For X-ray rooms that personnel can enter, you must also install warning lights that show the on-off status of the X-ray.

- Include clear and prominent signs providing guidance on emergency procedures and safety protocols for X-ray equipment operation. Position these signs at various locations in the lab, including doors and within the lab space.

5.0 Makerspace Facilities

Makerspaces are used for diverse activities aimed at fostering innovation and hands-on learning, including:

- 3D printing.
- Crafting like thermoforming, painting, jewelry-making, ceramics, and textile work.
- Electronics prototyping.

- Metal and woodworking.

These activities let people bring their ideas to life, but also have potential hazards that must be considered and managed.

Using household or otherwise hazardous materials may require chemical storage facilities, emergency equipment, and local exhaust capture devices like snorkels, fume hoods, canopy hoods, spray booths, or dust collection systems.

Metal or woodworking equipment have infrastructure requirements, such as emergency shut-off buttons, dust collection systems, and controls to limit access.

If you anticipate the presence of chemical or biological hazards in a makerspace, review Section 4.0 Lab Design for additional design requirements.

These sections describe the minimum setup requirements for makerspace facility equipment.

5.1 3D Printers

Provide a designated shelf or staging area outside the printing area to keep food and drinks.

Corrosive and flammable liquid baths associated with 3D printers can produce strong odors and irritate eyes. To address these hazards:

- Design room or local exhaust ventilation to adequately address these hazards.
- Locate an eyewash station near 3D printers.
- Provide adequate storage capacity for flammable liquids as needed, such as for storing isopropyl alcohol squeeze bottles.
- Don’t use carpeting in rooms where 3D printers are operated.

5.1.1 3D Printer General Ventilation Guidelines

For 3D printers without an integrated enclosure and a well-designed filtration system with a specified changeout schedule, provide ventilation that printer users can manually or electronically switch on when operating the printer.

Ventilation control examples:

- Install single unit local exhaust ventilation systems, such as snorkel fume extraction arms.
- When using multiple printers, operate printers on enclosed ventilated racks.

Ventilation options ranked by effectiveness, starting with the most effective:

- Directing exhaust outdoors.
- Connecting the enclosure to a HEPA and activated charcoal filtration unit with a specified changeout schedule that avoids breakthrough.
- Increasing the room ventilation to at least 4 ACH to 6 ACH.

  Only implement this ventilation option if:

  - No more than two printers are concurrently operated.
  - Printers aren't operated in the immediate vicinity of an occupied workstation.
  - Printers are placed near room exhaust grilles.

5.1.2 Desktop Fused Deposition Modeling Printers

For desktop fused deposition modeling (FDM) 3D printers:

- Provide local exhaust airflow near non-enclosed printers. You must implement this exhaust ventilation for acrylonitrile butadiene styrene (ABS) and similar polymers.
- Locate printers away from areas where people spend an extended amount of time.

5.1.3 Desktop Stereolithography or PolyJet Printers

For desktop stereolithography or PolyJet printers:

- Include ventilation and storage for flammable materials for the rinse baths.
- Include storage space for proper PPE for handling uncured resins. Proper PPE includes gloves, lab coats, and safety glasses.

- Design a layout and setup that either:
  - Prevents resin from contaminating other lab items.
  - Segregates these printers to restrict access to only trained users.

5.1.4 Professional Level Fused Deposition Modeling Printers

For professional level FDM 3D printers:

- You may not need to provide direct ventilation for certain brands of printers with integral filtration systems provided by the manufacturer.
- When possible, consider choosing available options that don't use sodium hydroxide baths.

Selective Laser Sintering PrintersYou can control particulate emissions from selective laser sintering (SLS) printers inside closed inert gas systems during print cycles. However, SLS printers can still emit particulates during filling, leveling, staging, filter changes, and cleanup.

Equip the printing area to manipulate materials like fine powders throughout the entire process lifecycle.

5.2 Laser Cutters

Ensure that these laser cutter ventilation and fire safety precautions are met:

- Provide compressed air for an air assist system that's either included with the laser head or added to the laser head separately. Design this system to remove smoke and debris in the laser's path.
- Connect spark arresters to the exhaust streams directly downstream of the laser cutters.
- Connect one equipment option further downstream (listed in order of decreasing preference):
  - Booster/inline fan to direct exhaust to building roof.
  - Filtration unit that discharges to a direct or thimble connection to building exhaust with about 10% more CFM than the filtration unit exhausts.

    Rationale: Laser cutters must typically be connected to exhaust fans that can draw about 500 CFM at about 6 inches w.c. static pressure (check manufacturer specifications for exact requirements). This *prevents particles from settling in the cutter, which degrades cutter performance and could potentially catch on fire. The filtration unit consists of a fan that can handle the volumetric flow rate and static pressure requirements, pre-filter, HEPA filter, and charcoal filter. The backup direct or thimble connection to the building exhaust system is necessary because charcoal filters can become saturated and be bypassed fairly quickly.*

- Include a mechanism to turn on the exhaust system only for the specific laser cutter currently in use.
- Include a mechanism that prevents laser cutters from turning on if the exhaust system is off.
- Include an alarm that activates during loss of exhaust during laser cutter operations.

  This alarm is especially important for laser cutters without visible or audible indications that the selected laser cutter exhaust equipment is turned off, like if the equipment is in a noise-dampening enclosure or a remote location.

  This alarm ensures the laser cutter user is alerted to start a shutdown process to allow adequate cool down time instead of automatically cutting off the laser cutter's power.

- Provide applicable fire extinguishers for sensitive electronic equipment.
- Follow all other laser system design, construction, and registration guidelines.

5.3 Makerspace Machinery

When planning the layout of machinery and equipment in makerspaces, consider:

5.3.1 Machinery Access Controls

Place high hazard machines in areas where access can be controlled. High hazard machines include table saws, metal and woodworking lathes, metal mills, wood, and metal computer numerical control (CNC) machinery.

Understand which type of access controls the makerspace plans to use to control access to their equipment.

Access Control Type	Description
Area	Area access controls limit access to the area to only authorized personnel. You can use these controls to limit access to only personnel who completed the required training.
Machine and equipment	You can install machine and equipment access controls on individual machines or pieces of equipment to limit access of that machine or equipment to authorized personnel only.

5.3.2 Machinery Energy Isolation

To facilitate safe equipment servicing, you must provide a means to secure power to each machine for implementing control of hazardous energy procedures (lockout-tagout).

In some cases, you must provide energy isolation to secure hazardous machinery from unauthorized users if no other means are available.

5.3.3 Machinery PPE & Segregation

Provide adequate segregation between machinery and equipment that requires using PPE from areas where tasks are performed that don't require using PPE.

Examples of PPE include hearing protection and safety glasses.

5.3.4 Metalworking Machinery

Metalworking machines like lathes, mills, and CNC machines typically splatter cutting oils and fluids on the floor and walls around the machinery.

In areas where these machines are installed, you must install easily cleanable wall surfaces and appropriate slip resistant flooring or mats.

5.3.5 Woodworking Machinery

Woodworking machines include saws, sanders, lathes, jointers, planers, and molders.

You must connect woodworking machines to a dust collection system.

The expected use of the makerspace dictates the best approach for dust control:

- Smaller, limited use applications should consider small individual units, such as shop vacuums. You can use devices that connect the vacuums to the woodworking machines, activating the vacuum when you energize the equipment.
- Larger, higher throughput facilities may require a system that can capture dust from several machines through a ducted system.

5.4 Makerspace Storage

When designing makerspaces, carefully assess these storage needs:

Storage Type	Storage Needs
Finished products	Plan adequate storage for finished products, especially those that require curing time and may off-gas volatile organic compounds while curing.
Hazardous materials	Consider storage for processing chemicals and waste. Consider adequate storage for flammable liquids, acids, bases, chemical waste containers, and required secondary containment.
Personal belongings	Consider day use and longer-term lockers for students and makerspace users to store personal belongings, including backpacks and jackets, while using the spaces. Providing a place to store personal belongings is especially important for spaces with machinery and robots.

Storage Type	Storage Needs
PPE	Understand PPE requirements and provide storage to maintain PPE clean and ready for use. Ideally, setup PPE storage near the entrance of the facility where the users can don PPE on their way in and doff PPE on their way out. PPE often required in makerspaces, robotics labs, and shops incudes lab or shop coats, eye and face protection like safety glasses, goggles, and/or face shields, and hearing protection like ear canal inserts or muffs.
Raw materials	Consider storage for bulk raw materials such as metals, wood, particle board acrylic sheets, and foam. Certain raw material products off-gas volatile organic materials, so you must consider exhaust ventilation requirements.

6.0 Architect/Designer Acknowledgement

I, *(print name)*________________________, a *(print title)*____,

at *(print firm)*_________________________, confirm that I have read and understand the issues outlined in this document. Further, I will ensure that the applicable conditions detailed in this document are incorporated by my company and/or any sub-consultants working under our direction into the design submittals that are required under the AIA B151, Abbreviated Standard Form of Agreement Between Owner and Architect, or other similar design contract, which I have executed with Harvard. I understand that as a condition of AIA B151 (or other executed design contract), all Architects and all Architect's consultants are required to provide design services according to all current laws, statutes, ordinances, building codes, rules and regulations applicable to the design of a project. I also understand that this manual provides some additional background on certain design requirements that relate to environmental, health and safety (EH&S) issues. This manual doesn't address and isn't intended to abrogate or assume responsibility for the duty to know and understand all governing requirements according to AIA B151 (or other executed design contract). Rather, it is provided solely to communicate certain EH&S design issues that may be overlooked during the design of a University project.

Company Name

Authorized Signing Authority (print name)

Authorized Signing Authority (signature)

Date