

MIT

Design Standards

Environment, Health and Safety (EHS)

T08 Thematic Folder

Issued 2022



Department
of Facilities

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END

1. PURPOSE

1.1 Purpose

The purpose of these guidelines is to provide specific MIT requirements and background on design issues that relate to Environment, Health and Safety (EHS). MIT expects Architects, Engineers, and Designers to design campus buildings and renovations that meet building codes and regulatory standards while providing safe and healthy environments for occupants and maintenance personnel.

2. SAFETY

2.1 Confined Spaces

Meet or Exceed the Following Standards

1. OSHA 29 CFR1910.146.

All structures shall be designed to eliminate or minimize the number of confined spaces. A confined space is an area that meets the following three requirements:

1. The space is large enough for an employee to enter and perform assigned work;
2. The space has limited or restricted means for entry or exit; and
3. The space is not designed for continuous employee occupancy.

A confined space can have hazards that make them significantly more dangerous to enter. These spaces are considered “permit required” confined spaces, which means one or more of the following characteristics exist:

1. The space contains or has a potential to contain a hazardous atmosphere;
2. The space contains materials that have the potential for engulfing an entrant;
3. The space has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
4. The space contains any other recognized serious safety or health hazard.

When the creation of a permit required confined space is unavoidable, one or more of the following actions should be taken to reduce the hazards associated with the space.

Prevention of Confined Space through Design

1. Make the confined space or confined space opening too small to bodily enter:

- a. This principle has limited applicability, but some spaces can be partitioned or otherwise broken into multiple compartments that are too small for a person to get inside.
 - b. Inability to enter due to size keeps employees out of harm's way and eliminates coverage under OSHA's confined spaces standard.
2. Provide unrestricted access and egress:
- a. Allow workers to enter without having to contort their bodies, crawl, or use their hands to climb in or out.
 - b. Provide large access openings, such as standard doorways, through which workers can pass easily and quickly.
 - c. Provide standard overhead clearances so that workers can stand in the space whenever possible.
 - d. Install standard steps with handrails in lieu of ladders or spiral staircases. Steps allow safer, unrestricted entry and exit from the space.
 - e. Provide sufficient aisle clearances within the space and provide clear access to openings and exits.
 - f. Locate pipes, ducts and other equipment so workers do not have to climb over, under or around them.
 - g. Provide multiple access openings at regular intervals in long spaces, such as crawl spaces and tunnels, to ensure that employees' ability to exit the space is not restricted by distance.
 - h. House equipment in buildings above ground with a standard doorway for access rather than placing equipment in a vault below grade.
3. Design spaces for continuous human occupancy during normal use.
- a. Install continuous-operation or door-switched mechanical ventilation to control air quality and temperature in confined spaces.
 - b. If a confined space is dependent on ventilation for human occupancy, install an alarm to indicate when ventilation is not working and consider installing fixed-gas equipment with an alarm to verify air quality.
 - c. Install adequate fixed permanent lighting in the space. Place light switches at entrances.
 - d. Seal the space to prevent water intrusion and ensure proper drainage to prevent accumulation of free-standing liquid.
 - e. Ensure that mechanical equipment is properly guarded and that electrical equipment is sealed correctly.
 - f. Guard open-sided edges, floor holes, wall holes, and any other hazards that may cause falls.

Eliminate the Need for Entry into Confined Spaces

1. Install critical equipment (valves, gauges, etc.) that require periodic operation, inspection, or maintenance outside the space so that entry will not be necessary.
2. Extend valve handles so they can be operated from outside the confined space.
3. Use flexible components and install retrieval systems for items that are located at the bottom of the confined space (e.g., sump pump) so they can be removed and serviced without entry.
4. Install extension tubes and fittings to make lubrication possible from outside the confined space.
5. Install catch baskets at the bottoms of tanks or other spaces that can be raised to retrieve fallen parts to prevent the need to enter the confined space.
6. Use remote monitoring systems (cameras, gas detection, leak detection, wireless meter readers, etc.) to obtain information while outside the space.
7. Select mechanical equipment for maximum service life and minimal maintenance requirements to reduce the number of entries required. Over the long term, the additional cost of such equipment may pale in comparison to the cost of routine confined space entry.
8. Install viewing and cleaning ports in tanks and other equipment so that the interiors can be seen and cleaned without entering the space.

Make Entry Impossible if Entry is not Required

1. If entry into a particular confined space will never be required, modify the space to make entry impossible.
2. Make access openings too small for a person to fit through.
3. If existing access openings are large enough to pass through, seal the openings using security locks, weld openings shut and so on, or block openings by installing grating across the opening.

If Entry is Necessary, Eliminate or Reduce the Health and Safety Hazards

1. Eliminate or minimize health hazards:
 - a. Prevent entry and accumulation of organic debris that could decompose and lead to oxygen deficiency or the generation of toxic gases.
 - b. Prevent moisture and water intrusion that could cause rusting and lead to oxygen deficiency. If this is not possible, use materials that do not rust or seal materials with a rust preventer.
 - c. Eliminate the placement of piping or conduit containing hazardous materials, gases, chemicals, or sewage in the confined space. Where pipes do enter the space, provide means to drain, purge, and blank any piping. Use welded joints on any piping that will carry hazardous materials to prevent leakage.

- d. Provide ventilation ports at regular intervals if there is potential for a hazardous atmosphere, and provide multiple openings at opposing ends of the space to facilitate complete and effective ventilation.
 - e. Seal or screen any openings to the space as needed to keep out insects and other animals.
 - f. When possible, select and install equipment with low noise ratings.
 - g. Remove or seal any asbestos-containing materials within the confined space.
2. Eliminate or minimize safety hazards:
- a. Install sumps and pumps to prevent accumulation of free-standing liquid, such as groundwater.
 - b. Ensure all electrical equipment is properly enclosed, grounded, and approved for the particular environment (e.g., Class 1 equipment for flammable gas and vapor environments, Class II equipment for combustible dust environments).
 - c. Ensure that all energy sources in the space can be locked out, ideally from outside the space.
 - d. Provide ladders or climbing devices as applicable.
 - e. Provide self-closing, swinging gates at the top access openings to fixed ladders.
 - f. Protect all open-sided floor edges, floor holes, wall holes, and similar hazards with standard railings and toe boards.
 - g. Use non-slip flooring materials where possible.
 - h. Ensure that the means of entry does not pose a hazard. Use mechanical devices to lift or open heavy in-ground doors or manhole lids. Use lighter composite lids if possible. Make sure doors will not swing shut in windy conditions.

Design to Ensure Ability to Rescue

1. If confined spaces cannot be eliminated, the space should be designed to facilitate non-entry rescue to the extent feasible.
 - a. Provide access platforms of sufficient size to accommodate entry and potential rescue when access openings are elevated above floor level.
 - b. Provide multiple access openings into the space, preferably at spread out locations for better access to all areas of the space.
 - c. Ensure openings are at least 24 inches wide or measure 24 inches in diameter.
 - d. Ensure adequate overhead clearance for use of a tripod or davit arm retrieval system during vertical entries. If there is not sufficient clearance, install a permanent anchor point with at least a 5,000-pound static load capacity above the opening to which a pulley or winch can be attached for rescue.
 - e. Employ a pulley system or install regular access points for rescue from spaces where a horizontal entry is used.
 - f. Install multiple large release hatches at the bottoms of sloped hoppers and silos

that could be opened to empty those structures quickly in case of engulfment.

2.2 Fall Hazards

Meet or Exceed the Following Standards

1. 29 CFR 1910 Subpart D.
2. Massachusetts State Building Code, 780 CMR.

Structures should be designed to eliminate fall hazards during routine and non-routine use, maintenance, repairs, and all other purposes. Where exposure to fall hazards are unavoidable, the hazards involved in working at heights above 4 feet, including roof tops and loading docks, should be minimized by incorporating the following into the building design:

Always Design to the Hierarchy of Fall Protection

1. Eliminate the hazard: Avoid work at height where possible or locate plant and equipment in safe locations where there is no risk of a fall.
2. Guard the hazard: When working at height is essential, ensure that workers are not exposed to unnecessary risks, consider providing a parapet or guardrail to eliminate the fall hazard.
3. Protect the worker: Where it is not possible to eliminate the risk of falling, use a suitable fall protection system to minimize the consequences of a fall. This can be achieved with a fall arrest or fall restraint system—two completely different entities, as long as it provides protection along entire route.
 - a. Fall Restraint:
 - i. These systems allow a person access to conduct their duties but prevent them from reaching a point where a fall could occur.
 - ii. Fall Restraint systems are generally suitable if the person needs to work at the edge of a hazard. For example, where there is a need to maintain gutters along the edge of a roof, or if there are other potential fall hazards such as a fragile roof, roof lights or air vents.
 - iii. If fitting a fall restraint system, it is recommended that the system should be tested to fall arrest loads to ensure a person's safety in situations where the system may be misused (i.e. when the person using it wears an over-length lanyard to enable access to the edge of a roof).
 - iv. Restraint systems are generally positioned more than 6 feet from the hazard. This is because common practice is for the worker to be connected to the system by a fixed length 4-foot lanyard.

- b. Fall Arrest:

- i. Install guardrails and toe boards (where toe boards are required by OSHA) where people are exposed to falls of 4 feet or greater. Standard railings with standard toe boards shall be installed on all exposed sides except at the entrance to the opening. Guardrails shall be 42 inch at the top rail and 21 inch at the mid-rail. Toe-boards shall be 4 inch from ground to top of board.
- ii. Where guardrails are not feasible, install permanent fall arrest anchor points for the use of personal fall protection equipment. Anchorages to which personal fall arrest equipment is attached shall be capable of supporting at least 5,000 pounds per employee. Prior to commissioning, a qualified person must verify the anchorage meets load requirements
- iii. A fall arrest system provides maximum freedom of movement for workers to conduct their duties. In doing so it allows them to reach the point where a fall could occur, such as the edge of a roof for gutter maintenance.

2.3 Fixed Ladders

Meet or Exceed the Following Standards

1. 29 CFR 1910.27 Subpart D.

Where it is necessary to install a fixed ladder, it shall comply with OSHA 29 CFR 1910.23. It shall also be constructed in accordance with ANSI standard A14.3-2008. These standards prescribe minimum requirements for design, construction, and use of fixed ladders. It also sets forth requirements for ladder safety systems used with fixed ladders.

2.4 Skylights

Meet or Exceed the Following Standards:

1. 29 CFR 1910 Subpart D. particularly note sections 29 CFR 1910.28 (b)(3)

Skylights shall be designed to prevent people from falling through them. OSHA concludes that, “a skylight shall be regarded as a hatchway, i.e., an opening in the roof of a building through which persons may fall.” Therefore, OSHA regulations require that skylights shall be guarded by a standard skylight screen, skylight that has the same load requirements of a screen or a fixed standard railing on all exposed sides.

Requirements for standard skylight screens are provided in the OSHA regulation 29 CFR 1910 Subpart D. The regulation states that skylight screens shall be of such construction and mounting that they are capable of withstanding a load of at least 200 pounds applied perpendicularly at any one area on the screen. They shall also be of such construction and mounting that under ordinary loads or impacts, they will not deflect downward sufficiently to break the glass below them. The construction shall be of grillwork with openings not more than 4 inches long or of slat work with openings not more than 2 inches wide with the length unrestricted.

2.5 Window Washing

Meet or Exceed the Following Standards

1. Installation shall be in accordance with ANSI and International Window Cleaning Association (IWCA) standard I 14.1 latest version
2. Powered platforms for window cleaning shall be constructed in accordance with the American Society of Mechanical Engineer's (ASME) standard A 120. latest version and ASME 120.1b latest version.

Roof anchors are to be installed on all new buildings that require windows to be washed by suspended scaffolds, boatswain's chair, rope descent system or other suspended system. An engineered drawing showing anchors, and their weight limits must be provided.

All anchors must be pull tested and commissioned by a qualified party as part of the installation.

Anchors shall be labeled as window washing anchors.

2.6 Emergency Eyewashes and Showers

Meet or Exceed the Following Standards. Refer also to the Plumbing Division - 22 and the Lab Design Thematic Folder of the MIT Design Standards.

1. ANSI/SEA Z358.1 Standard for Emergency Eyewashes and Shower Equipment.
2. OSHA 29 CFR 1910.151(e) Eyewashes.
3. Massachusetts Plumbing code 248 CMR

Introduction

Emergency eyewashes and showers are to be installed in all laboratories and other types of non-lab work areas, which have hazards that include but are not limited to those listed below. **In lab buildings**, if the current hazards do not trigger the need for this equipment, piping shall be installed during the current renovation (left capped at either end to avoid "dead legs" and labeled for future use). This is to facilitate installation of eyewashes and/or showers when hazards change (often before the renovation is completed or soon after) or during a future space change. The goal is to reduce the cost of, time involved, and impact of the installation on the users.

Hazards and Other Triggers

1. All lab spaces equipped with sinks or fume hoods.
2. Equipped with ventilation equipment chemical fume hoods, specialized local exhaust ventilation (SLEV) and containment equipment such as biological safety cabinets.
3. Use and store chemical and biological materials. This includes but is not limited to corrosive or flammable liquids.
4. Open flame devices are used.
5. Spaces designated as Biosafety Level 1 (BSL-1) and higher.
6. Animal quarters (vivarium) designated as Animal Biosafety Level 1 (ABSL-1) and higher: Eyewash should be located outside of rooms with animal cages to prevent contamination of the animals' drinking supply. Eyewashes and sinks should be installed in animal procedure rooms including non-human primate testing and test preparation areas.
7. Animal quarters, which have cage washing facilities because 55-gallon drums of corrosive cleaning compounds are used.
8. Cleaning areas where corrosive products are used including labware washing, commercial kitchens.
9. Shops with metal and wood working equipment (particulates are produced).
10. Other non-lab facilities with the above types of exposures including pH neutralization system locations, battery charging areas, spraying operations, high dust areas, printing areas, shops, hazardous waste main accumulation areas, etc.

Equipment Specifications

1. The lever that is pushed, pulled or squeezed to activate the eyewash/ shower should be designed to remain on without requiring the use of the operator's hands. It should be easy to operate in an emergency.
2. The water or fluid should flow until intentionally shut off or until the specified amount has been discharged.

Eyewashes

1. Fluid should be provided to both eyes simultaneously via two nozzles or other means.
2. Nozzle protection should automatically come off when the water/ fluid starts to flow.
3. Eyewashes must be located where they can be effectively used hands free once the unit is engaged. Provide accessible clearances and heights for users with disabilities.
4. There are access limitations with some sink-mounted eyewashes for individuals who might need them at a lower height due to disability or short stature. Lower eyewash stations may be required in areas where needs have been identified.
5. MIT researchers prefer eyewashes that are activated by pulling one vertical arm

downward. These have a much smaller footprint compared to the swing activated (horizontal) type, which spray water on the bench during testing.

6. The endpoint of the eyewash arm shall be 14 inches or less from the leading edge of the lab bench. Users of all heights must be able to lean over the sink to reach the water stream. Install longer arm eyewashes if necessary. If the PI agrees, units may be panel mounted (at a 45-degree angle outward).
7. Eyewash units should be installed at sinks for proper draining to allow for required weekly testing of the units. If there isn't a sink in the room and a sink can't be installed, then appropriate provisions must be made in the plumbing design to allow for capture and drainage of one minute's flow of water from the unit to allow for the required testing.
8. Eyewashes should not be installed in the wall unless the unit is connected to the lab waste system and the wall is protected from water damage/ mold growth.
9. Drench-hose type eyewashes are only allowed as supplementary equipment in spaces where another approved eyewash is installed.
10. Faucet-mounted eyewashes are prohibited.

Showers

A water flow sensor reporting to the BMS shall be installed on all emergency showers located in public hallways or in remote locations such as mechanical rooms where hazardous chemicals are used and stored such as pH neutralization spaces.

If an emergency shower is chosen that is activated by a handle that hangs down, the end of the long shower handle should hang as close to the wall and as far away from the path of travel as possible to prevent inadvertent activation and head injuries. Acceptable Options:

1. A handle that is wall mounted.
2. A handle that can be adjusted in length based on the needs of the current lab users.
3. A long chain with eye hooks so the chain hangs along the wall.
4. A handle that is behind the smaller panel of a double leaf door.

Some of the Specifications for the Water or Fluid Supply are Described Below.

ANSI Z358.1-2009 527 CMR 10.02 248 CMR 10.13	Eyewash	Emergency Shower
Water/Fluid Temperature	<i>Tepid water (ANSI does not specify temperature range); Tempered water between 70 and 90 F (527 CMR 10.02, 248 CMR 10.13)</i>	

Water/Fluid Pressure	<p>Plumbed or self-contained Eyewash: <i>not less than 0.4 gpm for 15 minutes</i></p> <p>Velocity <i>should be low enough to be non-injurious to the user</i></p> <p>The eyewashes should be limited to not more than 45 psi static and 30 psig minimum when activated.</p>	<p><i>Minimum of 20 gpm at a velocity low enough to be non-injurious to the user (ANSI Z358.1)</i></p>
Water/Fluid Quality	<p><i>Potable water, preserved water, saline solution or any medically acceptable solution (ANSI) potable water (527 CMR 10.02, 248 CMR 10.13)</i></p>	
Control valve	<p><i>Valve should be the on/off type designed to remain activated until intentionally shut off</i></p>	
Prevent stagnation	<p><i>Installing equipment in a manner that prevents the stagnation of water in the piping 248 CMR 10 section (l) 5</i></p>	

Location Selection and Installation Standards

Select location that is adjacent to the hazard but there must be enough room so that the victim and emergency responders will be safe. For example, installing an eyewash/ shower “immediately adjacent” to an exhaust hood is not recommended. The emergency shower and eyewash unit must be located on the same level of the hazard and the path of travel must be free of obstructions that would inhibit the immediate use of the equipment. Doors to the eyewash or shower must swing in that direction. For strong acid and strong caustic hazards the eyewash unit should be immediately adjacent to the hazard.

The ANSI standard for Emergency Eyewash and Shower Equipment specifies the distance of the unit from the standing surface and the wall (or the nearest obstruction). This is to ensure that the unit will be reachable by any user and that the user will not be injured.

Emergency showers should be located within the laboratory as close to the main door as possible. This minimizes water possibly being sprayed on to electrical equipment that may be in the lab and it is less likely that items will block access to the shower.

36-Inch Clearance Zone for Showers

No obstructions, protrusions, or sharp objects shall be located within 16 inches from the center of the spray pattern of the emergency shower. Electrical apparatus, telephones, thermostats or power outlets should not be located within 18 inches of either side of the emergency shower or eyewash.

In specific limited cases where the equipment is to be installed outside the lab, the lab door must swing out and the doorway must be recessed so pedestrians will not be hit by the door. The

emergency shower and eyewash unit must be located on the same level of the hazard and the path of travel must be free of obstructions that would inhibit the immediate use of the equipment.

Code/Regulatory Citations

	Eyewash	Emergency Shower
OSHA 29CFR 1910.151(c)	<i>Within the work area for immediate emergency use.</i>	
ANSI Z358.1-2009 7.7.4 and 4.6.1	<i>In accessible locations that require no more than 10 seconds to reach (...), on the same level as hazard (i.e. on the same floor). The path of travel (to the safety equipment) should be free of obstructions (i.e. <u>locked</u> doors, boxes, etc.). It is acceptable to go through an unlocked door.</i>	
	<i>For a strong acid or caustic, (it) should be immediately adjacent to the hazard.</i>	
527 CMR 10.02 (2) 248 CMR 10.13	<i>Should not be located greater than 50' from an experimental area</i>	

Accessibility and Signage

Emergency wash equipment that meets the ADA requirements should be installed when new buildings are constructed or when the building is renovated. Designers of new labs should refer to the Massachusetts Access Architectural Board (MAAB) guidelines for approach and reach.

Typical Solution: One sink is at the regular height and the eyewash is installed there. One shallow sink is at the lower height required by ADA with nothing underneath it. The sink is equipped with a tight fitting cover so the lab bench can be used until it is needed. Alternatively, install the piping in such a way that the lower sink could be installed easily when needed. Refer to the Plumbing Division for specifications for ADA compliant sink where a pull-down eyewash can be installed.

Each emergency shower or eyewash location “should be identified with a highly visible sign and the area around the equipment should be well lighted”. (ANSI Z358.1). The signs must have contrasting color of green and white and be at least 70 square inches in area (527 CMR 10.02 (2)). (Refer also to the Signage Thematic Folder in the MIT Design Standards).

The wall sign for the equipment shall be visible from most points within the lab or work area.

The area under the shower shall be clearly identified to ensure that the lab users do not block access to the shower. For example, this can be done with a “keep area clear” graphic, contrasting colored flooring or other demarcation on the floor. The marking chosen should be permanent, slip resistant and resistant to wear.

2.7 Fire Protection and Life Safety Features

Exit Corridors

1. Comply with MAAB, ADA and all Massachusetts Building and Fire Code requirements. Do not design fixed obstructions in corridors. Do not plan for storage of equipment in corridors, proper egress cannot be obstructed.

2.8 Flammable / Combustible Liquid and Chemical Storage

Control Areas

1. Control areas are spaces within a building, where quantities of hazardous materials not exceeding exempt amounts are stored, dispensed, used or handled.
2. Whether new construction or renovation, project team must identify and maintain separations and ensure planned storage quantities fit within the control areas for that building/complex and for the floor within the building.
3. Where exempt quantities are not exceeded, control areas shall be used to store flammable and combustible liquids inside buildings. The design, construction, location and number of control areas shall meet the requirements of the Massachusetts State Building Code 780 CMR, and shall not exceed allowable amounts of hazardous materials per control area (as specified in 780 CMR). Maximum quantities may be increased under the following conditions:
 - a. When storage is in a building equipped throughout with automatic sprinklers in accordance with 780 CMR.
 - b. If flammable materials are stored in approved cabinets, gas cabinets, fume hoods or ventilated cabinets.
4. Cambridge Fire Dept. does not allow flammable liquid storage and Class I flammable liquids below the first floor.
5. The number of permitted control areas per floor, the percent of allowable exempt quantities per control area, and the degree of vertical fire separation shall meet the requirements of 780 CMR.
6. Fire separation assemblies shall be in accordance with 780 CMR. Control areas are not permitted more than two levels below grade.
7. Floor and supporting structures for all floors within a control area shall have the required fire rating.
8. Control areas should be clearly delineated within the construction drawings.

Hazardous Chemical Inventory

1. Architects, Engineers and Designers shall obtain a complete hazardous chemical inventory of chemicals that will be stored and used in the renovated space or new building from the applicable MIT User Group through EHS. The inventory is necessary to design the control areas, and to meet Massachusetts State Building Code, Cambridge Fire Department, Cambridge Local Emergency Planning Committee (LEPC) and Division of Homeland Security requirements. This is also needed for the flammable liquids, gases, and solids permits required by the City of Cambridge.
2. Hazardous chemical inventories (an inventory of potentially hazardous chemicals or products) must be completed/updated by the MIT User Group prior to occupying new laboratories/workspaces, auxiliary spaces, and non-lab areas or leaving old or existing spaces.
3. Chemicals meeting the definition of an oil under 40 CFR 112 and stored in containers of 55-gallons or greater must be included in the MIT Spill Prevention, Control, and Countermeasure (SPCC) Plan. Chemical storage meeting this description should be coordinated through EHS to ensure the MIT SPCC Plan can be updated accordingly.

Inside Flammable Liquid Storage Rooms

1. Meet or exceed the following standards:
 - a. NFPA 70, National Electrical Code, 2014.
 - b. NFPA 80, Standard for Fire Doors and Fire Windows.
 - c. Flammable and Combustible Liquids Code, NFPA 30, Current Edition.
2. Location: If desired design criteria quantities of stored flammable and combustible liquids exceed maximum allowed quantities (MAQs) per control area, an inside liquid storage or cut off rooms (a room including one or two outside walls) is required. Inside storage rooms would be considered have to meet all the requirements of H-2 or H-3 occupancy and cannot be constructed in basements.
3. Design: Inside storage rooms shall be constructed to meet the applicable requirements of 780 CMR and the Massachusetts Comprehensive Fire Safety Code and NFPA 30, Flammable and Combustible Liquids Code, 2015. Inside storage area shall not exceed 500 square feet. Cut off rooms exceeding 500 square feet shall have at least one exterior door approved for Fire Department access.
4. Fire Resistance Ratings: Fire resistance ratings for inside storage areas shall meet the minimum requirements of NFPA 30. In mixed use groups fire separation shall meet the separation specified in 780 CMR. Fire doors shall be installed in accordance with NFPA 80, Standard for Fire Doors and Fire Windows.
5. Fire Detection: All inside flammable storage areas shall be provided with fire detection system as per 780 CMR including flame detection.

6. Sprinkler Protection: Inside flammable liquid storage rooms shall be protected by an automatic fire protection system installed in accordance with 780 CMR. Secondary containment for indoor storage areas shall be designed to contain a spill from the largest vessel plus the design flow volume of fire protection water calculated to discharge from the fire-extinguishing system over the minimum required system design area or area of the room or area in which the storage is located, whichever is smaller. The containment capacity shall be designed to contain the flow for a period required by Cambridge Fire Department (20 minutes is a guideline).
7. Electrical: Electrical wiring and equipment located in inside rooms used for Class I liquids shall be suitable for Class I, Division 2 classified locations when concentration in the area is in excess of 25% of the LEL. 527 CMR 12.00, Massachusetts Electrical Code, 2015 and NFPA 70, National Electrical Code, 2014, provide information on the design and installation of electrical equipment.
8. Ventilation: Every inside room shall be provided with continuous mechanical exhaust ventilation system.
 - a. Mechanical ventilation systems shall provide at least one cubic foot per minute of exhaust per square foot of floor area, but not less than 150 CFM (at least 6 air changes per hour).
 - b. The mechanical ventilation system shall be equipped with an airflow switch or other reliable method which is interlocked to sound an audible alarm upon failure of the ventilation system and connected to BMS.
 - c. Exhaust ventilation shall be taken from the ceiling and the floor, depending on the density of the vapor produced.
 - d. The location of both the exhaust and inlet air openings shall be arranged to provide, as far as possible, air movement across all portions of the floor to prevent the accumulation of flammable vapors.
 - e. Exhaust from the room shall be vented directly to the exterior of the building without recirculation.
 - f. All ducts shall comply with Massachusetts Building Code, 780 CMR.
9. Storage: In every flammable storage room, an aisle of at least 3 feet wide shall be maintained. Containers over 30 gallons capable of storing Class I or Class II liquids shall not be stored more than one container high.
10. Spill Control: Flammable liquid storage rooms shall be provided with spill control, secondary containment and drainage control. Please refer to OSHA 29CFR 1910.106(d)(4)(i).
11. Portable Extinguishers: At least one portable fire extinguisher, having a rating not less than 20-B, shall be located outside of but not more than 10 feet from the door opening into the liquid storage room.
12. Leak Detection: All flammable liquid storage rooms where storage, dispensing or pouring occurs shall have a supervised alarm to indicate a leak in the storage room.
13. Vapor Monitoring: Vapor monitoring will satisfy the leak detection requirements including:

- a. Flammable liquid storage rooms, where open use, dispensing or pouring will occur, shall be monitored for Lower Explosive Limit (LEL).
 - b. The LEL alarm system shall activate on alarm points of 20% and 50% of the LEL. These set-points may need to be lower for liquids that are also toxic.
 - c. The monitoring system shall be equipped with an audible and visual alarm indicator.
 - d. The alarm signal shall be transmitted to a constantly attended station. The audible alarm shall exceed background ambient levels by 15 db.
 - e. The visual alarm shall be labeled.
 - f. The alarm sensors shall be located no higher than 12 inches above the floor.
 - g. Signage shall be posted outside the room. The signage shall include appropriate hazard warnings, as well as response instructions (e.g., “Do Not Enter if the alarm has been activated.”) contact information and emergency phone numbers.
 - h. When the flammable liquid dispensing involves use of an automatic pumping system (as opposed to manual), the pump shall shut-down upon LEL alarm activation (or line leakage detection) to stop the flow of liquid.
 - i. The local authority having jurisdiction may require additional safeguards.
 - j. Exception: flammable liquid storage rooms where dispensing or pouring will not be conducted or when pouring/dispensing is done in fume hood in storage room.
14. Explosion Venting: Where Class IB liquids are in open use or being dispensed in excess of maximum allowable quantities, explosion venting shall be provided in accordance with 780 CMR.

Flammable Storage Cabinets

Flammable storage cabinets must meet NFPA 30, Flammable and Combustible Liquids Code and 527 CMR 14.00. These cabinets are used for storage of flammable and combustible liquids, and must have leak proof pans at the base of the cabinet to contain spills. These cabinets can be under fume hood cabinets or free standing. Cabinets must be labeled “Flammable - Keep Fire Away”.

Flammable storage cabinets are not required to be vented for fire protection purposes. Venting a cabinet could compromise the ability of the cabinet to adequately protect its contents from involvement in a fire because cabinets are not generally tested with any venting. Therefore, venting of flammable storage cabinets used exclusively for non-highly toxic or non-highly noxious/odiferous flammable liquids is **not** recommended.

If venting the cabinet is necessary due to storage of highly toxic or highly noxious/odiferous flammable materials, the cabinet shall be vented directly to outdoors in such a manner that will not compromise the specified performance of the cabinet and in a manner that is acceptable to the Fire Department. Means of accomplishing this can include thermally actuated dampers on the vent openings or sufficiently insulating the vent piping system to prevent the internal temperature

of the cabinet from rising. Any make-up air to the cabinet should also be arranged in a similar manner.

The ventilation rate should not be less than 50 air changes per hour based on the volume of the cabinet.

If vented, the cabinet should be vented from the bottom with make-up air supplied to the top. Also, mechanical exhaust ventilation is preferred and should comply with the Massachusetts Building Code, 780 CMR.

References: Flammable and Combustible Liquids Code, NFPA 30; Massachusetts Building Code, 780 CMR

Refrigerators: All refrigerators designated to store flammable liquids must comply with NFPA 45 and be UL listed for the appropriate electrical classification such as Class 1, Group C and D.

Cold Rooms: Flammable and combustible liquids cannot be stored or used in cold rooms unless the electrical and refrigeration equipment is specifically designed as explosion proof and mechanically ventilated with an exhaust rate of 6 air changes per hour.

Grounding System: For dispensing of flammable and combustible liquids of more than one gallon from metal containers, grounding bars, cables and clamps shall be provided.

Acid Storage Cabinets

1. Acid storage cabinets have corrosion resistant liners (powder-coated cabinets and cabinets with corrosion resistant liners) and for under fume hood cabinets are vented into the hood using acid resistant pipes which lead to the interior of the hood. This is typically behind the baffle in a location where good air volume will be drawn into cabinet.
2. Acid storage cabinets are used to store non-flammable materials that are toxic or odiferous. These cabinets can be under fume hood cabinets or free standing, exhausted cabinets. See section Chemical Storage for more information.
3. MIT EHS does not recommend cabinets with metal standards, clips, etc. because the metal will corrode. Molded plastic standards are an acceptable option for this application. The design of cabinet adjustable shelving should allow researchers to properly secure and level shelves. The supporting system should be stable and easy to readjust to another stable setting.

2.9 Fire Extinguishers

Meet or Exceed the Following Standards

1. OSHA 1910.157 Portable Fire Extinguishers, latest version.
2. NFPA 10 Portable Fire Extinguishers, latest version.

3. Massachusetts Comprehensive Fire Safety Code, 527 CMR 1.00, latest version.
4. Massachusetts State Building Code, 780 CMR, most current edition.

Portable fire extinguishers shall be installed as part of a space change renovations and/or new building construction. The type, location and size (capacity) of portable fire extinguishers are based on the specific fire hazard(s) present in the work area.

Massachusetts Comprehensive Fire Safety Code, 527 CMR 1.00, 2015, Paragraph 13.6, Portable Fire Extinguishers, NFPA 10, OSHA 1910.157 outline requirements for the selection and placement of portable fire extinguishers in the work place. Key points include:

1. They must be readily accessible.
2. Extinguishers intended for use on Class A fires (ordinary combustibles) shall be placed so as not to exceed a 75-foot travel distance.
3. Extinguishers intended for use on Class B fires (flammable and combustible liquids) shall be placed so as not to exceed 50-foot travel distance.
4. Extinguishers intended for use on Class C fire (electrical) shall be placed based on the appropriate hazard for Class A or Class B fires.

For most occupancies at MIT, a multi-purpose, dry chemical (ABC) type portable fire extinguisher (50-foot travel distance spacing) will provide adequate protection. The suggested UL rating is 4A:80BC. This is preferred over carbon dioxide and pressurized water extinguishers.

1. Exception 1: certain high hazard laboratory operations may need special protection.
2. Exception 2: multi-purpose dry chemical (ABC) type extinguishes, containing ammonia compounds, are prohibited for use on oxidizers containing chlorine and bromine. Water type extinguishers should be used for these areas.

Portable fire extinguishers for kitchens within offices and commercial kitchens (utilizing grease producing equipment such as fryolators etc.) shall use “Class K” extinguishing agent. The travel distance from the hazard shall be a maximum of 30 feet.

Portable fire extinguishers for areas that have combustible metals shall use “Class D” extinguishing agent. The travel distance from the hazard shall be a maximum of 30 feet.

Portable fire extinguisher locations shall be marked by an indicator sign.

2.10 Hoists and Lifting Equipment

Whenever hoists or related equipment are installed or modified as part of a project, including - hoisting machinery, derricks, cableways, machinery used for discharging cargoes, and temporary elevator cars used on excavation work or used for hoisting building material, lattice cranes, cranes with or without wire rope, overhead hoists (underhung), overhead cranes, underhung cranes, monorail cranes, overhead bridge cranes, electric or air driven hoists, pendant controlled hoists, lifting devices, powered platforms and any other equipment that has the minimum capability of hoisting the load higher than 10 feet and that has the capability of lifting loads greater than 500

pounds must include the following criteria that shall be provided to the crane and hoist owner or DLC Management for their records:

- Stamped drawing of installation by Engineer of record
- Certified load testing results
- Pre-Inspection by 3rd party vendor experienced in the installation, maintenance and repair of cranes and hoists.

2.11 Floor Drains

General

In accordance with Massachusetts Department of Environmental Protection (DEP) regulations, floor drains cannot discharge directly underground or to surface water. Non-approved connections to floor drain systems shall be prohibited. Refer also to the Lab Design Thematic Folder.

Per 360 CMR 10.023, the following items are specifically prohibited from discharge to the MWRA sewer system via the floor drain system:

1. Groundwater, storm water, surface water, roof or surface runoff, tidewater, or subsurface drainage, except construction site dewatering in a combined sewer area when permitted by the authority and municipality.
2. Non-contact cooling water, non-contact industrial process water, uncontaminated contact cooling water, and uncontaminated industrial process water, and cooling tower blow down. (Small volumes of chilled water from small leaks may go to floor drain/sewer.)
3. Fuel oil, crude oil, lubricating oil, or any other oil or grease of hydrocarbon or petroleum origin unless an approved and appropriate gas/oil separator that is in compliance with 360 CMR 10.016 is used.
4. Any liquid, solid, or gas, including, but not limited to, gasoline, kerosene, naphtha, benzene, toluene, xylene, ethers, alcohols, ketones, aldehydes, peroxides and methyl ethyl ketone, which by reason of its nature or quantity or by interaction with other substances, may create a fire or explosion hazard.
5. Any noxious or malodorous liquid, gas, or solid or any other pollutant which either singly or by interaction with any other Waste causes or contributes to the creation of a public nuisance, makes it dangerous for personnel or equipment to enter the Sewer for purposes of maintenance, repair, inspection, sampling, or any other similar activity, or which results in the presence of toxic gases, vapors, or fumes within the sewer system in a quantity that may cause acute worker health and safety problems.

Research Laboratories,

Refer to the MIT Lab Design Thematic Folder: Section 8.3

Food Preparation/Service Areas, Residential Areas, Cafeterias or Commercial Cooking Areas and Vehicle Maintenance Areas

Refer to the Plumbing Division 22 of the MIT Design Standards for the requirements in these areas.

Where the Massachusetts Plumbing Code requires connection of floor drains to grease traps or oil-water separators these devices must meet the requirements outlined in the codes and the Plumbing Division 22.

2.12 Design of Mechanical Rooms/Spaces

. Refer also to Division 23 - HVAC for EHS related HVAC design guidelines.

Interior Mechanical Room Spaces

Chemicals requiring eye washes and safety showers: Many chemicals may be present in the mechanical rooms. Most common are water treatment chemicals for cooling tower, chilled water and hot water systems and chemicals to manufacture RODI water. It is necessary that safe storage handling and disposing methods be employed including eyewash and safety showers where needed.

Proper access to higher equipment: By nature, several equipment installed in the mechanical rooms are high with components requiring maintenance also high. It is necessary that access ladders, platforms and other devices be provided. Without proper maintenance access, maintenance may not be performed. For instance, this access may include chain operation capability on valves located high.

Noise

Equipment inside mechanical rooms by nature is noisy.

Mechanical equipment manufacturers commonly provide sound data in octave band frequencies as either sound power level (PWL) or sound pressure level (SPL) at a given distance. Usually, the critical octave band frequency selected for mechanical equipment is 250 Hz.

At this frequency at which:

- Equipment sound levels are high,
- To attenuate noise is difficult
- Human hearing perception is good.

Multiple equipment running together add to the noise level. Where multiple pieces of equipment are used, the PWLs must be added logarithmically. Hearing protection may be required

Safety guards: The mechanical room layout should ensure that all guards on moving parts are not obstructed.

Electrical Layout: The National Electric Code (NFPA 70) and Mass electric code in general prohibit installation of incoming electric service or emergency generators in mechanical rooms. They are installed in separate 2 hour rated rooms.

Exterior Mechanical Room Spaces

Noise: Loud noise outside mechanical rooms due to mechanical equipment may even be more objectionable.

Vibration: Excessive vibration outside mechanical room can similarly be deleterious to teaching, research or other work. It is critical that vibration isolation be provided on any moving equipment.

3. FUEL STORAGE TANKS

3.1 Aboveground and Underground Storage Tanks

Meet or Exceed the Following Standards

1. 40 CFR 112 Spill Prevention, Control and Countermeasure Regulation.
2. 310 CMR 80 Underground Storage Tanks
3. 310 CMR 80.00 Underground Storage Tank Regulations.
4. MIT Spill Prevention, Control and Countermeasure (SPCC) Plan.
5. Flammable and Combustible Liquids Code, NFPA 30, Current Edition.

Storage Tanks; above-ground (AST) and under-ground (UST):

1. MIT periodically installs storage tanks for the storage of flammable or combustible materials. In most cases these are fuel oil tanks used in conjunction with diesel driven emergency generators or fire pumps, but could also include tanks installed for storage of other types of flammable or combustible liquids including but not limited to electrical insulating oils, lubricating fluids etc.
2. The regulations covering the installation, use, permitting and licensing of storage tanks are from a variety of agencies including federal, state and local. For instance, there are local permitting requirements for specific tank installations, licensing requirements for the quantity of flammable materials stored on the particular property and MassDEP tank registration requirements (UST's only.) In most cases, tanks installed as part of construction and renovation projects only require approval from the local authorities. To gain approval, an application for installation and an application for fuel use and storage must be submitted to the Cambridge Fire Department. Once the applications have been approved, corresponding permits are issued to the installer or MIT. Copies of all permits shall be submitted to the EHS Office.
3. Tanks used for storing oils in containers of 55-gallons or greater are also subject to the Federal requirements for spill control and countermeasure planning (SPCC.) The design

should include spill protection features including double-walled construction, above ground dikes, berms or other means to prevent the spread of material in the event of a spill. For underground tanks, the use double walled components and continuous monitoring to protect from (and detect) subsurface releases caused by a failure (e.g. piping leak) are required. Interstitial space leak detection is also required. Lastly, underground storage tanks are subject to periodic tightness testing, while above ground tanks are subject to regular visual inspections per the requirements of the MIT SPCC Plan.

4. The EHS Office assists Project Managers with permitting and licensing, maintains copies of material storage permits and coordinates the annual renewal process with the Cambridge Fire Department. This includes inspections and payment of applicable renewal fees.
5. Above ground storage tanks located inside buildings must be protected in rooms with 3-hour fire rated walls, floor and ceiling and foam suppression systems.

4. DECONTAMINATION AND DECOMMISSIONING

4.1 Laboratory decommissioning and decontamination considerations

Laboratory Staff responsibilities:

Lab staff must leave the laboratory in a clean and safe condition for construction crews. Prior to vacating the laboratory; laboratory staff must remove all chemical, biological, and radiological materials and they must decontaminate all work surfaces and equipment. This can be done by the laboratory personnel or a hired environmental contractor (at the expense of the lab or Dept.). They must also arrange for removal of all equipment (unless arrangements have been made otherwise) and any garbage or other items that will not be wanted by the new occupants, or items that need to be out of the way of renovation activities.

EHS Project Liaison / EHS Office responsibilities:

EHS works directly with the lab vacating a space to ensure the associated hazards are removed or identified. Depending on the scope of work, EHS assesses the following locations within a lab for hazards and documents the findings for the incoming renovation project team. EHS provides the project manager a summary report documenting the work completed either by the lab or environmental vendor, along with the remaining hazards in the lab, should they exist. EHS also posts the Notice of Laboratory Decontamination form on the doors of the associated spaces.

Hazards Assessed by EHS:

- Mercury in sink traps
- Perchlorates in fume hood duct work
- Asbestos containing material (ACM) in floor tiles, ceiling tiles, benches and fume hoods

Project Manager responsibilities:

Must verify that the laboratory is clean and decontaminated prior to demolition or construction of a lab to help prevent unexpected delays or unsafe working conditions. It is strongly encouraged that the project manager or representative visit with the laboratory safety representative, department EHS coordinator or a member of the central EHS office, to verify that the laboratory is clean before construction begins.

4.2 PCB's in Building Equipment and Materials

Polychlorinated biphenyls, or PCBs, refer to a class of compounds that were used in a variety of industrial applications, including as dielectric fluid in transformers and capacitors. PCBs were added to caulking and sealants to improve their plasticity. In 1976, the United States Environmental Protection Agency (US EPA) banned the manufacture and continued use of PCBs in concentrations above 50 parts per million (ppm). The most common sources of PCBs impacting building renovations and demolition are in electrical equipment, namely transformers and capacitors, building materials such as caulking and sealants, and hydraulic oils pre-dating 1976. The EHS Office is responsible for ensuring that MIT complies with proper PCB management practices as identified under the Toxic Substances Control Act (TSCA), 40 CFR 761.

The Massachusetts Department of Environmental Protection deems waste containing PCBs in concentrations of 50 ppm or more to be hazardous. Removal of PCB containing wastes from projects is to be coordinated through the Environmental Management Program within the EHS Office and must be removed by a licensed contractor.

At the project outset, building age and repair/renovation history shall be used as a guide for determining whether sampling is required. Buildings constructed after 1980 are not expected to require sampling. Buildings constructed or renovated between 1950 and 1980 require sampling if engineering data is not available to rule out the presence of PCBs.

Relative to sampling for PCBs, MIT's PCB management program distinguishes between individual window repairs or small scale renovation projects (1-2 rooms) versus building demolition or large scale renovation.

Repairs/Small Scale Renovations

If the building was built and/or renovated between 1950 and 1980, any caulking removed shall be presumed to potentially contain PCBs and the waste handled accordingly. *If the building was constructed after 1980, it can be assumed that PCBs are not present.* If the building was built before 1950, PCBs are likely not present.

Large Scale Renovation

If the building was built and/or renovated between 1950 and 1980, and engineering data is not available to rule out the presence of PCBs, then caulking and sealants must be sampled. If

sampling reveals PCB concentrations in excess of 50 ppm, then additional sampling of masonry may also be required. The EHS Office provides direction to the Project Manager and the contractor on sampling protocol, including analytical method. In the event a remediation plan is required, the Project Manager shall work with the EHS Office and a technically qualified Contractor to develop and execute the plan.

Electrical Equipment Removal

Transformers and capacitors pre-dating 1980 must be evaluated for date of manufacture and presence of oil. Oil containing equipment must be tested prior to removal from MIT campus.

5. INTEGRATED PEST MANAGEMENT

5.1 Integrated Pest Management (IPM) Design Guidelines

Integrated Pest Management (IPM) is an effective and environmentally responsible approach to pest management that uses a variety of methods to control pests by modifying conditions which may attract and support habitats for pests. Integrating IPM considerations in design will eliminate or reduce pest infestation and has the goal of minimizing if not totally eliminating the use of pesticides at MIT.

In as much as feasible, implement the following pest management recommendations in the new construction projects, renovation projects and demolition projects. Emphasis should be placed on the grade floor(s), all building entrances and exits, building connections, and additional support structures as piping and ventilation. Design considerations include:

1. Landscaping and Grounds

a. Playgrounds

- Exterior fencing around playgrounds and park like settings should have a smooth vertical surface to prevent pests from climbing, and a top that prevents rodents from getting over the top of fence, for example a T-cap.
- Exterior fencing should have 24 inch metal extension below grade and have holes no greater than 1/4 inch in any dimension to prevent rodent burrowing.
- Below grade metal fence extensions, preferably constructed from stainless steel or other resilient material, shall be contiguous and where possible bank outward away from the protected area.
- Hollow posts shall be tightly capped.

b. General Spaces

- Gates and joints present a vulnerable point as they can provide an access

point. The contact points between fencing and buildings, and contact points between fencing and trees also present potential entryways for rodents and a design solution must be implemented as part of fence installation.

- Tree wells and raised beds should be bordered and continuously lined with 1/4-inch sturdy stainless steel mesh to prevent harborage and nesting areas.
- If stone is used it should be 3/4-inch minimum rounded stone to the depth of at least 4 inches on top of landscape fabric to discourage rodents from burrowing.
- All vegetation/plantings should be assessed to avoid attractive food sources for rodents and other pests. Limit the use of dense ground cover as it provides excellent camouflage for rodents. Use of dense ground cover must be coordinated with a landscaping system that will prevent burrows.
- Exterior plantings should be kept a minimum of 2 to 4 feet off the exterior of the building. The goal is that vegetation not touch buildings. Mulch should not be used up against buildings.
- Water retention areas should have metal mesh with openings 1/8-inch or smaller.

2. Building Exteriors

- a. All access points into a building (exterior doors, mechanical doors, garages, loading docks, windows) should be assessed from an Integrated Pest Management (IPM) perspective.
- b. Exterior doors must make use of door sweeps and self-closers. The door sweeps should be constituted of a rodent proof material, and the placement of door sweeps and self-closers should ensure gaps are less than 1/8 of an inch in length or height. Further, door sweeps and self-closers should be easily maintained or replaced.
- c. The exterior building envelope should be tight with no gaps larger than 1/8 inch to prevent pest access (for example bees, mice, rats).
- d. Exterior ledges, particularly over entrances, should be eliminated. Smooth, sloped (45 degree angle) surfaces work best. The goal is to prevent birds from resting or nesting. Additional anti-bird/pigeon measures include netting.
- e. Sidewalks, parking lots, and ground level surfaces surrounding buildings should slope and drain during inclement weather to prevent puddle formation.
- f. Exterior lighting choices should not attract pests such as moths, June bugs, or night flies.

3. Building Interiors

- a. Provide tightly sealed access panels to all “dead spaces” such as pipe chases and ceilings other than drop ceilings.
- b. Perforations and other spaces through which pipes and cables are laid throughout the facility shall be properly sealed and fire stopped. Typically fire stopping will provide a barrier that will prevent pest/rodent travel but individual systems should be reviewed to these criteria before use.
- c. Overhead rolling doors shall be flush and tight with no gaps larger than 1/8 inch and preferred to be motion detection enabled, automatically closing when no activity is present.
- d. Provide door sweeps on all interior mechanical spaces, food service, loading docks and “back of the house” doors.
- e. Custodial closets and storage spaces should have finished floors and door sweeps. Sinks in closets must be properly caulked and sealed to the floor and wall. Drain cover should not allow large particles into drain. See more details in the MIT Design Standards – Plumbing Division 22.
- f. Provide sealed hatches or coverings for sewage ejector pits.
- g. If raised floors with utilities below are used, means of pest control and regular inspection must be considered and addressed in the design.
- h. Floor mounted heating and cooling vents shall be screened to a less than 1/8 inch diameter opening, and have the ability to be regularly cleaned and maintained.

4. Kitchens

- a. Food service counters, benches, cabinets, etc. should be flush with floors and walls to prevent nesting opportunities underneath and behind.
- b. Flooring materials for commercial kitchens shall be commercial kitchen grade such as quarry tile or epoxy and resistant to hot water and grease. Kitchens in office areas are typically resilient tile.
- c. Baseboard moldings shall include coved corners, be at least 4 inches high and allow for water containment, cleaning and protection of walls. All breaches, holes and penetrations in flooring must be sealed.
- d. Cabinets in kitchens and cabinets designed for food storage must seal tightly, with full back panels and kick plates. Once installed, any holes in cabinets for utilities or factory provided accessories must be tightly and properly sealed.
- e. Bulk food storage rooms shall have rodent proof features incorporated. The walls should extend to the slab above, have door sweeps, cleanable surfaces and be sized to eliminate storage in corridors. All breaches and pathways into space must be sealed and fire stopped. Avoid dropped ceilings.
- f. Provide access and easily cleaned surfaces below belted areas and spaces where food may be dropped.
- g. Kitchen designs shall include fixtures, and appropriate space to allow for the

initial collection, consolidation, storage and disposal of compostable materials and food wastes generated in kitchens.

- h. Plumbing associated with grease traps and other fixtures that require access shall allow regular cleanouts and maintenance. The mechanical rooms or spaces within kitchens where this equipment is located should have cleanable surfaces.

5. Waste Management

- a. Waste compactors shall be self-contained, water tight, and sealed between the ram and the container.
- b. Animal bedding waste containers (dumpsters/compactors), must be sealed between the ram and container.
- c. Compactor doors shall be self-closing and latching.
- d. Surfaces where compactors are placed shall be level, well drained, sealed or painted, concrete or asphalt surface.
- e. Design dumpster locations, water sources, and floor drains for proper housekeeping practices. Alternative dumpster locations and types need to be considered if the building site interferes with trash and recycling removal from surrounding buildings.
- f. Exterior trash and recycling receptacles should be covered and rodent proof. Big Belly solar compactors or equivalent are the standard for any new exterior receptacles.
- g. Buildings shall have easy access to a trash/recycling wash room. These wash rooms shall have water resistant walls and flooring, sanitary floor drains, a warm water source and be sized for cleaning collection receptacles.
- h. Consider power and mounting capabilities for fly lights in waste areas.
- i. Where commercial kitchens are present, the waste area for facility must allow for consolidation, storage and disposal of compostable food wastes from kitchens.

5.2 Integrated Pest Management (IPM) During Demolition and Construction

The MIT construction Project Manager or selected contractor shall contract with MIT's pest control provider for any pest control services provided to projects to better coordinate integrated pest management efforts Institute-wide.

For large renovations and all capital projects, pest control inspections of the job site should occur on an established basis (i.e. weekly) with a written report generated by pest control vendor including any identified corrective actions needed. MIT project managers shall monitor corrective action completion and follow-up with contractors as needed. If pest problems persist, the PM will call meetings of pest control vendor and contractors as necessary. For minor and small projects pest control issues should be managed on an as needed basis.

Occupants of neighboring buildings or areas should be notified prior to work starting of potential impact of increased pest activity due to demolition/construction activities. Communication shall remind occupants how to report pest problems. Design considerations include:

1. Demolition Sites

- a. Demolition debris should be removed from the site as quickly as feasible or possible.
- b. Piles of demolition debris left for any period of time may become infested and create increased pest activity in the surrounding buildings in the area.

2. Construction Sites

- a. Appropriate rodent control actions must be taken along the perimeter and surrounding areas of construction sites.
- b. Construction dumpsters shall not be used for food waste disposal and must be emptied on a regular basis.
- c. The dumpster location shall be kept clean to prevent harborage and food sources.
- d. A City of Cambridge Ordinance that requires all dumpsters, including construction dumpsters be licensed and maintained.
- e. Pest proof, covered exterior and site trash receptacles are required where needed for use by construction personnel and catering trucks.
- f. Pest sightings or evidence of pest activity should be immediately reported to the MIT Project Manager and pest control vendor for immediate action.
- g. Access points on the perimeter of project areas to neighboring spaces should be sealed and door sweeps installed wherever possible.
- h. Doors leading to and from renovation areas must be kept closed at all times, particularly exterior doors. This includes before or after deliveries of materials to the job site.
- i. Construction dumpsters shall be emptied on a regular basis and the dumpster location kept clean to prevent harborage and food sources.
- j. Construction waste dumpsters must not be used for the disposal of food or food packaging related wastes.
- k. Staging areas are required to be clean at all times to prevent harborage and food sources.
- l. Work sites should remain “broom clean” and all waste generated removed daily, particularly food waste generated from coffee or lunch breaks, to prevent harborage and food sources.
- m. A pest control survey should occur prior to the interior of the building being “buttoned up.” This survey shall identify breeches, gaps, and other areas that need to be sealed, fire stopped or have debris removed.

- n. Periodic (as needed) pest control meetings should be held between project managers, construction managers, and representatives of EHS and MIT's pest control provider to discuss issues in remediation from the beginning to acceptance of the project.
- o. Prior to project areas being turned over to MIT, the project should be inspected by MIT's outside pest control services vendor to be certified as being "pest free".
- p. Punch lists and walkthrough inspections, shall pay particular attention to breaches and penetrations.

6. CONSTRUCTION MITIGATION

6.1 Construction Mitigation Plans

Mitigation concerns for the MIT Community and abutters include: vibrations, noise, dust, odors, debris, vehicle and pedestrian traffic, fire exiting during construction, and crane operations.

Submit construction mitigation plans for MIT EHS review.

7. WASTE HANDLING

7.1 General Waste Handling

Meet or Exceed the Following Standards

1. 310 CMR 19.017 Waste Disposal Ban.
2. 310 CMR 30.00 Hazardous Waste Regulations.
3. Mass DEP Waste and Recycling guide.
4. City of Cambridge Dumpster permit requirements.

Waste is generated through all phases of a project and a building's life span including demolition, construction, and operations. The project management team should work with the EHS Office to ensure demolition debris from laboratories is assessed and managed properly.

In addition, the project design team should ensure that waste storage alcoves or stations are designed into new buildings and renovations to allow occupants the ability to manage their various waste streams properly.

7.2 Hazardous Materials Waste Management

Existing buildings slated for demolition or renovation should be assessed by EHS prior to the project's demolition phase to ensure potential hazards are identified and/or removed. All

radioactive, biological and chemical materials and wastes must be removed from a space before work can begin by the project, as indicated in these guidelines.

Common hazardous materials include, but are not limited to:

1. Polychlorinated Biphenyls (PCBs) in window caulking.
2. Asbestos in façade and building materials.
3. Lead in paint.
4. Mercury in sink traps, chip tanks, plumbing fixtures, piping.
5. Perchlorates in fume hood exhaust systems.
6. Universal Waste Items; light bulbs, rechargeable batteries, ballasts, etc.
7. Potentially contaminated soils.

7.3 Construction and Demolition Waste Management

Many of the waste streams generated during building demolition and construction projects are recyclable. Construction and Demolition (C&D) Wastes have been identified as a major target for reuse and recycling because this material typically represents a large volume of material.

The Commonwealth of Massachusetts has banned the landfill disposal of C&D debris. This means that asphalt pavement, brick and concrete (ABC) rubble, as well as other waste materials (see list below) must be handled in accordance with Massachusetts Solid Waste Regulations.

Contractors are required to obtain a dumpster permit through the City of Cambridge. In addition, the contractor should review the location of the proposed dumpster with the Recycling and Materials Management Office prior to the delivery of the dumpster.

MIT requires that, at a minimum, the following materials be recycled:

1. Clean dimensional wood.
2. Uncoated asphalt, bricks, and concrete (ABC).
3. Metals including stud trim, ductwork, piping, reinforcing steel (rebar), roofing, steel, iron, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze.
4. Any other materials for which reuse, salvaging, or recycling results in a net cost that is equivalent to or less costly than landfill disposal or incineration.

In addition, contractors shall be aware that the Commonwealth of Massachusetts has banned the following waste streams from incineration or landfill disposal. These MIT waste materials may not be included in shipments destined for incineration or landfills. These include:

1. Lead-acid and lithium type batteries.
2. White Goods (Appliances).

3. Cathode Ray Tubes (CRTs) including computer monitors.
4. Leaves and Yard Waste.
5. Whole Tires.
6. Metal, Plastic and Glass Containers.
7. Paper and Cardboard.

General Contractors hired for new building construction, renovations or demolition projects should submit a Waste Management Plan to the MIT Project Manager. The Plan should include the following:

1. A written breakdown of the waste materials expected to be generated by type and approximate quantity.
2. The name of all landfill(s) and/or incinerator(s) proposed for trash disposal, the respective tipping fee(s) for each of these disposal options including transportation costs, and the projected cost of disposing all project waste in the landfill(s).
3. A list of each material proposed to be salvaged, reused, or recycled during the course of the project, the proposed end use or local market for each material, and the estimated net cost savings or increase resulting from recycling (versus land filling) each material, taking into account revenue from the sale of recycled or salvaged materials and tipping fees saved due to diversion of materials.

The Waste Management Plan shall include provisions for periodic reporting to MIT, including types and quantities of waste materials hauled off-site. In this way, the MIT Project Team can demonstrate the waste management and recycling efforts through-out the course of the project as opposed to attempting to collect, analyze, and report the data at the end of the project.

7.4 Waste Management Features in Building Design

For new building construction and full building renovations, consideration should be given to the staging areas within the building and at the loading dock level for general waste management, which includes recycling. MIT Recycling and Materials Management Office, Custodial Services, and the EHS Office should be contacted for review of these locations. Locations at each floor level should be provided for occupants or service staff to bring the following materials:

1. Broken down cardboard
2. Larger volumes of recyclables (glass, plastics 1-7, aluminum, paper)
3. Styrofoam materials
4. Rechargeable batteries and small CFL bulbs
5. Toner cartridges and small electronics
6. Plastic film and wrap

If floor level kitchenettes are available, organic food waste collection should be provided near the trash and recycling bins. Signage should accompany containers for all streams generated.

If a café or food venue is in the space, proper container placement and signage should be included for recycling, organic food waste, and trash.

At the loading dock level, ample space should be provided for collection and removal of bulk streams mentioned above.

8. VALUE ENGINEERING

8.1 Standards

The EHS Office is available to comment during VE initiatives. Value Engineering Change Proposals (VECP) should be reviewed by EHS in those situations where the VE analysis results in a direct (or indirect) effect on safety. The role of the EHS Office is to conduct a hazard and risk assessment to assist the project team with decision-making and if necessary, identify possible alternatives to the VECP.

For additional information, contact the MIT EHS Office.

9. FURNITURE

9.1 Flammability

When purchasing new furniture for renovation or new building, comply with current regulations for flammability.

Note: In most cases the Massachusetts Fire Code allows furnishings in public spaces within sprinklered buildings to have seating that meets California standard TB 117-2013.

10. WORKSTATION DESIGN PRINCIPLES

10.1 General

Computer workstation ergonomic design principles need to be considered to give the user the best overall positioning and the adjustability required to improve worker comfort and productivity while preventing workplace injuries including musculoskeletal disorders and repetitive strain injuries.

The purpose is to adapt the workplace to the worker, dependent on the job description, required tasks, duration and physical make-up of the employee performing those tasks.

One of the best ways to prevent and control injuries and illnesses is to "design out" or minimize risks early in the design process and to build in/plan for adjustability. Workstations may be used by multiple persons of a wide variation of sizes, either by being shared or over time. Newer work styles which require sit/stand positioning as well as use of voice transcription should be accommodated. By addressing safety and health needs in the design process, the goal, to prevent or minimize work-related hazards and risks associated with workstations can be achieved.

Many ergonomic factors are involved in the design of a computer workstation such as:

1. Chair design/adjustability.
2. Keyboard placement/adjustability/articulating keyboard tray.
3. Workspace adjustability.
4. Work environment/heating and cooling.
5. Adjustable work surface/desk.
6. Ambient office and task lighting.
7. Sit to stand stations.
8. Ease of adjustability.
9. Adequate space.
10. Location of other components/telephone/headsets.
11. ADA accommodations.
12. Type/location of input devices.
13. Anti-glare screens.
14. Foot rests.
15. Monitor adjustability and monitor arms.

All of the above issues when properly addressed in the design process may reduce or eliminate musculoskeletal disorders associated with poor ergonomic design or equipment. It is important that designers meet with those that will be using or have knowledge of the work to understand the job function in order to apply appropriate design principles. All workstations should be adjustable, for areas with many users, adjustability is an even more important consideration and these workstations should be suitable for users of many sizes.

For more information or guidance please contact the Environment, Health and Safety Office environment@mit.edu for assistance with office ergonomic design issues.

Or visit:

EHS ergonomic web page <https://ehs.mit.edu/site/content/ergonomics>

MIT Assistive Technology Information Center (ATIC Lab) <http://ux.mit.edu/atic>

OSHA ergonomic web site <http://www.osha.gov/SLTC/etools/computerworkstations/>

11. AIR EMISSION SOURCE PERMITTING

11.1 Standards

Meet or Exceed the Following Standards

1. MIT Title V Operating Permit.
2. 40 CFR 50 – National Primary and Secondary Ambient Air Quality Standards.
3. 40 CFR 60 -- Standards of Performance for New Stationary Sources.
4. 40 CFR 63 -- National Emission Standards for Hazardous Air Pollutants for Source Categories.
5. 40 CFR 70 -- State Operating Permit Programs.
6. 310 CMR 7.00 - Air Pollution Control.

11.2 Equipment

MIT periodically installs combustion equipment in the buildings such as emergency generators, boilers, hot water heaters, etc. A process or piece of equipment (emission source) at MIT has the potential to be included in the campus-wide Title V Operating Permit if it uses and/or emits any of the following substances above threshold levels. Notify EHS if these are being considered.:

1. Volatile Organic Compounds (VOCs);
2. Carbon monoxide (CO);
3. Nitrogen oxides (NO_x);
4. Sulfur dioxide (SO₂);
5. Lead;
6. Particulate matter with diameter of 10 micrometers or smaller (PM₁₀);
7. Ozone Depleting Substance (ODS); and
8. Hazardous Air Pollutants (HAPs).

Examples of equipment to consider:

1. Boilers.
2. Emergency generators.
3. HVAC.
4. Space heaters.
5. Water heaters.
6. Chillers / cooling towers.

7. Parts cleaners / degreasers.
8. Painting / coating operations.
9. Furnaces.
10. Soldering operations.
11. Printing operations.
12. Welding operations.

11.3 Requirements and Permitting

Massachusetts Department of Environmental Protection (Mass DEP) and US EPA regulate the installation, use, and permitting of all combustion sources. Particular care is required when locating these emission sources so as to avoid causing a localized health or nuisance problem from emissions or sound impacts.

If emission unit has an outside stack, that stack shall be configured to discharge the combustion gases vertically and cannot be equipped with any part or device that restricts the vertical exhaust flow of the emitted combustion gases, including rain protection devices “shanty caps” and “egg beaters”. Depending on the size (power output or heat input rating) of the emission unit, either minimum stack heights and/or emission control equipment may be required. Any emission impacts of exhaust stacks must be minimized by employing good engineering practices. Such practices might include:

1. Avoiding locations that may be subject to downwash of the exhaust;
2. Installing pollution control equipment to minimize impacts on sensitive receptors (people, windows, doors, fresh air intakes, etc.); and
3. Installing stacks of sufficient height in locations that will prevent and minimize episodes of air pollution. See Specification Division 26 – Electrical, Section 3.5 for specific stack requirements for emergency generators.

Emission unit should be located so as to avoid the creation of a noise nuisance, as defined in the City of Cambridge Noise Ordinance or 310 CMR 7.10 MassDEP noise requirements. Units located outside should be housed in enclosures specifically designed to attenuate sound.

EHS must be notified prior to the installation or emission sources, including those that are exempt from permitting requirements as they may still require initial notification and, are required to be registered with Mass DEP in the next required Source Registration (the annual air emissions report).

Permits are required for many activities that result in air pollutant emissions. Air permits identify what pollutants are emitted, how much can be released according to standards, and what controls are implemented to reduce emissions, including plans to monitor the pollution at the site.

A compliance certification to Mass DEP is required if you install one of the following:

1. Emergency generator, fire pump or other similar engine rated at 37 kilowatts and up, or
2. Non-emergency engine rated at 50 kilowatts and up.
3. Boilers with heat input ratings of ten (10) to 40 million British thermal units (Btu) per hour.

All engines must comply with EPA emission standards and have a stack that exhausts vertically. EHS will submit the certification for these units.

12. CONTAMINATED SOILS AND GROUNDWATER

12.1 Standards

Meet or Exceed the Following Standards

1. Massachusetts Contingency Plan 310 CMR 40.0000
2. MCP Reportable Concentration in Soil and Groundwater
3. Note: Construction sites projects greater than 1 acre performing dewatering or disturbing greater than 1 acre must have a storm water or dewatering management program and NPDES permit in place if the discharge will potentially reach a storm drain or water body. These permits are issued by the City of Cambridge and U.S. Environmental Protection Agency.

12.2 Introduction

A significant portion of the MIT Cambridge campus is located on soil known as urban fill. This material often contains materials from burning of fires and wastes from the early industrial revolution which includes significant amounts of coal ash. These soils and possibly, groundwater, may also be contaminated by years of vehicle emissions from leaded gasoline internal combustion engines, and in some cases from factories or service stations formerly located in the area. As a result, excavated soil may contain metals such as lead or arsenic, hydrocarbon compounds considered hazardous materials and organic contaminants.

12.3 Applications, Requirements, and Selection

Work involving excavation of soil is typically performed according to the Massachusetts Contingency Plan (MCP), a program of the Massachusetts Department of Environmental Protection (MA DEP) that is designed to identify and clean up contaminated properties. The MCP requires owners, such as MIT, who cause or become aware of contamination on their property to clean it up or otherwise control the hazards so there is no significant risk to the public. As part of this work fill is excavated, transported to MIT EHS approved off-site disposal sites and replaced with clean, non-contaminated fill per the MIT imported fill specification. In addition, abandoned fuel underground storage tanks have been frequently found during excavation projects and have required remediation. The regulation also requires that a Licensed Site Professional (LSP) be

employed for managing the MCP process at a site, with EHS signing off on all required MCP approvals.

Projects with excavation or underground utility work that disturb soils should consult with EHS during project planning to determine scope of soils work and applicability of soils and groundwater contamination regulations. For utility work located on City of Cambridge property for MIT projects, contact EHS early in the project to discuss the stringent City soils pre-characterization requirements.

During excavation should any unusual odors or discolored soil conditions be found, stop the excavation and contact EHS as soon as possible to determine whether the site has potential contamination. This type of contamination may require the contractor to report to MIT a condition where MA DEP must be notified within 2 hours by MIT EHS.

Project Managers should review the MIT GIS system to ascertain whether the project site is listed as having an Activity Use Limitation (AUL) from a past project and require certain procedures for future work as required by the MCP. Contact EHS when working on an MIT site that is a listed AUL.

12.4 Testing and Permitting

On excavation projects, analytical testing of soils is required for MCP site classification and off-site disposal. An LSP is required to supervise this work and make any required notifications to MA DEP, on behalf of MIT.

13. MAKER SPACES AND MACHINE SHOPS

13.1 Introduction

Maker spaces/Shops, and other locations where material fabrication and assembly work occur are important resources at MIT. Whether curricular or non-curricular, for students and faculty or employee use only, these spaces provide the equipment and instrumentation through which our educational, research, and infrastructure maintenance goals are met.

The purpose of this section is to outline design guidance from an EHS perspective regarding location, attributes, layout, and other features of maker space/shops on campus.

13.2 Shop Parameters

Size

1. Sized to accommodate the intended equipment and operations, plus routine storage needs for fixtures, stock parts etc. Consider any needs for proximity to ancillary functions such as formal teaching spaces or classrooms, laboratories, dedicated computing spaces, photographic / imaging studios, etc.
2. Floor-to-ceiling heights should also be evaluated to accommodate tall equipment and any needed overhead mechanical or electrical services
3. Space should be allocated to lockers and / or shelving for personal possessions, clothes, and other items. For professional (employee-only) shops, lockers and access to changing areas and showers may also be required by contract language

Accessibility

Consider material in- and outflows along with loading dock access. Consider the size of the largest tools and materials to be used or assembled. May require large / expandable door systems, and freight elevator access. Where such features are needed but unavailable, identify alternate method(s) for managing material and equipment transport and movement. For new maker space/shops or substantial renovations of existing maker space/shops, the project should include the procurement of any necessary lifts, powered industrial trucks, or other special means of material transport or handling.

Structural Integrity and Capacity

1. Ensure structural integrity and capacity, verify floor load rating.
2. For maker space/shops in multi-story buildings, heavy or highly sensitive equipment may require additional floor strengthening / stiffening and / or placement in lower floors and / or along supported walls to minimize floor deflection, vibration, or tool “bounce”

Utility Hook-ups

Ensure space has or can readily accommodate necessary mechanical service requirements. These include but are not limited to basic 120/220 V electrical power, 3-phase electrical power, water, wastewater discharge, ventilation systems, data / internet connectivity, compressed air, and hydraulics. Hard wired tools should include electrical disconnects to facilitate lockout/tagout.

Neighbors

Consider and actively work to mitigate potential impacts from shop operations on all adjacent neighbors, whether MIT or non-MIT. Potential impacts include noise, vibration, dust, chemicals, spills, off-hours deliveries and material transport, and pedestrian and vehicular traffic.

Access Control

Limit shop and tool access to authorized individuals

1. Maker space/shops must be lockable to secure and restrict access to authorized individuals only. This can be accomplished by the use of traditional keyed door locks, digital security punch codes, or standard MIT ID card door access control. Whichever system is used, it must be MIT-approved and consistent with applicable Emergency Management and Business Continuity Office and MIT Police requirements to ensure emergency responder access. It is further recommended that highest hazard class (Class 3) student maker space/shops allow for the use of standard MIT ID card access control for user tracking and accountability purposes, at the discretion of the shop manager.
2. Where Class 3 power tools must be located within a larger shared or otherwise uncontrolled open access area, they must be protected from unauthorized use by a main power disconnect, disabling of the individual tool(s), or installation of a lockable partition, cage or room divider

Shop Entryways

1. Shop entryway areas shall provide visual accessibility into the shop, using clear glass door view panels, sidelights, windows, or window walls. All clear openings must be of impact-resistant construction and meet applicable fire rating
2. Main shop entryways must be furnished with standard MIT room door safety identification sign holders and any additional hazard warning signage applicable to the materials or operations inside the shop

Separate Shop from Non-Shop Areas

If a separate room is not possible, establish and demarcate clear separation(s) between the shop proper and any break, eating locations, meeting, classroom, desk, or other non-tool areas. Depending upon the nature of the shop, this demarcation may be a painted line or other symbol on the floor, area signage, chains, bollards, cones, gates, or doors.

Offices

Any interior office(s) for shop manager(s) or instructor(s) should be sited in a central or otherwise readily accessible location, with high visibility onto the shop floor through unobstructed doorways, windows, window walls, or other design elements.

General Layout and Configuration Considerations

Design Goal: Design and layout maker space/shops to optimize space utilization and storage, enhance the learning experience, promote safety, and ensure accessibility for future service and maintenance.

Tools and Tool Layout

1. Provide adequate space and clearance around all tools for safe access during use, service and maintenance, and nearby pedestrian traffic and material flows
2. In student shops, additional clearance space should be provided for safe clustered group teaching, targeted observations, and instructor-led demonstrations
3. Consider any anticipated long stock materials or oversized finished projects
4. Provide storage for tooling, jigs, gages, fixtures, dies, and other items in close and ready proximity to the machine(s) they support
5. For specific tool layout requirements, consult the manufacturer's guidance (if available). Visit other maker space/shops with similar tools to interview managers and instructors about layout advantages and disadvantages. Maker space/shops used for training and teaching purposes will generally require more open space around tools than other maker space/shops
6. Tools with the potential to produce hazardous "flying objects" (i.e., loose chuck keys or tooling, handles or wrenches, improperly secured parts) should be oriented to minimize injuries to others nearby. For example, metalworking lathes should always be oriented parallel but skewed to each other to prevent flying objects from hitting operators on adjacent machines in a row

Fire and Life Safety

Existing and proposed new maker space/shops must meet basic fire and life safety rules, including appropriate number and sizing of emergency egress pathways, fire-rated separations between shop and surrounding non-shop spaces, maximum occupancy and assembly limits, and applicable building designations.

Egress

All egress routes and exit doors must be posted and their routes kept clear.

Smoke / Fire Detection, Alerting, and Suppression

1. Specific fire alarm considerations may include hard-wired, battery back-up smoke / heat rise detection systems with local audible alarm(s). In spaces anticipated to generate significant amounts of dust, humidity, or mists, consider avoiding photoelectric style smoke detectors and instead rely upon heat rise detection
2. All occupied spaces must be protected by MIT standard fire sprinkler systems. Within the maker space/shop consider installing protective caging on all sprinkler heads
3. Provide one or more prominently located and labeled portable fire extinguishers (reference MIT standard here), typically as a 10-pound Class ABC dry chemical extinguisher. Where laser, electronic, optical, or other sensitive equipment could be damaged by dry powder, carbon dioxide extinguishers, or other approved gaseous agents may generally be substituted. If combustible metals are present, provide Class D

extinguisher or extinguishing agent such as dry sand or Met-L-X Class D extinguishing powder.

Hot Work

1. Hot work tools and operations must adhere to the MIT Hot Work Program and City of Cambridge requirements, including safe work distances for open flames, non-combustible surfacing, compressed gas cylinder storage, and limits on maximum quantities of flammable materials
2. Welding, cutting torches, brazing, and related high temperature “hot work” operations can produce hazardous fumes, sparks and other hot particles, and create ocular hazards to nearby persons. Hot work areas must be isolated from other tools and operations by use of a separate room or other means of distance and shielding. Non-combustible opaque solid shields or welding curtains must be provided to prevent inadvertent ocular exposure and provide protection against sparks and other hot particles
3. All working surfaces in or around hot work areas must be of non-combustible construction
4. Supplemental dedicated portable fire extinguishers must be provided for hot work areas
5. Depending upon the type, materials and frequency of the hot work, local exhaust ventilation or portable “fume extractors” may be required
6. Provide storage areas for welding helmets, gloves, and fire-resistant coats or aprons.

Material Handling and Storage

Provide adequate capacity and means to safely transport and store the anticipated range and size of raw materials, finished products, and shop equipment and supplies.

Material Transport and Handling

1. Consider needs for any overhead trolleys, hoists, cranes, and other lifts. (See guidelines on Hoists and Overhead Lifting Equipment for additional information)
2. Ensure that shop aisles and walkways have sufficient width for anticipated material transport, including the use of hand-carts, rolling carts, lifts, or powered industrial trucks

Storage

1. Determine the preferred method(s) for storage in the shop, ranging from the creation of formal tool and materials “cribs” to the use of open, decentralized storage. Final decisions will be dependent upon shop type, user base, staffing, and value or hazards of stored materials and tooling
2. Minimize footprint loss by using vertical or stacking storage systems where feasible, or co-locating storage areas in adjacent spaces. Design should consider safe and easy access to materials.

3. Rolling carts and parts bins often provide maximum flexibility for varied work projects

Compressed Gases and Flammable Liquids

Compressed gases and flammable chemicals require special storage arrangements.

Cylinders of any compressed gases must be secured against tipping and falls by wall chains or another approved restraint system.

Flammable materials, including liquid chemicals, most aerosol spray can products, and flammable compressed gases are subject to City of Cambridge and Massachusetts Fire Code (527 CMR, Chapter 60) maximum allowable quantity limits.

Flammable materials shall be stored in compliance with 527 CMR or the applicable NFPA Code.

Electrical

Appropriate, code-compliant electrical power service and distribution to maximize operational flexibility and maintain a safe work environment.

1. Following the Massachusetts Building and Electrical Code, maximize the number of separate circuits to avoid overloads, ensure circuit breaker boxes and individual circuits are well-marked and coded, and centrally located for quick access
2. All equipment must be UL listed or have other NRTL certification.
3. Special Electrical Needs
 - a. Identify any special electrical service requirements (i.e., 3-phase power, uncommon line voltage equipment) during planning and design
 - b. Avoid floor-level electrical outlet service; instead, use overhead electrical busses to provide maximum accessibility for future tool installations and / or re-orientation of existing tools
 - c. Provide an adequate number and distribution of common 120 and 240 V outlets
 - d. Consider installing overhead retractable cord and reel units for larger open assembly areas and for flexible multi-function shop spaces
4. Emergency Power Shut-Offs
 - a. In addition to emergency shut-off buttons on all fixed location power tools, room-level under-voltage trip/relay should be provided in all shops. These can be simple shunt-trip circuit disconnects or full-room electrical controller switches. Where installed, they must be prominently labeled. Strong consideration should also be given to also using a button style that requires a key or ID card to reset power in order to force a review of the cause for the emergency shut-off event
 - b. Room-level electrical control switches can also be used to affirmatively depower some or all of the tools in a shop, manually or by a time-of-day clock. This approach can serve as a reliable means to “de-rate” the hazard classification of a shop to enable

its broader use or to simply ensure that no work can occur in that space without specific on-site supervision

- c. In dusty or wet shops, consider installing emergency power shut-off buttons inside clear weather-proof covers

Other Design Issues

1. In general, surfaces should be smooth and easily cleanable
2. Seamless sheet or epoxy-coated flooring is preferred in wet areas and locations subject to spills
3. Flooring choices should consider the impact of dropped tooling or parts. Select “softer” finishes where the cost of damages will be high. Alternatively, consider rubber / composite non-skid area “anti-fatigue” matting
4. Avoid sub-floor raceways, hatches, access covers, etc. Where unavoidable, ensure that they are securely covered and do not pose any slip, trip, or other hazards to pedestrians, carts, or other transport devices

Lighting

1. General Approach: take advantage of natural light sources or features, as feasible
2. Room Lighting
 - a. Incorporate high efficiency lighting systems wherever feasible
 - b. Lighting fixtures should be arranged so lighting is even with no shadows
 - c. Although recessed lighting is preferable to suspended styles, it is generally infeasible in most shop environments with large open ceiling plans
 - d. Protect all exposed / suspended lighting fixtures against inadvertent impact and damage with covers, cages, or protective shades or lenses
3. Task / Tool Lighting
 - a. Provide increased illumination for tool-level task lighting, preferably with low-voltage lights (i.e., < 50 V). Where standard 110/120 V tool-level lighting must be used, ensure that bulbs and shades are covered, armored, or otherwise protected from inadvertent impact and damage.

Compressed Air, Vacuum, and Hydraulic Systems

1. Location
 - a. Compressors, vacuum pumps, and hydraulic control pumps are noisy and a source of significant vibration. Select the lowest noise emitting units possible when procuring new equipment
 - b. Locate these system components in either a separate space or within a special enclosure in the shop
 - c. Wherever placed, use isolation mounts to minimize vibration and provide ready access for routine service and maintenance

2. Distribution
 - a. Shut-off valves should be located to facilitate routine service needs, and pipes located on walls or ceilings.
 - b. Pipes should be prominently labeled by service
 - c. Flexible reinforced hosing should only be used at terminal service ends and for equipment connections
 - d. Compressed Air delivery nozzles should be restricted to < 30 PSI to minimize potential injuries and meet OSHA requirements.

13.3 HVAC and Ventilation for Machine Shops

Meet or Exceed the Following Standards

1. ACGIH Industrial Ventilation Manual – latest edition
2. Clean Air Act (CAA) Section 608 (40 CFR 82 Subpart F) Refrigerant Management Regulations

The overall approach is to provide adequate general ventilation for overall air quality supplemented by local exhaust and local filtration systems that control contaminants at their sources and limit their spread. It is also desirable to be able to where possible have local exhaust systems operate with the tool or work station and may be turned on/off or controlled by users. Filtration of local exhaust may also be necessary before discharge to the outside or in some cases re-circulated in the space. Hood design, placement, and exhaust quantity are critical for effective capture, refer to the above mentioned ACGIH manual for details. Manufacturers of tools and filtration systems may also have specifications and guidance on ventilation volumes, pressure drops, etc. The Industrial Hygiene Program (IHP) staff in the EHS office should review shop ventilation systems.

Heating and Cooling

1. Design should consider the use of refrigerants with the least ozone-depleting potential available or non-regulated refrigerants.
2. HVAC equipment containing 50 pounds or greater of regulated refrigerants must be coordinated with EHS and DOF such that it can be added to the MIT Refrigerant Management Program database.

Ventilation

1. Good general ventilation should be provided for maker space/shops since odors, mists and dusts may be produced from activities such as machining and storage or use of

cutting fluids. ASHRAE provides guidance of 6 air changes per hour of ventilation. Both local and general exhaust can be included in this number.

2. General exhaust grills should allow for good mixing and be accessible for cleaning. It is preferable if general exhaust can be single pass air if supply air is not the only means of heating and cooling. BMS controls should be provided to set back the general ventilation when the shop is not in use.

System Determination

1. Both the types of materials being machined and the particle size generated by the machine tool must be considered when determining if local ventilation will be needed for a given tool. Band saws and drill presses produce large chips and generally do not need local ventilation unless the metals being machined contain beryllium, lead or other toxic metals.
2. Metal working lathes and mills can produce smoke from cutting fluids and some potentially metal fume (depending on process). Some process will generate aerosols of cutting fluids, mist eliminators can be used to capture these locally. Consider adding a snorkel to mills and lathes that will be heavily used or used with toxic metals.
3. Grinding and sanding operations produce fine dust particles and almost always require a source control such as a downdraft table or local exhaust. A HEPA filtered vacuum cleaner can be used as a source of particulate control if dry operations only are being conducted.
4. Exhausted local ventilation systems must be equipped with filtration, preferably located before the exhaust fan and accessible for maintenance. Access to shop personnel is helpful if materials are collected in a suitable manner for recycling.
5. To provide maximum flexibility, portable fan\filtration units are sometimes the best solution for providing local exhaust when needed. These can be turned off when not in use and can be picked up by a general ventilation system when toxicity levels or odors require exhausting to the outside.

Machining of Plastics

Local exhaust discharged to outdoors is recommended for large volume machining of plastics where significant odors and fumes are generated.

Woodworking Maker Space/Shops

1. Local exhaust with filtration (dust collection) is required for most woodworking tools. Recirculation back to the shop is usually acceptable if the collection efficiency of the dust collector is high and general ventilation is also provided. Exhaust ports are needed at/on each tool.
2. A determination should be made early in the design process as to whether central dust collection system is warranted or if each tool should have its own filtration system. If

multiple tools are used simultaneously or regularly, consider an appropriately sized dust collection system with primary (typically a cyclone) and secondary (high efficiency bag filter or paper filter) collectors. The system can be located in the shop or outside. If outside, weatherproofing and other fire related codes will need to be addressed

Laser Cutters

Laser cutter exhaust is a critical, often challenging element in the overall ventilation system design. Although laser cutters may be purchased with filtration units, it is usually preferable to exhaust them to the outside to the outside. Most laser cutters require stand-alone high static pressure exhaust systems which tend to be noisy. and are best designed with on-off capability integrated into the laser cutter controls. To avoid odors from freshly cut materials the exhaust should stay on for a few minutes after the run is completed.

3D Printers

Required ventilation for 3D printing will depend upon the printing technology and materials, manufacturer recommendations, number and size of machines and room configuration. Since the ventilation requirements are variable and the technology is evolving rapidly, an understanding of planned and future 3D printing needs is critical. At a minimum, good general exhaust ventilation is required in all 3D printing areas. Locating the 3D printing area to take advantage of room airflow patterns to more quickly exhaust odors and fine particles should be considered. Some 3D printers come with enclosures and in some cases filtered enclosures can be added. To allow for future flexibility some capability for local exhaust should be included even if no tools requiring exhaust are identified in the design phase. 3D printers that use powdered metals or plastics may have additional requirements for ventilation and other infrastructure.

CNC Equipment with Enclosures

CNC equipment with enclosures may have ports for ventilation to be exhausted to the outside or connected to a mist eliminator/smoke eliminator and re-circulated in the shop. The machine specifications, materials to be machined, cutting fluid and volume should be reviewed to determine if ventilation is necessary and the type to be installed.

Small Shop Hoods for Spray Painting and Adhesives Work

Many maker space/shops, studios, and assembly areas may require a small hood for the solvent vapors and paint droplets produced from activities such as spray painting and applying adhesives. These contaminants must be exhausted from the building via a non-recirculating system (100% exhausted to the outside), and should be equipped with a paint mist filter (installation of large spray booths should be evaluated for additional safety and infrastructure measures). These hoods should be on/off with an exhaust flow monitor that can be muted when the hood is off. Controls may include occupancy sensors, timers or other technology.

EHS should be consulted when specifying these types of equipment for evaluation of air emissions permitting requirements.

Welding and Cutting Operations

Local exhaust vented to the outside will be required for all welding operations.

Additional Equipment That May Require Special Ventilation

- Hot wire cutters
- Heat treating furnaces and ovens
- Indoor work with combustion engines
- Etching and plating
- Abrasive / sandblasting
- Any hazardous chemical operations

System Controls

Where feasible, tool-based local exhaust ventilation systems should be connected to the tool power control and / or room ventilation system. This ensures that contaminant capture is actuated when the tool is turned on, and turned back off again upon completion of the task. Under certain circumstances, shut-off time delays may be needed to provide additional ventilation time.

Special Water or Wastewater Issues

Identify special water consumption, quality and quantity needs, and wastewater- generating activities during planning and design to ensure suitability of the intended shop location and address any potential regulatory requirements. This is especially important for equipment and operations that use water or water-based coolants that may require discharge to drain (e.g., non-recirculating water jets, water-cooled mills).

Municipal Water

1. City water may not be used for single use, pass-through cooling of mechanical systems or tools; instead, use house chilled water, process chilled water, or a stand-alone point-of-use recirculating water chiller
2. For equipment or operations that generate wastewater special permitting and / or pre-discharge treatment systems may be required. Consult MIT EHS for assistance.

Sinks

1. Maker space/shops should contain or have immediate access to a handwashing sink, with soap and paper towel dispensers.

2. Larger maker space/shops may also benefit from a “slop” or janitorial style wash sink, with a hose bib attachment on the faucet spout

Emergency Eyewashes and Showers

Emergency shower needed in Maker Space/shop if flammable or corrosive liquids will be used. Eye wash recommended for dusty (wood) environments as opposed to particulates (e.g. metal/plastic particles).

Waste Management and Collection

Adequate space and collection devices for safe, compliant disposal of all waste materials generated in the shop.

Best Practices

1. Dedicate one or more areas to the collection of regular trash, recyclable materials, special shop-generated wastes, and any hazardous and other regulated wastes
2. Locate waste storage areas in readily-accessible parts of the shop to encourage use and facilitate routine pick-up and removal
3. For any hazardous chemical wastes, additional collection area features are generally required, including secondary containment, special signage, and training

Shop Safety Features

Consistent, readily-identifiable access to PPE, safety equipment and other safety features in all shops.

Provide the following at or near the main entry point or other common area of each shop:

Safety Station

Highly visible “safety station” that will house:

1. Safety glasses, goggles, face shields, hearing protection, etc., as appropriate to shop operations
2. Hair and beard tie-back accessories (e.g., hats, head bands, ponytail ties, hair and beard nets)
3. Any other personal protective equipment required for the shop
4. Basic first aid kit
5. SDS station and binder (as applicable)
6. Small tool out-of-service / mini-LOTO (lock-out/tag-out) kit

Telephones

Each shop must have one or more landline telephone(s) with posted campus emergency contact numbers, including building number and street address to aid emergency responders.

Remote Monitoring

1. Remote monitoring by CCTV or internet camera(s) is an optional feature, but recommended for Class 3 shops (shops with higher hazard tools) and for higher hazard student shops. Such a feature can enable remote real-time viewing of shop activities by an instructor or manager
2. Where installed, it is critical that all responsible parties understand the limits of remote monitoring technology and that it is not observed 24 / 7 for emergency response purposes. Remote monitoring systems must meet MIT's video surveillance policy. Notices must also be prominently posted in the area informing occupants that the space may be under video surveillance

Machines and Machine Safeguarding

Although largely tool-specific, several general concepts guide the safeguarding of all shop tools and machines. Consult MIT EHS prior to ordering any new or replacement shop tools or equipment.

1. Tool Safeguarding
 - a. For each tool, provide safeguarding that meets regulatory (e.g., OSHA), advisory organization (e.g., ANSI), and Institute requirements, regardless of manufacturer-provided guarding and controls. Refer to the MIT EHS Shop and Makerspace Safety SOP (EHS-0076) for details.
 - b. Any required post-purchase retrofits or upgrades to meet safeguarding requirements are the responsibility of the acquiring department. Consult MIT EHS for assistance in identifying approved parts suppliers and installers
2. Welding, torch cutting, laser cutting, and other operations with the potential for harming eyes and human vision must be enclosed or shielded by opaque welding safety barriers or curtains
3. Tools with potential for releasing flying objects may require Lexan, woven wire, or other shielding as additional area protections against injury
4. Large open-access equipment and tools such as self-standing 3-D manufacturing robots may require light curtains, other proximity sensing controls, and /or moveable barriers to provide for safe set-up and operation.
5. Tools positioned in separate / remote spaces for ventilation, noise, or other physical safety reasons will require remote tool operation controls and remote visual monitoring through safety glass panels, video or CCTV, mirrors, or a periscopic device.
6. Some tools, especially those that are top heavy or can tip, as well as those recommended by the manufacturer must be secured to the floor or other means to prevent tipping. Bench-top machine tools must be securely mounted to the work surface or bench.

14. COMPRESSED GASES AND CHEMICAL STORAGE

14.1 Compressed Gases

Refer to Lab Design Thematic Folder.

14.2 Chemical Storage

Refer to Lab Design Thematic Folder.

1. Non-Lab Areas:
 - a. When designing a shop space, the needs for chemical storage should be factored in. All shops are required to maintain a chemical list, and this list can be used in evaluating storage needs.
 - b. When large numbers of spray cans are used, or other flammables, space should be planned for flammable storage cabinets, perhaps the biggest chemical storage need in a shop. In some cases, it may be desirable to vent the flammable cabinet. In rare cases, it might be appropriate to design a flammable storage room with appropriate diking and fire protection
 - c. There should be sufficient shelving for storage of non-flammable chemicals.
 - d. If drums of chemicals are used, sufficient space for such storage needs to be planned.
 - e. Chemicals meeting the definition of an oil under 40 CFR 112 and stored in containers of 55-gallons or greater must be included in the MIT Spill Prevention, Control, and Countermeasure (SPCC) Plan. Chemical storage meeting this description should be coordinated through EHS to ensure the MIT SPCC Plan can be updated accordingly.
 - f. For shops with welding or other operations requiring compressed gas, appropriate space and securing should be planned for storage of the cylinders.
 - g. Chemical waste accumulation areas should be planned in areas such as vehicle maintenance shops.

15. GAS AND VAPOR MONITORING

15.1 Standards

Meet or Exceed the Following Standards - Refer also to Lab Design Thematic Folder

1. Massachusetts State Building Code, 780 CMR, most current edition
2. Massachusetts Comprehensive Fire Safety Code, 527 CMR 1.00, 2015
3. International Fire Code, 2009
4. Factory Mutual Global Data Sheets, 2015
5. Standard on Fire Protection for Laboratories Using Chemicals, NFPA 45, 2015
6. Compressed Gases and Cryogenic Fluids Code, NFPA 55, 2016
7. Compressed Gas Association Standards
8. Standard System for the Identification of the Hazards of Materials for Emergency Response, NFPA 704, 2012
9. SEMI International Standards

15.2 Introduction

Gas monitoring may be required when highly toxic, toxic, flammable, or pyrophoric (spontaneously combustible in air) gas use is planned. Under some conditions oxygen monitoring is required in locations with compressed and liquefied inert gases; and LEL (Lower Explosive Limit) monitoring in locations such as storage areas for flammable gases and chemicals. This section applies to Lab and Non-Lab areas.

General recommendations for permanently installed gas monitoring systems:

1. Monitor type, alarm set points, automated actions and notifications for monitoring systems are determined by the project design review team based on MIT EHS and Facilities specifications, code requirements, building infrastructure and research needs.
2. All monitoring systems must report alarm details back to a continuously monitored station (e.g. the Facilities Operations Center and if available, a DLC response team.). Exceptions to this rule must be approved by EHS.
3. A visual and audible alarm must be present inside and outside of the lab with the ability by emergency responders to silence the alarm. Alarm details in a display panel (alarm type, level, etc.) must be available inside and immediately outside of the monitored area
4. A remote monitor is required in the Fire Command Room or near the main building Fire Alarm Panel. Signage should indicate the warning signal intent. The signage shall include appropriate hazard warnings, as well as response instructions (e.g., “Do Not enter the laboratory if the alarm has been activated”) contact information and emergency phone numbers. The researcher is responsible for writing a response procedure that is reviewed by EHS which they are posted at the lab including alarm levels and contact information that the DLC, Operations Center and EHS would follow in case of an alarm. The response protocol would be distributed to Operations Center, EHS and be covered as part of the lab specific training. The response procedures and any other supporting

- documentation will be kept in a secure location such as in the Fire Command Room or blue locked box mounted outside the lab entry
5. The location of gas sensors will be based on the properties of the gas and potential leak points. Sensors shall be located within 12 inches of the floor for gases heavier than air) and near the ceiling for gases lighter than air. Ambient air sensors for toxic gas monitoring will be located near breathing zone height
 6. Monitoring equipment make/models should be standardized as much as possible to facilitate maintenance requirements. Contact Facilities and EHS to ensure that an acceptable monitor is purchased
 7. Emergency power, battery backup (24 hours) must be provided for monitoring systems. The monitoring system should continue to operate without interruption.

15.3 Pyrophoric, Highly Toxic and Toxic Gases

Certain gases with very high toxicity and/or pyrophoric properties (e.g., silane, arsine, and phosphine) require continuous 24 hour air monitoring in the work area, ventilated equipment/enclosures and possibly duck work. Automatic gas shutdown at the gas source and tool shutdown in the event of ventilation failure or gas detection may also be required. An automatic fire detection system must be installed in rooms or areas where highly toxic compressed gases are stored or used. Flame detection is required for pyrophoric gases.

Toxic gas alarm set points are based on the American Conference of Industrial Hygienist Threshold Limit Values (ACGIH TLVs). Typically monitors are set to alarm at half of the TLV and the TLV. For detection inside of ventilated enclosures (e.g., gas cabinet or tool enclosure) the lab should be evacuated and gas source automatically shut down. For highly toxic and pyrophoric gas detection at the TLV level or higher in ambient/breathing air, the building is evacuated.

The monitoring system shall be equipped with an audible and visual alarm indicator. The audible signal shall be at least 15 dB above the ambient sound level. The visual alarm beacons shall be amber for equipment and gas cabinet/enclosure alarms and blue for ambient alarms. The visual alarm beacons shall be labeled.

While toxic gas use may not require the same monitoring and controls as very toxic gases, each planned use of toxic gas requires some level of engineering controls and/or monitoring. Especially of concern are toxic gases that may not provide adequate warning below the TLV due to high or no odor thresholds and olfactory fatigue (e.g., carbon monoxide, hydrogen sulfide or hydrogen chloride).

Highly toxic, toxic and pyrophoric gas monitoring requires that sensing ports be located in the gas cabinet, tool/equipment enclosure, and lab area.

Compressed gas cylinders containing highly toxic, toxic and pyrophoric gases shall be stored in a gas room or approved cabinet, exhausted gas cabinet, or exhausted enclosure with a fire

suppression system in accordance with requirements specified in 527 CMR Chapter 60 Table 60.4.2.1.1.3.

The cabinet shall be equipped with an excess flow control valve and flow restrictor in cylinder and exhaust monitor/interlock for gas flow shutdown upon exhaust loss.

There shall be a manual emergency shutoff at the gas cabinet.

For high hazard group H occupancies, the exhaust ventilation system serving gas cabinets, as well as any tool enclosures, shall be provided with emergency power. The local authority having jurisdiction may require additional safeguards.

1. Note: SEMI and Massachusetts Building Code define a highly toxic gas as having an LC_{50} of 200 ppm or less and a toxic gas as having an LC_{50} of greater than 200 ppm and less than or equal to 2000 ppm for a one-hour exposure to albino rats between 200 and 300 grams. [SEMI F6-92]. NFPA 704 uses an LC_{50} of less than or equal to 1000 ppm for its highest health hazard rating of 4 and an LC_{50} of 1000 to 3000 ppm for a hazard level of 3

Small returnable cylinders (lecture bottles) containing less than 10 cubic feet of gas by volume that are kept inside gas cabinets or fume hoods:

1. Require local (temporary) monitoring
2. Must be kept in the gas cabinet/fume hood at all times
3. If their use is restricted to inside the hood and not piped to equipment outside the hood, an excess flow control valve/flow restrictor is not required
4. If their use is not limited to inside the hood and piped to equipment outside the hood the cylinder must be equipped with an excess flow control valve and flow restrictor in cylinder and the equipment and ambient air must have continuous monitoring
5. See Table 1 for suggested sequence of operations

15.4 Inert Gases

Some research laboratories use compressed and liquefied gases in locations where the potential for a low oxygen, <19.5% O₂, atmosphere exists. These areas are required to have oxygen sensors. Examples include liquid helium cooled magnets or dilution refrigerators, MRI rooms, MEG rooms, nitrogen generator rooms, nitrogen filling stations and storage areas for inert gases. Where there is potential for high level oxygen, the set point would be 23.5%.

EHS with assistance from the project design group will review the proposed research, location and gas quantities to determine whether oxygen level monitoring may be required. In some cases provisions for emergency exhaust triggered by an alarm may be required. Positioning of sensors should be based on gas density at the time of release relative to ambient conditions. Sensors for MRI and MEG rooms should be designed for these rooms to eliminate interference with the image quality.

The signage shall include appropriate hazard warnings, as well as response instructions (e.g., “Warning! Low Oxygen Alarm”) contact information and emergency phone numbers. Refer to a template sign for consistency. Response protocols should also be developed and distributed as outlined above in the toxic gas section.

See Table 1 for suggested sequence of operations.

15.5 Flammable Gases

The purpose of the lower explosive limit (LEL) monitoring of gases within a laboratory space or gas storage room is to give early warning to personnel of a potentially hazardous condition.

When a gas is both toxic and flammable or pyrophoric, the more stringent (sensitive) monitoring requirement shall be used. Both monitors are not required.

The monitoring system shall be equipped with an audible and visual alarm indicator. The audible signal shall be at least 15 dB above the ambient sound level. The visual alarm beacons shall be labeled.

The location of gas sensors shall be determined based on the properties of the gas.

Compressed gas cylinders containing flammable gases shall be stored in a location equipped with a fire suppression system. This shall be a room, a gas cabinet, or other code-approved enclosure.

Flammable gas cabinets do not require fire suppression systems, if the room that they are located in is protected by a fire suppression system.

Any flammable gas cylinder containing greater than 33 cubic feet of gas must be contained in a gas cabinet, if sprinkler protection is not provided in the room.

The cabinet shall be equipped with an excess flow valve and exhaust monitor/interlock for gas flow shutdown upon exhaust loss.

There should be a manual emergency shutoff at the gas cabinet.

For high hazard group H occupancies, the exhaust ventilation system serving gas cabinets, as well as any tool enclosures, shall be provided with emergency power. Flammable gases should be monitored by a continuous monitor in the lab room and any non-toxic flammable gas cylinders outside a gas cabinet should have an excess flow valve. For non-toxic flammable gas, sensors are required in the gas cabinet, equipment/tool enclosure and lab area.

Exceptions:

1. When the cylinder contains less than or equal to 10 cubic feet of non-toxic flammable gas by volume (lecture bottle)

2. Natural gas plumbed as a “house gas” to labs need not be monitored
3. For experiments using a small cylinder of flammable gas (Airgas size 35, approximately 33 cubic feet of gas)
4. If ventilation in the space is adequate and the release risk is not higher than normal, continuous monitoring may not be required but is still a best practice
5. If monitoring is used, hand-held or local alarm is acceptable
6. When gas is flowing, the experiment should be continuously attended
7. All other flammable gas controls apply: flashback arrestor, adequate piping/tubing, restricted flow orifice, excess flow valves.

Any non-toxic flammable gas cylinder containing greater than 33 cubic feet of gas must be contained in a gas cabinet if sprinkler protection is not provided in the lab.

The local authority having jurisdiction may require additional safeguards. Response protocols should also be developed and distributed as outlined above in the toxic gas section.

See Table 1 for suggested sequence of operations.

15.6 Flammable Liquid Vapors

The purpose of the lower explosive limit (LEL) monitoring of flammable liquid vapors within a laboratory space or flammable liquid storage room (FLSR) is to give early warning to personnel of a potentially hazardous condition. In the case of an FLSR, these areas are normally unoccupied; thus, it is possible that a leak or spill could result in high concentrations of flammable vapors that could go undetected.

LEL monitoring may be required in locations designed as flammable liquid storage rooms (FLSR) where dispensing will occur. Requirements include:

1. The LEL alarm system shall activate on a single alarm point set at 20 %. This set-point may need to be lower for liquids that are also toxic
2. The monitoring systems shall be equipped with an audible and visual alarm indicator. The alarm signal shall be transmitted to a constantly attended station. The audible alarm shall exceed background ambient levels by 15db. The visual alarm shall be labeled
3. The alarm sensors shall be located no higher than 12 inches above the floor
4. Signage shall be posted outside the FLSR. The signage shall include appropriate hazard warnings, as well as response instructions (e.g. “Do Not Enter if the Alarm has been Activated”) contact information and emergency phone numbers
5. When the flammable liquid dispensing involves use of an automatic pumping system (as opposed to manual,) the pump shall shut-down upon LEL alarm activation (or line leakage detection) to stop the flow of liquid
6. The local authority having jurisdiction may require additional safeguards
7. Exception: FLSR where dispensing will not be conducted

Response protocols should also be developed and distributed as outlined above in the toxic gas section. See Table 1 for suggested sequence of operations.

15.7 Toxic and Flammable Gases in Non-Lab Areas

Carbon monoxide monitoring is required in all residential areas, commercial kitchens, Ice Rink and garages (to start ventilation fans only). Natural gas monitoring is required in commercial kitchens. Where there is an assumed high hazard to occupants from the natural gas/carbon monoxide exposure in other non-lab buildings, a discussion will take place between the designers and EHS to determine the appropriate monitoring in these areas. Response protocols should also be developed and distributed as outlined above in the toxic gas section.

15.8 Table 1 - Suggested Sequence of Operations

Condition	Building Management System	System Supervisory on Fire Alarm	Local Horn / Strobe	Gas or Liquid Valve Closure	Evacuate Lab or Area (local alarm)	Evacuate Building/ Alarm Signal to Fire Alarm, Priority 2 Alarm Broadcast to Building Evacuation ⁵
Highly Toxic and Pyrophoric Gas, ½ TLV in gas cabinet/enclosure and equipment	X		X ¹			
Highly Toxic and Pyrophoric Gas, TLV in gas cabinet/enclosure and equipment	X	X	X	X	X	
Highly Toxic and Pyrophoric Gas, ½ TLV in ambient air	X	X	X ¹	X	X	
Highly Toxic and Pyrophoric Gas, TLV or greater in ambient air	X		X	X	X	X
Toxic Gas, ½ TLV in gas cabinet/enclosure and equipment	X		X ¹			
Toxic Gas, TLV in gas cabinet/enclosure and equipment	X	X	X	X	X	
Toxic Gas, ½ TLV in ambient air Note: carbon monoxide gas in cylinders, 15ppm ³	X	X	X ¹	X	X	

Condition	Building Management System	System Supervisory on Fire Alarm	Local Horn / Strobe	Gas or Liquid Valve Closure	Evacuate Lab or Area (local alarm)	Evacuate Building/ Alarm Signal to Fire Alarm, Priority 2 Alarm Broadcast to Building Evacuation ⁵
Toxic Gas, TLV or greater in ambient air Note: carbon monoxide gas in cylinders, 25ppm ³	X		X	X	X	X
Flammable Gas, 10% LEL ³	X		X ¹			
Flammable Gas, 20% LEL ³	X	X	X	X	X	
Flammable Gas, 50% LEL ³	X		X	X	X	X
Oxygen, 19.5%	X	X	X	X (for s source)	X	
Flammable Liquid Vapor, 20% LEL ⁴	X	X	X	X	X	
Flammable Liquid Vapor, 50% LEL ⁴	X		X	X	X	X
Flammable Liquid Leak Detection ⁴	X	X	X	X	X	
Emergency Gas Off Pull Station	X		X	X	X	X
Combustion gas carbon monoxide 15 ppm ²	X		X ¹			
Combustion gas carbon monoxide 25 ppm ²	X	X	X	X	X	
Combustion gas carbon monoxide 200 ppm ² Note: for MIT Ice Rink, set point is 125 ppm.	X		X	X	X	X
Natural gas 10% LEL ²	X		X ¹			
Natural gas 20% LEL ²	X	X	X	X	X	
Natural gas 50% LEL ²	X		X	X	X	X
Panel Trouble	X		X			
Battery Alarm / Power	X		X			

¹ Strobe only

² Non-lab areas, residential areas (where required), e.g., residential, boilers, furnaces, water heaters, kitchens, garages, generators, engines

³ High pressure gas from cylinders in equipment and ambient air

⁴ Room/enclosure, equipment and ambient air, lab and non-lab

⁵ Pretone, message, alert tone same as fire alarm. Release fire doors

END OF DOCUMENT