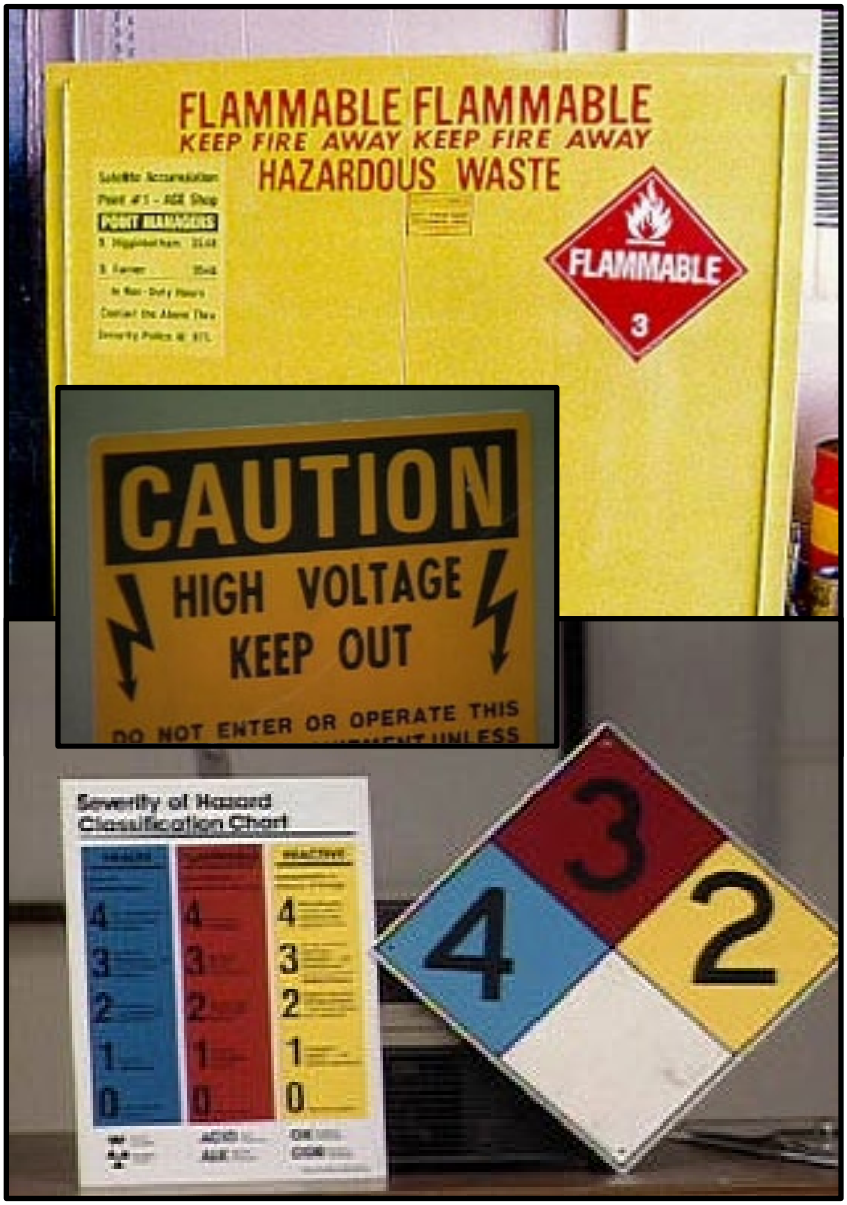
EPA FACILITIES MANUAL: VOLUME 3

FACILITIES SAFETY MANUAL



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1. Overview

1.1 EPA Facilities Manual

This *Facilities Safety Manual* is a volume of the *EPA Facilities Manual*. The *EPA Facilities Manual* is composed of four distinct, yet complementary, volumes for planning, designing and managing EPA facilities.

- Volume 1: The *Space Acquisition and Planning Guidelines* contain information on space planning, space utilization standards and furniture.
- Volume 2: *Architecture and Engineering Guidelines* (referred to hereafter as the A&E Guidelines) provide requirements for the design, construction, renovation, and alteration of EPA facilities.
- Volume 3: The *Facilities Safety Manual* establishes facility safety requirements to protect against injury, illness and loss of life.
- Volume 4: The *Facilities Environmental Manual* establishes environmental specifications to be addressed by designers and managers of EPA facilities.

1.2 Purpose

The purpose of this Facilities Safety Manual is to detail safety criteria for EPA facilities to achieve the following objectives:

- Provide reasonable safeguards against injury, occupational illness and loss of life.
- Prevent loss of real and personal government property.
- Prevent interruption of government operations.

The criteria in this Facilities Safety Manual are designed to reflect national building codes to establish a minimum standard for EPA facilities across the country. As a result, some criteria may exceed building codes.

1.3 Scope

The criteria in this Facilities Safety Manual apply to facilities owned or directly leased by the EPA and may be incorporated at the agency's discretion into the Owner's Project Requirements for new EPA leases through the U.S. General Services Administration (GSA). GSA leases follow the Owner's Project Requirements (also known as the Program of Requirements) and the standard GSA lease language, not this EPA Facilities Manual directly. The construction criteria in this manual reiterate the safety related criteria in the A&E Guidelines. This manual also addresses safety considerations for operations and maintenance of EPA owned or directly leased facilities.

If conflicts exist between applicable codes and standards and the criteria in this Facilities Safety Manual, the discrepancy will be brought to the attention of the Real Property Services Division (RPSD) and the Safety, Occupational Health and Sustainability Division (SOHSD) for resolution. Where meeting the criteria in this Facilities Safety Manual at existing facilities does not seem feasible, consult RPSD and SOHSD for advice or a variance. Under special circumstances, a variance may be granted by SOHSD.

1.4 EPA Responsibilities

RPSD, SOHSD and appropriate program office or regional management are jointly responsible for ensuring that EPA facilities provide safe workspaces for EPA personnel. This section describes the responsibilities assigned within the EPA for the safe design, construction and operation of EPA facilities.

- RPSD, with SOHSD's assistance, will review the criteria set forth in the Owner's Project Requirements for new EPA facilities and modifications to existing facilities, before awarding a design contract.

- RPSD, with SOHSD's assistance, will review, approve, and comment on the design plans and construction drawings for new and modified facilities at all design stages and ensure the Project Architect/Engineer (A/E) addresses all comments and concerns.
- RPSD is responsible for ensuring that the design and construction of EPA facilities complies with the requirements specified in the Owner's Project Requirements (for owned and leased facilities), A&E Guidelines (for owned facilities) and GSA lease (for leases).
- SOHSD is responsible for ensuring EPA facility compliance with fire and life safety, electrical safety, hazardous material management and laboratory safety, and indoor air quality requirements.
- During construction, a representative acceptable to SOHSD shall inspect the critical safety features of a new or modified facility, such as fume hoods, sprinkler systems, and fire alarms, for compliance with the design and construction specifications. These features also shall be acceptance-tested against the design and construction specifications prior to occupancy.
- RPSD and SOHSD are jointly responsible for reviewing and approving requests for variances to the criteria in this Facilities Safety Manual. The following criteria apply to requests for variances:
  - Requests for variances to the criteria described in this Facilities Safety Manual must be submitted in writing to RPSD and SOHSD for review.
  - Documentation of granted variances must be maintained by the facility as long as applicable.
- RPSD and SOHSD are jointly responsible for updating this Facilities Safety Manual, as necessary, to reflect changes in safety technologies and best practices relevant to EPA facilities.

1.5 Codes, Standards and References

Appendix A of this Facilities Safety Manual includes a list of required regulations, codes, standards, references and guidance. Citations of regulations, codes, standards, references or guidance within this manual shall be assumed to refer to the most recent edition. Any publication dates specifically stated in this manual reflect the version in use when this manual was published. When using this Facilities Safety Manual, the user shall verify that the documents referenced are the most recent and have not been superseded.

In addition, a glossary is included as Appendix B to facilitate understanding of the terminology used throughout the Facilities Safety Manual.

2. Fire and Life Safety

2.1 Purpose

This chapter provides criteria for fire and life safety at EPA facilities. This chapter includes guidelines on occupancy classification, fire protection systems, automatic sprinkler systems, fire extinguishers, smoke control and fire safety criteria for egress.

2.2 References

Unless otherwise specified in this Facilities Safety Manual or approved by RPSD and SOHSD, all building materials and structural components and assemblies shall conform to the applicable requirements of the National Fire Protection Association (NFPA) and other codes and standards specified in Appendix A, as well as the design requirements in the A&E Guidelines.

2.3 Classification of Occupancies

Buildings and spaces shall be classified by occupancy to determine fire separation requirements, types of construction and other fire safeguards. The use of a building or structure determines its occupancy or use classification. Methods of classification are presented in the building and fire codes, NFPA 101, NFPA 45, NFPA 13, as well as other NFPA codes and standards that may apply to specific situations. The basis of these classifications varies with each code or standard. Some of the methods of classification are listed below:

- The International Building Code (IBC) use classification is based on the use of the building or area considered. Examples are Use Group B (business), S-1 (moderate hazard storage) and F (factory and industrial).
- NFPA 101, *Life Safety Code*, occupancy classification is based on the use of the building or area considered Examples are assembly, business, industrial and storage occupancies.
- NFPA 13, *Standard for the Installation of Sprinkler Systems*, hazard classification is based on the degree of fire hazard represented by the use of the building or area to be protected by sprinklers. Examples are Light Hazard and Ordinary Hazard (Groups 1 and 2).
- NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, laboratory unit fire hazard classification is based on the amount of flammable and combustible liquids and liquefied flammable gases per floor area present in a laboratory unit. Examples are Class A, Class B and Class C.
- NFPA 10, *Standard for Portable Fire Extinguishers*, hazard classification is based on the degree of fire hazard represented by the use of the building or area where the fire extinguisher is expected to be used. NFPA 10 uses the same hazard classification terminology as NFPA 13 (i.e., Light Hazard, Ordinary Hazard and Extra Hazard); however, the two standards do not have interchangeable requirements.

Occupancy classifications shall be clearly identified in design documents, construction documents, as-built/record drawings and specifications. Since occupancy classifications are specific to the respective codes and standards, all relevant occupancy classifications shall be indicated. For example, a single laboratory could have the following occupancy classifications:

- IBC—Group B (Business) or Group H (high hazard)
- NFPA 101—Industrial
- NFPA 13—Ordinary Hazard (Group 2), or Extra Hazard (Group 1) if flammable compressed gases
- NFPA 45—Class B Laboratory
- NFPA 10—Ordinary Hazard

If a conflict exists between the various codes and standards, the discrepancy shall be brought to the attention of RPSD and SOHSD for resolution.

2.4 Types of Construction

Identification of construction classifications is required to meet both the building code criteria and EPA, GSA, and NFPA standards. The various types of construction are defined in NFPA 220 and the model building codes. The construction classifications shall be indicated on design documents as applicable.

2.4.1 Building Elements

The fire-resistance hourly ratings for materials and designs shall be obtained either by actual fire testing or by conformance to designs listed by UL, FM Approvals, or other nationally recognized testing laboratories.

- **Atriums:** Because of atrium smoke control requirements, atrium hazard-level requirements, and the need to maintain liquid-tight floors in laboratories, laboratory rooms shall not open into an atrium. Occupancies located within an atrium and opening into an atrium must have low or ordinary hazard contents as defined by NFPA 101. Atriums should not be used as a required means of transporting chemicals or laboratory waste materials.
- **Attachments and Additions:** Cornices, marquees, and skylights shall be of noncombustible construction. Attachments and additions for the purpose of providing additional space shall conform to the same construction height and area limitations as the base building.
- **Elevators:** Refer to IBC, NFPA 101 and building code requirements.
- **Escalators:** Refer to IBC, NFPA 101 and building code requirements.
- **Fire Doors:** Refer to IBC, NFPA 101 and building code requirements.
- **Fire Exposures:** A fire exposure is any building, structure, yard storage or industrial operation containing combustible substances that, if involved in a fire, would present a danger to the building being evaluated. Classification of exposure severity and determination of minimum separation distance shall be in accordance with the IBC, NFPA 80A, and building code requirements. Requirements for explosion venting should comply with NFPA 45 (for laboratories), NFPA 68 and the applicable building code, whichever is the most stringent. The methods for determining the more stringent requirements shall be documented in the project submittals.
- **Fire Walls, Fire Barriers and Fire Partitions:** Fire barrier walls and fire partitions normally have less fire resistance than do fire walls and have different performance requirements when compared to fire walls. The type of fire-rated assembly generally depends on its intended use and the degree of fire potential. These walls are used to create fire areas, protect specialized occupancies or provide protected egress paths. Refer to the IBC, NFPA 101 and building code requirements for the application of these fire-rated assemblies and the associated protection of openings in these assemblies.
- **Floor-Ceiling Assemblies:** Floor-ceiling assemblies shall be in accordance with criteria set forth in IBC, NFPA 101 and building codes. EPA facilities shall not utilize fire-resistive floor-ceiling assemblies which include t suspended acoustical ceiling tile as part of the listed assembly. The routine operation and maintenance of laboratories require periodic access to the space above the suspended ceiling.
- **Monumental Stairs:** Refer to IBC, NFPA 101 and building code requirements.
- **Penetrations:** Through penetration firestop systems shall be provided to protect penetrations through fire-rated walls and partitions, openings between exterior walls and floor slabs, and openings in floors and shaft enclosures, to form an effective fire barrier between stories and between horizontal compartments. The installation, testing, and rating of through penetration firestop systems shall be in accordance with IBC and NFPA 101. The materials used shall be capable of maintaining the fire resistance of the assembly being penetrated. Such systems shall be listed by a nationally recognized testing laboratory.

- **Utilities:** Pipes, wires, cables, ducts, and other utilities or services shall not be embedded in or between the required fireproofing and structural members unless the listed assembly has been specifically tested in this condition and has achieved the required fire resistance. A 1-inch or smaller steel conduit with wiring to clocks, receptacles, telephones, thermostats or switches may be embedded in the fireproofing if the necessary thickness of fireproofing is not reduced. In such cases, electrical boxes shall be steel, limited to 4-inch nominal size, securely anchored in place, and located at least 2 feet apart or on opposite sides of the structural member.
- **Vertical Openings and Shafts:** Refer to IBC, NFPA 101 and building code requirements.
- **Walls – Panel, Curtain and Spandrel:** Refer to IBC, NFPA 101 and building code requirements.
- **Windows:** There shall be no operable windows in EPA laboratory rooms or in other locations where an operable window would interfere with temperature or humidity control or create undesirable airflows. For additional details, refer to IBC, NFPA 101 and building code requirements.

2.4.2 Hazard Segregation

Areas shall be segregated as noted below and as required by the IBC, NFPA 101 and building codes.

- **Assembly Areas:** Because of the high number of occupants permitted in auditoriums, cafeterias, and other places of assembly, such occupancies shall be located on the exit level of the building or on a floor close to the exit level whenever possible. See NFPA 101 for minimum egress requirements.
- **General Storage Areas:** Storage areas shall comply with NFPA 101. All areas used for storage of maintenance supplies, pesticides, solvents, paints, art supplies or other materials that may contain volatile organic compounds shall be equipped with adequate exhaust and shall have no air recirculation. At a minimum, any such storage area shall be separated from adjacent spaces with fire-resistive construction or protected with sprinklers as required by NFPA or the applicable building code.
- **Accessory (Incidental) Occupancies:** Accessory (IBC) or Incidental (NFPA 101) occupancies are occupancies that take up 10 percent or less of the building area of the story in which it is located. Accessory occupancies do not have to be segregated with fire separations from other occupancies. The means of egress, construction, protection and other safeguards shall be determined by the requirements of the predominant occupancy.
- **Mixed Occupancies:** Mixed occupancies are areas in which two or more classes of occupancy coexist within a building. There are several methods of approaching mixed use occupancies within a building (e.g., separated, non-separated) Refer to IBC, NFPA 101 and building code requirements.

2.5 Fixed Fire Suppression Systems

This section describes the appropriate fire suppression system to be installed for different occupancies. All fire suppression systems will be tested and maintained as required by the applicable NFPA standards.

- **Automatic Sprinkler Systems:** Automatic sprinkler protection shall be provided in all new EPA owned or leased facilities.

  For new facilities where automatic sprinkler protection is not required by applicable codes and standards, a variance can be requested to omit automatic sprinkler protection. Factors that will be considered in this request include, but are not limited to, building occupancy, hazard severity, mission criticality, and potential replacement cost of both building and contents. These determinations will be made on a case-by-case basis with concurrence of SOHSD.

Existing unsprinklered facilities shall be provided with sprinkler protection under the following circumstances:

- In major modifications to existing laboratories that use chemicals, flammable liquids or explosive materials.
- Throughout all floors of any building where EPA occupancy is 75 feet or higher. The height shall be measured from the lowest point of fire department access to the floor level of the highest occupiable story.
- Throughout occupancies exceeding the area or height limitations allowed by the IBC.
- Throughout windowless buildings, windowless floors of buildings (including below grade areas that meets the definition of windowless in the IBC) and windowless areas that exceed the allowable limits of the IBC.
- In cooling towers with more than 2,000 cubic feet of combustible fill when the continued operation of the cooling tower is essential to the operations in the area it services; the building is totally sprinkler protected; a fire in the cooling tower could cause structural damage or other severe fire exposure to the building; or the value of the cooling tower is five or more times the cost of installing the sprinkler protection.
- In any location where the maximum fire potential of the occupancy exceeds the fire-resistance capabilities of exposed live-load-bearing structural elements (e.g., when a flammable-liquids operation is moved into a former office area).
- Throughout electronic operation areas, including data storage areas.
- In any location where there is a higher fire potential or other elevated fire-life safety hazard, as determined by the SOHSD Fire Protection Engineer.
- Where other factors such as hazard severity, economic impact, mission criticality, force protection or replacement cost warrant additional sprinkler protection. These determinations will be made on a case-by-case basis with concurrence of SOHSD.

Any variance request regarding automatic sprinkler protection in an existing facility will be evaluated based on multiple factors, including, but not limited to, building occupancy, hazard severity, mission criticality, and potential replacement cost of building and contents. These determinations will be made on a case-by-case basis with concurrence of SOHSD.

- **Standpipes and Hose Systems:** Standpipe systems shall be provided in all EPA facilities as required by the applicable codes and standards. All laboratory buildings shall possess standpipe systems in accordance with NFPA 14 when required by NFPA 45. If building fire code requirements dictate the installation of hose systems in addition to the standpipe system, hose systems shall comply with NFPA 14 and shall be pressure tested annually in accordance with NFPA 1962.
- **Halon 1301 Fire-Extinguishing Systems:** Fire protection systems that contain Halon 1301 shall not be used in EPA facilities. Refer to the EPA Facilities Environmental Manual for information on removal of halon systems from EPA facilities.
- **Gaseous Fire-Extinguishing Systems:** Carbon dioxide fire-extinguishing systems must meet the requirements of NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, and the Code of Federal Regulations (CFR) Title 29 Part 1910.162(b)(5). Clean agent fire-extinguishing systems shall not be hydrofluorocarbon-based and must meet the requirements of NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*. Carbon dioxide and clean agent fire-extinguishing systems are not recommended for use in normally occupied spaces. Any carbon dioxide or clean agent fire-extinguishing system that is to be used in normally occupied spaces as permitted in NFPA 12 or NFPA 2001, respectively, must be reviewed and approved by RPSD and SOHSD. Gaseous fire-extinguishing systems shall not be considered

as a replacement for automatic sprinkler protection when such protection is required by IBC, NFPA 101 or building codes.

- **Dry Chemical Systems:** Dry chemical systems stop the chain reaction that occurs in combustion. Dry chemical is difficult to remove from electrical contacts. Dry chemical systems can be utilized for protection of detached hazardous materials storage buildings when approved by SOHSD. Refer to NFPA 17 for technical requirements, applications and specifications.
- **Wet Chemical Systems:** Wet chemical systems are generally pre-engineered and are primarily used to protect exhaust hoods, plenums, ducts and associated cooking equipment such as fryers and grills. Refer to NFPA 17A for technical requirements, applications and specifications.
- **Kitchen Fire-Extinguishing Systems:** The EPA requires that any oven, stovetop, or range in EPA space must have ventilation exhaust and a UL 300 (or equivalent) listed fire extinguishing system, in addition to at least one Class K portable fire extinguisher (see portable fire extinguisher requirements below). The exhaust and fire extinguishing systems require routine inspection, testing, maintenance, training, and cleaning in accordance with NFPA 96 and manufacturer's recommendations.

2.6 Portable Fire Extinguishers

Portable fire extinguishers shall be provided in accordance with IBC, NFPA 101, NFPA 10 and 29 CFR 1910.157; however, if the building is an office building owned by the EPA or GSA and protected throughout with quick-response sprinklers, follow GSA PBS-P100 and provide portable fire extinguishers only in areas such as mechanical and elevator equipment areas, computer rooms, UPS rooms, generator rooms, kitchen areas, security screening stations, and special hazard areas.

Portable fire extinguishers shall also be provided in every laboratory room. It is good practice to also locate a fire extinguisher in the corridor outside the laboratory in addition to those located within the laboratory.

Portable fire extinguishers shall be provided based on the classes of anticipated fires and the size and degree of hazard affecting the extinguishers use. One extinguisher may be installed to provide protection for several hazard areas provided that travel distances are not exceeded and the extinguishers are listed for use with each hazard present.

Portable fire extinguishers containing carbon tetrachloride or halon (chlorobromomethane) extinguishing agents shall not be used.

2.6.1 Fire Extinguisher Maintenance and Inspections

Portable fire extinguishers shall be in a fully charged and operable condition and shall be suitably placed, distinctly marked, and readily accessible. Portable fire extinguishers shall be inspected monthly, and tags shall be attached with the inspection date clearly recorded. All portable fire extinguishers shall be subjected to an annual maintenance check (certified).

2.6.2 Training

Per 29 CFR 1910.157, where the employer has provided portable fire extinguishers for employee use in the workplace, the employer shall also provide an educational program to familiarize employees with the general principles of fire extinguisher use and the hazards involved with incipient stage firefighting.

2.7 Fire Alarm Systems

A fire alarm system shall be provided for all new construction projects and in all major renovation/rehabilitation projects, except in buildings with a total building area of less than 5,000 square feet and an occupant load of less than 50 persons, unless otherwise required by the IBC or GSA PBS-P100. Where required, fire alarm systems shall be installed in accordance with NFPA 70, *National Electrical Code* Article 760 and NFPA 72. Fire alarm systems must be completely independent from other building systems, with the exception of mass notification systems where provided.

Air-handling systems equipped with smoke detection and controls shall be in compliance with NFPA 72 and NFPA 90A. All supply, return, relief and exhaust air ventilation systems shall have interlock controls that interface with the fire and smoke detection system controls. In the event of fire, these interlock controls shall either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire through the building, as required by NFPA 90A.

2.8 Smoke Control

Smoke control requirements shall be identified early in the design process and coordinated with the design of the building's heating, ventilation and air conditioning (HVAC) systems. Smoke control systems shall be provided in accordance with NFPA 72, NFPA 90A, NFPA 92, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Handbook of Smoke Control Engineering* and ASHRAE *Handbook of HVAC Systems and Equipment*. Smoke control systems include stair and elevator pressurization, atrium exhaust, zoned control by wing or area, and similar systems. The following guidelines shall be followed:

- Dedicated life safety fans shall be controlled by the fire alarm system.
- Breakable windows could be considered in lieu of engineered smoke control if allowed by building code, security requirements and other facility-specific requirements. This alternative is contingent upon review and approval by RPSD and SOHSD.
- HVAC fans shall not be used for required smoke control if dedicated smoke exhaust fans can achieve the same results at a similar cost, particularly in buildings with complex ventilation and control systems.
- If HVAC fans are to be used for smoke control, the direct digital control must be listed for that purpose and respond in the time frame required by building code.
- Fans and dampers shall not be controlled by both the fire alarm and the direct digital control.
- Manual override control is required and must be clear and usable.

Special exhaust systems shall be designed to include fire and smoke safety controls as required by NFPA 91. Kitchen exhaust ductwork systems shall be designed to include all fire and smoke safety controls as required by NFPA 96. Refer to IBC, NFPA 101 and building code requirements for more information on smoke control systems.

2.9 Means of Egress

The means of egress for all EPA facilities shall comply with NFPA 101. In addition to NFPA 101, means of egress for laboratory facilities shall comply with NFPA 45.

2.9.1 Exit Facilities

The exit provisions of NFPA 101 shall be followed for all EPA facilities.

- **Exit Access Corridors:** The fire resistance of exit access corridors shall be in accordance with NFPA 101 requirements. The width of any corridor serving as a required exit or as a means of travel to or from a required exit shall meet NFPA 101, shall meet the occupant load being served and shall not be less than 44 inches clear width (36 inches if occupancy is less than 50 people). Except in open-plan office space, continuous corridors shall be provided connecting to every exit. (Continuous corridors connect exits in such a way that access to all the exits can be gained without leaving the corridor system.)
- **Exit Availability and Distance:** At least two separate exits shall be available on every floor. Exits shall be remotely located in accordance with NFPA 101. Exits shall be arranged to minimize the possibility that both may be blocked during an emergency.
- **Exit Discharge:** Exit discharge shall be in accordance with NFPA 101 requirements.
- **Exit Doors:** All exit stair doors and all other doors opening onto exit routes, except those opening directly to the outside, shall be self-closing or shall be automatically released by smoke detectors. Doors shall be

located or recessed to ensure that they do not swing to impede pedestrian flow in corridors or other egress routes. In new laboratories and where required by NFPA 101, NFPA 45, or other codes or standards, exit and exit-access doors shall swing in the direction of egress. Vision panels, in accordance with NFPA 80, shall always be provided in stairway and horizontal exit doors and anywhere else where they are necessary for alleviation of potential personnel traffic hazards.

- **Exit Reliability:** Emergency egress paths from the building shall be continuously maintained free of all obstructions and impediments.
- **Exit Stairs:** All exit stairs in new construction and all exit stairs added to existing buildings shall conform to NFPA 101 requirements. Fire escape stairs, as defined in NFPA 101, are not an acceptable component for means of egress.
- **Latches:** Latches on stair doors shall be operable from both the stairs and the occupied space side of the doors. For security reasons, ingress may be restricted as long as such restriction does not impede emergency egress and complies with NFPA 101 requirements.
- **Panic Hardware:** Panic hardware (e.g., metal bar on exit door) could be used in any door, but it must be used for all doors that exit to the outside and all interior-latched exit doors from classrooms, theaters, and other places of assembly with a capacity of more than 50 people.
- **Smokeproof Enclosures:** Smokeproof enclosures shall be in accordance with NFPA 101 requirements.

Fire areas or subdivisions may be developed to improve life-safety conditions in existing EPA buildings where complete correction of existing stair and exit deficiencies is not feasible. Fire areas/subdivisions may be used to develop horizontal exits in cases where occupants require assistance for a safe evacuation. Fire areas/subdivisions may be used in conjunction with a smoke control system. Unless greater fire resistance is required for other purposes, fire barrier walls installed to improve existing exit facilities, or for smoke control, shall be of 1-hour fire-resistive construction. A higher fire-resistance rating should be used to enclose such areas as horizontal exits and areas of refuge. Any such arrangements shall be reviewed and approved by SOHSD.

2.9.2 Emergency Lighting

The means of egress, exterior steps and ramps shall be adequately lighted to prevent accidents.

- Per NFPA 101, the minimum required level of initial illumination is 1 foot-candle measured at the floor for common areas, 10 foot-candles on stairs and 5 foot-candles at the surface of externally illuminated exit signs.
- Per NFPA 101, emergency lighting is required to provide at least 90 minutes of illumination, with illumination at the end of the required duration at least 60 percent of the initial level of emergency illumination.

2.9.3 Exit Signs

Exit signs shall be NFPA 101 compliant and meet the following criteria:

- Exit signs shall be at least 7.5 inches high by 11.5 inches wide.
- Letters shall be at least 6 inches tall.
- The maximum physical distance to a visual sign shall not exceed 100 feet. In addition, an exit sign shall be visible from all points in the corridor.
- In conjunction with the testing of emergency lighting systems, internally illuminated exit signs shall be tested monthly and annually in accordance with NFPA 101 to ensure that the emergency power for the signs is functioning properly.

2.9.4 Occupant Emergency and Fire Prevention Plans

Each facility is required to develop a local Occupant Emergency Program, as well as a written Comprehensive Occupant Emergency Plan (OEP) in accordance with the guidance and templates issued by the EPA Security Management Division (SMD), including the *Nationwide Emergency Preparedness Program Guidance* and the *Best Practices Guidance: Implementing Occupant Emergency Plans in a Hybrid Workplace*. The OEP provides a detailed approach for preparing, responding and recovering from emergency situations, including fires.

Facilities are required to provide trainings related to the OEP, including:

- Initial training for new employees.
- Periodic practice emergency evacuations (fire drills) so that personnel will be familiar with evacuation procedures in cases of actual emergencies.
- Supplementary training if an employee's role with respect to the plan changes.
- Annual OEP Team Training for the OEP Response Team members.
- Annual OEP Awareness Training for all staff, contractors and grantees.
- Refresh training if there are changes to the OEP.

In addition to the OEP, each EPA facility shall develop a Fire Prevention Plan, which can be included in the OEP. Required elements of a Fire Prevention Plan include, at a minimum:

- List of the major workplace fire hazards and ignition sources, as well as associated fire protection equipment or systems.
- Names or job titles of personnel responsible for maintenance of fire prevention and control equipment and systems.
- Housekeeping procedures for flammable and combustible materials.
- Maintenance procedures for heat producing equipment to prevent accidental ignition of combustible materials.

2.10 Fire Life Safety Requirements for Specific Room Types

This section describes special, and often more stringent, fire life safety requirements for specific room types.

2.10.1 Telecommunications Rooms

When communications equipment is essential to the continuity of operation of the building or is otherwise critical, the communications room shall meet the requirements of NFPA 76.

2.10.2 Information Technology Equipment Rooms

Except as noted below or elsewhere in this Facilities Safety Manual, the provisions of NFPA 75 shall be followed for electronic equipment rooms where such equipment is essential to the continuity of operation of the building or is otherwise considered mission critical. Application of this section shall be with the concurrence of the SOHSD.

- **Fire Suppression:** Automatic wet-pipe sprinkler protection shall be provided for electronic equipment operations areas, including data storage areas, in accordance with NFPA 13. No sprinkler piping shall penetrate the shell of the room(s). To prevent accidental striking of the sprinkler and to keep the wet pipe of the sprinkler main outside the perimeter of the room(s), sprinklers in these areas shall be either (1) concealed, dry barrel, sidewall sprinklers; or (2) flexible dry sprinklers with a concealed pendant sprinkler. The sprinkler piping serving the room(s) may be valved separately, but valves shall be provided with tamper switches connected to the building fire alarm system.

- **Emergency Power Off Switches:** Per NFPA 75, emergency shutoff switches shall be provided at all exits from the electronic equipment area. These switches will allow for the disconnection of all power to the electronic equipment and air-conditioning systems. The same shutoff switch shall be connected to a sprinkler waterflow device so that the power to the computer room, including the air handlers, will be shut off automatically when the sprinkler system operates. The waterflow device used to disconnect power to the equipment shall be equipped with a supervised bypass switch so that maintenance testing can be conducted without disconnecting power to the computer room equipment.

2.10.3 General Material Storage Areas

Nonflammable/noncombustible substitutes should be considered whenever possible when choosing building maintenance materials such as:

- Cleaning solvents
- Adhesives
- Caulking
- Sealants
- Paints
- Finishes/varnishes
- Wood paneling
- Floor coverings

General material storage areas, particularly those areas which utilize shelving or racks to store items (other than plastics) to a height over 8 feet (5 feet for plastic materials), can also pose a challenge as it pertains to automatic sprinkler protection of the space. In such areas, consult with the SOHSD Fire Protection Engineer to ensure that the sprinkler system is adequate to protect the proposed storage configuration.

Refer to Sections 4.4 and 4.6 of this Facilities Safety Manual for storage and handling requirements for flammable and combustible chemicals.

2.10.4 Laboratories

To ensure personnel and property protection and efficient operations, it is desirable to consolidate laboratory space into separate fire areas exclusive of other occupancies. Laboratories that handle or store hazardous chemicals, flammable gases, flammable liquids, explosives, or biological materials shall not be established or expanded in EPA buildings that are mainly occupied with office space unless the Project Architect/Engineer completes a formal evaluation with concurrence of SOHSD.

2.10.5 Trash/Recycling Rooms

Trash/recycling rooms shall be designed and maintained in accordance with the IBC, International Fire Code and NFPA 101. Storage rooms shall be kept in order and a general housekeeping schedule for the storage rooms shall be maintained to reduce the chance of fire. Recycled paper and other combustible materials shall be kept in appropriate containers and not be allowed to accumulate in large quantities.

2.10.6 Stages

All stages, platforms in auditoriums, and similar arrangements shall conform to IBC, NFPA 101 or building code requirements. Per All curtains and draperies for stages and platforms shall be of a noncombustible material, such as fiberglass, or shall be of material impregnated to be flame resistant for the life of the fabric (25 washings).

2.10.7 Child Care Centers

Child care centers must comply with IBC, NFPA 101 or building code requirements, as well as GSA's *Child Care Center Design Guide* (PBS-140 including amendments) and the licensing requirements of the local jurisdiction.

2.11 Accessibility and Safety

EPA facilities must consider the needs of people with disabilities and ensure that all personnel are able to evacuate in an emergency or are able to access emergency equipment. The EPA requires compliance with the Architectural Barriers Act (ABA) Accessibility Standards on all EPA projects. The criteria below summarize some of the considerations related to accessibility and safety.

- **Elevator Controls:** Ensure that the controls and emergency telephones of self-service elevators are within reach of a person in a wheelchair.
- **Exit Paths:** Ensure that exit paths are wide enough to permit access by people using wheelchairs or electrically powered carts. Also ensure that there are no items stored in exit paths that would impede the exit of a person in a wheelchair or an electric cart.
- **Fire Alarms:** Provide visual warning devices to alert people who are deaf or hard of hearing.
- **Fire Doors:** Ensure that the hardware of fire and exit doors, particularly self-closing fire doors, can be operated by a person in a wheelchair.
- **Ramps:** Examine the slope, length, surface-friction attributes and exposure to weather of access ramps to ensure that they meet the applicable ABA Accessibility Standards.
- **Occupant Emergency Plans:** These plans shall specifically address the needs of employees with disabilities in general and the particular needs of EPA employees assigned to the facility.

The above criteria do not address the occupational exposures of individuals with disabilities. When providing laboratory workspaces that are accessible to people with disabilities, the EPA will conduct a careful analysis of the hazards associated with the work to be performed and the specific needs of individual employees. The following list delineates common considerations that may need to be addressed for individual EPA employees:

- Accessibility of emergency equipment, such as emergency showers, eyewashes, alarms, fire extinguishers and automated external defibrillators.
- Appropriateness, accessibility, transportation and use of hazardous materials within the facility.
- Accessibility of fume hoods, height of work benches, and accessibility of controls on laboratory equipment.

2.12 Backup Power Systems

See the A&E Guidelines for specifications on backup power systems, including legally required life safety emergency power and legally required standby power.

When provided, inspection, testing, and maintenance of backup power systems shall meet the requirements of NFPA 101, NFPA 110 and the building code.

2.13 Lightning Protection

A lightning protection system shall be provided for all facilities containing laboratory modules, as well as for facilities containing radioactive or explosive materials or facilities having research or communication towers/antennas. The requirements and installation criteria for lightning protection systems shall be in accordance with the A&E Guidelines and NFPA 780.

3. Electrical Safety

3.1 Purpose

The purpose of this chapter is to describe procedures and protocols for ensuring the safe construction, operation and maintenance of electrical systems. Topics addressed include overcurrent protection, grounding, lockout/tagout, classified locations, power transmission and distribution, underground electrical installations, energized substations and portable space heaters.

3.2 References

Unless otherwise specified in this Facilities Safety Manual or approved by RPSD and SOHSD, all electrical installations, operations and maintenance shall meet all applicable requirements of the current national standards specified below and in the A&E Guidelines.

- NFPA 70, National Electrical Code
- Institute of Electrical and Electronics Engineers (IEEE) C2, *National Electrical Safety Code*
- 29 CFR 1910.147, The Control of Hazardous Energy (Logout/Tagout)

3.3 Overcurrent Protection

To protect operators against electrocution, all circuits shall be protected against overload. Overcurrent protection devices must be readily accessible, clearly labeled, not exposed to physical damage and shielded such that their operation will not cause exposure to injury due to arching or sudden movement of parts. Fuse cabinets shall have tight fitting doors that can be locked.

Disconnects shall be provided and located or shielded so that injury will not occur when the disconnect is operated. Switches, fuses, and automatic circuit breakers shall be marked, labeled, or arranged for ready identification of the circuits or equipment which they supply. Switches, circuit breakers, fuse panels and motor controllers located out-of-doors or in wet locations shall be in a weatherproof enclosure or cabinet.

3.4 Grounding

All electrical circuits shall be grounded in accordance with NFPA 70 and IEEE C2. A ground shall be provided for non-current-carrying metallic parts of generators, switches, motor control cases, fuse boxes and distribution cabinets. Portable electrical tools and equipment shall be grounded with a multiconductor cord possessing an identified grounding conductor and a multi-contact polarized plug-in receptacle.

Grounding rod pipes and electrodes shall be free of non-conducting coatings and, if practicable, shall be embedded below permanent moisture levels. Permanent grounding shall be in accordance with NFPA 70 Article 250.

All receptacle outlets that provide temporary electrical power during construction shall have ground-fault circuit interrupter (GFCI) protection for personnel. Receptacle outlets that are part of the permanent wiring of the facility shall use a portable GFCI device if the receptacle outlets are not already GFCI protected. The portable GFCI device shall be as near as practicable to the receptacle outlet.

Receptacles shall be provided with Class A GFCI protection in accordance with NFPA 70, which includes, but is not limited to, all receptacles (rated at the NFPA 70 specified voltage and current levels) in:

- Bathrooms.
- Kitchens.
- Areas with sinks and permanent provisions for food preparation, beverage preparation or cooking.

- Sink areas where receptacles or corded appliances are installed within 6 feet from the top inside edge of the sink bowl.
- Locker rooms with showers.
- Other indoor damp or wet locations.
- Outdoor locations.

In addition, per NFPA 70, Class A GFCI protection shall be provided for certain appliances (rated at the NFPA 70 specified voltage and current levels), including, but not limited to:

- Dishwashers.
- Drinking water coolers and bottle filling stations.
- Electrical ranges, wall-mounted ovens and counter-mounted cooking units.
- Microwave ovens.
- Vending machines.

The EPA also requires:

- Any receptacle within 6 feet of a water source (e.g., interior hose bibb, emergency shower) shall be grounded in accordance with NFPA 70 and provided with Class A GFCI protection.
- All non-GFCI receptacles that are otherwise GFCI protected (e.g., via another GFCI receptacle or a GFCI branch circuit) shall be marked "GFCI Protected."

GFCI outlets shall be tested according to manufacturer's recommendation. If no guidance is available, inspect and test monthly.

3.5 Lockout/Tagout

Prior to any servicing or maintenance on a system where the unexpected energizing, start-up, or release of kinetic energy could occur and cause injury or damage, the system shall be isolated. All personnel shall be trained in the lockout/tagout procedure prior to commencing any work. Training will consist of the following: recognition of applicable hazardous energy sources, the type and magnitude of the energy available in the workplace, the methods and means necessary for energy isolation and control, and the purpose and use of the energy control procedure. All other employees who may be in an area where energy control procedures may be utilized shall be instructed about the procedure and to not attempt to restart equipment which are locked or tagged out.

Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period the exposure is expected and shall indicate the identity of the employee applying the device. Lockout devices shall be substantial enough to prevent removal. Tagout devices shall have a standardized print and format, be weatherproof, and warn against the hazardous condition resulting from system energization. Tagout devices, including their means of attachment, shall also be substantial enough to prevent inadvertent or accidental removal.

The authorized employee shall ensure that all energy isolating devices needed to control energy to or within the system are identified and that the system is shut down, isolated, blocked and secured in accordance with the hazardous energy control procedure. Any system operated by a remotely controlled source will be completely isolated such that it cannot be operated by that or any other source. The authorized employee shall affix lockout and/or tagout devices to each energy isolating device in accordance with the established lockout/tagout procedure.

In areas not under strict control of personnel involved with hazardous energy control activities and in areas with public access, padlocks must be installed on the isolation devices along with appropriate tags. Prior to starting

work on systems that have been locked out or tagged out, workers must verify that the systems have been isolated and de-energized.

Before lockout or tagout devices are removed and energy restored to the system, it shall be ensured that the work has been inspected and nonessential items have been removed from the system, the system components are operationally intact, and all employees have been safely positioned or removed from the area. All affected personnel must be notified that the lockout or tagout devices are about to be removed. Each lockout or tagout device shall be removed from each energy isolating device by the employee who applied the device (Refer to 29 CFR 1910.147(e)(3) for exceptions).

3.6 Hazardous (Classified) Locations

Locations of electrical and electronic equipment and wiring shall be classified based on the properties of the flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, combustible fibers/flyings or ignitable fibers/flyings which may be present and the likelihood that a flammable or combustible concentration is present. Each room, section or area shall be classified in accordance with NFPA 70 Article 500 as summarized in Table 3-1.

Table 3-1: Hazardous Location Types

Class I Flammable Gases, Flammable Liquid-Produced Vapors or Combustible Liquid-Produced Vapors		**Class II** Combustible Dusts		**Class III** Combustible Fibers/Flyings or Ignitable Fibers/Flyings	
Division 1	Division 2	Division 1	Division 2	Division 1	Division 2

All equipment, wiring methods, and installations of equipment in hazardous locations shall be either approved as intrinsically safe, approved for the hazardous location, or demonstrated to be safe in that location. Equipment and wiring approved as intrinsically safe shall be permitted in hazardous locations included in its labeling or listing. Equipment and wiring approved for the hazardous location shall be approved not only for the location class but also for the ignitable or combustion properties of the specific vapor, gas, dust, or fiber. Equipment approved for a specific hazardous location shall not be installed and intermixed with equipment approved for another specific hazardous location. All wiring components required to be explosion proof shall be maintained in that condition.

3.7 Power Transmission and Distribution

Before starting work, existing conditions shall be determined by inspection and/or testing. Such conditions shall include the location of energized lines and equipment (e.g., power and communications), conditions of poles, and the location of circuits and equipment (e.g., fire alarm circuits). Electric equipment shall be considered energized until it is determined to be deenergized (by tests or other means) and grounds are applied. The operating voltage of equipment and lines shall be determined before working on or near energized parts.

The minimum phase to ground working distance and clear hot stick distances in 29 CFR 1910.269 Appendix B shall not be violated. The minimum clear hot stick distance refers to the distance from the hot end of live-line tools to personnel when performing live-line work.

Upon completion of work on deenergized lines or equipment, it shall be determined that all personnel are clear and that protective grounds have been removed and that all tags and locks have been removed prior to energization.

3.8 Underground Electrical Installations

Warning signs and barricades shall be placed when covers of manholes, handholes and vaults are removed. Maintenance holes and unvented vaults shall be treated as and subject to the requirements of confined spaces. Prior to using open flames in maintenance holes or vaults, they shall be tested and found safe or cleared of any combustible gases or liquids.

When underground facilities are exposed (electric, gas, water, telephone or cables other than the one being worked on), they shall be protected to avoid damage. Before cutting into a cable or opening a splice, the cable shall be identified and verified to be the proper cable and deenergized. When working on buried cable or on cable in manholes, metallic sheath continuity shall be maintained by bonding across the opening.

3.9 Energized Substations

When working in an energized substation, authorization shall be obtained prior to commencement of work. Extraordinary caution shall be exercised in the handling of busbars, tower steel, materials and equipment near energized facilities. Work on or adjacent to energized control panels shall be performed by qualified personnel. Precautions shall be taken to prevent accidental operation of relays or other protective devices due to jarring, vibration or improper wiring. All mobile cranes shall be effectively grounded when being moved or operated near energized lines or equipment or the equipment shall be considered energized.

When a substation fence must be expanded or removed, a temporary fence affording similar protection shall be provided. Adequate interconnection with ground shall be maintained between the temporary and permanent fences. All gates to all unattended substations shall be locked at all times.

3.10 Use of Portable Space Heaters

CFR Title 41 Part 102-74.190 prohibits the use of portable heaters in government-controlled facilities unless authorized by the federal agency building manager. Portable heating devices shall only be used to accommodate employees with diagnosed medical conditions or to supplement inadequate base building heating systems. See the EPA's guidance on personal electronic devices for more information.

Where a heater is approved, the heater shall meet the following requirements:

- The heater is approved or listed by the American Gas Association, UL or other nationally recognized testing authority.
- The heater contains at least two wattage settings, thermostat control, and safety switches that turn the heater off when tilted too far or overheated.
- The heaters should have a guard around the heating element, such as a wire grill to protect fingers, or fabrics from touching the element.
- The branch circuit carrying the heater conforms with requirements of NFPA 70, as applicable.
- Combustion space heaters are directly vented to the outside by a flue to avoid the contamination of the occupied space with combustion gases.
- Portable liquid-fueled space heaters shall not be used in EPA-occupied spaces.
- All heaters are installed in accordance with manufacturer requirements and with the involvement of the facility owner and the EPA Safety, Health and Environmental Management Program (SHEMP) Manager.

In addition, use of the heater shall conform with safety tips recommended by the U.S. Consumer Product Safety Commission in the publication titled *Reducing Fire Hazards for Portable Electric Heaters, CPSC Publication #098*, including:

- Before using, be sure to read and understand instructions for operation and maintenance of the heater. Maintain the heater in good operating condition.
- Place the heater on a solid, level surface.
- Keep combustible materials at least 3 feet from the heater.
- Do not use extension cords or power strips. Plug all personal devices directly into a wall outlet.
- Do not run the heater cord (or any electric cord) under rugs or carpets.

- Do not operate the heater unattended.
- To avoid potential electrical shock and/or electrocution, never place heaters near water or handle heaters when wet.
- Never use the heater as a means to dry clothes or thaw frozen water pipes.

4. Hazardous Materials Management and Laboratory Safety

4.1 Purpose

This chapter describes the management of hazards in laboratories and hazardous material storage areas at EPA facilities. Specific topics discussed in this chapter include guidance on establishing a written safety and health program, safe handling and storage of chemicals and hazardous materials, emergency eyewash and shower equipment, laboratory ventilation, and radiation safety.

4.2 References

These guidelines comply with the Occupational Safety and Health Administration's (OSHA) 29 CFR 1910, Occupational Safety and Health Standards. Unless otherwise specified, the safety features of laboratories and chemical storage areas shall conform to the applicable requirements of NFPA standards and other cited references in Appendix A.

4.3 Safety and Health Programs

All EPA facilities shall maintain written safety and health programs in accordance with the EPA SHEMP Guidelines and OSHA's 29 CFR 1910, Occupational Safety and Health Standards.

Facilities with employees who engage in work requiring the use or management of hazardous chemicals shall develop a chemical handling and storage program as part of the safety and health program. See EPA SHEMP Guideline 23, *Chemical Handling and Storage*, for requirements to develop program components, including:

- Hazard communication program that establishes policy, procedures and responsibilities for disseminating information to employees on the safe handling of hazardous chemicals (29 CFR 1910.1200).
- Chemical hygiene plan that defines work practices and procedures to help ensure that laboratory workers are protected from health hazards associated with the hazardous chemicals (29 CFR 1910.1450).
- Personal protective equipment program that protects employees from workplace hazards in conjunction with safeguards, administrative controls, engineering controls and sound management practices (29 CFR 1910.132).
- Respiratory protection program that includes standard operating procedures governing the selection and use of respirators (29 CFR 1910.134).

A key component of an effective safety and health program is a comprehensive training program. The training program shall be developed in accordance with the EPA SHEMP Guideline 51, *Mandatory Health and Safety Training*, and shall include, but is not limited to, hazard recognition, hazard containment and control measures, hazard assessment, chemical handling and storage, employee personal protection equipment selection and use, respiratory protection (if applicable), and chemical hygiene plans (if duties involve working with chemicals in a laboratory).

4.4 Hazardous Material Storage and Management

Facilities shall be provided with storage for the hazardous materials that are necessary for laboratory or facility operations. Chemical storage areas shall conform to NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* and building and fire prevention code requirements. Storage areas for flammable or combustible liquids (including new and waste chemicals) shall be segregated inside the building in accordance with NFPA 30, *Flammable and Combustible Liquids Code*, and building and fire prevention code requirements, or shall be housed separately in a hazardous materials storage building in accordance with the separation distances specified in NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.

If a room is used for mixed waste-chemical storage, proper segregation shall be provided to prevent mixing of incompatible chemicals. This segregation shall include, but not be limited to, diking provisions between storage areas of incompatible chemicals. Additional requirements specific to different types of hazardous chemicals are listed below.

4.4.1 Compressed Gases

NFPA standards shall be used as a basis for determining requirements. Depending on the type of installation, NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*; NFPA 54, *National Fuel Gas Code*; NFPA 55, *Compressed Gases and Cryogenic Fluids Code*; or NFPA 58, *Liquefied Petroleum Gas Code*, shall be used. The requirements for chemical laboratories are outlined in NFPA 45. In situations not covered by NFPA standards, the Compressed Gas Association publications shall be used as guidelines. Generally, management of compressed gases shall adhere to the following requirements:

- **Cylinder Size and Quantity:** Cylinder size and number permitted within a facility will depend upon system size, room size, room location, construction, room ventilation, cylinder contents and the availability of fire suppression mechanisms. No single flammable gas cylinder or oxygen cylinder shall exceed 220 cubic feet (approximately 10 inches in diameter by 50 inches in length). The amount of compressed gases in storage and use shall not exceed the maximum allowable quantities specified in NFPA 45 and NFPA 55.
- **Cylinder Construction and Use:** All cylinders shall be constructed, charged, shipped and maintained in accordance with applicable U.S. Department of Transportation (DOT) Hazardous Materials Transportation Regulations (49 CFR 171-179) and NFPA 45. Compressed gas cylinders shall be visually inspected by the employer pursuant to 49 CFR 171-179 to ensure that the cylinders under their control are in a safe condition. For instances when DOT inspection requirements do not apply, inspections shall comply with Compressed Gas Association C-1, *Methods for Pressure Testing Compressed Gas Cylinders and Tubes*, and C-8, *Standard for Requalification of DOT-3HT, CTC-3HT, and TC-3HTM Seamless Steel Cylinders*.
- **Pressure Relief Devices:** Compressed gas cylinders, portable tanks, and cargo tanks shall be fitted with pressure relief devices and maintained in accordance with Compressed Gas Association S-1.1, *Pressure Release Device Standards-Part 1-Cylinders for Compressed Gases,* and S-1.2, *Pressure Release Device Standards-Part 2-Portable Containers for Compressed Gases*.
- **Anchoring:** Gas cylinders shall be stored in an upright secure position by a chain, nylon strap, or metal channel assembly attached to a countertop, wall, column, substantial pipe, or similar permanent structure. Cylinders shall not be secured to tables or desks that are not attached to the structure. Cylinder stands attached to or near the base of gas cylinders shall not be used. Cylinders shall not be secured in a manner that limits egress from the storage location.

  Cylinders shall be restrained near or above the center of gravity (about two thirds of its height), but not so high as to allow the cylinder to slide out. In seismic areas, a second strap shall be used below the center of gravity. Cylinders must be secured individually. In a laboratory, cylinders shall not be grouped together with a single strap, though this practice is permissible in storage areas or where gas cylinders are delivered.
- **Supply Lines:** Supply lines leading from high-pressure cylinders shall be securely fastened or anchored every 5 feet to minimize whipping of the line in case of failure of the line and/or fitting. Supply lines shall meet the pressure relief requirements of NFPA 45. To reduce the probability of an inappropriate use, permanent piping and piping which passes through walls shall be labeled at the supply point and each discharge point with the name of the material used.

4.4.2 Cryogenic Gases

For the purposes of this Facilities Safety Manual, cryogenic gases are defined as any substance stored at or below the temperature of -73.3 °C (-100 °F). Above this temperature, the substance exists only as a vapor. The requirements for storage and use of cryogenic materials are as follows:

- The ductility and chemical reactivity of materials must be considered accordingly. When selecting facility-related materials for cryogenic use, refer to the American Society of Mechanical Engineer's *Boiler and Pressure Vessel Code*, Section VII for guidance.
- To reduce the chances of personnel exposures to extreme temperatures, cryogenic materials shall not be stored or used in corridors or other places of routine access by non-involved personnel.
- Vent lines should be routed to the outdoors to preclude a hazardous accumulation of flammable, toxic or inert gas in the work area.

4.4.3 Flammable and Combustible Gases

Flammable gases shall be separated from oxidizing gases (e.g., oxygen, compressed air, chlorine) and from combustible or flammable materials. Flammable-gas containers shall be stored outside the building whenever possible, with the gas piped to the workplace in accordance with NFPA criteria. As a last resort, gas containers shall be located inside the building in a ventilated, fire-resistant room conforming to NFPA standards. Ventilation rates in any room using flammable gas cylinders shall be sufficient to prevent the gas concentration from reaching the lower explosive limit resulting from leakage from one cylinder. See NFPA 55 for required ventilation rates.

4.4.4 Flammable and Combustible Liquids

Flammable liquids and combustible liquids shall be stored and handled in a manner that will reduce the risk of fire and/or explosion. Chemical laboratory requirements for specific quantities of flammable liquids are outlined in NFPA 45 and are based on the classification of the laboratory unit. Flammable/combustible liquids at EPA facilities shall be managed as follows:

- All flammable/combustible liquids shall be stored away from heat and ignition sources in a designated flammable liquids storage room with suitable fire protection, ventilation, spill containment trays, and with equipment satisfying OSHA requirements. Areas for storage shall not be in direct sunlight, on the roof or in the center of the building. The storage room shall have at least one exterior wall.
- Flammable/combustible liquids shall be stored in laboratory cabinets approved by a nationally recognized testing laboratory in accordance with NFPA 30. If testing or evaluation identifies that a health hazard exists from the storage of chemicals in the cabinet and administrative controls are ineffective, venting to the outside atmosphere of the cabinets or the building may be mandated to control the risk.
- All flammable/combustible liquids shall be segregated from other hazardous materials such as acids, bases and oxidizers.
- Storage cabinet contents shall be stored in accordance with the manufacturer's requirements (e.g., no materials stored in the containment sump) and shall not exceed the quantity limits specified by the manufacturer and NFPA 30. The cabinet shall also be free of paper, cardboard and other combustible materials.
- If NFPA Class I flammable liquids are required to be cooled or stored at low temperatures, they shall be stored in a refrigerator, freezer or cooler that meets the requirements of NFPA 45. In general, NFPA 45 requires this equipment to be listed as special purpose units for use in laboratories or listed for Class I, Division 1 hazardous locations (as defined in NFPA 70 Article 500). If the laboratory area in which the refrigerator, freezer, or cooler is located is a Class I hazardous location, the equipment shall be approved for use in Class I, Division 1 or 2 hazardous locations. All refrigerators, freezers or coolers that meet the requirements for storage of NFPA Class I flammable liquids shall be labeled as such.

- Transfer of flammable liquids shall be performed in designated storage areas or over a spill tray in an effective fume hood. Drums shall be electrically grounded and bonded and shall be equipped with pressure relief devices and dead-man valves.
- Safety cans shall be used for amounts less than 2 gallons, and users shall never disable the spring-loaded closure.
- Additional site-specific provisions may be necessary to comply with OSHA 29 CFR 1910.106, *Flammable and Combustible Liquids*, the Chemical Hygiene Plan and the EPA SHEMP Guidelines.
- For information specific to storage and management of hazardous waste and petroleum fuels for compliance with environmental regulations, refer to the EPA Facilities Environmental Manual. For more information regarding design of hazardous material storage areas, refer to the A&E Guidelines.

4.5 Emergency Eyewash and Shower Equipment

Emergency eyewash and shower equipment or combination eyewash/shower units shall meet the American National Standards Institute (ANSI) Z358.1, *Emergency Eyewash and Shower Equipment*, installation, performance, use, testing, maintenance and training requirements. Emergency eyewash and shower equipment must be located in accordance with ANSI Z358.1 for the emergency treatment of the eyes or body of an employee who has been exposed to a hazardous material. A hazardous material is any substance or compound that has the capability of producing adverse effects on the health or safety of employees. ANSI Z358.1 includes the following requirements:

- Emergency eyewash and shower equipment shall be in accessible locations that require no more than 10 seconds to reach at a normal walking speed (no more than 55 feet) from the hazard location.
- Emergency eyewash and shower equipment also shall be located on the same level as the hazard, and the path of travel shall be free of obstructions that may inhibit immediate use. A door is considered an obstruction; however, where the hazard is not corrosive, one intervening door can be present providing (1) it opens in the same direction of travel as the employee attempting to reach the emergency eyewash or shower and (2) the door's closing mechanism cannot be locked to impede access.
- For highly corrosive chemicals, emergency eyewash and shower equipment must be located adjacent to the hazard. The exact distance should be based on professional guidance, and the equipment shall be situated to prevent any hazards (e.g., preventing splashes to exposed electrical conductors).
- Emergency eyewash and shower equipment shall be capable of delivering a continuous supply of flushing fluid for at least 15 minutes at the flow rate specified in ANSI Z358.1. The flushing fluid must be between 16 and 38 °C (60 and 100 °F).

The EPA specifies the following additional requirements for all new installations of emergency eyewash or shower equipment:

- All emergency eyewash and shower equipment shall meet ABA Accessibility Standards.
- The location of emergency eyewash and shower equipment shall be standardized as much as possible to aid in wayfinding for the user.
- At least one emergency eyewash shall be provided for every laboratory room. For larger laboratory rooms, more than one emergency eyewash may be required in accordance with ANSI Z358.1.
- When an emergency shower is located inside a laboratory room, it is preferred that the shower be located near the room entrance on the hinge side of the door. For instrument laboratories and laboratory support spaces, emergency showers should be located in the corridor at the handle side of the laboratory room exit door.
- For new laboratory construction, and to the extent feasible renovations, emergency eyewashes and showers shall be fully plumbed (supply and drain) with tepid potable water. Where appropriate, all supply

piping for an emergency shower should be above the ceiling, except for the showerhead and pull bar connection. Emergency shower floor drains must be plumbed such that waste can be intercepted and isolated for disposal or treatment in a wastewater system. When installation of floor drains in an existing building is not feasible or is cost prohibitive, consult with SOHSD to request a variance.

- In locations where emergency eyewash or shower equipment is required but plumbed-in water or heat is not provided, self-contained units may be allowed upon approval by SOHSD.
- All emergency shower equipment should be installed with activation alarms for each unit where feasible.
- Emergency eyewashes and showers shall be placed in locations away from additional hazard sources (e.g., fume hoods). Discharge from emergency eyewashes and showers shall not impact powered electrical equipment. Emergency showers shall be at least 6 feet away from any electrical devices (e.g., switches, outlets, panels).
- Walls adjacent to emergency showers shall be water- and mold-resistant (e.g., mold-resistant gypsum, paperless gypsum board, coated with a waterproof coating).
- A modesty curtain should be provided at each emergency shower location.

EPA facilities shall activate and flush eyewashes monthly and emergency showers semiannually following the procedures in ANSI Z358.1. EPA facilities shall also inspect all emergency eyewash and shower equipment in accordance with ANSI Z358.1 (1) on an annual basis and (2) after any maintenance or repair activities that affect the eyewash or shower equipment or the associated water supply.

4.6 Laboratory Ventilation

Building HVAC systems must have adequate ventilation capacity to control vapors/gases, odors, and airborne contaminants; permit safe operation of exhaust hoods; and cool the significant heat loads which can be generated in laboratories. General laboratory ventilation cannot be relied on for protection from toxic substances. Exposure control devices, such as laboratory fume hoods, are the primary method of contaminant control in laboratories. For laboratory construction and renovations, the Project Architect/Engineer shall perform a hazard evaluation and risk assessment in accordance with ANSI/American Society of Safety Professionals (ASSP) Z9.5, *Laboratory Ventilation* to determine appropriate exposure control devices and ventilation specifications.

HVAC systems for the sections of laboratory buildings, including corridors, where the laboratory and laboratory support rooms are located shall be dedicated outside air systems supplying 100 percent outside air, with the exhaust directed through fume hoods (where fume hoods are present) and general exhaust ducts. Under no circumstances shall the air supplied to any laboratory space be re-circulated to any other space.

During installation of laboratory ventilation systems, the project team shall follow the steps outlined in the *EPA Performance Requirements for Laboratory Ventilation Systems* to review, inspect and test the systems prior to acceptance. A summary of the steps are as follows:

- Prior to completion of installation and before sealing components behind finished walls or other enclosures that would inhibit inspections, inspect the ventilation system components, including the exposure control devices.
- Verify testing, adjustment and air balancing (TAB) activities are performed in accordance with the TAB Plan.
- Upon substantial completion of TAB for the laboratory ventilation system, conduct laboratory ventilation system commissioning in accordance with the Commissioning Plan.
- Upon substantial completion of laboratory ventilation system commissioning, conduct laboratory environment commissioning and functional performance tests in accordance with the Commissioning Plan.

- Upon substantial completion of laboratory environment commissioning, conduct precursory exposure control device certification tests a representative sample of laboratories to verify proper test methods and performance meets EPA requirements.
- Upon approval of the precursory certification tests, conduct certification tests of all exposure control devices. Certification tests of fume hood systems shall comply with ANSI/ASHRAE Standard 110, ANSI/ASSP Z9.5 and all EPA performance requirements.
- Assemble a Building Airflow Management Plan compliant with ANSI/ASSP Z9.5.

During laboratory operations, the onsite EPA facilities engineering; operations; and environmental, health, and safety staff shall be responsible for ensuring the laboratory ventilation systems and exposure control devices continue to meet the needs of the occupants, provide safe laboratory environments, comply with ANSI/ASSP Z9.5 and meet EPA operating specifications and performance requirements. In accordance with the process outlined in the *EPA Performance Requirements for Laboratory Ventilation Systems* and the standard operating procedures in the facility's Building Airflow Management Plan, the onsite EPA facilities staff along with SOHSD will conduct routine tests (at least annually) of the ventilation systems, laboratory environment, and exposure control devices to verify proper operations. Preventative maintenance activities shall be coordinated with routine/annual tests to help improve reliability of system performance.

If certain areas of the laboratory or exposure control devices are to be turned off, the local EPA SHEMP Manager must empty, decontaminate and properly label ("tag out") the decommissioned laboratory or exposure control device, so no user operates or enters a potential hazardous situation. SOHSD must be notified of all decommissioned laboratories and exposure control devices. Under no circumstance shall fume hoods be used for long-term storage in lieu of proper storage cabinets.

For details on laboratory ventilation design, construction, and operations, refer to the A&E Guidelines and the *EPA Performance Requirements for Laboratory Ventilation Systems*.

4.6.1 Laboratory Fume Hoods

Fume hoods are an integral part of a laboratory ventilation system and are considered primary hazard control devices for personnel working with hazardous substances in laboratories. All laboratory fume hoods in EPA facilities shall comply with NFPA 45, ANSI/ASSP Z9.5, the A&E Guidelines and the *EPA Performance Requirements for Laboratory Ventilation Systems*.

In addition, facility managers and laboratory personnel shall understand and comply with the following general operating and maintenance rules regarding fume hoods:

- **Fume Hood Operation:** The hood exhaust fans shall remain in operation at all times when hoods are in use and for a sufficient time thereafter to clean the hoods of airborne hazardous substances. Hood face velocity will meet the *EPA Performance Requirements for Laboratory Ventilation Systems*. SOHSD will consider requests to operate hoods at other settings after careful design control considerations and risk assessments demonstrate safe use. Any request for a lower operating average face velocity must include information on the performance of the hood at lower operating velocities, the location of the hood and the type and location of ceiling supply air diffusers. Fume hood sashes shall be closed at all times except when performing work or adjusting apparatus inside the hood. Hoods and exhaust ducts shall be checked before each use to ensure the hood is cleared of foreign objects. Any apparatus placed in the hood shall be placed on the floor of the hood at least 6 inches away from the front edge to maintain sufficient ventilation.
- **Allowable Uses:** Fume hoods shall not be used as chemical storage units. Fume hoods also shall not be used as disposal units for hazardous substances. Chemicals are not to be disposed of through evaporation unless vapors are trapped and recovered for proper disposal.
- **Fume Hood Performance:** Fume hoods shall be tested (e.g., as-manufactured, as-installed, and annually) following the process outlined in the *EPA Performance Requirements for Laboratory Ventilation Systems*

and the standard operating procedures in the facility's Building Airflow Management Plan to ensure operating parameters are met. When performance of existing hoods is unsatisfactory, the local EPA SHEMP Manager shall notify EPA stakeholders, implement proper safety measures immediately to protect personnel, and notify RPSD and SOHSD's fume hood subject matter expert. Personnel shall be aware of emergency shutdown procedures to reduce vapor generation in cases of hood failure. Emergency Shutdown Procedures shall include shutdown operations, vessel or container closure, hood sash closure, and proper facility notifications.

4.6.2 Flammable Liquid and Chemical Storage Rooms

The inside storage areas for hazardous chemicals and flammable liquids should be vented to the outside atmosphere by a mechanical exhaust system that meets NFPA 30 criteria, including:

- Exhaust shall be taken from within 12 inches of the floor a wall opposite from the makeup air inlet, which shall also be within 12 inches of the floor, such that ventilation is achieved across all floor areas and flammable vapors do not accumulate.
- If ducts are used for the ventilation system, they shall not be used for any other purpose and must comply with NFPA 91. Exhaust must not be vented into a fume hood or its associated exhaust system.
- The ventilation rate must be at least 1 cubic foot per minute of exhaust per square foot of floor area, but not less than 150 cubic feet per minute.

4.6.3 Hazardous Material Storage Cabinets

Storage cabinets used for hazardous material, chemical or flammable storage must be appropriate for their intended use (e.g., acid/corrosive storage, pesticide storage, flammable storage).

Hazardous material storage cabinets **shall not** be vented, unless required by local fire code or to address a specific health hazard/exposure risk for which administrative controls are determined to be ineffective. Under-the-hood hazardous/flammable storage cabinets may be ventilated through the fume hood per the manufacturer's design.

If ventilation of a storage cabinet is required, the cabinet shall be vented by a mechanical exhaust system that meets NFPA 91. Vented cabinets shall also meet the following requirements:

- The ventilation rate shall be determined on a case-by-case basis and based on risk and space requirements.
- Air shall be supplied at the top of a cabinet, exhausted from the bottom, and swept across all the shelves.
- Cabinet vent openings shall incorporate a flame arrestor.
- If a separate exhaust fan is used, it must be roof-mounted, spark proof and weatherproof.
- The cabinet exhaust must not be vented directly into a fume hood (i.e., the cabinet exhaust must not be routed into the fume hood sash opening or through the fume hood casing). Cabinet exhaust may be connected and vented through a fume hood's associated exhaust system as manufactured and designed. The ventilation system and its components must be compatible with the materials stored in the cabinet.

Hazardous Chemical Storage Cabinets

Laboratory cabinets (e.g., under the hood storage cabinets) used for hazardous chemical storage must be appropriate for their intended use (e.g., acid storage vs. pesticide storage). Standard cabinets/casework/storage shelves shall not be used for hazardous chemical storage unless physically compatible with the chemicals being stored.

Ignitable Liquid (Flammable or Combustible) Storage Cabinets

In addition to the requirements above, storage cabinets for ignitable liquids (flammable or combustible) that are required to be vented shall meet the following additional requirements:

- The ventilation system design, including the location of vent discharge, shall meet NFPA 30, as well as the recommendations discussed in NFPA 30 Annex A. The vent systems (e.g., tubing or piping) shall be fire-rated in accordance with NFPA 30 unless other methods of protecting the fire integrity of the vent openings are provided. Means of achieving this protection may include thermally actuated dampers and/or sufficiently insulated vent tubing.
- Ducting shall be rigid steel tubing with a diameter no smaller than the cabinet opening.
- A fan with non-sparking blades and a shroud which exhausts directly to the outside shall be used.
- The total local exhaust duct length shall not exceed 25 feet.

4.7 Radiation Safety

For EPA laboratories that use radioactive materials and/or radiation producing devices, a Radiation Safety Program must be developed and implemented in accordance with the EPA SHEMP Guideline 38, *Radiation Safety and Health Protection Program*. The program shall assure that levels of EPA workers' exposures to radiation are "as low as reasonably achievable." The basic elements of the Radiation Safety Program include dose monitoring and control, training, recordkeeping, standard operating procedures, and emergency response plans.

As part of a Radiation Safety Program, the work practices related to radioactive materials shall ensure compliance with the radiation exposure limits in 10 CFR 20. Radiation safety measures shall comply with all applicable codes and standards. Refer to the EPA Facilities Environmental Manual for information on managing radioactive materials and disposing of radioactive waste.

For EPA laboratories containing equipment and devices that produce ionizing (e.g., x-ray machines) and nonionizing (e.g., lasers, microwaves, and ultraviolet [UV] lamps) radiation, operation of these devices requires stringent physical and administrative controls to prevent overexposure to operating and support personnel and those in adjacent work areas. The following sections describe the hazards associated with some of these devices and the engineering controls to be considered during their design and installation.

4.7.1 X-Ray Machines

Sources of exposure to radiation from X-ray machines include the primary beam, leakage of primary beam through cracks in shielding, diffracted beams, as well as radiation generated by rectifiers in the high beam voltage power supply. Severe burns can result from exposures of the hands, arms, or eyes to the direct or diffracted beams. Installation of non-medical x-ray equipment shall comply with the EPA's *Safety Guidelines for the Installation and Operation of X-Ray Generating Equipment at EPA Facilities* and NFPA 70, Article 660. Analytical x-ray equipment shall be equipped with engineering controls as follows:

- **Safety Devices:** Devices that prevent the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path must be provided on all open-beam configurations. Failsafe interlocks on all protective barriers of the unit needed to meet the 0.25 milliRoentgen per hour (mR/h) limitation. Interlocks shall be tested at least annually.
- **Shielding:** Shielding adequate to reduce the exposure rate at 5 centimeters from any accessible surface to less than 0.25 mR/hr for normal operations shall be provided.
- **Warning Devices:** Open-beam configurations must be labeled so that their purpose is easily identified and must have fail-safe characteristics. In addition, they shall be provided with a readily discernible indication of:
  - **X-ray Tube Status:** Whether the tube is on or off; located near the radiation source housing, if the primary beam is controlled in this manner.

  - **Shutter Status:** Whether the shutter is open or closed; located near each port on the radiation source housing, if the primary beam is controlled in this manner.

- **Ports:** Unused ports on radiation machine source housings must be secured in the closed position in a manner which will prevent casual opening.
- **Labeling:** The system shall bear a label "Caution: This equipment produces X-rays when energized – to be operated only by qualified personnel," or the equivalent.
- **Shutters:** On open-beam configurations, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.
- **Warning Lights:** A warning light of adequate size and brightness labeled with the words "X-RAY ON" shall be located near any switch that energizes x-ray tube and must be illuminated only when the tube is energized. Warning lights must have fail-safe characteristics.

4.7.2 Lasers

Safety concerns with lasers include eye and skin damage, electrical hazards from high-energy power sources, chemical exposure, fire/explosion hazards, and exposure to cryogenic materials such as hydrogen and oxygen. Many lasers emit invisible UV or infrared radiation. Additional information and guidance regarding fire and explosion hazard mitigation is provided by NFPA 115. Lasers are classified into four basic categories:

- Class I. Lowest power lasers that do not emit hazardous levels.
- Class II. Low-power lasers that pose a hazard only if viewed directly for extended periods.
- Class III. Medium-power lasers that pose moderate risk and can cause injury.
- Class IV. High-energy, high-risk lasers that can cause injury to the eyes and skin from direct or diffused reflection.

Engineering controls shall be included when designing and installing laser equipment to provide for safety. In most instances, engineering controls are included on the equipment as provided by the laser manufacturer because of the performance requirements mandated by the Federal Laser Product Performance Standard. The following engineering controls recommended in ANSI Z136.1, *Safe Use of Lasers*, shall be considered:

- Protective housing
- Master switch controls
- Optical filter interlocks
- Beam stops or attenuators
- Laser activation warning systems
- Interlocked service access panels
- Remote interlock connectors

4.8 Ultraviolet Lamps

EPA laboratories may have a variety of artificial sources of UV radiation, including biological safety cabinets, germicidal lamps, UV-transilluminators (UV light boxes) and crosslinkers. The effect of UV radiation overexposure depends on UV dosage, wavelength, portion of body exposed and the sensitivity of the individual. Overexposure of the eyes may produce painful inflammation, a gritty sensation and/or tears within 3 to 12 hours. Overexposure of the skin will produce reddening (i.e., sunburn) within 1 to 8 hours.

Adequate eye and skin protection are essential when working around UV radiation. In addition, engineering controls shall be included when installing UV equipment to ensure safety, including:

- Containing or confining UV radiation to a restricted area when practicable.
- Containing UV radiation with opaque materials, such as cardboard or wood. Transparent materials, such as glass, polyvinyl chloride, plexiglass and acrylic, block UV radiation in varying degrees. Generally, carbonated plastics provide adequate UV protection. Some kinds of clear glass (including some kinds of window glass and optical glass) transmit significant amounts of UV-A radiation.
- Providing interlocked access to high-power UV sources, so they are shut off when the protective enclosure is open.

5. Indoor Air Quality

5.1 Purpose

The purpose of this chapter is to describe general strategic planning and maintenance activities for facility indoor air quality (IAQ). Specific topics covered by this section include guidance on preventing, identifying and correcting IAQ problems.

Unless otherwise approved by RPSD and SOHSD, all ventilation system installations shall conform to the applicable requirements in the A&E Guidelines and *EPA Performance Requirements for Laboratory Ventilation Systems*.

5.2 IAQ Management Plans

High quality IAQ is an important component of a healthy workplace environment, contributing to the productivity, comfort and well-being of all employees. Indoor air must be free of significant odors, dust, and contaminants and must be circulated at an acceptable rate. Facility IAQ shall be maintained at the best practical level employing the most current knowledge and proven technologies that are cost effective and consistent with the normal function of the EPA laboratory facility and/or office.

The majority of IAQ problems can be prevented by utilizing effective building design, operation practices and facility IAQ maintenance programs. For construction projects, the Construction Contractor is required to develop a Construction Indoor Air Quality Management Plan in accordance with the A&E Guidelines. To reduce indoor air contaminants from ongoing operations and maintenance activities, each facility shall develop an IAQ Management Plan. SOHSD can provide a template for facilities that have not already developed an IAQ Management Plan.

5.3 Sources of Airborne Contaminants

Indoor air contaminants can originate from sources outside or inside of the building. If the source of contamination is outside, the introduced air may need to be filtered or cleaned prior to distributing into a building. Contaminated inside air may need to be exhausted. This section discusses the sources of contaminants which may affect the workplace environment.

Table 5-1: Common Indoor Air Contaminants

Contaminant	Sources	Acute Health Effects
Radon	Seepage from building foundation	No acute health effects are known but chronic exposure may lead to increased risk of lung cancer from alpha radiation
Carbon dioxide	Metabolic human activities	Difficulty concentrating, drowsiness, increased respiration rate
Carbon monoxide	Tobacco smoke, incomplete combustion, automobile traffic	Dizziness, headache, nausea, cyanosis, cardiovascular effects, and death
Ozone	Automobile exhaust, copy machines, electrostatic air cleaners	Eye, respiratory tract, mucous membrane irritation; aggravation of chronic respiratory diseases
Formaldehyde	Off-gassing from foam insulation, plywood, particle board, and paneling	Hypersensitive or allergic reactions; skin rashes; eye, respiratory and mucous membrane irritation; odor annoyance
Volatile organic compounds	Carpeting, cleaning solvents, lacquers and paints, adhesives	Nausea; dizziness; eye, respiratory tract, and mucous membrane irritation; headache; fatigue
Microorganisms	Air handling system condensate, damp organic material, porous wet surfaces	Hypersensitivity diseases, Legionellosis

5.3.1 Outdoor Sources

Outdoor sources of pollution include adjacent and nearby stationary pollution sources such as exhausts from other research facilities or commercial buildings (e.g., dry cleaners, restaurants), roadways, parking lots, loading docks, trash storage, and garages.

Previous uses of the property can affect IAQ. Properties with contaminated soil and groundwater may emit volatile organic compounds which can seep into a building. Examples of potentially significant prior uses are wood preservation and treatment; solid or hazardous waste handling, storage, treatment, or disposal; dry-cleaning processes; leather, paint, or chemical manufacturing; refrigerated storage; gasoline storage or dispensing; and agriculture. Even nearby building demolition can result in significant site contamination through release of building materials such as asbestos into air or soil. Prior to developing a new site, the EPA will conduct pre-development investigations in accordance with the A&E Guidelines and the agency's Environmental Due Diligence Process to evaluate the environmental impacts of past uses of the property.

5.3.2 Indoor Sources

Building layout, construction materials, furnishings, operations and maintenance activities such as cleaning and pest management, and occupant activities may affect IAQ in an EPA facility. Table 5-2 includes examples of potential indoor sources of air contaminants.

Table 5-2: Potential Indoor Sources of Air Contaminants

Construction Materials and Furnishings	Operations, Maintenance and Occupant Activities
• Architectural paints, coatings and primers • Adhesives • Sealants and caulking • Insulations: thermal, fire, and acoustic • Composite wood products (e.g., particleboard, waferboard, medium-density fiberboard) • Ceiling tiles • Floor coverings (e.g., carpet) • Wall coverings	• Lubricants • Janitorial cleaning products • Pesticides • Fungicides • Laboratory chemicals/wastes • Dust • Pollen • Perfumes/fragrances • Standing water, water leaks/floods

5.4 IAQ Investigations

IAQ issues are often identified through occupant concerns. IAQ concerns must be addressed as soon as they are identified to prevent the problem from compounding. Successful investigation of IAQ problems requires the cooperation of the building contractors, EPA employees, other occupants (if the EPA shares the building with other tenants), managers and investigators. The general process for investigating and mitigating an IAQ issue is:

- **Initial Walkthrough:** Conduct a visual inspection and discuss with occupants to determine if there is a reason for the complaint.
- **Problem Investigation:** Observe occupant activities, inspect HVAC systems, determine pollution pathways, and search for pollutant sources as needed to develop hypotheses about the source of the IAQ problem.
- **Hypothesis Testing:** Manipulate building conditions or conduct testing.
- **Implementation of Control Strategy:** Implement changes expected to mitigate the IAQ problem.
- **Verification:** Conduct follow-up surveys and walkthroughs to confirm the changes have resolved the IAQ problem.

Refer to *Building Air Quality: A Guide for Building Owners and Facility Managers* for additional guidance for investigating IAQ concerns.

5.5 Mitigating IAQ Problems

Successful prevention and mitigation of IAQ problems can involve a combination of strategies, including source control, ventilation controls, and proper operation and maintenance of HVAC systems. These strategies must be applied during building design, construction, and operations and maintenance. IAQ problem mitigation also requires the cooperation of building occupants; therefore, all occupants should be educated about the causes of IAQ problems and about the actions that must be taken or avoided to prevent and solve IAQ problems.

5.5.1 Source Control

The most effective means of indoor air quality control is to eliminate, reduce or contain the sources of indoor air contaminants. Effective source control requires that potential sources be clearly identified and addressed. Section 5.4 above discusses common sources of outdoor and indoor air contaminants.

To control exterior sources of pollution, the HVAC system's outside air intake shall be located to provide the cleanest possible source of fresh air for the building. Placement must consider the location of pollution sources (e.g., traffic exhaust, industrial processes, building exhausts and vent stacks), as well as temporal and spatial variations in wind direction and velocity. Adjacent buildings may affect wind patterns causing re-entrainment of the facility's own exhausts. Refer to the A&E Guidelines for HVAC design requirements.

Approaches to control internal sources of indoor pollutants are thoughtful building design, careful material selection, and isolation and management of contaminant-generating activities. All products and materials selected for use during building construction, operations, and maintenance must be reviewed and evaluated for the potential to emit or off-gas toxic or irritating chemicals in the facility. These include HVAC system components, insulation, sealants, finish materials, furnishings, lubricants, janitorial cleaning products, among others. Upon adequate review and evaluation (e.g., safety data sheets, specification sheets), the EPA reserves the right to disallow installation and/or use of a given product or material in any EPA facility.

5.5.2 Ventilation Controls

Outside Air Ventilation

Ventilation is often used to correct or prevent indoor air quality problems. HVAC systems must be designed to provide outside air in accordance with ASHRAE Standard 62.1.

Air Cleaning

The building automation system must be programmed to select the most cost-effective mix of air cleaning, outside air supply, and recirculated air based on the thermal properties and contaminant contents of the outside air and return air relative to design conditions.

Where outdoor air pollutants exceed National Ambient Air Quality Standards (included in ASHRAE Standard 62.1 Informative Appendix E, Table E-1), air-cleaning devices (e.g., scrubbers) may be required. This may involve the provision of air cleaning beyond the usual panel type particulate filters currently used in most commercial buildings. However, precipitators, absorbers, and scrubbers should be avoided because of their high maintenance costs. Where these systems are proposed, a cost/benefit study must be submitted.

Air Distribution

This method of indoor contaminant control presents a large potential for significant improvement in ventilation efficiency and, thereby, in indoor air quality. Poor ventilation efficiency results in deterioration of indoor air quality and increased operational costs. A written description of the approach and calculations illustrating ventilation efficiency must be completed by a design professional knowledgeable in HVAC system design. An Air Distribution Performance Index of at least 80 percent is required for office spaces. Ceiling plenums may be used for return air provided that sufficient return dampers and duct headers are provided to permit accurate air balancing and

provided that all code wiring provisions are followed for smoke and fire safety. Refer to the A&E Guidelines for HVAC efficiency design considerations for office space and laboratories.

Flush Out

A flush out shall be employed to mitigate IAQ problems after the installation of new building materials or furnishings. Though most building materials and furnishings are selected to minimize emissions, there may be some materials that off-gas organics and vapors over a period of time after installation. The main purpose of the flush out is to remove chemical emissions from materials in the building prior to occupancy.

The flush out procedures shall be included in the Construction Indoor Air Quality Management Plan and shall include tests on the HVAC system(s) to determine the maximum amount of outside air the system(s) can deliver while adequately controlling indoor temperature and humidity levels. Flush outs are conducted after interior finish installations, punch-list items, cleaning and HVAC TAB are complete. The flush out is achieved by ventilating the space with a sufficient volume of air, while maintaining appropriate temperature and humidity controls in accordance with LEED for Building Design and Construction: New Construction v4.1 "Indoor Air Quality Assessment" credit (regardless of whether the project is pursuing LEED certification).

Depending on the HVAC system and outdoor temperature and humidity levels, a flush out may add several days to weeks to the construction schedule and delay occupancy. The flush out must be carefully planned and conducted to avoid adverse effects on building components and equipment.

In lieu of flush out procedures, testing for specific indoor air quality contaminants could be conducted, with concurrence from SOHSD and RPSD.

5.5.3 Operation and Maintenance

Proper operation and maintenance of the facilities and their HVAC systems are critical to maintaining good IAQ. HVAC systems must be designed to allow for maintenance, frequent inspection and cleaning of surfaces exposed to the airstream. Explicit assumptions regarding operation and maintenance must be made during design and must be documented in a facilities operation manual. They must reflect a clear intent to maintain indoor air quality at the highest practicable level. EPA facilities shall institute and document a maintenance program to ensure that designed HVAC performance levels are maintained. This program, at a minimum, shall address periodic:

- Filter cleaning and replacement.
- Cleaning and maintenance of the HVAC duct, coil, condensate drip pan and air-handler room.
- Biological testing, or biocide monitoring, of the water in cooling towers and condensate drip pans.
- Performance testing, including, but not limited to, fan efficiency, air distribution, and amount of outside air.
- Training of operations and maintenance personnel, as well as occupants, in HVAC operations.

Refer to *Building Air Quality: A Guide for Building Owners and Facility Managers* for a model HVAC maintenance program.

5.6 Acceptable Workplace Temperature and Humidity

General indoor air complaints can often be reduced by maintaining proper indoor air temperature. The type of work activity, age, and physiology of employees must be considered when determining a comfortable indoor temperature for the workplace environment. Facility indoor air temperature should range according to the season and employee comfort. Facility temperature should be uniform throughout, and HVAC systems must be designed to prevent air stratification. Refer to ASHRAE Standard 55*, Thermal Environmental Conditions for Human Occupancy* and the A&E Guidelines for specific design requirements for HVAC systems and facility indoor air temperature.

Moisture control is also important to prevent and control IAQ problems. Indications that a building may have a moisture problem include a musty odor; a damp clammy feeling to one's skin when entering; mold growing in corners and on walls; or condensation on walls, the inside of windows, or pipes. Possible health effects and symptoms associated with human exposures to mold spores include allergic reactions, asthma and other respiratory complaints. In some cases, severe reactions can occur to overexposure to molds; and in excessively damp environments, some molds may produce mycotoxins.

HVAC systems must be designed to minimize conditions of accumulated moisture that, together with warmth and darkness, encourage the growth of microorganisms. For HVAC design requirements for humidity control, refer to the A&E Guidelines and ASHRAE Standard 62.1.

Facility managers must take steps to address building facilities that have been damaged by moisture. For example, drywall that has retained more than 20 percent moisture after 48 hours or that has evidence of mold shall be replaced. Water-damaged furniture and wet paper products shall be disposed, and wet non-porous surfaces shall be cleaned with a sodium hypochlorite bleach solution or a biocide to prevent microbial growth.

Appendix A: Required Regulations, Codes, Standards and References

This appendix includes a list of required regulations, codes, standards, references and guidance. Citations of regulations, codes, standards, references and guidance within this manual shall be assumed to refer to the most recent edition. Any publication dates specifically stated in this manual reflect the version in use when this manual was published. When using this Facilities Safety Manual, the user shall verify that the documents referenced are the most recent and have not been superseded. In cases of conflict between codes, standards or other requirements, the most stringent, technically appropriate criteria shall apply. Where it is unclear which set of requirements is applicable, consult SOHSD for direction.

- American Conference of Governmental Industrial Hygienists
  - *Industrial Ventilation, A Manual of Recommended Practice for Design*
  - *Industrial Ventilation, A Manual of Recommended Practice for Operation and Maintenance*
- American National Standards Institute
  - Z136.1, *Safe Use of Lasers*
- American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers
  - Standard 15, *Safety Standard for Refrigeration Systems*
  - Standard 55, *Thermal Environmental Conditions for Human Occupancy*
  - Standard 62.1, *Ventilation and Acceptable Indoor Air Quality*
  - Standard 110, *Method of Testing Performance of Laboratory Fume Hoods*
- American National Standards Institute/American Society of Mechanical Engineers
  - A17.1, *Safety Code for Elevators and Escalators*
- American National Standards Institute/American Society of Safety Professionals
  - Z9.2, *Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems*
  - Z9.5, *Laboratory Ventilation*
- American National Standards Institute/Health Physics Society
  - N43.3, *General Radiation Safety – Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources for Energies Up to 10 MeV*
- American National Standards Institute/International Safety Equipment Association
  - Z358.1, *Emergency Eyewash and Shower Equipment*
- American National Standards Institute/NSF International
  - 49, *Biosafety Cabinetry: Design, Construction, Performance, And Field Certification*
- American Society of Heating, Refrigerating and Air-Conditioning Engineers
  - *Handbook—Fundamentals*
  - *Handbook—HVAC Systems and Equipment*
  - *Handbook of Smoke Control Engineering*

- Code of Federal Regulations
  - 10 CFR Part 20, Standards for Protection Against Radiation
  - 29 CFR Part 1910, Occupational Safety and Health Standards
  - 29 CFR Part 1960, Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters
  - 41 CFR Part 102, Federal Management Regulations
  - 49 CFR Parts 100-181, Pipeline and Hazardous Materials Safety Administration, Department of Transportation
- Compressed Gas Association *Handbook of Compressed Gases*
- Institute of Electrical and Electronics Engineers C2, *National Electrical Safety Code*
- Insurance Services Office Fire Suppression Rating Schedule
- International Code Council
  - A117.1, *Accessible and Usable Buildings and Facilities*
  - International Building Code
  - International Energy Conservation Code
  - International Existing Building Code
  - International Fire Code
  - International Mechanical Code
  - International Plumbing Code
- National Fire Protection Association
  - 1, *Fire Code*
  - 3, *Standard for Commissioning of Fire Protection and Life Safety Systems*
  - 4, *Standard for Integrated Fire Protection and Life Safety System Testing*
  - 10, *Standard for Portable Fire Extinguishers*
  - 12, *Standard on Carbon Dioxide Extinguishing Systems*
  - 13, *Standard for the Installation of Sprinkler Systems*
  - 14, *Standard for the Installation of Standpipe and Hose Systems*
  - 15, *Standard for Water Spray Fixed Systems for Fire Protection*
  - 17, *Standard for Dry Chemical Extinguishing Systems*
  - 17A, *Standard for Wet Chemical Extinguishing Systems*
  - 20, *Standard for the Installation of Stationary Pumps for Fire Protection*
  - 22, *Standard for Water Tanks for Private Fire Protection*
  - 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*
  - 25, *Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems*
  - 30, *Flammable and Combustible Liquids Code*

- 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*
- 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*
- 45, *Standard on Fire Protection for Laboratories Using Chemicals*
- 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*
- 54, *National Fuel Gas Code*
- 55, *Compressed Gases and Cryogenic Fluids Code*
- 58, *Liquefied Petroleum Gas Code*
- 68, *Standard on Explosion Protection by Deflagration Venting*
- 70, *National Electrical Code*
- 72, *National Fire Alarm and Signaling Code*
- 75, *Standard for the Fire Protection of Information Technology Equipment*
- 76, *Standard for the Fire Protection of Telecommunications Facilities*
- 80, *Standard for Fire Doors and Other Opening Protectives*
- 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*
- 88A, *Standard for Parking Structures*
- 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*
- 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*
- 92, *Standard for Smoke Control Systems*
- 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*
- 101, *Life Safety Code*
- 110, *Standard for Emergency and Standby Power Systems*
- 111, *Standard for Stored Electrical Energy Emergency and Standby Power Systems*
- 115, *Standard for Laser Fire Protection*
- 150, *Fire and Life Safety in Animal Housing Facilities Code*
- 214, *Standard on Water-Cooling Towers*
- 220, *Standard on Types of Building Construction*
- 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*
- 232, *Standard for the Protection of Records*
- 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*
- 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*
- 400, *Hazardous Materials Code*
- 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*
- 750, *Standard on Water Mist Fire Protection Systems*

  - 770, *Standard on Hybrid (Water and Inert Gas) Fire-Extinguishing Systems*
  - 780, *Standard for the Installation of Lightning Protection Systems*
  - 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*
  - 855, *Standard for the Installation of Stationary Energy Storage Systems*
  - 914, *Code for the Protection of Historic Structures*
  - 2001, *Standard on Clean Agent Fire Extinguishing Systems*
  - 2010, *Standard for Fixed Aerosol Fire-Extinguishing Systems*
- National Research Council *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*
- Peter S. J. Lees and Morton Corn (1983) *Health, Safety and Environmental Criteria for Siting of Laboratory Facilities*, American Industrial Hygiene Association Journal, 44:4, 286-291
- U.S. Access Board *Architectural Barriers Act Accessibility Standards*
- U.S. Department of Defense (DoD) Unified Facilities Criteria (UFC) (For EPA facilities on Department of Defense Installations)
  - UFC 1-200-01, *DoD Building Code*
  - UFC 3-600-01, *Fire Protection Engineering for Facilities*
  - UFC 3-601-02, *Fire Protection Systems Inspection, Testing, and Maintenance*
  - UFC 4-021-01, *Design and O&M: Mass Notification Systems*
- U.S. Environmental Protection Agency
  - *Building Air Quality: A Guide for Building Owners and Facility Managers*
  - *EPA Performance Requirements for Laboratory Ventilation Systems*
  - *EPA Safety Guidelines for the Installation and Operation of X-Ray Generating Equipment at EPA Facilities*
  - *EPA Safety, Health, and Environmental Management Program Guidelines*
  - *EPA SMD Nationwide Emergency Preparedness Program Guidance*
  - *EPA SMD Best Practices Guidance: Implementing Occupant Emergency Plans in a Hybrid Workplace*
- U.S. General Services Administration PBS-P100, *Facilities Standards for the Public Buildings Service* (select requirements as identified in this Facilities Safety Manual)

Appendix B: Glossary

Unless otherwise noted, the following definitions were developed by using Webster's Collegiate Dictionary, 10th edition; NFPA codes; IBC; and other miscellaneous sources.

Chemical Hygiene Plan	Written plan which sets formal procedures, equipment, personal protection equipment and work practices for protecting personnel from the health hazards presented by hazardous chemicals in a laboratory.
Curtain Wall	A nonbearing enclosure wall not supported at each story.
Ductility	The flexibility of a material or its ability to be shaped into a new form. As related to cryogenics, the ability of a material under the expected operating temperatures to resist fracturing.
Exit	The portion of a means of egress that is separated from other spaces of a building to provide an appropriate level of protection.
Exit Access	The portion of a means of egress that leads to an exit.
Fire Area	The floor area enclosed and bounded by fire walls, fire separation assemblies, or exterior walls of a building to restrict the spread of fire.
Fire-Resistance Rating	The time, in minutes or hours, that materials or assemblies have withstood a fire test exposure as established in accordance with the test procedures of NFPA 251 or another recognized test.
Fire Subdivision	An area of a building separated from all other areas by fire resistive construction.
Floor-Ceiling Assembly	Construction composed of the floor and ceiling below, used as integral components to provide the required fire resistance between occupied levels of a building.
Foot-candle	A unit of illumination, which represents a direct measure of the visible radiation falling on a surface.
Hourly Rating	See fire-resistance rating.
Means of Egress	A continuous and unobstructed way of exit travel from the building or structure to a public way.
Monumental Stairs	Wide, often unenclosed, stairs that are designed more for architectural aesthetics than exit capacity. These are often found in assembly occupancies or historic structures.
Noncombustible Construction	Construction that uses materials that will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.
Off-gassing	The release of vapors (typically volatile organic compounds) to the environment from interior furnishing or finishes.
Panel Wall	A nonbearing wall supported by each story on a skeleton frame. Also referred to as a skeleton wall.

Safety Data Sheet	A document which describes the chemical and physical properties of a chemical and explains the hazards presented to those working with the substance. The safety data sheet aids in establishing a program for the safe and proper handling of the substance in question.
Sash	The glass and frame part installed on the front of a laboratory fume hood that can be raised, opened, and closed.
Spandrel Wall	That portion of a panel wall above the head of an exterior window or door.
Windowless Building or Area	A building, or portion thereof, which lacks a means of direct access to the outside from the enclosing walls or lacks outside openings for ventilation or rescue through windows. See NFPA 101 or applicable building code for criteria to determine if an area is considered windowless. Various exemptions exist for different conditions.

Appendix C: Acronyms and Abbreviations

ABA	Architectural Barriers Act
A&E	Architecture and Engineering
A/E	Architect/Engineer
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASSP	American Society of Safety Professionals
CFR	Code of Federal Regulations
CPSC	U.S. Consumer Product Safety Commission
°C	degrees Celsius
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
GFCI	ground-fault circuit interrupter
GSA	U.S. General Services Administration
HVAC	heating, ventilation and air-conditioning
IAQ	indoor air quality
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
Laser	light amplified by stimulated emitting radiation
mR/h	milliRoentgen per hour
NFPA	National Fire Protection Association
OEP	Occupant Emergency Plan
OSHA	Occupational Safety and Health Administration
PBS	Public Buildings Service
RPSD	Real Property Services Division
SHEMP	safety, health and environmental management program
SOHSD	Safety, Occupational Health and Sustainability Division
SMD	Security Management Division
TAB	testing, adjustment and air balancing

UFC	Unified Facilities Criteria
UV	ultraviolet