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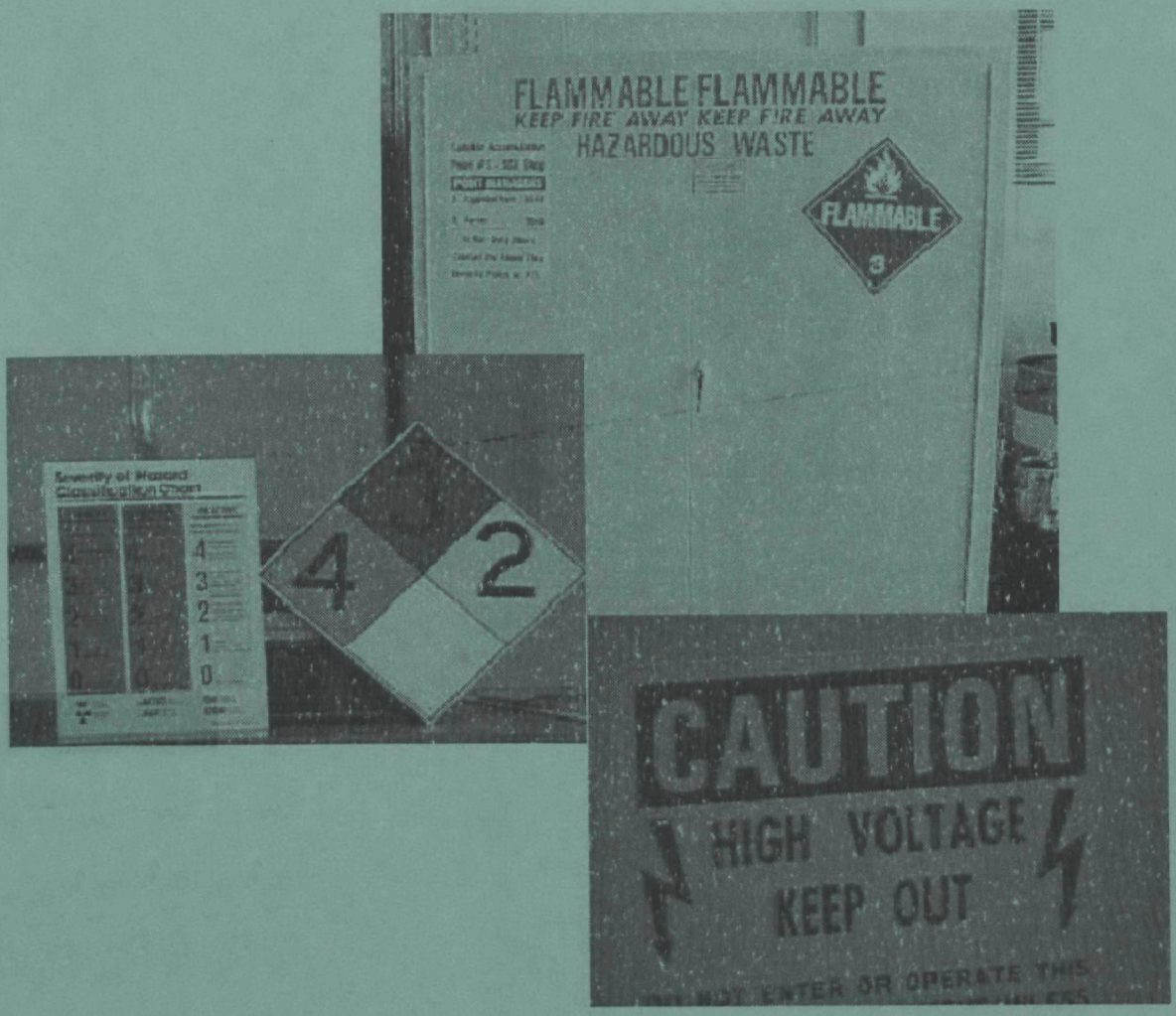
EPA FACILITIES MANUAL, VOLUME 3

Safety, Health, and Environmental Manual:

Safety and Health Requirements



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Foreword

The *EPA Facilities Manual* is comprised of four distinct, yet complementary resources for planning and managing Environmental Protection Agency (EPA) facilities. These four volumes are meant to be used simultaneously to determine design intent, requirements, and the ongoing evaluation of all EPA facilities. The use of one volume without reference to the other three would result in an incomplete understanding of the requirements for EPA facilities.

Volume 1: The *Space Acquisition and Planning Guidelines* contain information on space planning, space estimation, environment, materials, furniture, process, and maintenance. EPA's Office of Administration and Resources Management developed this document to help EPA facilities managers, space managers, and line personnel plan and use their space.

Volume 2: The *Architecture and Engineering Guidelines* (referred to as the *A&E Guidelines*) provide guidance for facilities management, engineering, planning, and architecture professionals in the design and construction of new EPA facilities and the evaluation of existing facilities.

Volume 3: The *Safety, Health, and Environmental Management Manual: Safety and Health Requirements* outlines safety and health considerations for owned or leased EPA facilities. The Manual's goal is to maintain a safe and healthful workplace that protects against injury, illness, and loss of life.

Volume 4: The *Safety, Health, and Environmental Management Manual: Environmental Management Guidelines*, establishes environmental specifications to be addressed by designers and managers of EPA facilities and related building systems.

Safety, Health and Environmental Manual: Safety and Health Requirements

CONTENTS

Chapter 1 - Introduction

1.1 Purpose

The purpose of this Manual is to detail safety and health considerations for facilities that are owned, leased, or occupied by the Environmental Protection Agency (EPA). The considerations or criteria in this Manual describe the full scope of the facility features required in EPA-occupied facilities to maintain a safe and healthful workplace, and may exceed local codes or federal standards, which generally describe minimum requirements necessary to protect against injury, illness, and loss of life. The criteria in this Manual are provided for EPA facilities in order to establish the following objectives:

- Providing reasonable safeguards against injury, occupational illness, and loss of life
- Preventing fire exposure, public health hazards, and environmental damage to the communities that surround EPA facilities
- Preventing loss of government real and personal property
- Preventing interruption of government operations
- Promoting the health, well-being, and productivity of occupants.

1.2 Scope

The facility safety and health criteria described in this Manual apply to facilities owned or leased by EPA, and facilities assigned to EPA by the General Services Administration (GSA) or other government agencies. In this Manual, owned and leased facilities shall be referred to as "EPA facilities." The criteria in this Manual, along with the criteria in the *Architecture and Engineering Guidelines* (*A&E Guidelines*), are mandatory for new construction or new leased space. Where meeting these criteria at existing facilities does not seem feasible, consult the Architecture, Engineering and Asset Management Branch (AEAMB) for advice or a waiver. Under special circumstances, a waiver may be granted by the Safety, Health and Environmental Management Division (SHEMD).

EPA-occupied facilities shall comply with the requirements provided by the EPA, NFPA, Occupational Safety and Health Administration (OSHA), GSA, and state and local building and fire prevention codes. If conflicts exist between state or local criteria and the criteria set forth in this Manual, the more stringent criteria shall apply. If there are conflicts between the local code and a model code, the discrepancy will be brought to the attention of AEAMB and SHEMD for resolution.

1.3 Authority

Authority for the criteria set forth in this Manual is based on the latest approved editions of the following codes, references, and standards. Years and publication dates specifically stated in this Manual reflect the version in use when the revised version of this Manual was written and published. When using the referenced standards listed below, ensure that the latest edition or version is current and has not been superseded.

- Occupational Safety and Health Act of 1970
- 29 CFR Part 1910, General Industry Standards
- EPA manuals, directives, and SHEMD program requirements
- Federal Executive Orders
- GSA, Facilities Standards for the Public Buildings Service (PBS-P100)
- Model building codes, such as the International Building Code (IBC)
- Uniform Federal Accessibility Standards (UFAS).

Appendix A, List of Standards and References, provides a more comprehensive list of the sources mentioned in the Manual. In addition, a glossary is included as Appendix B to facilitate understanding of the terminology used throughout the Manual.

1.4 EPA Responsibilities

This section describes the responsibilities assigned to divisions or departments within EPA for enforcing the criteria set forth in this Manual.

- AEAMB is responsible for ensuring that the design and construction of EPA facilities comply with local codes as well as with the criteria described herein.
- AEAMB and SHEMD are jointly responsible for ensuring that EPA facilities provide safe, healthful, and environmentally sound work spaces for EPA personnel.
- AEAMB and SHEMD are jointly responsible, when appropriate, for reviewing and approving requests for a waiver for variances or exceptions to the criteria set forth in this Manual. The following criteria apply to requests for variances:

  (1) Requests for variances to the criteria described in this Manual must be submitted in writing to AEAMB and SHEMD for review.

  (2) Documentation of granted variances must be maintained by the facility as long as applicable.

- AEAMB and SHEMD are jointly responsible for updating this Manual, as necessary, to reflect changes in technology and recognized standard practices in safety, health, and environmental management relative to EPA facilities.

1.5 Requirements

To meet the policy and objectives set forth above:

- AEAMB, with SHEMD's assistance, will review the criteria set forth in Programs of Requirements (PORs) and Solicitations for Offers (SFOs) for new EPA facilities, and for modifications to existing facilities, before awarding a design contract.

- At significant design and construction points, AEAMB, with SHEMD's assistance, will review, approve, and comment on the design plans and construction drawings for new and modified facilities.

- During construction, a representative acceptable to SHEMD shall inspect the critical safety, health, and environmental management features of a new or modified facility, such as fume hoods, sprinkler systems, and fire alarms, against the design and construction specifications. These features also shall be acceptance-tested against the design and construction specifications prior to occupancy.

- AEAMB, with the assistance of SHEMD, shall inspect and test leased spaces against the criteria contained in this Manual before signing the lease and shall document these criteria in the lease where appropriate.

Chapter 2 - Fire Life Safety

2.1 Purpose

This chapter provides criteria for establishing a fire life safety program at EPA-owned or -leased facilities. This chapter includes guidelines on occupancy classification, fire safety criteria for egress, flammable materials, fire protection systems, automatic sprinkler systems, fire extinguishers, and smoke control.

2.2 References

Unless otherwise specified in this Manual or approved by the Architecture, Engineering and Asset Management Branch (AEAMB) and the Safety, Health and Environmental Management Division (SHEMD), all building materials and structural components and assemblies shall conform to the applicable requirements of the National Fire Protection Association (NFPA) and other safety codes specified below, as well as the design requirements in the *Architecture and Engineering Guidelines (A&E Guidelines)*.

- NFPA 10, Standard for Portable Fire Extinguishers
- NFPA 12, Standard on Carbon Dioxide Extinguishing Systems
- NFPA 13, Standard for the Installation of Sprinkler Systems
- NFPA 14, Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems
- NFPA 17, Standard on Dry Chemical Extinguishing Systems
- NFPA 17A, Standard for Wet Chemical Extinguishing Systems
- NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals
- NFPA 68, Guide for Venting of Deflagrations
- NFPA 70, National Electric Code® (NEC)
- NFPA 72, National Fire Alarm Code®
- NFPA 75, Standard for the Protection of Electronic Computer/Data Processing Equipment
- NFPA 80, Standard for Fire Doors and Windows
- NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Fire Exposures
- NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems
- NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
- NFPA 92A, Recommended Practice for Smoke-Control Systems
- NFPA 92B, Guide for Smoke Management Systems in Malls, Atria, and Large Areas
- NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
- NFPA 101, Life Safety Code®
- NFPA 110, Standard for Emergency and Standby Power Systems
- NFPA 220, Standard on Types of Building Construction
- NFPA 221, Standard for Fire Walls and Fire Barrier Walls
- NFPA 230, Standard for the Fire Protection of Storage

- NFPA 251, Standard Methods of Tests of Fire Endurance of Building Construction and Materials
- NFPA 780, Standard for the Installation of Lightning Protection Systems
- NFPA 1962, Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles
- International Building Code
- ASHRAE manual, *Design of Smoke Control Systems for Buildings*
- ASHRAE's *Handbook of HVAC Systems and Equipment.*

2.3 Classification of Occupancies

Buildings and spaces shall be classified by occupancy to determine 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 Chapter 6 of NFPA 101, Chapter 2 of NFPA 45, Chapter 2 of NFPA 13, other NFPA codes and standards that may apply to specific situations, and local building and fire prevention codes. The basis of these classifications varies with each code or standard. Some of the methods of classification are listed below.

- NFPA 101 classification is based on use of the building or area considered. Examples are business, assembly, and industrial occupancies.

- Model building code classification is based on use of the building or area considered. Examples are Use Group B (business), S-1 (moderate hazard storage), and F (factory and industrial) as defined by the International Building Code (IBC).

- NFPA 13 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 (Group 2).

- NFPA 45 classification is based on the amount of flammable and combustible liquids and liquified flammable gases per floor area present in a laboratory unit. Examples are Class A, Class B, and Class C.

- NFPA 230 classification is based on the type of materials stored and their burning characteristics.

The General Services Administration (GSA) also has a special occupancy classification for high-severity occupancy, which includes storage areas larger than 1,000 square feet with racks or shelves taller than 12 feet, libraries with stacks taller than 9 feet, and record or archive centers with open file shelves. The special design considerations outlined in PBS-P100 must be followed for these occupancies. Further details regarding classification of occupancy can be found in the standards referenced above.

Occupancy classifications shall be clearly identified in design documents, construction documents, as-built drawings and specifications. Since occupancy classifications are specific to the respective codes and standards, all relevant occupancy classifications shall be indicated. For

example, a Class B laboratory as defined by NFPA 45 could be either Use Group B (business) or H (high hazard) as defined by the International Building Code, and an Industrial Occupancy as defined by NFPA 101. The following list could represent the occupancy classifications for a single laboratory project.

NFPA 45	Class B Laboratory
NFPA 101	Industrial
IBC	Business
NFPA 13	Ordinary Hazard (Group 2)
NFPA 10	Ordinary Hazard

If the local building code is not based on the International Building Code, or there are conflicts between the local code and a model code, the discrepancy will be brought to the attention of AEAMB and SHEMD for resolution.

2.4 Types of Construction

Identification of construction classifications is required in order to meet both the local building code criteria and the criteria of EPA, the General Services Administration (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.

The type of construction of an EPA building shall be the one determined to be the most suitable and economical for the occupancy classification and the height and area limitations dictated the local building code. Height and area, including the area of any floor in the building shall not exceed the limits set forth in the local building code. Where more than one occupancy is housed, the higher group classification shall govern for determining area limitations.

2.4.1 BUILDING ELEMENTS

The fire-resistance hourly ratings for building elements shall be determined in accordance with ASTM E 119/NFPA 251. The hourly ratings for various materials and designs shall be obtained either by actual fire testing or by conformance to designs listed by Underwriters Laboratories, Inc., or Factory Mutual.

- Fire Walls and Fire Barrier Walls. Fire barrier walls, also known as fire partitions or fire separations, normally have less fire resistance than do fire walls and fail to meet one or more of the requirements for a fire wall. The fire resistance of a fire barrier wall generally depends on the wall's intended use and the degree of fire potential. These walls are used to create fire areas, protect specialized occupancies, or provide protected egress paths. See Section 13 of the *A&E Guidelines* and NFPA 221 for treatment of openings in fire walls and fire barrier walls.

- Vertical Openings and Shafts. Refer to Section 13 of the *A&E Guidelines*.

- 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. For further details, refer to Section 13 of the *A&E Guidelines*.

- 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.

- Monumental Stairs. Refer to Section 13 of the *A&E Guidelines*.

- Escalators. Refer to Section 14 of the *A&E Guidelines*.

- Elevators. Refer to Section 14 of the *A&E Guidelines* and NFPA 101 for criteria, technical requirements, and specifications.

- Penetrations. Fire stopping shall be provided in all penetrations through walls, partitions, openings between exterior walls and floor slabs, and openings in floors and shaft enclosures, to form an effective fire and smoke barrier between stories and between horizontal compartments. The installation, testing, and rating of fire-stopping materials and methods (through-penetration protection system) shall be in accordance with NFPA 221. The materials used shall be capable of maintaining the fire resistance of the assembly being penetrated. Refer to Section 13 of the *A&E Guidelines*.

- Panel, Curtain, and Spandrel Walls. For details, refer to Section 7 of the *A&E Guidelines*.

- Windows. There shall be no operable windows in EPA laboratory rooms or in other locations where they may interfere with temperature or humidity control or create undesirable airflows. For additional details, refer to Section 8 of the *A&E Guidelines*.

- Ceilings. Floor-ceiling assemblies shall be in accordance with the criteria set forth in Section 9 of the *A&E Guidelines*. Suspended ceilings shall not be considered part of a fire-resistive assembly in laboratory areas. The routine operation and maintenance of laboratories require periodic access to the space above the suspended ceiling. It has been the experience of EPA that a rated floor-ceiling assembly is not a design that can be reasonably maintained as a fire-resistive assembly over the life of the laboratory.

- Fire Doors. Refer to Section 8 of the *A&E Guidelines* and Section 2.9 of this Manual for additional requirements for exit doors.

- 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 assembly has been tested 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.

- 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 NFPA 80A, and the local building code. Requirements for explosion venting should comply with Chapter 5 of NFPA 45 (for laboratories), NFPA 68, and the local building code, whichever is the most stringent. The methods for determining the more stringent requirements shall be documented in the project submittals.

2.4.2 HAZARD SEGREGATION

In general, occupancies posing different levels of risk shall be separated by fire-resistive construction. Areas shall be segregated as noted below and as required by local building codes and NFPA 101.

- Assembly Areas. Because of the high number of occupants permitted in auditoriums, cafeterias, and other places of assembly, it is necessary to provide appropriate protected egress paths from these locations to the outside of the building. Whenever possible, such occupancies shall be located on the exit level of the building, or on a floor close to the level of exit. See NFPA 101, Chapters 12 and 13 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 (VOCs) shall be equipped with adequate exhaust and shall have no air recirculation. In addition, these areas shall meet the requirements for indoor air quality in GSA's PBS-P100. 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 local building code.

- Ancillary Occupancies. Ancillary or accessory occupancies are occupancies that take up approximately 10 percent or less of a building's overall area. Ancillary 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 or intermingled occupancies are areas in which two or more classes of occupancy coexist in such a way that separate safeguards are impracticable. In such cases, the means of egress, construction, protection, and other safeguards shall be based on the occupancy that demands the more stringent requirements.

- Blind Stands and Self-Service Stores. Blind stands and self-service stores shall be separated from the remainder of the building by 1-hour fire-rated enclosures and doors. If the entire floor is protected by automatic sprinklers, fire-rated enclosures are not needed.

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 standard and Section 15 of the *A&E Guidelines*.

- Automatic Sprinkler Systems. All EPA-owned or -leased facilities are required to have sprinkler fire protection unless such protection is not economically feasible with respect to mission-continuity cost or with respect to building and content replacement cost. An analysis shall be performed to justify new facilities with no sprinkler protection. The provision of sprinkler protection (when not required by another code or standard) shall not be used as a basis for reducing other levels of protection provided for that facility. However, where a code or standard allows alternatives based on the provision of sprinklers, as in NFPA 101, the alternatives allowed for sprinklered space may be applied. All sprinkler systems shall comply with NFPA 13. The occupancy classification will often provide a building-code basis for required sprinkler protection.

- Standpipes and Hose Systems. All laboratory buildings that are two or more stories below or above grade level shall possess standpipe systems in accordance with NFPA 14. If local building fire code requirements dictate the installation of hose systems, hose systems shall comply with NFPA 14 and shall be pressure tested annually in accordance with the methods presented in NFPA 1962.

- Halon-1301 Fire-Extinguishing Systems. Fire protection systems that contain Halon 1301 shall not be used in EPA facilities. Refer to the *Environmental Management Guidelines* for information on removal of halon systems from EPA-owned or -leased facilities.

- Gaseous Fire-Extinguishing Systems. Carbon dioxide fire extinguishing systems may be used though it is not recommended that they be used as a total flooding agent in areas that are typically occupied. Refer to NFPA 12 and Section 15 of the *A&E Guidelines* for technical specifications and AEAMB and SHEMD certification requirements.

- Dry-Chemical Systems. Dry-chemical systems stop the chain reaction that occurs in combustion. Dry chemical is difficult to remove from electrical contacts. Use is generally restricted to cafeteria exhaust hoods and plenums, deep-fat fryers, and grills. Pre-engineered systems are satisfactory for this use. Refer to NFPA 17 and Section 15 of the *A&E Guidelines* for technical requirements 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 deep fat fryers and grills. Refer to NFPA 17A for technical requirements, applications, and specifications.

2.6 Portable Fire Extinguishers

Portable fire extinguishers shall be provided and located within recessed cabinets, in accordance with NFPA 10. Portable fire extinguishers shall be provided on the basis of the classes of anticipated fires and the size and degree of hazard affecting the extinguishers' use. Portable fire extinguishers containing halon shall not be used.

- 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. Extinguishers in laboratories and hazardous materials management areas shall be inspected monthly, and tags shall be attached with the inspection date clearly recorded. Fire extinguishers placed in EPA administrative and office spaces shall be inspected annually.

- Fire extinguisher locations. Portable fire extinguishers shall be provided in every laboratory room. In other areas of an EPA owned or leased facility, the minimum number of fire extinguishers needed for protection shall be determined in accordance with NFPA 10, Chapter 3, Distribution of Fire Extinguishers. One extinguisher may be installed to provide protection for several hazard areas provided that travel distances are not exceeded.

  (a) Class B extinguishers shall be located so that the travel distance to the extinguishers does not exceed 50 feet.

  (b) Class C extinguishers shall be located on the basis of the anticipated Class A and B hazard.

  (c) Class D extinguishers shall be located so that the travel distance to the extinguishers does not exceed 75 feet.

  (d) Class K extinguishers for fire involving combustible cooking media shall be located as specified in Chapter 3 of NFPA 10.

- Training. When portable fire extinguishers are provided for employees to use, the employer shall provide training upon initial employment and annually thereafter.

2.7 Fire and Smoke Alarm Systems

Fire alarm systems shall be installed in accordance with NFPA 70, National Electrical Code (NEC) Article 760, and NFPA 72. Fire alarm activation devices must be completely separated from other building systems. In general, fire alarm systems at all facilities owned or operated by EPA must comply with the following standards and codes:

- Sprinkler Systems, NFPA 13
- Standpipe and Hose Systems, NFPA 14
- National Fire Alarm Code, NFPA 72

- GSA/PBS-P100
- Americans with Disabilities Act (ADA).

Fire alarm systems are required in any building possessing two or more stories above the level of exit discharge, occupied by more than 100 occupants or consists of more than 50,000 square feet. Fire alarms shall also be provided for all occupancies where the occupants cannot be efficiently warned by human voice, gas-powered horns, or other devices. Storage occupancies equal to or larger than 100,000 square feet shall have fire alarm systems. Refer to Section 13 of the *A&E Guidelines* for additional information about fire alarm systems.

All air-handling systems shall be provided with the smoke detection and controls in compliance with NFPA 72. 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. Engineered smoke pressurization and smoke evacuation systems shall be provided as described in Section 2.8 of this chapter.

2.8 Smoke Control

Smoke control system shall be provided in accordance with NFPA 72, NFPA 90A, NFPA 92A, NFPA 92B, ASHRAE manual *Design of Smoke Control Systems for Buildings*, and ASHRAE's *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. Smoke control systems should take into account the building or facility's general HVAC system and should not compete with it. The need for smoke control should be identified early in the planning process so as to incorporate its design in concert with the building's HVAC system. The following guidelines should be followed.

- Dedicated life safety fans should be controlled by the fire alarm system.
- Operable sash and breakable windows should be considered in lieu of engineered smoke control if allowed by the code.
- Environmental fans should not be used for required smoke control if dedicated fans can achieve the same results at a similar cost, particularly in buildings with complicated ventilation and control systems.
- If environmental 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 code. Backup power may be necessary.
- Fans and dampers should 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 Section 13 of the *A&E Guidelines* for more information on smoke control systems.

2.9 Means of Egress

Emergency egress paths from EPA buildings shall be maintained whenever the building is occupied. Egress from buildings or to an area of refuge shall be in accordance with timed calculations.

- Personnel in the fire area can travel toward the fire for no more than 15 seconds.
- Personnel in the fire area should be able to relocate from the fire area within 90 seconds.
- Unimpeded horizontal movement is calculated at 3½ feet per second.
- It should take no longer than 8 minutes to exit downward or upward to the outside of the building.

Areas such as storage rooms with limited or no ventilation or access shall be evaluated to ensure the reliability of the exits using the egress criteria set forth by NFPA 101. If blocking a single exit could create a hazardous condition, provisions will be made either to prevent the exit from being blocked, to provide a means of communication from inside the space, to provide adequate ventilation, or to otherwise prevent the area from becoming a confined space as defined by 29 CFR §1910.146. Refer to discussion on hazard segregation in this chapter for ventilation requirements for storage rooms.

2.9.1 EXIT FACILITIES

Except as noted below or elsewhere in this Manual, the exit provisions of NFPA 101 shall be followed for all EPA facilities.

- Exit Availability and Distance. At least two separate exits shall be available on every floor. Exits shall be as far away from each other as possible, in accordance with the local building code or NFPA 101, whichever requirement is more stringent. Exits shall be arranged to minimize the possibility that both may be blocked during an emergency. Emergency egress paths from the building shall be continuously maintained free of all obstructions and impediments whenever the building is occupied.
- Exit Stairs. All exit stairs in new construction, and all exit stairs added to existing buildings, shall conform to the requirements in NFPA 101 for Class A stairs and shall have a minimum width of 44 inches. Fire escape stairs, as defined in NFPA 101, are not an acceptable component of the means of egress.
- Exit Merging. Where means of egress from stories above and below converge at an intermediate story, the capacity of the means of egress from the point of convergence shall be at least the sum of the two individual stairway capacities.
- 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, should always be provided in stairway and horizontal exit doors and anywhere else where they are necessary for alleviation of potential personnel traffic hazards.

- Latches. Latches on stair doors shall be operable from both the stairs and the occupied space side of the doors. In no instance shall doors at the top (or next to the top) and the bottom stair levels be secured. For security reasons, ingress may be restricted as follows as long as such restriction does not impede emergency egress:

  (a) The door may open directly to the exterior.

  (b) The door may open from a stair to an exit-access door (e.g., lobby or courtyard) to the outside.

  (c) An individual stair door may be locked against ingress from the stairway when this decision has been fully justified in writing and where no other reasonable means can be developed to provide necessary security.

  (d) Each secured door shall be clearly marked and directions shall be posted showing the nearest floors, above and below, where reentry can be made. In buildings that are equipped for relocation of personnel via a voice fire-alarm system, the use of secured doors and the mode of reentry shall be coordinated (e.g., reentry into the building must be coordinated because the door becomes secure after the fire alarm resets).

- Corridors. The fire resistance of exit-access corridors shall be in accordance with NFPA 101 and the local building code. The width of any corridor serving as a required exit or as a means of travel to or from a required exit shall not be less than 44 inches clear width. Obstructions such as partitions, columns, doors, and other projections shall not impinge on the 44-inch clearance. The width of passageways will comply with NFPA 101. 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 Discharge. Except as provided below, and as detailed in NFPA 101, every exit stair shall discharge directly to the outside or to a protected corridor leading directly to the outside. A protected corridor shall consist of a totally unoccupied passageway or other space, such as a lobby, separated from all occupied areas by fire barrier walls with 1-hour or greater fire resistance; all doorways in these walls shall be protected by Class C or higher fire doors that either are self-closing, or automatic closing and controlled by ionization smoke detectors located on the occupied side of the wall.

- Two-Doorway Discharge. When a stair discharges through two separate doorways into two separate fire areas at ground level, exit passageways are not necessary. Under these conditions, appropriate markings shall be provided within the stairwell to indicate each exit and the availability of alternate exits. For example, the sign over an exit door might

read, "Exit to Main Street," and a clearly visible sign nearby would read "Exit to Market Street - Down One Floor."

- Panic Hardware. Panic hardware (e.g., metal bar on exit door) may be used anywhere, 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 100 people.

- Smokeproof Towers. Smokeproof towers that conform to the requirements of NFPA 101 are acceptable but are not required unless specified by the local building code.

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 large numbers of handicapped occupants must be provided with safe exit facilities. 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.

2.9.2 EXIT LIGHTING AND MARKINGS

The requirements for exit lighting and marking are contained in NFPA 101 and the local building code. Exit lighting and exit signs shall be provided to clearly indicate the location of exits in conformance with 29 CFR §§1910.36 and 1910.37 and NFPA 101. The means of egress, exterior steps and ramps shall be adequately lighted to prevent accidents. Internally illuminated signs shall meet the following criteria:

- Emergency lighting for the area shall conform to OSHA and Life Safety Code and shall provide at least 5 footcandles on the sign surface.
- Exit signs shall be at least 8 inches high by 12½ inches long.
- Letters shall be 6 inches high.
- 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.
- Exit signs shall be inspected monthly to insure that the emergency power for the signs is functioning properly.

2.9.3 OCCUPANT EMERGENCY AND FIRE PREVENTION PLANS

A written occupant emergency plan shall be provided for all EPA-owned or -leased facilities. The following elements, at a minimum, shall be included in the plan:

- Emergency escape procedures and evacuation route assignments. Postings of the evacuation routes shall be posted at key points throughout the building to facilitate efficient evacuation during emergencies.
- Procedures for those employees who must remain to operate critical facility operations
- Procedures for accounting for all employees after emergency evacuation has been completed
- Rescue and medical duties of those employees who are to perform them.

- Preferred means of reporting fires and other emergencies and who to contact.
- Names and job titles of those persons or departments who can be contacted for further information or explanation of duties under the plan.
- Training for employees, including periodic practice emergency evacuations (fire drills) so that personnel will be familiar with evacuation procedures in cases of actual emergencies.

EPA facilities shall also have fire prevention plans, either as a separate document or combined with the occupant emergency plan. Required elements of a fire prevention plans 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.

2.10 Fire Life Safety Requirements for Specific Room Types

This section describe special, and often more stringent, fire life safety considerations that shall be followed for specific room types.

2.10.1 OPEN-PLAN OFFICE SPACE

The fire safety objective in open-plan offices is to maintain adequate egress facilities and a low-risk environment. This objective can be achieved through provision of complete automatic sprinkler protection, limitation of open-plan areas to low-hazard occupancies (such as office space), maintenance of well-marked egress paths, and fulfillment of the requirements of NFPA 101. The following conditions shall be met for emergency egress in open-plan office space:

- The space layout shall ensure maintenance of rational exit routes with well-marked secondary exits.

- Color dynamics (e.g., colored lines, walls) and other innovative directional guidance may be needed in large installations.

- The height of dividers and acoustical partitions should be limited (discussed in Section 6 of the *A&E Guidelines*), and partitions should be arranged to allow air circulation and permit occupants to quickly identify problems that may arise from fire in the area and to locate available exit routes. Partitions taller than 5½ feet, which would obstruct view of the open-plan space, should be avoided where possible or limited to the periphery.

- Freestanding space dividers shall resist an overturning force of 25 pounds perpendicular to the face applied at a height of 60 inches above the floor and shall be arranged so as not to interfere with egress.

2.10.2 LABORATORIES

Fire safety, personal safety, and health issues in laboratories present a need for careful design and construction 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, or explosives, and biological laboratories should not be incorporated into plans for EPA office buildings or into buildings that are being considered for EPA-leased office space. Laboratories shall not be established or expanded in existing EPA buildings that are mainly occupied with office space. Refer to Chapter 4 of this Manual for additional information on laboratory safety. Refer to Section 1 of the *A&E Guidelines* for technical data and requirements concerning laboratories.

2.10.3 FLAMMABLE AND COMBUSTIBLE MATERIAL STORAGE AREAS

Refer to Section 4.6 of this Manual for information on storage and handling requirements for flammable and combustible chemicals in hazardous chemical storage areas. Nonflammable/noncombustible substitutes should be considered whenever possible when choosing the following building maintenance materials:

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

2.10.4 TRASH/RECYCLING ROOMS

In any building where combustible trash is expected to accumulate or to be collected in a central location, a properly protected trash room shall be provided. Trash rooms shall be enclosed and separated from the remainder of the building by 1-hour fire-resistive construction. The door to the trash room shall be at least a 45-minute self-closing fire door. Trash rooms and any areas used as a staging area for trash collection shall be sprinkler protected. The water supply for the sprinklers in trash rooms or staging areas that are less than 250 square feet in size may be the domestic water system.

Facilities shall provide for spaces that facilitate the collection, separation, compaction, storage and transportation of recyclable materials. Recyclable materials storage rooms should be kept in order and a general housekeeping schedule for the storage room should be maintained to reduce the chance of fire. Recycled paper and other combustible materials should not be allowed to accumulate in large quantities and shall be kept in appropriate containers.

2.10.5 COMMUNICATIONS ROOMS

When communications equipment is essential to the continuity of operation of the building or is otherwise critical, the communications room shall be protected by fire barrier walls. Communications installations shall meet the requirements of NFPA 70.

2.10.6 ELECTRONIC EQUIPMENT ROOMS

Except as noted below or elsewhere in this Manual, the provisions of NFPA 75 shall be followed for electronic equipment rooms. The scope of NFPA 75 shall be used to determine applicability of this section.

- Construction. All operations shall be housed in a building of fire-resistant or noncombustible construction and shall be separated from other occupancies within the building by 1-hour fire-rated construction. All materials used in construction shall have a flame spread rating of 25 or less and a smoke development rating of 450 or less (Class A rating per NFPA 101). Raised floors shall be of noncombustible construction. Except for small supervisory offices directly related to the electronic equipment operations, no activity shall be located within the fire-rated enclosure. Important and vital records that have not been duplicated and stored at a different location shall be stored in a room with 2-hour fire-rated enclosure. Class 150 1-hour-or-better data storage equipment shall be provided only for vital data that have not been duplicated and that are being stored within the electronic equipment operations area.

- Ventilation. A separate air-conditioning system should be provided for the electronic equipment operation area. If the system serves other areas, dampers to protect against both smoke and fire shall be provided for the duct work at every penetration of the electronic equipment area fire separation. No other ducts shall pass though the electronic equipment areas.

- Emergency Accessories. Emergency lights, alarms, strobe lights, and all necessary appurtenances shall be provided as required by NFPA 75. Smoke detectors shall be provided at ceilings and in raised floors and for data storage areas, in accordance with NFPA 72. Refer to Section 13 of the *A&E Guidelines* for details.

- Fire Suppression. Automatic wet-pipe sprinkler protection shall be provided throughout all laboratory areas containing electronic equipment operations areas, including data storage areas. In accordance with NFPA 13, the sprinkler systems shall be designed to provide 0.10 gallons per minute (gpm) per square foot over 1,500 square feet for electronic equipment areas, and 0.15 gpm per square foot for 3,000 square feet for tape libraries and storage areas that are less than 9 feet above floor level. For storage heights of 9 feet or higher, systems shall be designed to provide 0.18 gpm per square foot for 3,000 square feet. The sprinkler piping may be valved separately, but valves shall be provided with tamper switches connected to the building fire alarm system. Refer to Section 15 of the *A&E Guidelines* for information about mechanical aspects of automatic sprinkler protection.

  Automatic dry-pipe sprinkler protection may be provided throughout computer rooms that are not associated with laboratory areas. The dry-pipe system shall be provided by means of a dual sensing pre-action sprinkler mechanism and controlled by a deluge valve. The deluge valve will be operated by a control panel to which the associated fire zone smoke detectors will be connected. The sprinkler heads used with the pre-action type system shall be pendant style or may be of the flow control (FC) type. The pre-action dry type sprinkler system will operate as follows:

(a) Under normal conditions, sprinkler system pipes will be filled with low-pressure air. A check valve mounted immediately above the deluge valve retains the supervisory air pressure. Sprinkler head or sprinkler piping damage causes loss of air pressure, resulting in trouble alarms without operation of the deluge valve.

(b) A two-zoned smoke detection system will be provided (e.g., "zone A" and "zone B"). When a smoke detector from zone A is activated, a warning alarm will sound. If a smoke detector from zone B is activated while the smoke detector from zone A is activated, the control panel will depressurize the pipes, the deluge valve will open, the pipes will fill with water, and the sprinkler heads will activate in accordance with the ambient temperature. Once the deluge valve is activated, the fire alarm system will also be activated, power to computer equipment will be cut off, and the associated heating, ventilation, and air-conditioning (HVAC) equipment will operate under smoke and/or fire mode automatically. Smoke detector actuation shall sound an alarm at the annunciator panel and automatically notify the local fire department or central monitoring station. Other methods of achieving this zoned approach shall be reviewed for acceptance by AEAMB.

- Electrical Switches. 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.

2.10.7 STAGES

All stages, platforms in auditoriums, and similar arrangements shall conform to the requirements of NFPA 101. Interior finish shall comply with NFPA 101 and Section 9 of the *A&E Guidelines*. 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).

Stages arranged or intended for theatrical or operatic use that involves movable scenery, rigging loft, and the like shall conform to the requirements listed below.

- Stages shall be separated from all other parts of the building by fire partitions having at least a 2-hour fire-resistive rating. The proscenium walls shall also have at least a 2-hour fire-resistive rating.

- The entire stage and all dressing rooms, storage rooms, prop rooms, and other backstage areas shall be protected by automatic sprinklers.

- The rooms over the stage shall have at least 1-hour fire-resistive construction and shall be provided with emergency venting of not less than one-eighth of the area of the stage.

- The proscenium opening shall be protected by a standard fire-resistive proscenium curtain arranged for automatic closing without the use of applied power.

- All interior construction for rigging and lighting shall be noncombustible.

2.10.8 DAY-CARE FACILITIES

Day-care centers must comply with NFPA 101, as well as EPA's guidelines, GSA's *Child Care Center Design Guide* (PBS 3425-13 / PBS-P140), and the licensing requirements of the local jurisdiction. Minimum requirements are described below.

- Construction. The day-care center must be separated from the rest of the building by at least 1-hour fire-resistive construction with 45-minute fire doors. No higher hazard areas, such as laboratories, shall be located in the same fire area as the day-care center. All higher hazard areas shall be separated from the day-care center by at least 2-hour fire-resistive construction regardless of sprinkler protection. Laboratories and other hazards shall not be located where they could present a hazard to occupants of the day-care center or expose the egress routes from the day-care center to hazard.

- Egress. Day-care centers must be located along a grade-level exit discharge and along an outside wall with operable windows. Preferably, there should be a door leading directly outside from the day-care center. The travel distance to an exit-access door from any point within any sleeping room must not exceed 50 feet. The travel distance to an exit from any door used as an exit-access must not exceed 100 feet. The travel distance from any point in a room to an exit must not exceed 150 feet. Increased travel distances due to sprinkler protection shall be allowed in accordance with NFPA 101.

- Emergency Accessories. Emergency lights and exit signs shall be provided for the day-care center and associated egress routes. Smoke detectors must be installed throughout the day-care center, including interior corridors, sleeping areas, and lounges. Refer to Section 16 of the *A&E Guidelines* for specific technical data concerning smoke detectors.

- Occupant Emergency Plans. The facility's occupant emergency plan must specifically address the day-care center, and all employees of the center must be trained and proficient in executing the plan.

- Toxic Substances. The day-care center shall not be located in an area with asbestos-containing materials, lead-based paints, or polychlorinated biphenyls (PCBs). Paint and similar surface-coating materials that contain mercury, asbestos, lead, or lead compounds are prohibited. All toys; articles of furniture; equipment for play, amusement, education, and physical fitness; and other products used for care of children shall have nontoxic paints or coverings. Lockable storage spaces for toxins, such as cleaning materials, must be provided. Additionally, there must be shelving in the locked storage area that is out of reach of preschool children.

- Security. The center must be provided with sufficient physical security to prevent entry by unauthorized persons. Outside play areas shall be so located and secured as to minimize exposure of children to unauthorized persons, vehicular traffic (consider also the possibility of runaway vehicles), animals, overhead electrical power lines, and overspray from HVAC cooling tower water.

- Additional Safety Concerns.

  (a) All unused electrical receptacles within reach of preschool children must be equipped with socket guards.

  (b) A means must be provided to limit hot water temperature to 120 °F in fixtures that are accessible to children. In addition, water fixtures that are accessible to children should be of the "mixer" type to limit the temperature of the water.

  (c) A means must be provided to prevent children from gaining access to the kitchen area.

  (d) Fans must be located at least 7 feet above floor level, and the fan blades must be guarded.

2.11 Safety for the Disabled

EPA facilities must take into account the special needs of disabled individuals and ensure that in cases of emergency, all personnel are able to evacuate; or in cases of potential chemical exposures, have accessibility to emergency equipment. Compliance with the Uniform Federal Accessibility Standards (UFAS), is mandatory on all EPA projects. Because the Americans with Disabilities Act (ADA) is a more contemporary document, the requirements of ADA Title III standards shall be followed where those requirements are more strict than UFAS standards. This policy is derived from GSA PBS-P100 and shall remain in effect until the UFAS requirements have been updated and reissued. (UFAS requirements were last updated in 1989.)

The criteria below address safety issues relating to general access to EPA facilities. For specific design guidance and requirements related to the following issues, refer to UFAS; ADA; and American National Standards Institute (ANSI) A117.1, *Providing Accessibility and Usability for Physically Handicapped People.*

- Fire alarms. Provide visual warning devices to alert the hearing impaired. (Refer to Section 13 of the *A&E Guidelines* for technical requirements concerning fire alarms.)

- Ramps. Examine the slope, length, surface-friction attributes, and exposure to weather of access ramps to ensure that they meet the applicable UFAS, ADA, and ANSI requirements.

- Exit paths. Ensure that exit paths are wide enough to permit access by wheelchairs and 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.

- Elevator controls. Ensure that the controls and emergency telephones of self-service elevators are within reach of a person in a wheelchair. Technical specifications for elevators are given in Section 14 of the *A&E Guidelines.*

- 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. (Refer to Section 8 of the *A&E Guidelines* for technical requirements concerning fire doors.)

- Occupant emergency plans. These plans shall specifically address the needs of handicapped persons 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 facility designs are modified to accommodate a disabled person, the facility design attributes will require a careful analysis of the hazards associated with the work to be performed and the specific needs of individual employees. The following list delineates the more common issues to be addressed for individual EPA employees:

- Accessibility of emergency equipment, such as emergency showers, eyewashes, and alarms

- Appropriateness, accessibility, transportation, and use of hazardous materials within the facility

- Accessibility of fume hoods, height of work benches, and accessibility of controls on test equipment.

2.12 Emergency Power

Where required, emergency power systems shall meet the requirements of Section 16 of the *A&E Guidelines*, NFPA 101, and NFPA 110.

2.13 Lightning Protection

Lightning protection shall comply with Section 13 of the *A&E Guidelines* and NFPA 780.

Chapter 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 distribution and transmission, underground electrical installations, and energized substations.

3.2 References

Unless otherwise specified in this Manual or approved by the Architecture, Engineering and Asset Management Branch (AEAMB) and the Safety, Health and Environmental Management Division (SHEMD), all electrical installations shall conform to the applicable requirements of the current national standards specified below and in Section 16 of the *Architecture and Engineering Guidelines* (*A&E Guidelines*).

- NFPA 70, National Electrical Code®, (NEC), National Fire Protection Association
- National Electric Safety Code (NESC) (ANSI C2), American National Standards Institute

3.3 Overcurrent Protection

In order 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 the NEC and NESC. 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 NEC 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. GFCIs shall be installed in accordance with the NEC; the permanent wiring shall consist of electrical currents grounded in accordance with the NEC.

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.

Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period of time the exposure is expected and 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.

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 can't 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, verification that isolation and deenergization of the system shall be successfully accomplished.

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; and all affected personnel have been notified that the lockout or tagout devices are about to be removed.

3.6 Classified Locations

Locations of electrical equipment and wiring shall be classified on the properties of the flammable vapors, liquids or gases or combustible dusts or fibers 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 and Table 3-1.

Table 3-1. Classified Locations

Class I Highly Flammable Gases or Vapors		Class II Combustible Dusts		Class III Combustible Fibers	
Division 1	Division 2	Division 1	Division 2	Division 1	Division 2

All equipment, wiring methods and installations of equipment in classified 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 those classified locations included in its labeling or listing. Equipment and wiring approved for the hazardous location shall be approved not only for the class of location but also for the ignitible 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 should be determined by inspection and/or testing. Such conditions shall include the location of energized lines and equipment, conditions of poles and the location of circuits and equipment including power and communication lines and fire alarm circuits. Electric equipment shall be considered energized until determined to be deenergized by tests or other means, and grounds 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 Table 3-2 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.

Table 3-2. Alternating Current Minimum Distances

Voltage Range (phase to phase)	Minimum working and clear hot stick distance (phase to ground)
2.1-15 kV	2 ft (24")
15.1-35 kV	2.25 ft (27")
35.1-46 kV	2.5 ft (30")
46.1-72.5 kV	3 ft (36")
72.6-121 kV	3.25 ft (39")
138-145 kV	3.6 ft (43")
161-169 kV	3.6 ft (43")
230-242 kV	5 ft (60")
345-362 kV	6.8 ft (82")*
500-552 kV	10.8 ft (130")*
700-765 kV	11.8 ft (142")*

* the minimum working distance and the minimum clear hot stick distance for these voltages may be reduced provided that such distances are not less than the shortest distance between the energized part and a grounded surface.

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

Portable electric space heaters may be used in inadequately heated areas provided the requirements listed below are met:

- The heater is approved or listed by the American Gas Association, UL, or another 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 branch circuit carrying the heater conforms with requirements of NFPA 70, *National Electric Code,* 2002 Edition, 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 all of the requirements of the manufacturer, and with the involvement of the facility owner and the EPA Safety, Health and Environmental Management Manager.

In addition, use of the heater should conform with safety tips recommended by the U.S. Consumer Product Safety Commission in the publication titled *Electric Space Heaters Fact Sheet, CPSC Document #098.* While all requirements are important, those particularly emphasized by the Commission are listed below:

- The heaters should have a guard around the heating element, such as a wire grill to protect fingers, or fabrics from touching the element.
- Before using, be sure to read and understand instructions for operation and maintenance of the heater.
- While not encouraged, if an extension cord must be used, the cord, connector, or attachment plug and receptacle should conform with requirements of NFPA70, Chap. 4, Article 422 mentioned under Item 2, above.
- The heater cord (or any electric cord) must never be run under rugs or carpets.
- The heater must never be operated unattended.
- To avoid potential electrical shock and/or electrocution, never place heaters near water, or handle heaters when wet.
- The heater should never be used as a means to dry clothes or thaw frozen water pipes.
- The heater should be maintained in good operating condition.
- The heater should always be placed on a solid level surface.

Chapter 4 - Chemical and Laboratory Safety

4.1 Purpose

This chapter describes the management of hazards in laboratories and chemical storage areas at EPA-owned or -leased facilities. Specific topics discussed in this chapter include guidance on establishing written a safety and health program, safe handling and storage of chemical substances, laboratory ventilation, and radiation safety. Refer to the EPA's *Architecture and Engineering Guidelines* (*A&E Guidelines*) for information on design issues for laboratories.

4.2 References

These guidelines are designed to comply with the Occupational Safety and Health Administration's (OSHA) Safety and Health Standards for General Industry (29 CFR Part 1910). Unless otherwise specified herein, the safety features of laboratories and chemical storage areas shall conform to the applicable requirements of the following National Fire Protection Association (NFPA) standards and other cited references:

- NFPA 30, Flammable and Combustible Liquids Code
- NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals
- NFPA 50A, Standard for Gaseous Hydrogen Systems at Consumer Sites
- NFPA 51, Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes
- NFPA 54 / ANSI Z223.1, National Fuel Gas Code
- NFPA 55, Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders
- NFPA 58, Liquefied Petroleum Gas Code
- NFPA 59A, Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG)
- NFPA 70, National Electric Code® (NEC)
- NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Fire Exposure
- NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
- NFPA 115, Recommended Practice on Laser Fire Protection
- *Safety, Health and Environmental Management Guidelines*, Safety, Health and Environmental Management Division (SHEMD), Environmental Protection Agency (EPA), 1997
- *Procedures Manual for Certifying Laboratory Fume Hoods to Meet EPA Standard*, SHEMD, EPA
- *Handbook of Compressed Gases*, Compressed Gas Association, Inc.
- *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council.
- *Safety Guidelines for the Installation and Operation of X-Ray Generating Equipment at EPA Facilities*

4.3 Safety and Health Program

All EPA-owned or -leased facilities with employees who engage in work requiring the use or management of hazardous chemicals shall maintain a written safety and health program in accordance with the EPA SHEMD's *Safety, Health and Environmental Management Guidelines*; and OSHA's 29 CFR Part 1910, *General Safety and Health Standards for General Industry.* This program shall include a written hazard communication (HAZCOM) program that establishes policy, procedures, and responsibilities for disseminating information to employees on the safe handling of hazardous chemicals (29 CFR §1910.1200). The program must include provisions for identifying and listing hazards, training programs, container labeling, and the use of material safety data sheets (MSDSs).

For laboratories, OSHA requires the development of a written 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). The elements of a written laboratory safety program shall include:

- Standard operating procedures for hazard recognition, control and containment
- Control measures to reduce employee exposure to hazardous chemicals
- Provisions for employee information and training
- Provisions for medical consultation and medical examinations
- Designation of personnel responsible for implementation of the Chemical Hygiene Plan.

4.4 Employee Training

A written comprehensive training program must be developed at EPA owned or leased facilities for employees working in laboratories or otherwise handling hazardous materials. Employers with employees working in each of these areas shall maintain respective programs required by OSHA 29 CFR §1910.1200, Hazard Communication Standard; 29 CFR §1910.120, Hazardous Waste Operations and Emergency Response; and 29 CFR §1910.1450, Occupational Exposure to Chemicals in Laboratories. The training program shall include, but 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). For specific employee training requirements for EPA facilities, refer to the EPA *Safety, Health and Environmental Management Guidelines.*

4.5 Personal Protective Equipment

Careful selection and use of PPE is essential to protect the health and safety of workers. The purpose of PPE is to shield or isolate workers from the chemical, physical, radiological, and biological hazards that may be encountered at the site. PPE use should not be considered the primary shield for the safety and health of employees. In conjunction with PPE, managers should implement engineering controls such as ventilation or barriers and administrative controls such as substituting hazardous chemicals for less toxic substances. The basic elements of a PPE program are:

- Assessment of the workplace hazards to determine if PPE use is warranted
- Selection of PPE that will adequately protect employees from identified hazards
- Procedures for retiring defective or damaged PPE
- Assurance that employee owned equipment is adequate
- Procedures for training employee who must use PPE.

If employees are required to use respiratory protection, OSHA Standard for Respiratory Protection, 29 CFR §1910.134, requires that a respiratory protection program be established. The respiratory program shall include standard operating procedures governing the selection and use of respirators.

4.6 Chemical Storage and Management

Facilities shall be provided with storage arrangements for the hazardous chemicals that are necessary for the operation of the laboratory or facility. Chemical storage areas shall conform to NFPA 45 or the requirements contained in the local building and fire prevention codes. Whenever the site arrangements permit, the storage of large quantities of hazardous chemicals, such as those required to support chemical laboratory operations, should be segregated in accordance with NFPA 30 or local codes, or separated in accordance with NFPA 80A. Facilities storing flammable liquids shall conform to NFPA 30.

Inside storage areas for hazardous chemicals or flammable liquids shall be separated from adjacent spaces by at least 2-hour fire-resistive construction. The room shall otherwise comply with the requirements presented in Section 4-4 of NFPA 30 and local building and fire prevention codes. This section applies to new chemical storage as well as to waste chemical storage. 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.

4.6.1 COMPRESSED GASES

NFPA standards shall be used as a basis for determining requirements. Depending on the type of installation, NFPA standards 50A, 51, 54, 55, 58 and 59A 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, construction, room ventilation, cylinder contents and the availability of fire suppression mechanisms. A gaseous system includes all regulators, relief devices, manifolds, piping and controls leading from the cylinders to point of use.

  No single flammable gas or oxygen cylinder shall exceed 220 cubic feet (approximately 10 inches in diameter by 50 inches in length). The total number of flammable gas and oxygen cylinders in a laboratory shall not exceed the amount specified in Chapter 8 of NFPA 45. Generally, within a 500 square-foot area, no more than six cylinders in a

sprinklered space and no more than three cylinders in a nonsprinklered are allowed. Liquified flammable gases are limited to three cylinders in a sprinklered area and to two cylinders in a nonsprinklered space.

- Cylinder Construction and Use. All cylinders shall be constructed, charged, shipped and maintained in accordance with applicable 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 CGA pamphlets C-1-1968 (Standards for the Visual Inspection of Compressed Gas Cylinders) and C-8-1962 (Standard for Requalification of ICG-3HT Cylinders).

- Pressure Relief Devices. Compressed gas cylinders, portable tanks, and cargo tanks shall be fitted with pressure relief devices and maintained in accordance with CGA Pamphlets S-1.1-1963 with 1965 addenda (Safety Release Device Standards- Cylinders for Compressed Gases), and S-1.2-1963 (Safety Release Device Standards- Cargo and Portable Tanks 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, or substantial pipe. 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 should be restrained near or above the center of gravity, 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 five 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.

4.6.2 CRYOGENIC GASES

For the purposes of this 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:

- 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 (ASME) 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.

4.6.3 FLAMMABLE AND COMBUSTIBLE GASES

Flammable gases shall be separated from oxidizing gases, such as oxygen, compressed air, and 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 (LEL) resulting from leakage from one cylinder. See NFPA 55 for required ventilation rates.

4.6.4 FLAMMABLE AND COMBUSTIBLE LIQUIDS

Flammable liquids (liquids possessing a flashpoint of less than 100°F) and combustible liquids (liquids with a flashpoint above 100°F) 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. Management of flammable/combustible liquids at EPA owned or leased facilities should practice the following guidance:

- All flammable/combustible liquids should 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 the requirements of OSHA. Areas for storage should not be in direct sunlight, on the roof or in the center of the building. The storage room should have at least one exterior wall.

- Flammable/combustible liquids should 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 is mandated in order to control the risk. Refer to Section 4.6.8 of this chapter for ventilation criteria.

- All flammable/combustible liquids should be segregated from other hazardous materials such as acids, bases, and oxidizers.

- Storage cabinets should not be overfilled; free from paper, cardboard and other combustible materials.

- Class I flammable liquids should not be stored in refrigerators. If the materials must be stored in low temperatures, they should be stored in explosion-proof refrigerators (listed for Class I, Division I, Group C and D) and approved by Underwriters Laboratory as a

"Special Purpose Refrigerator and/or freezer." All explosion-proof refrigerators 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 should be electrically grounded and bonded, and should be equipped with pressure relief devices and dead-man valves.

- Safety cans should be used for amounts less than 2 gallons, and users should 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, in the Chemical Hygiene Plan and EPA's *Safety, Health and Environmental Management Guidelines.*

For information specific to storage and management of hazardous waste and petroleum fuels for compliance with environmental regulations, refer to *Environmental Management Guidelines* (EPA Facilities Manual, Volume 4), Chapters 4 and 5, respectively. For more information regarding design of hazardous chemical storage areas and space management, refer to the *A&E Guidelines* (EPA Facilities Manual, Volume 2).

4.7 Emergency Eyewash and Shower Equipment

Emergency eyewash and shower equipment shall be provided within the work areas where the eyes or body of an employee may be exposed to corrosive or hazardous materials, including in hazardous materials or hazardous waste storerooms.

Emergency eyewash and shower equipment shall be in accessible locations that can be reached in no more than 10 seconds walking time from the location of the hazard. The eyewash and shower shall be located on the same level as the hazard and the path of travel shall be free of obstructions that may inhibit the immediate use of the equipment. For a strong acid or strong caustic, the eyewash and shower should be immediately adjacent to the hazard.

The shower and eyewash should be plumbed to provide a continuous supply of potable water for at least 15 minutes.

The eyewash and shower will meet the minimum performance and use requirements incorporated in the American National Standards Institute (ANSI) standard for *Emergency Eyewash and Shower Equipment, ANSI Z358.1-1998* (or current ANSI revision). Other requirements are discussed below.

- For new laboratory construction, eyewashes in repetitive laboratory modules shall be fully plumbed (supply and drain) to facilitate periodic testing and annual inspection of the equipment. In locations where eyewash stations or showers are required but where plumb-in water or heat is not provided, self-contained units facilitating the above criteria will be allowed upon approval by SHEMD.

- New eyewash and shower equipment should be plumed to tepid potable water. The temperature of the tepid water should have an mean temperature of 85 degrees Fahrenheit (30 degrees Centigrade) and not be in excess of 100 degrees Fahrenheit (38 degrees Centigrade).

- The need for a floor drain for an emergency shower is determined by an assessment of local conditions. Floor drains may be provided for shower systems if laboratory runoff can be intercepted and isolated for disposal or treatment in a wastewater system.

- Discharge from emergency showers should not impinge on powered electrical equipment.

- For new laboratory construction, eyewashes and showers shall be installed with activation alarms for each unit.

- For new laboratory construction, all eyewash and showers, will be located with a minium clear floor space that allows unit accessability to all employees.

4.8 Laboratory Ventilation

Building heating, ventilation and air conditioning (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. Design and installation requirements for ventilation systems are detailed in Section 15 of the *A&E Guidelines*. General laboratory ventilation, however, should not be relied on for protection from toxic substances. Local exhaust ventilation devices, such as laboratory fume hoods, are the primary method of contaminant control in laboratories. The requirements for local ventilation are described below.

4.8.1 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 purchased for use by EPA shall comply with EPA's fume hood design, installation, and performance criteria described in Section 15 of the *A&E Guidelines* and Chapter 6 of NFPA 45. Each hood shall have an ASHRAE 110 standard performance rating "as manufactured" (AM) of 4.0 AM 0.05. In addition, facility managers and laboratory personnel should 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 for air should be 100 linear feet per minute (fpm) ± 10 fpm with the sash 80% open. SHEMD will consider requests to operate hoods at 80 fpm average face velocity with a sash opening of 80%. Any request for a lower operating average face velocity should 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. Under no circumstances can the control velocity be less than 80 fpm at any sash height.

Fume hood windows shall be closed at all times except when performing work or adjusting apparatus inside hood. Hoods and exhaust ducts should be checked before each use to ensure hood is cleared of foreign objects. Any apparatus placed in the hood should 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 should 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. Hoods shall be checked periodically to ensure operating parameters are met. When performance of existing hoods in unsatisfactory, attention should first be directed to achieving the specified hood face velocities. When correct face velocities have been achieved, attention should be directed to external factors such as hood location and room ventilation. When the best environment for the hood has been achieved, the remaining features, such as airfoils, air volume moved, and control of the air pattern in the zone of the operator, should be considered. In cases of hood failure, personnel shall be aware of emergency shutdown procedures to reduce vapor generation. Procedures should include shutdown operations, vessel or container closure and hood sash closure. If a new hood is needed, refer to Section 15 of the *A&E Guidelines* for design and technical requirements.

- Annual Certification. The performance of fume hoods shall be certified annually and after any significant maintenance has been performed on the exhaust system or room air supply system. The performance certification shall be performed in accordance with the *Procedures Manual for Certifying Laboratory Fume Hoods to Meet EPA Standard* and shall be approved by representatives from SHEMD. Records of the certification must be maintained on site.

4.8.2 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 the following criteria:

- 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.

- The source of air supply should be within 12 inches of the floor on one side of the room.

- Exhaust should be taken from within 12 inches of the floor on the opposite wall of the room from the makeup air.

- Exhaust must not be vented into a fume hood or its associated exhaust system.

- If ducts are used for the ventilation system, they shall comply with NFPA 91.

4.8.3 OTHER VENTILATED ENCLOSURES

Laboratory Cabinets. Laboratory cabinets used for hazardous chemical storage must be appropriate for their intended use. Cabinet venting to the outside atmosphere is necessary when health hazard exposures warrant ventilation and administrative controls are ineffective in controlling the risk. When a cabinet is vented, it shall be vented by a mechanical exhaust system that meets the criteria of NFPA 91 and Appendix A of NFPA 30 as discussed below.

- The ventilation rate must be 5 to 20 cubic feet per minute (cfm).
- Air should be supplied at the top of a cabinet, exhausted from the bottom, and swept across all the shelves by arranging the shelves as baffles or constructing the shelves of perforated metal.
- The inlet fitting should incorporate a flame arrestor.
- If a separate exhaust fan is used, it must be roof-mounted and sparkproof, and it should be weatherproof.
- The cabinet exhaust must not be vented into a fume hood but may be connected and vented through a fume hood's associated exhaust system if the operations served by that exhaust system are not incompatible with the materials stored in the cabinet.
- The vent systems (e.g., tubing or piping) for flammable storage cabinets 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.

Flammable/combustible storage cabinets. Flammable/combustible storage cabinets shall not be vented unless a health hazard exists from the storage of chemicals in the cabinet and administrative controls are ineffective. Metal caps shall be used to seal cabinet openings in place of flash arrestor screens. If venting is necessary, the following requirements must be followed:

- Metal caps shall be replaced with flash arrestor screens, and top-most inlet should serve as the fresh air inlet.
- The bottom cabinet opening will be used as an exhaust, and be connected to 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 should be used.
- The total exhaust duct length shall not exceed 25 feet.

4.9 Radiation Safety

A Radiation Safety Program must be developed and implemented for EPA laboratories that use radioactive materials and/or radiation producing devices. The program shall be devised to assure that levels of EPA workers' exposures to radiation are "as low as reasonably achievable" (ALARA). The basic elements of the Radiation Safety Program include dose monitoring and control, training, recordkeeping, SOPs, and emergency response plans.

As part of a Radiation Safety Program, the work practices related to radioactive materials shall be designed to ensure compliance with the radiation exposure limits established in 10 CFR Part 20. Refer Chapter 8 of the *Environmental Management Guidelines* (Volume 4 of the EPA Facilities Manual) for information on managing radioactive materials and disposing of radioactive waste.

EPA laboratories may also contain equipment and devices that may produce ionizing (e.g., x-ray machines) and nonionizing (e.g., lasers, microwaves, and 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.

4.9.1 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 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 mR/hr limitation. Interlocks shall be tested at least annually.

- Shielding. Shielding adequate to reduce the exposure rate at 5 cm 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 have fail-safe characteristics. In addition, they should 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.

4.9.2 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 ultraviolet or infrared radiation. Additional information and guidance regarding fire and explosion hazard mitigation is provided by NFPA115. Lasers are classified into four basic categories:

- Class 1. Lowest power lasers that do not emit hazardous levels.
- Class 2. Low-power lasers that pose a hazard only if viewed directly for extended periods.
- Class 3. Medium-power lasers that pose moderate risk and can cause injury.
- Class 4. High-energy, high-risk lasers that can cause injury to the eyes and skin from direct or diffused reflection.

Engineering controls shall be considered 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 (FLPPS). The following engineering controls recommended in the ANSI Z136.1 standard, *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.

9.3 ULTRAVIOLET (UV) LAMPS

EPA laboratories may have a variety of artificial sources of UV radiation, including biological safety cabinets, germicidal lamps, UV-transluminators (UV light boxes), and crosslinkers. The effect of UV radiation overexposure depends on UV dosage, wave length, 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 three to twelve hours. Overexposure of the skin will produce reddening (i.e., sunburn) within one to eight hours.

Adequate eye and skin protection are essential when working around UV radiation. In addition, engineering controls shall be considered 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 (PVC), plexiglass and perspex, 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 that they are shut off when the protective enclosure is open.

Chapter 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. Refer to Section 15 of the *Architecture and Engineering Guidelines (A&E Guidelines)* for design specifications for heating, ventilation, and air conditioning (HVAC) systems, including ventilation requirements for laboratories, offices, and other EPA spaces.

5.2 References

Unless otherwise specified in this Manual or approved by the Architecture, Engineering and Asset Management Branch (AEAMB) and the Safety, Health and Environmental Management Division (SHEMD), all ventilation system installations shall conform to the applicable requirements of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards and the American National Standards Institute (ANSI) safety codes referenced in the *A&E Guidelines,* Section 15, including the following.

- *Building Air Quality: A Guide for Building Owners and Facility Managers.* U.S. EPA and the National Institute for Occupational Safety and Health (NIOSH)
- *Building Air Quality Action Plan.* U.S. EPA and NIOSH. December 1991.
- ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy
- ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality.

5.3 General Requirements

Good 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. An IAQ Control Plan shall be developed to address in detail building materials selection, measures to minimize introduction of outdoor air pollution, pre-occupancy procedures to accelerate off-gassing, and operations and maintenance procedures that limit introduction of harmful chemicals.

5.4 Sources of Airborne Contaminants

Indoor air contaminants can originate from inside processes or may be introduced from exterior sources. 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 Pollutants

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 (VOCs)	Carpeting Cleaning solvents Lacquers, paints Adhesives	Nausea; dizziness; eye, respiratory tract, and mucous membrane irritation; headache; fatigue
Microorganisms	Air handling system condensate Damp organic material and porous wet surfaces	Hypersensitivity diseases, Legionellosis

5.4.1 EXTERIOR SOURCES

Exterior sources of pollution include adjacent and nearby stationary pollution sources, for example, exhausts from other research facilities or from commercial buildings such as dry-cleaning establishments, restaurants, photograph developing businesses, chemical storage areas, laboratory facilities, nearby roadways, parking lots, loading docks, trash storage, and garage and their motor vehicle traffic patterns.

Previous uses of the property can also have a great effect on IAQ. Properties which contain contaminated soil and groundwater may emit volatile organic compounds which seep into a building through cracks in the foundation or up through the septic system. Some 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 into soil, which may remain on-site or be backfilled onto it. A site evaluation should be conducted to evaluate the environmental impacts

of past uses of the property. Refer to Section 2 of the *A&E Guidelines* for detailed information on site evaluation.

5.4.2 INTERIOR SOURCES

Building layout, construction materials, and occupant activities may affect IAQ when designing and constructing an EPA owned or leased facility. The building fabric itself, floor materials, caulking, adhesives, wall and ceiling coverings, cleaning products, furnishings, pesticides; and human metabolism and activities may all have an effect on IAQ. For example, due to its large surface area, carpeting may be a significant indoor source of VOC emissions.

Table 5-2. Potential Sources of Indoor Air Pollutants

Adhesives	Wood paneling
Sealants	Composite wood products such as particle board, chipboard, wafer board, cardboard, etc.
Caulking	
Wood preservatives and finishes	Gaskets
Pesticides	Glazing compounds
Fungicides	Control joint fillers
Carpet	Floor coverings
Carpet padding	Wall coverings
Paints	Ceiling tiles, panels
Insulations: thermal, fire, and acoustic	Standing water, water leaks/floods

5.5 Diagnosing IAQ Problems

Poor IAQ is most 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 facility shares the building), managers, and investigators. The general process for investigating and mitigating an IAQ issue is:

- Initial walkthrough: investigation preparation and visual inspection to determine if there is a reason for the complaint
- Problem investigation: observation of occupant activities, HVAC system inspection, determining pollution pathways, and searching for pollutant sources (air sampling)
- Hypothesis testing: manipulation of building conditions and testing
- Implementation of control strategy: observation to validate changes
- Verification: involves follow-up surveys and walkthroughs.

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

5.6 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. 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.

5.6.1 SOURCE CONTROL

The most effective means of indoor air pollution control is to eliminate, reduce, or contain the sources of indoor air pollution. Effective source control requires that potential sources be clearly identified and addressed. Section 4 of this chapter discuss common sources of indoor and outdoor air pollution. Evidence must be provided that this strategy has been applied to every aspect of the building design, construction requirements, and operational requirements.

Approaches to control internal sources of indoor pollutants are thoughtful building design, careful material selection, materials modification and treatment; isolating and management of pollution-generating activities. The design professional must review and evaluate all products and materials that are likely to emit or off-gas toxic or irritating chemicals in the completed facility. These include HVAC system design and components, insulation, sealants, finish materials, and furnishings, among others. EPA reserves the right to require emissions testing of selected products, at no cost to the government, to determine chemical content, emissions rate, or change in composition due to environmental exposure. Based on test results, EPA may disallow installation of a given product or material in the completed facility.

To control exterior sources of pollution, the HVAC system should contain a fresh-air intake which is located as far from a pollution source as possible, and placement should take into account prevailing weather and wind direction. Temporal and spatial variations in wind direction and velocity, traffic patterns, and emissions from industrial processes that affect air quality at the site must be considered. The locations and forms of adjacent buildings that might result in local wind patterns causing reentrainment of the facility's own exhausts must be considered and addressed. Refer to Chapter 15 of the *A&E Guidelines* for HVAC design requirements.

5.6.2 VENTILATION CONTROLS

Outside air ventilation. Ventilation modification is often used to correct or prevent indoor air quality problems. HVAC systems must be designed to provide a minimum fresh air requirement of 20 cubic feet per minute per person in office spaces. This requirement also applies to HVAC systems possessing a variable air-flow component (VAV systems). However, this requirement is based on the assumption that the total air supply will be free of pollutants. If the indoor environment is found to contain unavoidable air contaminants, the contaminants may be diluted by increasing the supply rate of outdoor air. Where multiple spaces with dissimilar ratios of

outside air to total air are served by a common HVAC system, refer to ASHRAE 62-2001 for calculating air supply necessity.

Air cleaning. There are several factors that determine whether air supply may need to be cleaned. HVAC systems must be able to adapt to circumstances which may arise during normal operations through the use of a building automation system (BAS). A viable BAS must be able to detect critical factors that will allow the automatic selection of the most cost-effective mix of air cleaning, outside air supply and recirculated air. The critical factors are the thermal properties and contaminant contents of both the outside air and the return air relative to the design conditions.

Where outdoor air pollutants periodically exceed established standards (National Ambient Air Quality Standards [NAAQS] and Table E-1, Ambient Air Quality Guidelines from ASHRAE 62), 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 (ADPI) of at least 80% 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 Section 15 of the *A&E Guidelines* for HVAC efficiency design considerations for EPA-owned or leased office space and laboratories.

Air-out. One of the procedures that may be employed in mitigating IAQ problems is conducting an "air-out." Though most indoor furnishings are selected to minimize emissions, there may be some materials that may have off-gassing of organics and vapors over a period of time after installation. The purpose of the air-out is to remove chemical emissions from materials in the building in order to reduce occupant exposure to these chemicals once occupancy commences

An "air-out" will be employed after completion of the building, commissioning of the equipment, and installation of major furnishings. The air-out is achieved by the use of adequate ventilation for an extended period of time. Some material, such as carpets and other flooring systems, may also require elevated air temperatures to accelerate their chemical emissions. Supplemental air movement devices such as portable fans shall be used to increase airflow within enclosed spaces to improve the efficacy of the air-out procedure.

An "air-out" requires an additional time period of 1 to 3 weeks after commissioning and prior to occupancy. The Government will provide an occupancy schedule for purposes of planning the

air-out process. The air-out must also be carefully planned and conducted to avoid adverse effects on building components and equipment.

5.6.3 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.

5.7 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 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, on 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.

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

HVAC systems must be designed to minimize conditions of accumulated moisture that, together with warmth and darkness, encourage the growth of microorganisms. The recommendation for the control the growth of mold and other microorganisms is to limit indoor humidity to 30-60%. Buildings with basements may require dehumidification systems. For HVAC design requirements in the control of humidity, refer to Section 15 of the *A&E Guidelines*.

Appendix A - List of Standards and References

Appendix A - List of Standards and References

This appendix lists the standards and references used in this Manual. Where possible, contact information is provided.

- Standards of the American National Standards Institute (ANSI) (arranged alphabetically)
  - Elevators, Dumbwaiters, Escalators and Moving Walks (ANSI A17.1)
  - Emergency Eyewash and Shower Equipment (ANSI Z358.1)
  - Fundamentals Governing the Design and Operation of Local Exhaust Systems (ANSI Z9.2)
  - General Radiation Safety Installations Using Non-Medical X-ray and Sealed Gamma Ray Sources for Energies up to 10 MeV (ANSI N43.3)
  - Laboratory Ventilation (ANSI/AIHI Z9.5)
  - Liquid Petroleum Transportation Piping System (ANSI B31.4)
  - Method of Testing Performance of Laboratory Fume Hoods (ANSI/ASHRAE 110)
  - Nuclear Power Plant Air Cleaning Units and Components (ANSI/ASME N509)
  - Protective Coatings for Nuclear Applications (ANSI N512)
  - Providing Accessibility and Usability for Physically Handicapped People (ANSI A117.1)
  - Safe Use of Lasers (ANSI Z136.1-1993)
  - Safety Code for Mechanical Refrigeration (ANSI/ASHRAE 15)
  - Thermal Environmental Conditions for Human Occupancy (ANSI/ASHRAE 55)
  - Ventilation for Acceptable Indoor Air Quality (ANSI/ASHRAE 62)

- Standards of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) (arranged alphabetically)
  - Method of Testing Performance of Laboratory Fume Hoods (ANSI/ASHRAE 110)
  - Safety Code for Mechanical Refrigeration (ANSI/ASHRAE 15)
  - Ventilation for Acceptable Indoor Air Quality (ANSI/ASHRAE 62)

- National Fire Codes of the National Fire Protection Association (NFPA) (arranged by NFPA number)

- Standard for Portable Fire Extinguishers (NFPA 10)
- Standard on Carbon Dioxide Extinguishing Systems (NFPA 12)
- Standard for the Installation of Sprinkler Systems (NFPA 13)
- Standard for the Installation of Standpipe and Hose Systems (NFPA 14)
- Standard on Dry Chemical Extinguishing Systems (NFPA 17)
- Standard for Wet Chemical Extinguishing Systems (NFPA 17A)
- Installation of Private Fire Service Mains and Their Appurtenances (NFPA 24)
- Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (NFPA 25)
- Flammable and Combustible Liquids Code (NFPA 30)
- Standard on Fire Protection for Laboratories Using Chemicals (NFPA 45)
- Gaseous Hydrogen Systems at Consumer Sites (NFPA 50A)
- National Fuel Gas Code (NFPA 54)
- Compressed and Liquefied Gases in Portable Cylinders (NFPA 55)
- Storage and Handling of Liquefied Petroleum Gases (NFPA 58)
- Storage and Handling of Liquefied Natural Gas (NFPA 59A)
- Guide for Venting of Deflagrations (NFPA 68)
- National Electrical Code (NEC) (NFPA 70)
- National Fire Alarm Code (NFPA 72)
- Protection of Electronic Computer/Data Processing Equipment (NFPA 75)
- Standard for Fire Doors and Windows (NFPA 80)
- Recommended Practice for Protection of Buildings from Exterior Fire Exposures (NFPA 80A)
- Standard for the Installation of Air-Conditioning and Ventilating Systems (NFPA 90A)
- Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids (NFPA 91)
- Recommended Practice for Smoke Control Systems (NFPA 92A)
- Guide for Smoke Management Systems in Malls, Atria, and Large Areas (NFPA 92B)
- Ventilation Control and Fire Protection of Commercial Cooking Operations (NFPA 96)
- Life Safety Code (NFPA 101)

- Emergency and Standby Power Systems (NFPA 110)
- Stored Electrical Energy Emergency and Standby Power Systems (NFPA 111)
- Water Cooling Towers (NFPA 214)
- Standard on Types of Building Construction (NFPA 220)
- Standard for Fire Walls and Fire Barrier Walls (NFPA 221)
- Standard for General Storage (NFPA 231)
- Standard Methods of Tests of Fire Endurance of Building Construction and Materials (ASTM E 119/NFPA 251)
- Standard Methods of Fire Tests of Door Assemblies (ASTM E 152/NFPA 252)
- Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source (NFPA 253)
- Standard Methods of Fire Tests for Flame Resistant Textiles and Films (NFPA 701)
- Hazard Classification System (NFPA 704)
- Lightning Protection Systems (NFPA 780)
- Water Supplies for Suburban and Rural Firefighting (NFPA 1231)
- Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles (NFPA 1962)
- Clean Agent Fire Extinguishing Systems (NFPA 2001)

- 10 CFR Part 20, Standards for Protection Against Radiation
- 29 CFR Part 1910, Occupational Safety and Health Act of 1970
- 29 CFR Part 1960, Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters
- 41 CFR 101-20, Federal Property Management Regulations
- 49 CFR, Parts 100- 181, DOT Hazardous Materials Transportation Regulations
- *Building Air Quality: A Guide for Building Owners and Facility Managers.* U.S. Department of Health and Human Services (DHHS), Center for Disease Control (CDC), National Institute of Occupational Safety and Health (NIOSH) Pub. No. 91-114

- *Criteria for Siting of Laboratory Facilities Based on Safety Environmental Factors*, prepared for U.S. EPA by Johns Hopkins University, School of Hygiene and Public Health, Peter S. J. Lees and Morton Corn, 1981
- EPA's Standard Chemical Laboratory Design Recommendations for VAV Fume Hoods
- EPA *Safety, Health, and Environmental Management Guidelines*
- *Facilities Standards for the Public Buildings Service* (GSA PBS-P100)
- Fire Suppression Rating Schedule (Insurance Services Office)
- *Handbook of Compressed Gases*, Compressed Gas Association, Inc.
- *Industrial Ventilation, A Manual of Recommended Practice*, American Conference of Governmental Industrial Hygienists (ACGIH)
- International Building Code (IBC)
- Local building codes
- Procedures Manual for Certifying Laboratory Fume Hoods to Meet EPA Standard
- *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council, 1995
- Standards for the Americans with Disabilities Act of 1990, Title III
- Standards for Bio-Safety Cabinets of the National Sanitation Foundation (NSF)
- Uniform Federal Accessibility Standards (UFAS)

Most of the documents listed above can be obtained by contacting the agencies listed here. In some cases, the agency that published the document may need to be contacted.

ANSI
Attn: Customer Service
11 West 42nd Street
New York, NY 10036
(212) 642-4900
http://www.ansi.org/catalog.html

ASHRAE
1791 Tullie Circle, NE

NFPA
1 Battery March Park
P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000
http://www.wpt.edu/nfpe/nfpa.html

National Technical Information Service
Sales Desk

Appendix B - Glossary

Appendix B - Glossary

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

Air Foil	A curved shape used at the sill corners to reduce the production of turbulence as air flows past the object.
Bus Duct or Busway	A grounded metal enclosure containing factory-mounted, bare or insulated conductors, which are usually copper or aluminum bars, rods, or tubes.
Blind Stand	A convenience shop located in an office building, which retails snacks and beverages with no cooking or food preparation.
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.
Coded Alarm System	A fire alarm system in which the alarm indicating devices are sounded intermittently with a prescribed pattern. The intermittent pattern is associated with an alarm device or area of the building.
Contaminant Generation	A laboratory operation or other event that results in the emission of potentially hazardous materials into the laboratory environment.
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.
Eddies	A circular or contrary air current that contributes to reduced capture efficiency of a laboratory fume hood.
Elevator Capture	See Elevator Recall.
Elevator Recall	The provision that automatically returns an elevator or elevators to a predesignated floor, typically the ground floor, thus taking them out of service, or permitting fire fighters to override the controls manually and use the elevators as necessary.
Etiological Organisms	An organism that has the potential to cause a disease or abnormal condition.

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 Flow	The calculated portion of the total water supply that is necessary to adequately supply hoses used by the fire department during a fire incident.
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-Stopped	The protection of penetrations through assemblies or materials that have a fire-resistance rating in accordance with the criteria of NFPA 101 and NFPA 221.
Fire-Subdivision	An area of a building separated from all other areas by fire resistive construction.
Flame Spread Rating	An index used to compare the ability of flame to propagate over a surface.
Flame Supervision	A control that responds directly to flame properties and indicates the presence or absence of flame and, in the event of ignition failure or unintentional flame extinguishment, causes a safety shutdown of the system.
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.
Footcandle	A unit of illumination, which represents a direct measure of the visible radiation falling on a surface.
Fuel Load	Also referred to as fire load, it is the weight per square foot of ordinary combustibles potentially involved in a fire incident. The weight is normalized for potential heat of combustion of the materials involved.
Furring Strips	Thin wood trim or lining used to form a level or plumb surface to attach wallboard or paneling.

Gang Chaining	Using chains to support one compressed gas cylinder from another in series with only the ends supported by a wall or other structural element.
Glazing Area	The area of a door or window opening that is sealed with a transparent or translucent material such as annealed glass, organic coated glass, tempered glass, laminated glass, wired glass, or a combination thereof. (Adapted from 16 CFR Part 1201)
Hourly Rating	See fire-resistance rating.
Material 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 MSDS aids in establishing a program for the safe and proper handling of the substance in question.
Means of Egress	A continuous and unobstructed way of exit travel from the building or structure to a public way.
"Mixer" Type Faucet Fixtures	A faucet fixture that ensures that the temperature of the water being discharged will not scald or otherwise injure a person or equipment.
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.
One-Pass Air	Air from outside the building that is conditioned and introduced into the workspace, then exhausted back to the outside of the building. There is no recirculation of air within the building.
On/Off Sprinklers	A sprinkler head that opens and closes automatically as heat conditions dictate.
Open Plan Office	A large floor area that is subdivided into cubicles by using office furniture and partitions that do not extend from floor to ceiling. (Adapted from NFPA Inspection Manual)

Panel Wall	A nonbearing wall supported by each story on a skeleton frame. Also referred to as a skeleton wall.
Phase to Phase	A method of defining the voltage when measured between two different alternating-current electrical lines supplied by the same generation or supply source. The phases in a three-phase service are 120 degrees apart.
Proscenium	The wall that separates the stage from an auditorium or the stage area in front of a curtain.
Sash	The glass and frame part installed on the front of a laboratory fume hood that can be raised, opened, and closed.
Setback	The required physical distance of a building with respect to a property line or other building.
Smoke Development Rating	An index used to compare the density of smoke generated by a material.
Spandrel Wall	That portion of a panel wall above the head of an exterior window or door.
Supervisory Condition	A signal at the fire alarm panel that indicates the need for corrective or preventive action with regards to the fire or life safety features of the facility.
Walking Surface	Any floor or other surface available for use (as in walking on or over) during the normal course of job-related duties.
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 local building code for criteria to determine if an area is considered windowless. Various exemptions exist for different conditions.
Zone of Contaminant Generation	The area around a laboratory process or operation that is affected by potentially hazardous emissions.
Zone of Influence (of Fume Hood)	The area in front of the hood opening that is affected by the operation of the fume hood and that can be impacted by other environmental sources (e.g., air supply, people).

Appendix C - List of Acronyms and Abbreviations

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ACGIH	American Conference of Government Industrial Hygienists
ACM	asbestos-containing materials
ADA	Americans with Disabilities Act
A&E	Architecture and Engineering
AEAMB	Architecture, Engineering and Asset Management Branch
AI	as installed
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
AM	as manufactured
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ARI	American Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
BACT	best available control technology
BAT	best available technology
Btu	British thermal units
CDC	Centers for Disease Control
CEQ	Council on Environmental Quality
CF_3Br	a halogenated fluorocarbon
CFC	Chlorofluorocarbon
CFM	Cubic feet per minute
CFR	Code of Federal Regulations
CGA	Compressed Gas Association, Inc.
CHP	Chemical Hygiene Plan
cm	centimeters
CPSC	Consumer Product Safety Commission
CX	Categorical Exclusion
°C	degrees Celsius
DHHS	Department of Health and Human Services
DoD	Department of Defense

DOT	Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPO	emergency power off
ERDA	Energy Research and Development Administration
°F	degrees Fahrenheit
FC	flow control
FM	Factory Mutual
FMSD	Facilities Management and Services Division
FNSI	Finding of No Significant Impact
fpm	feet per minute
FPMR	Federal Property Management Regulations
GFCI	ground-fault circuit interrupter
gpm	gallons per minute
GSA	General Services Administration
HAP	hazardous air pollutant
HAZMAT	hazardous materials
HCFC	hydrochlorofluorocarbon
HEPA	High-Efficiency Particulate Air
HFC	hydrofluorocarbon
HVAC	heating, ventilation, and air-conditioning
IAQ	indoor air quality
IBC	International Building Code
lbs.	pounds
LEL	lower explosive limit
Laser	light amplified by stimulated emitting radiation
LNG	liquefied natural gas
LPG	liquefied propane gas
µg/L	micrograms per liter
mg/L	milligrams per liter
MSDS	material safety data sheet
NC/LC	noncombustible/limited combustible
NEC	National Electrical Code
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association

NIOSH	National Institute of Occupational Safety and Health
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NSF	National Sanitation Foundation
NSPS	New Source Performance Standards
OSHA	Occupational Safety and Health Administration
PBS	Public Buildings Service
PCBs	polychlorinated biphenyls
pCi/L	picocuries per liter
Pd	Probability of detection
PEI	Petroleum Engineers Institute
Pfa	Probability of false alarm
PM	particulate matter
PNL	Pacific Northwest Laboratory
POR	Program of Requirements
POTW	publicly owned treatment works
PPE	Personal Protective Equipment
ppm	parts per million
QA/QC	quality assurance/quality control
RACT	Reasonably Available Control Technology
RCRA	Resource Conservation and Recovery Act
RSO	Radiation Safety Officer
RTP	Research Triangle Park North Carolina
SBC	Standard Building Code
SBCCI	Standard Building Code Congress International
SEFA	Scientific Equipment and Furniture Association
SF	Standard Form
SFO	Solicitation for Offers
SHEMD	Safety, Health and Environmental Management Division
SHEMP	Safety, Health and Environmental Management Program
SNAP	Significant New Alternatives Policy
SOP	standard operating procedure
SPCC	spill prevention control and countermeasure plan
TBT	tributyltin
UFAS	Uniform Federal Accessibility Standards
UL	Underwriters Laboratory, Incorporated

UBC	Uniform Building Code
UPS	uninterruptible power supply
UST	underground storage tank
VAV	variable air volume
VOCs	volatile organic compounds

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Index

The *Safety and Health Manual* is indexed by major subject area and page number. Where a paragraph contains only a cross-reference to another section of this manual or to another publication, the numbers have been set in *italic* type.