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CHAPTER 1 FIRE PROTECTION DESIGN OVERVIEW

1.1 PURPOSE

- A. This Fire Protection and Life Safety Design Manual (Design Manual) identifies the fire protection and life safety design criteria for new facility designs, upgrades, and modifications to existing facilities and spaces.
- B. This Design Manual provides requirements for protecting all Smithsonian Institution (SI) occupants and for limiting SI property loss from fire.

1.2 SCOPE

- A. This Design Manual applies to all designs, upgrades, and modifications to SI-owned, occupied, leased, or operated facilities.
- B. These requirements apply to all SI-managed facilities, operations, programs, and activities.
- C. The Director, OSHEM, is the Smithsonian's "Authority Having Jurisdiction" for fire protection and life safety matters, as defined and used in the National Fire Codes, and is the designated fire code official (also referred to as the "Fire Marshal") as defined and used in the International Fire Code.

OSHEM serves as the AHJ for all fire protection and life safety matters involving Smithsonian facilities and activities. This design manual consolidates design intent and standards.

1.3 CODES & STANDARDS

- A. **Minimum Standard:** Typical building and fire codes establish the minimum standard of performance for buildings and facilities. The codes focus on issues of life safety and firefighter safety, but do not adequately address continuity of operations, property protection, or protection for collections.

This Design Manual works in concert with the national codes and standards to establish the minimum design requirements for life safety, firefighter safety, continuity of operations, property protection, and the protection of collections for all SI facilities. The SI Design Manager shall confer with the OSHEM Fire Protection Engineer on the applicable codes and standards and any additional requirements. Where construction is not on Federal property, more restrictive codes may be required by the local jurisdictions (e.g., Metropolitan Washington Airports Authority, New York City).

- B. **Original Design Codes:** The fire protection related codes and standards in effect when facility design commences (code of record) remain in effect for the life of the facility, unless a significant hazard that endangers the building occupants or the public is identified, or unless the building is modified. In these cases, the facility is upgraded to the current requirements of the applicable code or standard. If the code of record cannot readily be determined, OSHEM shall stipulate the code to be utilized.
- C. **Current Codes:** When upgrades or modifications are made, the current edition of the code applies to the upgrade or modification. When substantial upgrades or modifications are made on fire protection systems, the entire system is upgraded to the current code or standard.

The Smithsonian facilities and museums outlast the typical design lifespan of average buildings. For example, The Smithsonian Institution Building, called “The Castle,” constructed in 1855, continues to serve as the headquarters of the organization. The Arts and Industries Building received \$100 million of upgrades in 2009 as part of the TARP initiatives. The National Air and Space Museum is slated to receive upgrades of \$900 million over the next 10 years. These significant investments in historic buildings demonstrate the Smithsonian’s dedication to historic preservation. Additional investment in fire protection and life safety features is warranted in buildings with extended life spans and/or housing irreplaceable collections, to avoid functional obsolescence, protect collections and historic structures, and provide operational flexibility.

For Historic Structures (building or other construction designated as having historic, architectural, or cultural significance), maintenance of the historic fabric – the materials, features, and finishes that existed during the most architecturally or historically significant period – may be at odds with current codes. In these situations, the goal is to maintain the buildings, their unique characteristics, and their fabric; protect housed collections; and provide for continuity of operations by providing reasonable levels of protection. NFPA 909, *Protection of Cultural Resource Properties – Museums, Libraries, and Places of Worship*, provides additional guidance on this topic and shall be used in establishing and documenting the appropriate levels of protection. .

- D. **Specific Guidance:** When site-specific guidelines or design specifications exist, they shall be included in all fire protection design packages as applicable. These guidelines can be found throughout the Design Manual.
- E. **Specifications:** SI standard Fire Protection Specifications included in Appendix B are to be used for all projects.
- F. **References:** The following Codes and Standards form the basis for this Design Manual.
1. Smithsonian Institution Directive (SD) 419, *Smithsonian Institution Safety and Health Program*, and SI Safety Manual.
 2. National Fire Codes and Standards, National Fire Protection Association, Latest Version, and their Annexes.
 3. International Code Council (ICC) Codes, latest edition:
 - i. International Building Code (IBC)
 - ii. International Fire Code (IFC)
 - iii. International Mechanical Code (IMC)
 - iv. International Plumbing Code (IPC)
 4. FM Global Loss Prevention Data Sheets

SI design requirements identified in this section apply to all Smithsonian projects. For projects located on non-federal property, other jurisdictions may impose more stringent codes. The OSHEM Fire Protection Division will work with these AHJ’s to clarify and consolidate construction requirements, and resolve conflicting standards.

SI utilizes NFPA 101, *Life Safety Code*, as the standard for life safety in our facilities and utilizes the International Building Code as its building code. There are inconsistencies between these two documents, but they are generally manageable. For example, International Building Code permits

handrails with a much smaller rounding radius than those allowed by the *Life Safety Code*. Where the requirements of these two standards conflict, the requirements of NFPA 101 will be followed for all matters concerning life safety.

- G. **Conflicts:** Where conflicts arise between codes and standards, the most stringent requirements shall apply, unless otherwise directed by the OSHEM.

1.4 EQUIPMENT

- A. **Listing:** All fire protection designs shall use equipment that has been tested and listed or approved by a nationally recognized testing laboratory (e.g., UL, FM) for its intended use.
- B. **Compatibility:** All equipment components specified in designs shall be compatible with existing equipment and installed as required by the applicable National Fire Protection Association (NFPA) codes and standards and manufacturer's recommendations.
- C. **Durability:** System reliability, longevity, and serviceability shall be included as criteria in specifying fire protection and life safety system components and in design decisions.
- D. **Testing:** Written acceptance tests and/or operating procedures shall be prepared and executed for all new system installations and/or modifications to verify that the systems perform as required. Acceptance test procedures shall be required as a separate submittal from the contractor based on the specified system performance and the specific equipment installed. Any deficiencies noted during the tests shall be documented and tracked until resolved or corrected. Operating procedures shall be required as part of the As-Built documentation submittals.

1.5 ABBREVIATIONS

- A. ASTM: American Society for Testing and Materials
- B. FM: FM Global (formerly Factory Mutual)
- C. ICC: International Code Council (Refer to 1.3 F for additional abbreviations)
- D. LSC: Life Safety Code, NFPA 101
- E. MCFL: Maximum Credible Fire Loss
- F. MPFL: Maximum Possible Fire Loss
- G. NFPA: National Fire Protection Association
- H. NRTL: Nationally Recognized Testing Laboratory
- I. OSHEM: Office of Safety, Health and Environmental Management
- J. SI: Smithsonian Institution
- K. UL: Underwriters Laboratories

1.6 DEFINITIONS

- A. **Fire Protection:** A broad term that encompasses all aspects of fire and life safety, including building construction and fixed building fire protection features, fire suppression and detection systems, fire water systems, emergency process safety controls, emergency firefighting operations (fire department), Fire Protection Engineering (FPE), and fire prevention. Fire protection is concerned with preventing or minimizing the direct and indirect consequences of fire on people, property, and programs. By extension, fire

protection also includes aspects of the following perils: explosion, natural phenomenon, and smoke and water damage from fire, suppression activities, or accidental discharge.

- B. **Fire Protection Systems:** Any system designed and installed to detect, control, or extinguish a fire; to limit fire damage; to alert occupants and/or the fire department that a fire has occurred; or to otherwise enhance life safety or property protection.
- C. **Life Safety Systems:** Any system designed and installed to alert occupants to a fire condition, provide sufficient capacity and a protected path for egress, provide structural stability, and provide passive or active defense against the spread of fire and its products. These include, but are not limited to, means of egress components, emergency lighting, exit signage, fire barriers, and structural fire protection.
- D. **Maximum credible fire loss (MCFL):** The damage to property and/or disruption to operations that would be expected from a fire, assuming that (1) all installed fire protection systems function as designed; and (2) the effect of emergency response is omitted except for post-fire actions such as salvage work, shutting down water systems, and restoring operations.
- E. **Maximum possible fire loss (MPFL):** The value of property (excluding land) and cost of operations disruption within a fire area, unless a fire hazards analysis demonstrates a lesser (or greater) loss potential. This assumes the failure of both automatic fire suppression systems and manual firefighting efforts.
- F. **Occupant:** Any person who resides or is present in an SI owned, operated, or leased facility, or who participates in a SI activity.
- G. **Redundant fire protection:** Fire protection measures implemented to mitigate the effects of fires or related perils in the event of a partial or total failure of the primary fire protection measures (e.g., two independent fire suppression systems to protect a high risk facility).
- H. **Performance-Based Design:** An engineering approach to fire protection design based on (1) established fire safety goals and objectives; (2) deterministic and probabilistic analysis of fire scenarios; and (3) quantitative assessment of design alternatives against fire safety goals and objectives, accepted engineering tools, methodologies and performance criteria. [See *SFPE Engineering Guide to Performance-Based Fire Protection*, 2007.]

1.7 FIRE PROTECTION DESIGN ANALYSIS

- A. A fire protection design analysis is required for all designs and must address the fire protection requirements of the project as required by this Design Manual. A summary of the fire protection design analysis shall be provided with the Concept submission. The fire protection design analysis shall be separate from other disciplines. Where applicable, the design analysis shall discuss the following minimum fire protection provisions (including a discussion of prescriptive requirements vs. protection provided):
 - 5. Building code analysis (i.e., type of construction, height and area limitations, and building separation or exposure protection).fire protection design analu
 - 6. Classification of occupancy.
 - 7. Requirements for fire-rated walls, fire-rated door assemblies, fire dampers with their fire-resistive ratings, smoke compartmentation, smoke barriers.
 - 8. Means of egress in accordance with NFPA 101, *Life Safety Code* (occupant loads, exit capacities, etc.).

9. Analysis of automatic sprinkler systems and other suppression systems and protected areas, including hydraulic analysis of required water demand.
10. Water supplies, water distribution, location of fire hydrants.
11. Smoke control methods and smoke control systems.
12. Fire alarm/mass notification systems (the type of system and location of equipment).
13. Fire detection system (the type of detection system and location of detectors).
14. Standpipe systems and fire extinguishers.
15. Interior finish ratings.
16. Connection to and description of fire alarm supervising system.
17. Occupancies and hazardous areas associated with the facility.
18. Coordination with security and antiterrorism requirements.
19. Fire Department access.
20. Unique requirements applicable to the project or facility (e.g. animal housing facilities).

Fire protection design analysis determines if the significant fire protection features for proposed buildings and modifications are addressed at the early stages of the project, minimizing the potential impact of fire protection changes. When addressed early, these features can often be included in an efficient and cost-effective manner, and code permitted offsets can be maximized.

1.8 PLAN REVIEW REQUIREMENTS

- A. All new projects, renovations, modifications, including associated scopes of work, shall be submitted to OSHM for review and approval.

1.9 FIRE SAFETY DURING CONSTRUCTION AND RENOVATION

- A. Coordinate with the facility prior to and concurrent with design.
- B. Separate all occupied areas from demolition, renovation, or construction activities by temporary smoke-tight construction partitions of gypsum board or other approved non-combustible or limited-combustible material in accordance with the requirements of NFPA 241, *Safeguarding Construction, Alteration, and Demolition Operations*. Barrier design shall be detailed in project documents.

Partitions shall be full height, extending through suspended ceilings to the floor slab or roof deck above and shall be one-hour fire rated, unless sprinklers are installed and are operational on both sides of the temporary partition whereupon the partition may be permitted to terminate at the ceiling in accordance with NFPA 241.

This requirement is due to the inherently greater potential for fire or hazardous materials incidents associated with the combustibles and operations of demolition/construction. This risk is heightened by the likelihood of compromised fire protection systems and fire/smoke resistant barriers. This does not obviate the need to provide other protective measures to contain dust and debris as specified under other SI requirements.

- C. Sprinklers are considered to be operational when they are installed and maintained in accordance with NFPA 13, *Installation of Sprinkler Systems* (including spacing, protection, distance from the ceiling, and adequate automatic water supply).
- D. Phase construction as necessary to ensure that exits are not obstructed or reduced in width. If exits must be obstructed during construction, provide alternate exit routes during each phase of construction and identify the alternate routes on the construction drawings.

The impact of construction on nearby occupied areas must be evaluated to ensure adequate egress is maintained for occupants in these spaces. Temporary egress paths may need to be provided. Where adequate egress cannot be maintained, it may be necessary to temporarily close areas adjacent to the construction.

- E. Minimize or avoid disruptions to fire alarm and sprinkler system service. Delineate phasing of construction to ensure that installations of new systems are expedited, and where possible, maintain existing systems in service until the replacement system is operational. If fire protection systems are to be impaired, follow the SI Fire System Impairment Permit to ensure procedures are implemented. Maintain equivalent levels of fire protection and provide formal notification to the facility while systems are down via the fire protection system impairment process (See SI Safety Manual, Chapter 36, "Fire Protection").

Impairment of fire systems during modifications and construction activities can subject Smithsonian facilities and occupants to greater risk. Application of these guidelines manages this risk to allow continued operations of the facilities concurrent with construction. Provision of adequate exits and sprinkler protection are especially effective in providing adequate fire protection and life safety.

- F. Contractors shall furnish their own fire extinguishers when an area is vacated for renovations. SI-owned fire extinguishers shall be removed from the vacated area and returned (or replaced with new) prior to re-occupation by SI.
- G. Hot work operations involving open flames or spark-producing processes shall be minimized through use of offsite fabrication or alternate work methods.

Hot work has been a major cause of fires at the Smithsonian Institution since its establishment in 1846. Constant attention to this source of ignition is a strict requirement for all SI work. Modifying projects to avoid or reduce hot work is preferable to conducting such high hazard operations on site.

1.10 PERFORMANCE BASED DESIGN

- A. It is permissible, often necessary, and usually desirable that performance-based fire safety design methods be applied to the renovation, restoration, remodeling or modernization of existing facilities to address the evaluation of a subsystem, system, or complete building when it is not possible to meet the provided prescriptive requirements for new construction. Design approaches shall follow the methodologies established in the Society of Fire Protection Engineers *Guide to Performance-Based Fire Protection or Performance-Based Fire Safety Design*, allowing adequate time and input from all stakeholders.
- B. Performance-based approaches to meeting the goals and objectives outlined in NFPA 909, Protection of Cultural Resource Properties – Museums, Libraries, and Places of Worship, or NFPA 150, Fire Protection and Life Safety for Animal Housing Facilities, shall be permitted, subject to the approval of OSHEM. Performance-based fire safety design methods must not

be used to eliminate the retained prescriptive requirements as described in the Performance-Based chapter of NFPA 101, Life Safety Code.

- C. Required design fire scenarios, performance criteria for acceptance, and input parameters for fire models used in the performance-based analysis shall be approved in advance by OSHEM, SI curatorial staff, and other stakeholders.

As a leader in fire protection design and construction for museums and historic structures, SI embraces performance based design approaches which meet the intent and requirements of the code. Such an approach can provide valuable design flexibility for both the construction of new facilities and the renovation of historic buildings.

CHAPTER 2 BUILDING FEATURES

2.1 TYPES OF CONSTRUCTION

- A. **New Construction:** New structures shall be constructed from fire resistive or noncombustible construction, Type I or II as defined in the IBC, unless otherwise approved by OSHEM.

For non-separated mixed-use buildings, the construction type shall be the most restrictive type based on the use groups and building height and area in accordance with the IBC.

- B. **Modifications:** Alterations, renovations, and additions to existing buildings shall match the existing building construction type, unless the height and area limitations of the IBC would be exceeded. In such case, the building separation requirements of the IBC shall be followed.
- C. **Wood materials:** Materials used for walls, platforms, blocking, furring, and similar applications shall be noncombustible or fire retardant pressure impregnated wood. Fire retardant coatings of intumescent paint or other surface treatments are not acceptable in lieu of fire retardant pressure impregnation.

Type I or II construction provides the durability, longevity, and fire resistance needed for significant Smithsonian buildings. This does not apply to minor support structures, sheds, maintenance buildings, and similar facilities.

2.2 USE GROUPS AND OCCUPANCIES

- A. **Classification for occupancy:** Use groups and occupancies shall be in accordance with the IBC.
- B. **Classification for egress:** The Life Safety Code chapters that correspond to the IBC use group shall be used to determine means of egress requirements and other special occupancy requirements.

SI utilizes NFPA 101, *Life Safety Code*, as the standard for life safety in our facilities, and utilizes the International Building Code as its building code. While the IBC includes life safety requirements, the Life Safety Code more thoroughly addresses egress and other life safety aspects for the wide range of occupancy types across the Smithsonian. To enable the use of both the IBC and LSC in a consistent and coherent manner, use groups and occupancies are based on a single code, the IBC, and life safety is based on the requirements of the LSC.

2.3 SITE CONSIDERATIONS

- A. **Emergency Access:** Provide access for emergency vehicles to SI buildings and additions in accordance with International Fire Code, including Annex D. Design roads, fire lanes, and turn-arounds for the weight and turning radius of fire apparatus. Consult local fire department for fire apparatus requirements. At minimum, one of the long sides of every building shall be accessible to fire department equipment.
- B. **Separation:** Distance between structures, fire ratings of exterior walls, and the protection of openings from fire exposures, shall comply with the IBC.
- C. **Urban Wildland Interface:** Clearances from combustible brush, trees, and other vegetation shall be maintained per the International Wildland-Urban Interface Code (IWUIC).

If there are discrepancies between SI and another AHJ, such as the National Park Service or WMATA, concerning the application of this code, then a wildland hazard assessment shall be completed and submitted to OSHEM for review.

2.4 FIRE AND SMOKE BARRIERS

- A. **Locations:** Fire and smoke barriers shall comply with the requirements of the IBC, the National Fire Codes, and this Design Manual.

Fire barriers for incidental use areas shall be as required by applicable codes and standards. In each case the most restrictive requirement among the IBC, National Fire Codes, and this Design Manual shall be followed. Refer to Appendix D of this Design Manual for a summary of requirements for some of the more common spaces.

- B. **Dampers:** Comply with the requirements of NFPA 90A, *Installation of Air-Conditioning and Ventilating Systems*, for treatment of HVAC duct penetrations, locations of smoke dampers, and smoke detector requirements.

HVAC ducts that penetrate smoke barriers provided to isolate collections storage rooms shall be equipped with listed combination fire/smoke dampers, operated by adjacent area smoke detection.

Subject to the approval of OSHEM, smoke dampers may be omitted in HVAC ducts that penetrate smoke barriers where the system is designed to perform any of the following functions:

21. Function as an engineered smoke-control system, including the provision of continuous air movement with the air-handling system.
22. Maintain pressure differentials during a fire emergency.

2.5 INTERIOR FINISHES AND DECORATIVE MATERIALS

- A. **Codes:** Interior finish, insulation, and decorative materials shall comply with this Design Manual, Chapter 36, "Fire Protection", of the SI Safety Manual, Exhibit Fabrication Guidelines in Chapter 8 of this Design Manual, and applicable Life Safety Code requirements.

- B. **Wall and Ceiling Materials:** Wall and ceiling materials, paneling, and acoustical tile shall be Class A or B, unless otherwise noted, with a maximum flame spread index of 75, and maximum smoke developed index of 450, as tested in accordance with ASTM E-84.

23. Exits (interior exit stairways, interior exit ramps and exit passageways) must be Class A (maximum flame spread index of 25, maximum smoke developed index of 450, per ASTM E84).
24. Interior finishes must be Class A in any space where automatic sprinkler protection is not provided.

Class B materials are allowed in areas others than exits where fire sprinklers are provided.

Note on Plastics: For many plastic materials, ASTM E84 does NOT adequately measure fire performance. Use of such materials for interior finish should be avoided. Limited application of these materials as trim or backing for graphics may be allowed on a case-by-case basis.

- C. **Wood:** Wood used for platforms, enclosures, cases over 100 cubic feet, cases with heat producing equipment, or for other purposes shall be fire retardant pressure impregnated lumber. Markings attesting to its fire retardant characteristics shall remain clearly visible.
- D. **Coatings:** Fire retardant coatings of intumescent paint or other fire retardant chemicals shall not be used in lieu of fire retardant pressure impregnated treatment.
- E. **Carpet on Vertical Surfaces:** No more than 6 inches of carpet shall be installed so as to run up the wall unless it meets the above ASTM E84 criteria for wall and ceiling materials.
- F. **Fabrics (not applied to solid backing):** All fabrics or other materials used in curtains, draperies, or similar treatments, must be certified as flame resistant in accordance with the criteria contained in NFPA 701, *Fire Tests for Flame Propagation of Textiles and Films*.
- G. **Surface Coverings:** Decorative materials including banners, bunting, streamers, fabric, paper, cotton batting, artificial and real vegetation; as well as wall, ceiling, and floor cover for acoustical or other effects, shall meet the requirements of NFPA 101.
- H. **Fire Retardant Treatments:** Textiles or other materials treated with a fire retardant shall be re-treated as per the recommended frequency by the treatment manufacturer. The building manager shall maintain a record of the date and type of treatment for as long as the material is in use.
- I. **Exhibit Staging:** Artificial rocks, faux environments, and similar construction shall be fabricated of noncombustible materials to the greatest extent possible. Gypsum, glass fiber, metal lath and other noncombustible materials shall be used in lieu of foamed plastics and other combustibles.

Cellular or foamed plastics, expanded plastics, and similar materials shall not be used in SI facilities unless they comply with the fire test criteria and limits on quantities of the IBC and the Life Safety Code. Data on all such materials shall be submitted to OSHM for review and approval.

- J. **Seating:** Theater and bench seating materials shall comply with California Technical Bulletin 133, *Flammability Test Procedure for Seating Furniture for Use in Public Occupancies*.

2.6 ROOF COVERINGS AND ROOF DECKS

- A. **Coverings:** Use roof coverings approved and listed by a NRTL. The UL Roofing Materials and Systems Directory lists three Classes (A, B, and C) of acceptable roof coverings based on compliance with UL 790, Tests for Fire Resistance of Roof Covering Materials and NFPA 256, *Fire Tests of Roof Coverings*.
- B. **Assemblies:** Roof deck assemblies must be FM Class I approved, or UL listed as Fire Classified or equal listing or classification by a NRTL.

Exceptions:

- 25. Fully sprinklered buildings.
- 26. Buildings less than 8,000 ft² (744 m²).

2.7 INSULATION

- A. **Fire Testing:** Use thermal and acoustical insulation with a flame spread index not higher than 25, and a smoke developed index not higher than 450 when tested in accordance with ASTM E84 (NFPA 255), *Test of Surface Burning Characteristics of Building Materials*.

- B. **Foam Insulation:** Use of foam plastic insulation shall meet the requirements of IBC Chapter 2603, Foam Plastic Insulation, including application of thermal barriers.
- Cellular foam plastic insulation shall be permitted only for exterior envelope, mechanical piping, and walk-in cool rooms/freezers, subject to the limitations identified in this Section.
- C. Insulation of Utility Systems:
27. Insulation of mechanical systems shall meet the requirements of the International Mechanical Code. All insulating materials, linings and coverings shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50, when tested in accordance with ASTM E84.
28. Cellular foam plastic insulation is limited to mechanical piping and subject to the following additional requirements:
- i. These insulation materials must be approved according to FM Approval Standard 4924, Approval Standard for Pipe Insulation. .
 - ii. Where the insulation thickness and diameter/sectional dimension are further limited according to the listing, these limitations shall be followed.

2.8 SMOKE CONTROL SYSTEMS

- A. **Codes:** Smoke control systems shall be installed where required by applicable NFPA Codes and SI standards.
- B. **Design Requirements:** All smoke control systems shall comply with the requirements of NFPA 92, *Smoke-Control Systems*.

Performance-Based Design of smoke control systems can result in lower required volumes of air movement and smaller HVAC equipment. This may result in considerable cost savings over prescriptive ventilation requirements and should be considered for larger projects.

CHAPTER 3 LIFE SAFETY

3.1 STANDARDS

- A. Facilities design shall comply with the requirements of the Life Safety code (NFPA 101).

NFPA 101 is utilized in lieu of Chapter 10 of the IBC, which is not applicable to SI projects. This code provides in-depth guidance for various occupancies at the SI.

3.2 BASIC REQUIREMENTS

- A. Unobstructed and adequately marked means of egress shall be provided to ensure safe emergency evacuation.
- A. Security measures or incidental building activities shall not impede exit doors, passageways, or any other part of a means of egress.
- B. Delayed egress door hardware may be used subject to OSHEM review.
- C. Utilities such as, but not limited to, wiring, computer (IT) cables, piping, ducts and other systems shall not penetrate through exit enclosures (stairwells and horizontal exits), unless serving only the exit enclosure.
- D. Exit doors shall be arranged so they can be readily opened from the egress side whenever the building is occupied. Locks, if provided, shall not require the use of a key, tool, or special knowledge or effort for operation from the inside of the building, unless permitted by NFPA 101 – Life Safety Code.

3.3 MINIMUM WIDTH

- A. The minimum unobstructed exit access width for aisles or corridors serving as the primary exit shall not be less than 44 inches (1118 mm), and, where deemed necessary by OSHEM, not less than 60 inches (1524 mm) in galleries.

Smithsonian enforces maintaining at least 60 inch exit access width for the primary circulation path through gallery spaces to prevent bottle necking of visitors as they move through exhibits, and to facilitate orderly evacuation during emergencies.

Special circumstances, such as anticipated high volume visitation, may warrant egress widths over 60 inches to permit ease of movement through exhibit spaces.

3.4 EMERGENCY LIGHTING

- A. Emergency lighting illumination levels shall meet the requirements of the Life Safety Code. Locations requiring emergency lighting include the following:
1. All assembly spaces (including galleries, large conference rooms)
 2. All means of egress. (exit access, corridor, stairs, route to the public way)
 3. Switchgear, mechanical equipment, emergency equipment, fire pump and transformer rooms.
 4. Security control rooms.
 5. Emergency command centers.

- E. Emergency lighting photometric plans are required during project design.

3.5 EXIT MARKING

- A. Mark means of egress in accordance with NFPA 101. All new internally illuminated exit signs must be light emitting diode (LED), electroluminescence (LEC), or cold cathode type. Incandescent or florescent fixtures are not permitted, except for existing fixtures, which may remain in use.
- F. Radioluminous and photoluminescent exit signs shall not be used without prior approval by OSHEM.

Smithsonian limits the use of radioluminous exit signs which contain tritium gas. These signs have to be tracked by each facility manager and reported to the Nuclear Regulatory Commission. The primary use of these signs is for temporary exhibitions, where walls are relocated several times a year, and areas with potentially flammable atmospheres.

Where permitted by OSHEM, photoluminescent exit signs and egress path marking may be installed, but must be provided with a reliable, 24 hour external illumination (charging) source of a type approved by the sign manufacturer, having a minimum illumination of 54 lux (5 foot-candles). Typically, fluorescent, metal halide, mercury-vapor, and blue LED with phosphor lights emit energy that can be absorbed and stored by the photoluminescent pigments used in this type of signage.

- G. Where deemed necessary by OSHEM, approved floor proximity exit signs and egress path marking shall be provided.

3.6 OCCUPANT LOAD MANAGEMENT

- A. Means for real time monitoring and management of occupant loads in assembly buildings shall be provided to prevent overcrowding.

Where deemed necessary by OSHEM and OPS to prevent overcrowding, automated visitor count systems have been installed and used to track and manage building wide occupant loads.

CHAPTER 4 WATER SUPPLY FOR FIRE PROTECTION

4.1 PRIVATE SYSTEMS

- A. Private water distribution systems and water supplies shall be installed in accordance with NFPA 20 – Standard for the Installation of Stationary Pumps for Fire Protection, NFPA 22 – Standard for Water Tanks for Private Fire Protection, and NFPA 24 – Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

4.2 SUPPLY DURATION AND MAIN SIZE CRITERIA

- A. The water supply for fire protection shall have a minimum supply duration of 2-hours. New primary distribution mains shall in no case be smaller than 12 inches (300 mm), building/facility loops shall be 8 inches (200 mm) or larger, and fixed suppression feeds shall, in no case, be smaller than 6 inches (150 mm).

Smithsonian enforces at least a 2-hour minimum water supply to sprinkler systems from a reliable/acceptable water source. Total required site wide water supply volumes shall be adequate to meet sprinkler and firefighting needs (flow rates and duration), based on an evaluation of national and local codes. Consult OSHEM prior to conducting such an evaluation.

4.3 DISTRIBUTION SYSTEM

- A. Fire protection water supply distribution systems for all new installations shall be looped to provide two-way flow, with sectional valves arranged to provide alternate water flow paths to any point in the system.

This allows for failure or maintenance on the water distribution loop while maintaining an alternate path to ensure a source of water is available at all times to fire protection systems.

- B. A single feed may be allowed, provided the system is reviewed and approved by OSHEM.
- C. Underground plastic pipe meeting the requirements of NFPA 24 is acceptable.

4.4 INDEPENDENT SOURCES

- A. Facilities having a Maximum Possible Fire Loss (MPFL) in excess of \$50 million shall have two independent sources of fire protection water.

Water supplies may be compromised during in-house or municipal repair and maintenance operations, placing entire facilities at significant risk. Providing a redundant water source for major facilities ensures fire suppression systems remain active at all times, reducing risk of property loss and business interruption.

4.5 HYDRANTS

- A. Fire hydrants shall be UL listed, FM approved, or listed or classified by NRTL and must have two 2-1/2-inch (65 mm) hose outlets and one 4-1/2-inch (115 mm) suction connection with national standard fire hose threads in accordance with NFPA 24 and NFPA 1963, *Fire Hose Connections*. Hydrant connections shall meet the standards of the local municipal water authority/fire department.
- B. Wet-barrel or California-type hydrants are preferable in areas where there is no danger of freezing. Dry barrel or traffic-type hydrants must be used in areas where there is a danger of freezing. Hydrants must be the aboveground type.

- C. Hydrants must be installed adjacent to paved areas, accessible to fire department apparatus. Hydrants must not be closer than 3 feet (1 m) nor farther than 7 ft. (2.1 m) from the roadway shoulder or curb line. Hydrants must be installed with not less than 6-inch (65 mm) connection to the supply main, and valued at the connection. Barrels must be long enough to permit at least 18-inch (450 mm) clearance between the center of the 4-1/2-inch (115 mm) suction connection and grade. The ground must be graded so that any surface drainage is away from the hydrant.
- D. Installation must be in accordance with NFPA 24. Suction connection should be perpendicular to the street to allow straight line connection to the pumper.
- E. A sufficient number of hydrants must be provided so that hose stream demand can be met without taking more than 1,250 gpm (4,740 L/min) from any single hydrant. Hydrants must also be spaced in accordance with the following requirements:
 - 1. All parts of the building exterior must be within 350 ft (106 m) of a hydrant, with consideration given to accessibility and obstructions. Hydrants must be located with consideration given to emergency vehicle access.
 - 2. At least one hydrant must be located within 150 ft (45 m) of the fire department connection due to hose connections available on each fire truck, unless, a shorter distance is required by the local AHJ.
 - 3. Hydrants protecting storage facilities are to be spaced a maximum of 300 ft (91 m) apart.
 - 4. Hydrants located adjacent to parking areas or other vehicle traffic areas, must be protected by bollards. The bollards must be located so they are not directly in front of an outlet.

CHAPTER 5 FIRE EXTINGUISHING SYSTEMS

5.1 GENERAL

- A. Designs of new facilities, as well as modifications to existing Smithsonian owned and leased buildings shall incorporate redundant fire protection concepts, employing active fire protection through automatic fire suppression and detection systems, passive fire barrier features, and limiting combustible fuel load to minimize potential injury to SI staff and losses to collections, mission, and infrastructure.

Specific fire protection design criteria is located within the body of the Design Manual, and in the attached SI master fire protection related specifications

- B. Complete automatic fire suppression systems are to be provided and installed in accordance with the applicable International Building Code (IBC) and National Fire Protection Association (NFPA) standards for all projects (regardless of funding sources) where the maximum credible fire loss (MCFL) without automatic fire suppression would result in the loss of use of a structure or equipment for a period longer than that considered acceptable by the program director.
- C. In addition to the above requirement, fire extinguishing systems shall be provided where required by the IBC and/or applicable NFPA standards.

Some of the requirements set forth in this document differ from the minimum NFPA and IBC requirements, which are focused on life safety and fire fighter safety, not property protection or business continuity. These codes also do not specifically address system ease of maintenance, flexibility for future modifications and durability. The SI fire suppression requirements ensure appropriate protection for the Smithsonian's valuable collections and mission critical operations. They also ensure systems are designed and installed to provide long term, lower maintenance service and to permit future modifications with least amount of disruption to our buildings.

- D. When the criteria above does not apply, automatic fire suppression may still be warranted based on any one of the following factors:
1. Programmatic importance
 2. Effects on operations
 3. Cost vs. benefit
 4. Exposure (e.g. wildland, adjacent buildings or sheds, storage)
 5. Future conditions

5.2 SPRINKLER SYSTEMS

- A. Fire Sprinkler System design criteria for SI facilities shall comply with NFPA 13, Installation of Sprinkler Systems, but shall be designed for no less than Ordinary Hazard Group 2 criteria (0.2 – 0.3 gpm/sf over 1500 sq ft (8.1 mm/min over 139 m²)).

The Smithsonian has many types of occupancies ranging from business to assembly to storage. The facilities are constantly changing out spaces which may impact occupancy classification. The Ordinary Hazard Group 2 criteria provides a sprinkler system with flexibility for future

expansion/modification to protect spaces where the use changes (e.g. from an office to a storage occupancy).

B. The following minimum design criteria shall be met:

1. Hydraulic calculations must be used for design. Pipe schedule design will not be accepted.

The sprinkler systems are constantly being modified within the Smithsonian due to construction in our spaces. This expansion or modification may change the water pressure and flow rate a system can deliver. Baseline hydraulic calculations assist in determining if an existing system can provide the required protection and, when necessary, the extent of the modifications when there is an occupancy change.

2. Reductions in the hydraulically most remote area allowed in NFPA 13 with the use of quick response sprinklers are not permitted.

The Smithsonian has many types of occupancies ranging from business to assembly to storage. The facilities are constantly changing out spaces which may impact the occupancy classification. By not permitting the reduction to the remote area, systems are designed with greater capacity to accommodate future expansion/modification.

3. Safety margin: The total demand water flow and pressure must be at least 10% less than the available water flow and pressure.

Over time the water supply pressure tends to decrease due to increased public water demands. Friction losses increase due to pipe corrosion. The safety margin allows for adequate water flow and pressure even though the available water supply and pressure may have decreased over time.

4. Pipe schedule: Schedule 40 or greater must be used for all sprinkler piping less than 4 inches (100 mm). Schedule 10, 40, or greater must be used for sprinkler piping 4 inches (100 mm) and larger.

Sprinkler mains are typically routed in open areas whereas branch mains are routed above exhibits/collection areas. Utilizing thicker walled piping (sch. 40) for branch lines reduces the risk of leaks over collections and critical operations.

5. Wet pipe sprinkler systems shall be designed as outlined in the wet pipe system specification 211313.
6. Dry pipe and pre-action sprinkler systems shall be designed as outlined in the dry pipe and pre-action system specification 211316.
7. Gate valves must be OS&Y style on systems with piping greater than 4 inches in diameter.

According to feedback provided by the SI OFMR Life Safety Shop and the SI plumbing shop, OS&Y valves are more reliable and typically installed in large mains where there is room for the stem to move up and down.

8. Butterfly valves may be used only on piping 4 inches (100 mm) and less.

9. Use of restrictive orifices, reducing flanges, unions, and plain-end fittings will not be permitted. Flanged fittings are permitted.
10. Branch outlet mechanical fittings and clamp-type fittings are not permitted unless approved by OSHM.

These fittings are not as reliable and more prone to catastrophic failure compared to threaded fittings and grooved couplings and grooved fittings. Per the SI Sprinkler Specifications, all pipes less than 4 inches are required to have threaded fittings and pipes 4 inches and larger are permitted to have grooved couplings and fittings since these larger mains are typically not routed over collections/exhibit spaces.

- C. Automatic sprinkler systems used to protect special occupancies, such as compact storage units (mobile shelving) and wet collections, shall meet the design requirements of Chapter 7 of this Design Manual.

5.3 STANDPIPE SYSTEMS

- A. When required, standpipe systems must be installed in accordance with NFPA 14, *Installation of Standpipe and Hose Systems*.
- B. Residual pressure requirements may be omitted for buildings under 150 ft (45 m) in height where fire department apparatus are expected to boost pressure in standpipe systems. Piping for standpipe systems must be designed by hydraulic calculation to show that the fire department pumper, connected to a fire department connection, can deliver the needed flow and pressure at the topmost hose connections.

Typically, the code requires high-rise buildings to have automatic standpipe systems that provide a residual pressure of 100 psi at the top. This section permits manual standpipes for high-rise buildings. Fire department pumper capabilities can change as years pass and accordingly, the hydraulic calculation associated with these standpipes should be reassessed every 5 years.

- C. All standpipe systems shall be Class I. Adapters shall be in accordance with the local fire department.
 1. Class I standpipe systems must be provided in exit stairways of buildings four stories or more in height.
 2. Class I standpipe systems must also be provided in non-sprinklered facilities where not all portions of the building can be reached with 150 feet of firefighting hose lines extended from the exterior of the building, regardless of building height. Locate fire hose connections such that all portions of the building can be reached with 100 ft. (30.5m) of hose plus 30 ft. (9.14m) of hose stream.

Class II and Class III standpipes are not permitted. A Class II or Class III standpipe permits attachment of occupant hoses to the standpipe riser. Due to the pressures associated with the water flow, an occupant must be trained to use the hose to decrease the risk of injury. The SI does not have trained fire brigades and therefore, does not install occupant hoses for safety reasons.

5.4 CLEAN AGENT EXTINGUISHING SYSTEMS

- A. Application

1. Clean agent fire extinguishing systems are suitable for protection of certain types of special occupancies, hazards, and facilities. Clean agent fire extinguishing systems are not a substitute for required automatic sprinkler systems.

Clean agent fire extinguishing agents are designed for mission critical rooms and sensitive collection storage areas where quick detection and suppression are appropriate. This type of system has a rapid response time and usually does not warrant the activation of the automatic sprinkler system. However, clean agent systems do not provide the same level of reliability as automatic sprinkler systems. Additionally, the fire sprinkler system is designed to protect the structure whereas the clean agent system is designed to protect the equipment and artifacts within a space.

B. Design Requirements

1. Clean agent fire extinguishing systems must conform to NFPA 2001, *Clean Agent Fire Extinguishing Systems*.
2. Provide stand-alone (not dependent upon the building fire alarm system for operation) control panels that are listed for releasing device service and monitored by the building fire alarm system.
3. Careful consideration must be given to compartment under/over-pressurization during the discharge of total flooding clean agent systems. Pressure relieving vents, located near the finished ceiling, may be necessary to regulate rapid pressure changes during discharge. Comply with the manufacturer's recommended procedures relative to enclosure venting.

5.5 COOKING EQUIPMENT SUPPRESSION SYSTEMS

- A. All commercial grease hood, ducts and kitchen suppression systems shall meet the most restrictive requirements of the current editions of NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, NFPA 17A – Standard for Wet Chemical Extinguishing Systems (as appropriate) and the International Mechanical Code.
- B. Grease ducts shall be protected by approved products, designed with clearance reduction methods and installed as fire rated enclosures.

5.6 PORTABLE FIRE EXTINGUISHERS

- A. Portable fire extinguishers are to be provided in SI facilities based on occupancy, length of travel between extinguishers, and hazard as required per NFPA 10 – Standard for Portable Fire Extinguishers, and this section.
- B. Clean agent or water-mist extinguishers rated for Class A:C fires are to be provided in any area with collections (i.e. all exhibit areas, collection storages rooms, conservations labs, etc.) unless waived by OSHEM. Areas with wet collections shall be provided with fire extinguishers appropriate for alcohol-based flammable liquid fires.

Clean agent or water mist extinguishing agents do not leave a residue like other extinguishing agents such as dry chemical. A residue film on collections could damage artifacts.

- C. Kitchens using deep fat fryers or other appliances utilizing combustible liquids shall have the appropriate size class K fire extinguishers located within 30 ft of such appliances.

- D. Additional requirements on the type and sizes of fire extinguishers for special areas are listed in Chapter 7, Special Occupancy Requirements. OSHEM shall be consulted as to the appropriate type of extinguishers for the occupancy.

5.7 FIRE PUMPS

- A. Fire pumps shall be located in dedicated 2 hour fire rated enclosures.

CHAPTER 6 FIRE ALARM SYSTEMS

6.1 PURPOSE

- A. Designs of new facilities, as well as modifications to existing SI owned and leased buildings, shall incorporate redundant fire protection concepts, employing active fire protection through automatic fire suppression and detection systems, passive fire barrier features, and limiting combustible fuel load to minimize potential injury to SI staff and losses to collections, mission, and infrastructure.

Specific fire protection design criteria is located within the body of the Design Manual, and in the attached SI master fire protection related specifications.

6.2 GENERAL REQUIREMENTS

- A. Fire protection systems installed in facilities on SI occupied sites shall be compatible with, and connected to, (where available) the site wide fire alarm monitoring system.

In accordance with OPS Policy Memo 27, OPS is responsible for responding to a fire alarm and notifying the fire department. The SI typically utilizes the Keltron Life Safety Event Monitoring system as this has the ability to remotely monitor numerous manufacturers' fire alarm panels. The Keltron often serves as a redundant fire alarm campus system.

- B. Fire alarm installations shall comply with the requirements and recommendations of NFPA 72, project specifications, and SI requirements.
- C. All new fire alarm systems shall be addressable unless otherwise permitted by OSHEM.

Addressable fire alarm systems provide the exact location of a fire incident in the building, which allows the OPS Officers to respond faster to an alarm condition.

- D. Complete smoke detection coverage shall be provided throughout SI facilities where early detection of fire can improve life safety or limit damage to collections and property (leased or owned) or where required by IBC and/or applicable NFPA codes.
- E. See Section 283111, Addressable Fire Alarm System, for fire alarm specification criteria.

6.3 SPECIAL REQUIREMENTS

- A. Where multiple fire alarm control panels are provided, they shall be interconnected in a Class A or Class X network arrangement.

Due to the complexity of some Smithsonian facilities, multiple networked fire alarm panels maybe needed. The importance of a fire alarm system for detection and evacuation require a reliable network. A Class A circuit (looped circuit) allows continuous operation of the fire alarm system despite a single break in the circuit. A Class X circuit (looped circuit) allows continuous operation of the fire alarm system despite a single break or short circuit.

- B. All fire alarm systems shall be monitored by a Smithsonian Institution Proprietary Supervising Station or a Central Supervising Station that meets the requirements of NFPA 72.
- C. All fire alarm circuits shall be installed in conduit (EMT, IMT, or rigid).

Fire alarm circuits installed in conduits minimize the risk of damage or accidental cutting of the circuits. In addition to minimizing the risk, conduits also facilitate repairs and future modifications. For instance, ease of pulling new wire or adding to an existing system. Limited use of MC cable can be considered on a case-by-case basis, depending on the condition of the contract area.

- D. Signaling Line, initiating circuits, notification appliance, and power circuits shall each be in separate conduit.

Installing SLC, initiating circuits, notification appliance and power circuits in separate conduits allows survivability of each circuit independently. Physical separation of circuits by type reduces the extent of potential disruption to critical fire alarm system functions during the frequent construction and repair activities that occur throughout the SI.

- E. Special fire alarm requirements are listed in Chapter 7 and Chapter 8.

6.4 PUBLIC ADDRESS SYSTEMS

- A. Public address systems used for mass notification shall comply with NFPA 72 and SI fire alarm specification 283111.

This requires coordination between OSHEM, OPS and the museum. Public address systems are typically utilized for facilities where fire alarm systems cannot achieve the intelligibility sound levels needed to communicate emergency information to the public and staff.

CHAPTER 7 SPECIAL OCCUPANCY REQUIREMENTS

7.1 COLLECTIONS STORAGE FACILITIES

- A. Collection storage rooms shall be dedicated for such purpose. Object processing, packing, unpacking, crate and packaging storage, research performed on objects, conservation of objects, and similar activities shall not be conducted in collection storage rooms. Separate spaces shall be incorporated into the design for these purposes.

Activities other than storage increase the fire risk to collections by introducing additional ignition sources and combustible material to the storage space. Even a small fire in a collections storage space could result in widespread smoke damage to collections.

- B. The storage of collections and high-value items (including art, artifacts, rare books, archival materials, specimens stored in alcohol solution, live animal collections, and objects of historic value) shall be protected by passive and active fire protection measures. These measures include the following unless determined otherwise by OSHEM:

The focus on both active and passive fire protection systems is for redundancy. Active systems such as smoke detectors and fire sprinklers will detect and/or control a fire. Should these fail, then passive fire protection measures, such as fire-rated construction, smoke barriers, and limited storage areas, will prevent fire and smoke from spreading to adjacent compartments and damaging collections beyond the area of origin.

OSHEM is currently developing a set of risk-based fire protection measures for the storage of collections at SI. When this document is complete and approved by the collections community, it will replace the requirements below.

Store as much of the collection as possible inside enclosed non-combustible (metal) files or cabinets to provide an additional level of separation and protection within collections and collateral areas. Coordinate protection of these items with SI Security requirements.

Replacement of wooden quarter units is advised. New (steel) quarter-units can reduce the risk of fire involvement/spread and can reduce smoke damage should a fire occur.

1. Separate from non-collection areas with minimum 2-hour fire-smoke barriers. Higher fire ratings may be required depending on the materials stored and hazard presented, as determined by OSHEM.

If a collection or portion thereof is considered to be of high value or in the high-risk category, higher fire ratings and supplemental fire protection systems should be considered to protect the objects.

2. Collections stored in remote facilities or buildings may not require fire-rated construction, as physical separation from other facilities or areas may serve as acceptable protection in lieu of passive features.
3. The maximum size of any single collection storage space shall be 30,000 ft² (2790 m²). Smaller spaces may be required, depending on the value of collection items stored.

This room size is provided to limit the loss of artifacts should a fire occur. The above area is based on the National Archives and Records Administration (NARA) requirement for collections storage, which is 20,000-40,000 ft², with a maximum storage volume of 250,000 cubic feet of records.

4. Protect with early warning smoke detection.

Early warning smoke detection is defined as either closely spaced spot smoke detectors, or an aspirating smoke detection system (such as VESDA). Providing early warning gives OPS and the fire department more time to respond to a fire, minimizing damage to collections. Air aspirating smoke detection, in comparison to spot smoke detectors, offers shorter activation times and greater ease of maintenance, and is therefore typically the preferred option of the SI for collection storage spaces.

5. Minimize or eliminate ignition sources within the collection storage space.

Examples of ignition sources are computers and any other electrical equipment that is not necessary to housing/preserving the collection.

6. Protect with an automatic sprinkler system.
7. Protect with additional fire suppression systems, such as gaseous fire suppression or other approved active systems when deemed necessary.

Another supplemental type of fire suppression is clean agent gaseous systems, which may be more appropriate for certain types of collections. These types of systems are designed to activate before sprinklers to suppress a fire during its early stages. The objective is to cause little or no damage to the collections. OSHEM and the collections staff should make the determination as to where supplemental fire suppression is necessary.

8. Provide compatible portable fire extinguishers.

Standard dry chemical extinguishers can leave residue that could damage collections, or be difficult to remove from objects. Water mist extinguishers might be more appropriate depending on the collection.

- C. Items of extreme value, as deemed by the museum curator, shall be stored in fire-resistant vaults, containers, or safes. Coordinate protection of these items with SI Security requirements.
- D. Collections processing areas, or other rooms where collections will be inventoried, processed, restored, cleaned, or undergo similar activities, shall be protected with 1-hour fire-rated construction. Barriers shall also be constructed as smoke barriers. Higher fire ratings may be required depending on the materials in process and hazards present, as determined by OSHEM.
- E. Rack and Compact Shelf Storage
 1. Compact (mobile) storage systems present a high fire protection challenge as they combine large fire fuel loads with severe and variable obstructions to the sprinkler system. Collections stored on compact shelving shall be protected in accordance with NFPA 909, *Protection of Cultural Resources Properties, Museums, Libraries, and Places of Worship* and this section.

2. In order to provide proper protection, design of the automatic sprinkler system must be considered together with the design of the shelving system.

The spacing and longitudinal/transverse separation of each compactor must be taken into consideration during design. The shelving design works in concert with the sprinkler system to limit fire spread and permit adequate sprinkler water distribution for effective suppression.

3. Summary of Design Options.
 - i. The options listed below do not include all detailed design requirements. See Appendix E for all sprinkler system and compact shelving design requirements.
 - ii. Enclosed Shelving.
 - (a) Appropriate for collections storage.
 - (b) Fully enclosed metal cabinets on compact shelving frames.
 - (c) Standard SI sprinkler requirements.
 - (d) Minimum clearance between compactor units is 0 inches.
 - iii. Moderate-density sprinkler system with wide spacing.
 - (a) Appropriate for collections storage consisting of books, file archives, and other similar types of storage.
 - (a) Compact shelving must have a solid metal canopy top, full-height metal longitudinal divider, and full-height metal transverse divider every 20 feet.
 - (b) Automatic sprinkler density of 0.3 gpm/ft² over 1500 ft².
 - (c) Minimum 4-inch spacing between compactor units.
 - iv. High-density sprinkler system with close spacing.
 - (a) Appropriate for collections storage consisting of books, file archives, and other similar types of storage.
 - (a) Compact shelving must have a full-height metal longitudinal divider and full-height metal transverse divider every 15 feet. The units must not have a canopy top.
 - (b) Automatic sprinkler density of 0.7 gpm/ft² over the shelving area.
 - (c) Minimum 1-inch spacing between compactor units.

The design options presented here include those protection options outlined in the Annexes of NFPA 909, *Protection of Cultural Resources Properties, Museums, Libraries, and Places of Worship*.

4. Storage of combustibles within high storage racks shall comply with NFPA 13, *Installation of Sprinkler Systems* and/or Factory Mutual Global Loss Prevention Data Sheets.
5. Aisles between storage racks (excluding compact storage units and library stacks) shall be a minimum of 36 inches (1 m) wide.

6. During design of racks and compact shelving, coordination shall occur to ensure that proper fire sprinkler coverage can be provided in the proposed shelving location. Head spacing and ceiling clearance above the shelving shall be considered.
 7. Material storage shall not exceed the capabilities of the fire sprinkler system available.
 8. A minimum 4-inch (100 mm) unobstructed transverse and longitudinal flue space shall be maintained in storage racks. Larger spaces may be required based on the depth of shelves and the results of a fire hazard analysis. The method of achieving this required spacing shall be determined as part of the design.
- F. Fluid-based, flammable liquid collections (i.e. “wet collections”) shall be stored in areas approved by OSHEM and in accordance with SI Safety Manual Chapter 38, “Fire Prevention” (Storage of Hazardous Materials section).
1. Storage areas may include, but are not limited to flammable liquid warehouse areas, flammable liquid cut-off rooms, flammable liquid storage lockers, and approved flammable liquid cabinets.
 2. Wet collections storage spaces less than 500 square feet (46.5 sq. m) shall comply with NFPA 30, *Flammable and Combustible Liquids Code*. Spaces shall be protected with fire detection systems appropriate to the hazard.

Wet collection storage areas are Class 1, Division 2, Zone 2 locations, and all equipment must be approved for use.

3. Design of wet collections storage facilities greater than 500 square feet (46.5 sq. m) shall be closely coordinated with SI OSHEM and shall incorporate the protection concepts outlined below.
 - i. Building Construction:
4. Separate buildings of Type I (4-hour) reinforced concrete construction. Building separation with a 4-hour MFL (Maximum Foreseeable Loss) wall. Exception: IBC requirements for fire separation distance may be followed and may reduce exterior wall fire resistance ratings subject to OSHEM approval.

NFPA 30 requires that larger flammable liquids rooms be enclosed by higher-rated fire barriers due to the increased amount of liquids being stored.

5. Subdivision of the building into compartments, with each compartment having two-hour walls. Compartments shall not exceed 5,000 square feet in size.

This is the same concept as that employed with general collection storage spaces to limit fire losses to collections by using passive fire protection.

6. Floor-to-floor separation of 4-hours.
7. Bulk alcohol storage rooms shall be constructed with 3-hour walls, a 3-hour ceiling, and explosion-venting panels along an exterior wall.

NFPA 30 requires the above fire-rated construction when flammable liquid storage areas exceed 500 square feet; the building is then designated as a flammable liquids warehouse for which additional requirements apply.

8. Fire Protection Systems:
 - i. Compact Storage Units (Mobile Shelving) or Tank Storage: Sprinkler system design density of 0.60 gpm/sq. ft. (24.5 lpm/sq. m) over an area of 3,400 sq. ft. (315 sq. m) in wet collections areas.

The basis of design for protecting this type of arrangement was developed during the design of the POD 5 facility at the Museum Support Center in Suitland, MD. See the Basis of Design document from OFEO Project 0230101 for additional details.

- ii. Fixed Shelving: Provide sprinkler protection appropriate for the arrangement and container type, per NFPA 13. The *Recommended Fire Protection Practices for Distilled Spirits Beverage Facilities* published by the Distilled Spirits Council of the United States, Inc. (DISCUS) may also be used as a reference in developing fire protection solutions when coordinated with OSHEM.
 - iii. A Class I standpipe system shall be provided.
 - (a) Draft curtains are to be considered in the design in order to subdivide each compartment into smaller areas to aid in sprinkler response and minimize the area of sprinkler activation.
 - iv. Provide high temperature quick-response sprinklers.

9. Spill Containment:

- i. Trench drains shall be located to prevent potential alcohol spills from flowing into corridors, limit pool size, and to provide a drainage system for fire protection water. They shall be designed to prevent incidental spills of alcohol from entering the drain; however, if there is a sprinkler system discharge, the trench shall accumulate and discharge the water.

Additional information can be found in the International Building Code (IBC) and NFPA 30.

- ii. The trench drains shall discharge to the exterior of the building, either to the storm system, sanitary system, or to grade. The municipal water /sanitary authority shall approve discharge locations.
10. Fire Alarm System:
 - i. Voice evacuation fire alarm system.
 - ii. Fire alarm notification appliances will consist of speakers and strobe lights.
 - iii. Detection appropriate to the space and hazard.

Wet collection storage areas are Class 1, Division 2, Zone 2 locations, and all equipment must be approved for use.

11. Special Detection and Control Systems:

- i. Hydrocarbon gas detection systems shall be provided. Design basis for the gas detectors shall be based on manufacturer's recommended spacing.
- ii. The hydrocarbon gas detection system shall be interlocked with the building fire alarm system and the HVAC system to initiate a supervisory alarm and a 100% purge sequence for the HVAC system serving the wet collections area.

12. All light fixtures and other electrical equipment in the wet collections storage rooms shall be Class I, Division 2.
13. Electrical receptacles are not permitted in the wet collections storage area.
14. Means of Egress
 - i. The wet collections storage areas shall be provided with a minimum of two remote exits.

NFPA 101, *Life Safety Code*, Chapter 7.11 requires two remote exits for high hazard areas over 200 square feet in size.

- ii. Within wet collections storage rooms, provide 2-hour separations between individual compartments and the center corridor to provide separated horizontal exits with a travel distance limit of 75 feet (23 m).
- G. Collection/Artifacts that may present an explosion or self-ignition hazard (e.g., munitions, cellulose nitrate film) shall be stored in locations approved by OSHEM. Spaces to house these items shall be designed with specific active and passive fire protection to address the unique hazards of the material. The design shall be informed by both the collections staff and OSHEM to determine the nature of the materials and the appropriate fire protection features.

Every attempt should be made to “safe” the collection or artifact prior to storage, in order to mitigate the potential hazard. The collection or artifact must be evaluated by OSHEM and the owner on a case-by-case basis, via risk-assessment, to determine the stability, general condition, and any adverse ramifications if the collection/artifact is exposed to fire or other unfavorable conditions. Storage areas for the collections may include, but are not limited to:

1. Magazines (permanent, portable, and/or fire resistant);
2. Fire-rated rooms;
3. Areas with special provisions, such as explosion venting; or
4. Remote buildings/facilities/areas that will not expose major facilities or other collections if the artifact/collection becomes unstable.

Cellulose nitrate film is the most common hazardous collection material at SI in this category. This type of film decomposes at normal storage temperatures, generating toxic and flammable gases. If the film is stored improperly, it can spontaneously combust and will burn extremely rapidly. Therefore, cellulose nitrate is often kept in cold-storage rooms in listed ventilated cabinets. This slows decomposition and decreases the chance for spontaneous combustion. Storage and handling for this film is governed by NFPA 40. *Storage and Handling of Cellulose Nitrate Film*. This standard describes the requirements for the storage cabinets, vaults and standalone buildings where film may be stored.

Most production of cellulose nitrate film ceased in the mid-1950s, but film stocks were used until they were depleted (likely into the late 1950s or early 1960s). If the film was made before 1960, verify whether it is cellulose nitrate or cellulose acetate.

H. ANIMAL HOUSING FACILITIES

1. All Animal Housing Facilities shall comply with this section and NFPA 150, *Fire and Life Safety in Animal Housing Facilities*.

2. A Fire Protection/ Life Safety Basis of Design narrative shall be prepared for each renovation and new construction project that affects animal housing facilities. This narrative shall include a description how the fire and life safety features/systems comply with NFPA 150.

The inability of most animals to leave their enclosures requires a shelter in place approach. Buildings may require special design features to safely house animals. Such design features need to be considered at the beginning of a project design in order to ensure constructability.

3. Means of egress shall be designed to meet the special requirements of animals and/or equipment necessary for egress.
4. All fire protection designs shall take into consideration the animals' ability to reach fire protection equipment, potentially harming the animal or damaging fire systems.

Animals have the ability to reach with enrichment tools such as bamboo sticks, balls, etc. All systems have to consider the space arrangement and the animal. For instance, an orangutan may be curious about a shiny new object (i.e. sprinkler) whereas a bird may not. Consulting with the animal keepers and OSHM is critical to any design in such areas.

5. All fire alarm systems shall take into account the need for a push-button that silences the fire alarm notification appliances in the animal areas only, but that activates a silent red beacon to indicate that the system is still in alarm.

The fire alarm tone and voice recording may be stressful to some animals. Providing a silence button allows keepers the option to silence the fire alarm only in the animal areas if they think it is necessary. An additional feature that should be considered is programming the fire alarm system to automatically silence the audible alarm in animal areas after 1 minute and to activate a red beacon if there is a fire alarm activation after staff hours.

6. Smoke exhaust systems shall be performance-based and take into consideration toxicity levels, temperature, and smoke layer height based, on the breathing zone and the tenability risk for the specific species housed.

Smoke control systems are installed in animal housing facilities to protect animals using a sheltered-in-place approach during a fire event. Properly designed smoke control systems can ensure that toxic gases do not reach the breathing zone of the animals being sheltered.

It should be noted that a smoke control system design requires computer-based fire modeling and significant analysis. During construction, coordination from multiple trades is necessary to ensure these systems are fully integrated.

7.2 MISSION CRITICAL SPACES

- A. Spaces housing mission critical information technology (IT) equipment, research laboratories, and other operations vital to SI's mission shall be protected by the following active and passive fire protection measures:

Mission Critical is defined as vital to the operation of the Institution. Examples of mission critical rooms would be:

- Rooms housing equipment, systems, or utilities, the loss of which would interrupt operations in more than one facility, or result in permanent loss of collections or mission data. (i.e. there is no off-site backup)
- Rooms containing the fiber entrance(s) for a critical facility.

1. IT Rooms shall comply with the requirements of NFPA 75, "Fire Protection of Information Technology Equipment," and the other requirements of this section.
2. 2-hour fire rated enclosures.
3. Very early warning smoke detection.

Very early warning smoke detection is defined as aspirating smoke detection (VESDA) and/or closely spaced spot smoke detection. Providing early warning allows for a quicker OPS or fire department response, minimizing fire impact.

4. Clean agent fire suppression system or other approved active system.

Clean agent systems are installed in addition to sprinkler systems. They are designed to operate prior to sprinklers to avoid collateral damage to sensitive electronic equipment.

5. One of the following:
 - i. One Type A:C fire extinguisher. (water mist, clean agent)
 - ii. One Type BC carbon dioxide extinguisher, and one Type A water extinguisher.

Dry chemical extinguisher discharge could damage the equipment in the space due to the residue left behind, and therefore they are not permitted.

6. A sign shall be located adjacent to each fire extinguisher to plainly indicate the type of fire for which it is intended.
7. Combustible storage, such as paper stock, inks, and unused recording media within the computer room shall be restricted to the minimum necessary for efficient operations, and shall be stored in closed metal cabinets.

Similar to collections storage areas, even a small fire in an IT space could cause widespread smoke damage to all equipment in the space.

- B. Local Area Network (LAN) rooms and similar second tier IT spaces shall be enclosed with 1-hour fire rated construction, be protected with sprinklers and smoke detection, and kept free of combustible storage.
- C. Where trash receptacles are specified as part of the design, only non-combustible containers shall be specified.

7.3 UTILITY ROOMS, SHOP AREAS, AND INCIDENTAL USE SPACES

- A. All unsprinklered storage rooms and sprinklered storage rooms over 100 sq. ft. (9.3 sq. m) shall be enclosed with 1-hour rated fire barriers.

The IBC requires fire-rated separation for various incidental occupancies. While the above is not within the requirements of the IBC, SI deems the above type of space as an incidental occupancy of

the same hazard level of those found in the Code. Additionally, this approach aligns with NFPA 101 Section 8.7 for areas with a higher degree of hazard.

- B. Incidental Use areas shall be enclosed with rated barriers as required by applicable codes and standards. In each case, the most restrictive requirement among the IBC, National Fire Codes, and this Design Manual shall be followed. Refer to Appendix D of this Design Manual for a summary of requirements for some of the more common spaces.

7.4 TRASH & RECYCLING DUMPSTERS

- A. If located inside of a building, trash dumpsters shall be placed within a 2-hour fire-rated room and protected with automatic sprinklers.
- B. If located outside, trash dumpsters shall have metal covers that are kept closed when the dumpster is not in use, shall not be located under metal eaves of a facility, in close proximity to combustible buildings, or adjacent to window openings. They shall be located no less than 15 feet away from a building.

7.5 LARGE ASSEMBLY BUILDINGS

- A. For buildings with an occupant load over 6,000 people, provide the following :
 1. Automatic smoke detection throughout
 2. A fire command center, as defined in IBC Section 911. Minimum size of existing command centers is 100 sq. ft.
 3. Automatic sprinkler system throughout
 4. Emergency responder radio coverage
 5. Remotely located risers in interior exit stairways
 6. Emergency voice/alarm communication system
 7. Stair pressurization systems

SI museums experience extremely heavy occupant loads during many times of the year. As such, additional measures are needed to ensure the safety of visitors, staff, and responding emergency personnel. Previously this Manual reduced the height at which a building was considered high-rise to ensure the features above were provided. This created confusion during design, and in response, the section was updated to require specific building features from the high-rise section. Items above shall be designed based on the applicable section of the IBC.

7.6 LABORATORIES

- A. Design of laboratories shall be in accordance with the requirements of NFPA 45, *Fire Protection for Laboratories Using Chemicals* and this Design Manual.
- B. All designs for laboratory spaces shall follow the lab unit approach as defined in NFPA 45. Limitations on allowable quantities of corrosives, toxic chemicals, and other hazardous materials not addressed by NFPA 45 shall comply with the requirements of the IBC.

7.7 ATRIUMS AND OTHER VERTICAL OPENINGS

- A. Atriums and other vertical openings shall be in accordance with the requirements of NFPA 101.

7.8 FLAMMABLE AND COMBUSTIBLE LIQUIDS

- A. The storage and handling of flammable and combustible liquids shall comply with Chapter 19, “Chemical Handling and Storage”, of the SI Safety Manual, NFPA 30, and the following requirements:
 - 1. Flammable liquid storage areas shall be separated from other areas by barriers having a minimum 2-hour fire rating.
 - 2. In sprinklered flammable/combustible liquids storage areas, the volume of anticipated sprinkler system discharge shall be considered, in addition to the quantity of flammable/combustible liquids in designing containment measures such as diking, trenches, and remote impounding.

7.9 MARINE OPERATIONS

- A. Marine craft shall comply with United States Coast Guard regulations and NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*.
- B. Marinas and boatyards shall comply with NFPA 303, *Fire Protection Standard for Marinas and Boatyards*.
- C. All boats and docking areas shall be equipped with portable fire extinguishers. The number and type of extinguishers shall be as specified in NFPA 302.
- D. Smoke detectors shall be provided on boats having sleeping quarters.
- E. All inboard-powered boats with an enclosed engine compartment shall have a fixed automatic fire suppression system in the engine space, or shall have a portable clean agent or carbon dioxide fire extinguisher that can be used in conjunction with a discharge port into the machinery space.
- F. Water supply for fire protection in marinas, piers, and boatyards shall be provided in accordance with the latest editions of NFPA 13, NFPA 14, *Installation of Standpipes and Hose Systems*, and NFPA 24, *Installation of Private Fire Service Mains and Their Appurtenances*.
- G. Standpipes shall be provided for piers or marine docks where the hose lay from the responding fire apparatus is in excess of 150 feet long per NFPA 303, *Fire Protection Standard for Marinas and Boatyards*, or where deemed necessary by OSHEM.

7.10 COMPACT STORAGE UNITS (MOBILE SHELVING) FOR GENERAL USE

- A. Sprinkler System Design
 - 1. For general storage of non-archival/collections items consisting of paper files, magazines, books and similar documents in folders and miscellaneous supplies with no more than 5 percent plastic, compact shelving may be installed according to the requirements and limits stated in the NFPA 13 section on Compact Storage of Commodities (20.6 in the 2013 edition). Per this standard, the shelving area is limited to 250 ft².
 - 2. The design sprinkler density is required to be a minimum of Ordinary Hazard II.

NFPA 13 does not specify a density in this section. Providing a minimum of Ordinary Hazard II sprinkler density allows for flexibility in future designs should the use of the space change.

- B. Other Fire Protection Design Options
 - 1. Shelving and sprinkler designs that are based on successful full-scale fire tests may be utilized subject to OSHEM review and approval. The design FPE shall provide

for review a copy of the fire test report, along with a summary of the storage configuration and sprinkler system design basis criteria.

2. Designs may utilize the design objectives stated in NFPA 909.

CHAPTER 8 EXHIBIT FABRICATION GUIDE

8.1 GENERAL

- A. This chapter sets forth the appropriate fire protection and safety requirements for organizations planning or engaging in exhibit construction, improvement and alteration projects.
- B. The Smithsonian Institution shall ensure that the established fire protection and life safety requirements outlined in the Smithsonian Safety Manual and this Design Manual are carried out in the planning and design of all exhibit construction, improvement, and alteration projects.
1. This consists of the most current edition of the codes and standards cited in this Design Manual, including, but not limited to:
 - i. IBC, International Building Code
 - ii. IFC, International Fire Code
 - iii. NFPA 101, Life Safety Code
 - iv. NFPA 13, Installation of Sprinkler Systems
 - v. NFPA 72, National Fire Alarm and Signaling Code
 - vi. OSHA Standards Part 1910, Occupational Safety and Health Standards for General Industry
 - vii. OSHA Standards Part 1926, Safety and Health Regulations for Construction
- C. Because of the broad scope of concern, the Office of Safety, Health and Environmental Management (OSHEM) should be consulted in the earliest stages of planning, and development or design for all projects to ensure adequate consideration of all necessary requirements within the project time constraints.
1. The SI office responsible for organizing, planning, or engaging in any exhibit construction, improvement and alteration project is responsible for ensuring OSHEM is consulted in the earliest stages of the exhibit planning.
 2. The Office of Safety, Health and Environmental Management (OSHEM) Director is responsible for directing and implementing fire protection, life safety, and occupational safety and health functions.
 3. OSHEM will provide technical supervision, assistance, review, and approval during the design and construction process.

Exhibits staff are encouraged to involve OSHEM directly in the initial stages of a design to ensure fire and life safety issues are identified and addressed early on.

- D. A checklist to aide exhibit design and fabrication with respect to Smithsonian Institution fire and life safety requirements and standards is provided in Appendix A of this Design Manual.
- E. Please refer to Appendix F, General Notes for Exhibit Design, and Appendix G, Frequently Asked Questions about Exhibits Materials, for additional information.

These sections are new to this edition of the Manual and contain information regarding general notes that should be present in every drawing set, as well as questions and answers about exhibit materials that are frequently the subject of conversations between OSHEM and exhibit design personnel.

8.2 EXHIBIT DESIGN DRAWINGS

A. General

1. Exhibit design, construction plans and specifications shall be submitted for OSHEM for review and approval at all contract submission milestones.
2. Plans shall be approved by OSHEM prior to the start of any construction or alteration activities.
3. The general notes found in Appendix F of this Manual shall be included in each exhibit design drawing set.

B. Key Plan

1. A key plan shall be provided showing the location of the project area in relation to the building floor plan.

C. Floor Plans

1. Plans shall indicate all new and existing wall, floor, and ceiling construction.
2. Areas where work is to be accomplished shall be labeled and the occupancy of the areas in close proximity to the project site (e.g. gallery, office, corridor, exit stair, collection storage) identified.
3. All new, relocated, and existing fire safety equipment on both the demolition and new work plans must be shown and labeled appropriately.
 - i. This equipment includes but is not limited to: sprinkler heads, smoke detectors, heat detectors, pull stations, standpipes/hose cabinets, fire extinguishers, bells/horns/speakers, strobe lights, remote indicator lights, exit signs, emergency lights, air supply and return ducts, fire-rated partitions, and fire doors.
4. Plans shall indicate exit details such as location, paths of access/egress, door swing, and width of passageways and doors.

The closure of a gallery for exhibit construction may impact egress from adjacent spaces. Where this occurs, plans should encompass the impacted areas.

Indicating the exit paths to the nearest stairwell or building exit on the drawings facilitates the project's life safety review. This may require showing more of the building on the plans than just the area of work.

5. Plans shall indicate the hourly rating of new and existing fire doors and frames, and include details of new fire door assemblies, such as area of glazing, materials of construction, and types of hardware.

D. Existing Conditions

1. Show locations of all existing fire alarm devices. Indicate make and model number, and type of existing equipment. Ensure devices will not be obstructed by new work.

A common issue found (especially with cycling exhibit galleries) is that new walls will obstruct the view of notification devices. Care should be taken to relocate fire alarm speakers and strobes if necessary. Ceiling mounted strobes can be used in lieu of wall-mounted devices to avoid conflicts with exhibit construction.

2. Show locations of all existing automatic sprinkler heads. Indicate height above the floor (if it varies) and sprinkler type (pendent, upright, or sidewall).

In general, exhibitry should be kept to a height 18" or more below the level of sprinkler deflectors. This will avoid sprinkler coverage issues.

3. Show locations of all exit signage.

E. Special Operations and Hazardous Materials

1. Any special operations to be performed, or hazardous materials to be used, in the work area or nearby spaces shall be noted on the drawings. Examples include: electrical hazards, use of flammable or toxic materials, special cleaning operations.

F. Exhibited Objects

1. Drawings shall include adequate information about the objects on display to assess their impact on the level of fire protection and life safety. Plans are to include the dimensions, exact location, and construction materials of large objects not enclosed within vitrines.

Advance coordination with OSHEM of fabrication is critical to ensure fire protection and life safety requirements are met. The goal of this interaction is to ensure adequate life safety for visitors and staff, while minimizing impact to the exhibited objects.

2. Objects or exhibit construction shall provide necessary details to demonstrate that hazards such as sharp edges, tip-over, and moving parts are properly mitigated.

8.3 EXITS

A. Exit Details

1. All public galleries shall have a minimum of two exits, arranged to be remote from one another.

Large galleries with capacities of more than 500 occupants, based on the criteria of NFPA 101, require three exits; galleries with capacities of more than 1000 occupants require four exits.

2. Ensure the clear width along all points on the primary egress path is a minimum of 5 feet (1524 mm).

The wider path compensates for circuitous routes through an exhibit, and allows occupants room to turn around and head towards an exit in the event of a fire.

3. Ensure the clear width along all points on the secondary egress paths is a minimum of 44 inches (1117 mm). (In certain situations, NFPA 101 and OSHEM may require greater clear width.)

Wider egress paths may be required to accommodate large exhibit spaces with higher occupant load capacities, per NFPA 101.

B. Exit Signs

1. Location

- i. Exits shall be properly identified by exit signs. Exit signs shall be listed or approved, readily visible, and of a distinctive color which contrasts with the surrounding decor.
- ii. No display, object or brightly illuminated signs shall be placed in the line of vision to distract attention from the exit signs.

2. Lettering

- i. Each exit sign shall have the word, "EXIT" in plain, legible letters not less than 6 inches (150mm) high, with the principal stroke of letters not less than 3/4 inches (19mm) wide.
- ii. An arrow, indicating the direction of exit travel, shall be used when the direction is not readily apparent. Refer to NFPA 101 for other specific requirements.

3. Illumination

- i. Exit signs shall be illuminated by either an integral light source or an external light source measuring not less than 5 foot-candles (54 lux) at the illuminated surface under both normal and emergency power.
- ii. Internally illuminated signs shall be listed in accordance with ANSI/UL 924.

4. Power Supply

- i. The power shall be supplied by continuous power source with secondary power from an emergency generator or integral battery.

C. Walking Surfaces

1. Changes in Elevation

NFPA 101 recognizes the changes in elevation noted below as tripping hazards. Any change in excess of the below must be achieved by a ramp or stair.

- i. Abrupt changes in elevation of walking surfaces shall not exceed 1/4 inch (0.63 cm).
- ii. Changes in elevation exceeding 1/4 inch (0.63 cm), but not exceeding 1/2 inch (1.3 cm) shall be beveled with a slope of 1 in 2.

2. Headroom

- i. Minimum headroom shall be 6 feet 8 inches (203 cm) at doors or stairwells.

3. Platforms

- i. Platforms protruding into walk spaces present a "strike the ankle" type hazard. Special lighting, color contrast, padding, or full height guardrails are recommended.

D. Stairs and Steps

1. Fewer Than Three Risers

- i. When fewer than three risers are used, measures shall be taken to create awareness of the elevation change. Examples include special lighting, color contrast, change in floor surface, or barriers.

2. Width and Height Requirements

The requirements below are taken verbatim from NFPA 101.

- i. Minimum width of stairs and steps shall be 44 inches (112 cm) and clear of all obstructions except handrails. Stair and landings shall not decrease in width along the direction of exit travel.
- ii. Treads shall not be less than 11 inches (27.9 cm).
- iii. Risers shall not be less than 4 inches (10.2 cm) nor more than 7 inches (17.8 cm).
- iv. Variations in width of adjacent treads and height of adjacent risers shall not exceed 3/16 inch (.5 cm). Variation between sizes of the largest and smallest risers or between the largest and smallest tread depths in a flight of stairs shall not exceed 3/8 inch (0.95 cm).

3. Landings

- i. Doors may not open immediately onto stairs without a landing of at least the width of the door, plus one tread dimension.

This configuration removes the risk of tripping or falling upon opening the door and is an NFPA 101 requirement.

4. Handrail Details

The requirements below are taken verbatim from NFPA 101.

- i. Stairs and ramps shall have handrails 34 to 38 inches (86 to 96 cm) high measured from the leading edge of the tread to the top of the rail.
- ii. Additional handrails that are lower or higher than the main rail are permitted. For areas where children are the primary users, it is recommended that an intermediate handrail be installed.
- iii. Handrails shall be installed to provide a clearance of at least 2-1/4 inches (56 mm) from the wall to which it is attached.
- iv. Handrails shall offer no obstruction to a smooth handhold surface along the top and both sides of the rail.
- v. Handrails shall have a circular cross section with an outside diameter of at least 1-1/4 inches (3.2 cm) and not greater than 2 inches (5 cm).
- vi. Handrails shall extend horizontally at least 12 inches (30.5 cm) beyond the top riser and continue to slope for a depth of one tread beyond the bottom riser.
- vii. Ends of handrails shall be turned into the supporting wall, floor or shall terminate at newel posts.

5. Guardrails

The requirements below are taken verbatim from NFPA 101.

- i. Guardrails shall be provided at floor openings, open-sided floors, platforms (30 inches (76 cm) or more above the floor or ground level) and ramps. All open sides shall be guarded by railings, except where there is an entrance to a ramp or stairway.
- ii. Guardrails shall have a vertical height of 42 inches (107 cm) measured from the upper surface of the top rail to the floor, platform, or runway.
- iii. Guardrails shall be capable of withstanding a load of at least 200 pounds (90.7 kg) applied in any direction at any point at the top of the rail.
- iv. Provide full-height (42") guardrails or barriers in lieu of cane rails.

Experience with cane rails at SI has shown that they often present a significant tripping hazard.

8.4 FIRE-RATED CONSTRUCTION

A. Penetrations Through Fire-Rated Construction

1. Penetrations through fire-rated construction (i.e. walls, floors, etc.), not protected by fire dampers or combination fire/smoke dampers, shall be sealed with an approved penetration firestop material that maintains the fire rating.

Most foaming insulation is not approved firestop material. This type of material will still burn in the presence of fire due to its chemical makeup.

2. All installations shall comply with the manufacturer's installation requirements.

8.5 MATERIALS OF CONSTRUCTION

A. General

1. All materials of construction shall be noncombustible or inherently fire retardant. These requirements typically do not apply to artifacts/collections to be exhibited, unless the object presents an appreciable fire risk as evaluated by OSHEM.

Extreme care must be exercised in the selection of interior finish materials. Some veneers and synthetic J wall, ceiling and floor coverings are dangerously combustible. Flames spread rapidly over them, generating large amounts of smoke and toxic products of combustion. The danger to collections and to the lives of visitors and staff from improperly selected interior finish materials cannot be overemphasized.

2. Readers are encouraged to reference Appendix F for common information required on exhibit design drawings.
3. When completed, readers are encouraged to reference Appendix G for approved materials for exhibit construction.

B. Testing

1. Fire tests for construction materials must be conducted by an independent, national testing laboratory, such as Underwriters Laboratories.

Such labs follow established test standards to rate the fire performance of construction materials, including how much fuel a material contributes to a fire, how quickly flame spreads over its surface, and how much smoke it generates.

Standardized fire testing is a costly and lengthy process. OSHEM recommends using products that have been previously tested to the ASTM standards listed below.

2. Fire performance is to be measured using a standardized test, recognized by national codes, and appropriate for the material type and application. Flame spread shall be measured using test standard ASTM E-84, and critical radiant flux is to be measured using test standard ASTM E-648.

For ASTM E-84, the lower the flame spread the better its performance in the test. For ASTM E-648 the higher the critical radiant flux the better its performance in the test.

3. Test results of any materials may be requested by OSHEM for review prior to approval.

C. Wall and Ceiling Materials

1. Wall and ceiling materials that are used in exhibit spaces or the means of egress such as paneling or acoustical tiles; shall have a flame spread rating of 25 or less, and a smoke developed index of 450 or less, as measured in accordance with ASTM E-84, Surface Burning Characteristic of Building Materials.

The above numerical values equate to a Class A rating in accordance with ASTM E-84. Common wall materials that meet this requirement are drywall, fire retardant MDF (e.g. Medite FR), and fire retardant plywood (e.g. Pyroguard).

The test results of ASTM E-84 are represented by a dimensionless number. For reference, mineral board has a flame spread of zero, and red oak has a flame spread of 100 per the test.

2. Materials not appropriate for testing with ASTM E84 shall pass NFPA 286.

Materials that are not appropriate for testing with E84 include materials that melt or drip. This includes most plastics and plastic foams, which are discouraged by this Manual. NFPA 286 is a more realistic fire test that utilizes a full-scale fire to approximate the contribution of a given material to a fire scenario in a compartment.

3. For exhibit spaces protected by an automatic sprinkler system, wall and ceiling materials shall have a flame spread rating of 75 or less.

Materials with a numerical flame spread rating from 26 up to and including 75 are considered to have a Class B rating, in accordance with ASTM E-84.

4. Wall mounted materials that have an aggregate surface area exceeding 10% of the wall area, and single pieces over 100 sq. ft. (9.3 sq. m) shall comply with the above requirements for wall and ceiling materials.

Wall mounted materials in this size or coverage begin to perform similarly to a wall finish. This size requirement includes backings for portraits and other wall-hung materials. Acrylic does not meet Class A or B ASTM E-84 requirements; therefore, the aggregate quantity of wall-mounted acrylic must have a surface area less than 10% of the wall area, and individual panels must have an area less than 100 sq. ft. Materials such as metal sign blank, fire retardant MDF, or glass are acceptable alternatives in this situation.

D. Wood

1. Wood used for walls, platforms, dioramas, blocking, furring, cases over 100 cubic feet (2.8 cubic m), light attics with electric lighting, and similar applications shall be fire retardant, pressure impregnated.
 - i. Fire retardant coatings and intumescent paint are not acceptable in lieu of fire retardant pressure impregnation treatment.

Fire retardant coatings and intumescent paints are not absorbed/impregnated into the wood, as pressure impregnated fire retardant treatments are. While paints and similar coatings can reduce the flame spread across the surface of a material, they do not alter the combustibility of the entire product. Additionally, such coatings can flake off or lose their effectiveness over time, leading to inadequate protection.

- ii. This requirement shall not apply to cabinets, showcases or finish trim.
- iii. Unenclosed spaces beneath table-style cases shall not contribute to overall case volume when considering the 100 cubic foot (2.8 cubic m) limit.

E. Carpeting

1. Flooring materials shall have a minimum critical radiant flux of 0.45 watts/cm², when tested in accordance with ASTM E-648, Standard Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source.

The numerical value above corresponds to a Class I finish in accordance with ASTM E-648.

2. Carpeting shall also pass the Methanamine Pill Test, Federal Flammability Standard FF-1-70 (ASTM D-2859).

All carpeting imported, sold, or brought into commerce within the USA must meet the test above.

3. For installations specifying carpeting on walls the following criteria shall be used:
 - i. The room shall be protected by an automatic sprinkler system.
 - ii. Materials shall have a Class A rating (flame spread 25 or less and smoke development factor less than 450), as measured by ASTM E-84.

Materials perform differently in a fire when oriented vertically versus horizontally. Vertical surfaces tend to spread fire more rapidly than horizontal surfaces; therefore carpeting specified for wall installation must meet a Class A rating as tested per ASTM E-84 for wall finishes.

F. Draperies, Bunting or Decorative Textiles

1. All material intended for decorative purposes, such as draperies, scrim or bunting shall be certified flame resistant in accordance with the criteria contained in the current edition of NFPA 701, Methods of Fire Tests of Flame- Resistant Textiles and Films. Samples and fire test data shall be submitted to OSHM for evaluation and approval.

Every effort should be made to obtain materials that are factory treated to meet NFPA 701. In the event that a fabric does not come in a fire retardant variety, it may be treated post-manufacturing with a fire retardant. The requirements above for test data and samples still apply.

- G. Plastics, fiberglass, exposed foamed plastics, materials containing foamed plastics
1. Plastics, exposed foamed plastics, and materials containing foamed plastics are prohibited from being used in the exhibit unless the specific criteria in the Life Safety Code and the IBC for Interior Finish and Furnishings, Decorations, and Scenery have been met.

Plastics are extremely flammable and produce toxic combustion products when burned. This type of material should not be selected for an exhibit when non-combustible or fire-retardant materials could be used.

The documents above refer to ASTM E84 for most materials. However, plastics used as a wall finish (such as HDPE panels) must pass NFPA 286. Plastics used as trim (and similar auxiliary uses) must pass NFPA 289/UL 1975.

However, the Codes do not adequately address items found in our galleries, such as fabricated models. Please see the model-making section below.

2. Samples and fire test data shall be submitted to OSHEM for evaluation and approval.
3. Vitrines materials with more than 100 sq. ft. (9.3 sq. m) of exposed vertical surface area shall comply with the interior finish requirements for walls and ceiling materials.

For vitrines, only the vertical (wall) surface area is tabulated, as flame spread over the vertical surfaces is of more concern than that of the horizontal ones. Acrylic use is limited to an aggregate exposed surface area of 100 sq. ft., since acrylic does not meet Class A or B ASTM E-84 requirements.

4. Fiberglass must use a fire-retardant resin and pass Class A or B interior finish requirements when tested in accordance with ASTM E-84 in the design thickness.
5. Aluminum Composite Materials (ACM) (e.g. di-bond) may be used for standalone signage and the backing of vitrines when the material does not exceed 100 sq. ft. in area. This material may not be used to construct casework. The material must pass ASTM E84 Class A.

OSHEM acknowledges that this material is preferred as a graphics backing material in some instances. While this type of material passes ASTM E84, it still contains a significant amount of plastic, which melts, drips, and burns when exposed to heat and flame. Thus, its use is limited to the above.

6. Desiccant chambers within cases less than 100 ft³ in size may be constructed of acrylic. ACM may be used in larger cases for this purpose. The ACM must pass ASTM E84 Class A.

The surfaces of desiccant chambers are required to be inert in terms of object conservation. Acrylic and ACM are two materials that have been approved by SI conservation staff. Barrier films (e.g. Marvelseal) are considered a last resort to accomplish separation between case materials and a specimen. Given the limited space that desiccant chambers occupy, the above-specified materials are permitted for this purpose.

H. Glass

1. Glass used in vitrines or displays that exceeds 48 inches (1219 mm) in any dimension shall be laminated safety glass.

The IBC requires safety glass for large panes of glass. The large number of cases and vitrines and high visitation in our public spaces, raises the risk of injury due to glass breakage. Thus, the IBC requirements for safety glass are applied in this situation.

I. Model-Making

1. It is not the intent of this Manual to prohibit the construction of models. However, models are often fabricated from plastic or foam. As stated in previous sections of this document, plastics and foam plastics are prohibited, unless meeting the specific requirements of IBC and the Life Safety Code.

Early collaboration with OSHEM on model design and fabrication is highly recommended.

2. Refer to Appendix G for guidelines on model fabrication.

8.6 FIRE ALARM AND DETECTION SYSTEMS

A. General

1. Smoke detection shall be installed in all areas and shall meet the requirements of the current edition of NFPA 72, the SI Fire Protection & Life Safety Design Manual, SI Standard Specifications, and the manufacturer's design specifications.
2. When a permanent gallery is closed to install a new exhibit, potential fire detection and alarm system upgrades must be evaluated and implemented. Ceiling-mounted notification appliances are preferred to provide maximum flexibility in exhibition design.
3. Smoke detectors and notification appliances shall not be field-painted.

Devices may be compromised if field-painted. Additionally, their listing/approval assigned by Underwriter's Laboratories (UL) or Factory Mutual (FM) will be invalidated. Field-painted devices can no longer be used as part of a listed/approved fire alarm system, and must be replaced.

4. Protective covers for fire detection and suppression devices shall be provided during dust-creating construction and painting operations. Protective covers shall be removed at the end of each workday. The SI Fire System Impairment Permit must be used each time detectors are covered or taken out of service by some other means.

Any work activity that will create dust can clog the sampling chamber of the smoke detectors and cause them to malfunction. If air sampling smoke detection (VESDA) is present in the gallery, the VESDA unit should be deactivated to preserve the filters. The system must be reactivated at the end of each workday, after dust has been cleared.

It cannot be emphasized enough that the museums are most vulnerable to fire while undergoing construction. It is critical to have fire detection systems operational, except when dust-generating activities are ongoing.

- B. Manual Fire Alarm Stations
 - 1. Manual fire alarm stations shall not be obstructed and shall remain accessible at all times.
- C. Placement of Bells, Horns, and Speakers
 - 1. Audible devices shall be installed so that they are at least 15 dB louder than the maximum noise level that normally occurs in the area served.
- D. Placement of wall and ceiling mounted strobes.
 - 1. Visual devices (strobes) shall be installed per NFPA 72, and not obstructed from view by exhibit construction.
- E. Relocation or Extension of Existing Equipment
 - 1. Determine final location of walls, barriers and ceilings before placing detection and alarm equipment.
 - 2. New equipment shall be compatible with the existing system.
- F. Testing of Devices
 - 1. OSHEM must witness acceptance testing of new or relocated devices.

8.7 AUTOMATIC SPRINKLER SYSTEMS

- A. General
 - 1. Provide automatic sprinklers in all areas. Sprinkler installations shall meet the requirements of the current edition of NFPA 13, SI Fire Protection & Life Safety Design Manual, SI Standard Specifications, and the manufacturer's design specifications.

Care must be taken to ensure that new exhibitry does not obstruct fire sprinkler discharge. In general, floating ceilings/objects less than 4 feet in diameter and kept at least 18" below the sprinkler head will not require sprinkler protection. Mesh/grate-type ceilings less than 70% open will require a separate level of sprinkler protection. Obstructions may also comply with the cloud ceiling requirements of NFPA 13 where permitted.

- 2. When a permanent gallery is closed to install a new exhibit, potential fire protection system upgrades must be evaluated and implemented.
- B. Relocation or Extension of Existing Equipment
 - 1. Determine final location of walls, barriers and ceilings before considering changes to the sprinkler system.
 - 2. If existing equipment must be extended or relocated, provide a layout showing location and size of existing and proposed piping.
 - 3. Sprinkler system additions and modifications shall be per the latest edition of NFPA 13 and designed for Ordinary Hazard Group II Occupancies.

Providing Ordinary Hazard II sprinkler density allows for flexibility in future designs.

- 4. Pipe sizes shall be determined by hydraulic calculation.

5. Obstructions over four feet in width require sprinkler coverage underneath.

This section does not apply to cases, tables, and similar construction.

- C. Sprinkler heads and concealed sprinkler plates shall not be field painted. Any sprinkler heads or plates coated with paint in the field shall be replaced.

When sprinkler heads or plates are painted, their ability to function is diminished. Care should be taken during painting stages to ensure that the heads do not need to be replaced. Please note that heads may not be “cleaned” to remove material if they have been painted; they must be replaced.

- D. Enclosed dioramas/cases greater than 150 square feet in size shall have sprinkler coverage installed within unless it meets all of the following requirements and is approved by OSHEM:

1. The exhibitry is constructed of noncombustible materials. Fire retardant wood is also permitted.
2. Light attics are enclosed in metal and separated from the primary cavity of the case by glass.
3. All lighting is low voltage.
4. No other line-voltage electrics are present in the case.
5. Minimal diorama/scenery is present within. Anything in the exhibitry (other than specimens/objects) must be noncombustible or fire retardant.

Sprinkler systems are designed to react to incipient fires and control them while they are small. Large unsprinklered casework and exhibitry can delay sprinkler operation, allowing a fire to grow unchecked. This represents a gap in the sprinkler protection strategy.

Very large objects/artworks will need to be evaluated by OSHEM on a case-by-case basis. That being said, large exhibits that visitors can enter or walk through are subject to this section due to the fire/life safety risk that results from a lack of sprinkler coverage.

8.8 EMERGENCY LIGHTING

- A. Location

1. Emergency lighting for exhibits shall be provided for all occupiable spaces (public and staff) and means of egress, including stairs and ramps.
2. Facility emergency/maintenance/security lighting shall not be altered to accommodate exhibitry without approval from OSHEM. Ensure that relocated fixtures remain on an emergency circuit.
3. If exhibit lighting is utilized for emergency lighting purposes, alterations shall be reviewed by OSHEM to ensure sufficient lighting is provided.

Significant changes to lighting layout in this scenario may require lighting calculations to ensure that an average of 1 foot-candle is provided along egress routes.

- B. Power

1. The power shall be supplied from a continuous fixed wiring power source with secondary power from either an emergency generator or battery pack.
- C. Illumination
1. Lights shall be located to provide an average level of illumination of 1 foot-candle (10 lux), measured at the floor.
 2. Where lighting dimming control systems are used one of the following conditions must be met:
 - i. Separately controlled emergency egress lighting is provided.
 - ii. Dimming control panel is connected to emergency power circuits and controlled lighting provides an average level of illumination of 1 foot-candle (10 lux) measured at the floor under both normal and emergency power.
- D. Testing
1. Emergency lighting shall be tested prior to the beneficial occupancy of each new exhibit.

Wiring and lighting controls are often modified during exhibit construction, potentially affecting the performance of emergency lighting.

8.9 PORTABLE FIRE EXTINGUISHERS

- A. Portable extinguisher coverage in exhibit spaces shall comply with the Standard for Portable Fire Extinguishers (NFPA 10), and the SI standard specifications for fire extinguishers.
- B. Water-mist extinguishers shall be provided in all exhibit spaces.

Of the various types of available portable extinguishing agents practical for exhibit spaces, water is generally considered the least detrimental to most collection materials. Water mist extinguishers use deionized water that is dispersed in droplet form with limited overspray. Dry chemical extinguishers, on the other hand, discharge a fine powder that can remain suspended in the air and migrate considerable distances, leaving a difficult to clean chemical residue on objects remote from the application site.

- C. The minimum classification of water mist extinguishers is 2A-C.
- D. The maximum travel distance to an extinguisher in an exhibit space is 75 feet (22.86 m).
- E. Extinguishers may be mounted on hangers or brackets, on shelves, or in cabinets. Extinguishers shall be mounted so that the top is no more than 5 feet (152.4 cm) above the floor and the bottom is at least 4 inches (10.2 cm) from the floor.
- F. Cabinets may be recessed to minimize the aesthetic impact. The door shall include a clear vertical viewing panel. The cabinet shall be labeled, "FIRE EXTINGUISHER" with minimum 1-inch (1.91 cm) letters and minimum 1/8-inch stroke width. At no time shall fire extinguisher cabinets be locked. Break-glass type cabinets are not permitted.
- G. Extinguisher cabinets recessed in fire rated walls must be listed for such purpose.
- H. Extinguishers shall be readily accessible and not hidden from view.

Locations of extinguishers that are not readily apparent should have a sign installed above the cabinet to alert occupants as to the presence of an extinguisher.

8.10 ELECTRICAL REQUIREMENTS (OTHER THAN FIRE ALARM)

- A. All new or altered electrical work shall be performed by qualified electricians and shall comply with the current edition of the NFPA 70, *National Electrical Code* as well as existing local electrical codes when specified.
- B. All wiring shall be installed in rigid conduit, EMT or flexible conduit. Aluminum conduit shall not be imbedded in concrete.

Wires placed in conduit are less susceptible to damage; damaged wires are a significant fire hazard.

Aluminum conduit reacts with concrete, which corrodes the aluminum and forms hydrogen gas. In the long term, the gas can expand and crack the concrete.

- C. Fixed wiring methods shall be metal raceways, nonmetallic raceways encased in not less than two inches of concrete, mineral insulated metal-sheathed cable or Type MC cable. Type AC cable (commercial EX) shall not be permitted.
- D. All new receptacles, switches and equipment shall be U.L. listed or equivalent. Where equivalent items are specified, pertinent features must be listed in the technical specifications and identified in the Special Conditions of the Contract.
- E. The number and placement of receptacles shall be adequate to support the required electrical loads.

8.11 AUDIO VISUAL EQUIPMENT

A. Open Audio Visual Areas

- 1. Open Audio Visual Areas shall be defined as those areas constructed within exhibit areas or structures for the purpose of housing audio visual support equipment which are open to above and unobstructed in accordance with NFPA 101 and NFPA 72.
- 2. All shelves and mounts shall be constructed of noncombustible materials.
- 3. Clearance from audio-visual equipment to any combustible materials shall be at least one foot horizontally, and two feet (61 cm) vertically.

B. Enclosed Audio Visual Areas

- 1. Enclosed Audio Visual Areas shall be defined as those areas constructed within exhibit areas or structures for housing audio-visual support equipment that are NOT open to above or are obstructed.
- 2. Enclosures shall be constructed of fire resistant materials subject to the approval of OSHEM.
- 3. All shelves and mounts shall be constructed of noncombustible materials.
- 4. Each enclosure shall be provided with a smoke detector connected to the facility fire alarm system.
- 5. Sprinkler protection shall be provided, where applicable.
- 6. All enclosures housing projection equipment shall be ventilated mechanically to remove excess heat, unless the design proves that mechanical ventilation is not required.

C. Audio Visual Control Rooms

1. Audio Visual Control Rooms shall be defined as those rooms within the facility that house the control equipment for one or more gallery's audio visual exhibit components.
2. Rooms shall be constructed with 1-hour fire rated construction with 45-minute opening protectives.

While AV rooms do not contain all of the same equipment as an IT room, the basis for the fire rated construction is the same: loss of the equipment would result in a high replacement cost and an interruption of operations.

3. Rooms shall be provided with smoke detectors connected to the facility fire alarm system.
4. Sprinkler protection shall be provided, where applicable.

D. Audio Visual Equipment Shutdown

1. Upon general fire alarm evacuation, all audio-visual equipment (including interactive displays) shall be designed to cease operation. Where hard shutdown of audio visual equipment may damage the equipment, this requirement may be waived with OSHEM approval when at least one of the following conditions is met:

Recent gallery upgrades have relied upon heavy use of A/V equipment, television screens, interactive exhibits, and ambient audio. These items can distract occupants in the event of a fire or overpower the sound of the fire alarm speakers.

- i. Normal audio-visual operation can be demonstrated to not interfere with or obscure emergency notification systems.
 - ii. Normal audio-visual operation can be replaced with an emergency message upon activation of emergency notification systems.
 - iii. Normal audio-visual operation can be replaced with a black screen.
 - iv. Other remediation approved by OSHEM.
2. Audio-visual shutdown is normally initiated via a fire alarm relay with a set of dry contacts (normally open and normally closed are typically both provided on the relay). The exhibit designer must confirm the location of existing fire alarm relays or include new relays in their design as necessary. The use of a shunt circuit breaker tripped by a fire alarm relay is an acceptable shutdown method, but should be discussed with the facility exhibit group since the breaker requires manual resetting.

If individual shutdown relays are provided in the gallery, they should be noted on the plans. If a central shutdown relay is provided in the building, then this should be indicated on the plans in a general note.

8.12 INSTALLATION OF EXHIBITS

A. Exit Access

1. Exhibit construction activities shall not block, remove, or otherwise inhibit exit access from nearby occupied galleries or spaces.
2. Exits shall be unobstructed and adequate in number and size.

3. Consideration shall be given to the orderly circulation of visitors and avoiding cul-de-sacs or dead ends.
- B. Exhibit Installation Barriers
1. Dust barriers shall be constructed of non-combustible or fire retardant materials that are classified as Class A or B per ASTM E-84, or shall pass NFPA 701, as applicable.
 2. For exhibit installations where sprinkler system outages are required, or where hot work is needed, a 1-hr fire barrier separating the work area from the occupied space shall be provided.
 3. Construction barriers shall be in accordance with the Standard for Safeguarding Construction, Alteration and Demolition Operations (NFPA 241).
- C. Access to Equipment
1. Fire protection equipment shall not be obstructed or interfered with during exhibit installation.

8.13 FINAL ACCEPTANCE AND APPROVAL

- A. Upon completion of each project, but prior to issuance of the beneficial occupancy permit, the COTR or person responsible for the exhibit construction shall contact OSHEM to conduct a final occupancy inspection/walkthrough of the space, noting any deficiencies or problems.
- B. Prior to beneficial occupancy, any fire protection and life safety system changes included in the project must pass final acceptance testing by OSHEM. Final acceptance testing may include any or all of the following:

In addition to the mandatory emergency lighting test, the following tests are required if the associated fire system/equipment has been modified or impacted during exhibit installation.

1. Hydrostatic Testing of Sprinkler Piping
 2. Functional Fire Alarm Testing
 3. Functional Fire Damper Testing
 4. Exit Door Opening Force Test
- C. A provisional occupancy certification may be issued where necessary for the installation of collection objects by SI staff.

APPENDIX A - FIRE AND LIFE SAFETY CHECKLIST FOR EXHIBIT CONSTRUCTION

- A. INTRODUCTION: This checklist is intended to assist exhibit designers and fabricators in approaching the design and construction of exhibits in SI facilities. It does not replace or exclude any of the requirements found in this Design Manual.

| EXHIBIT CONSTRUCTION CHECKLIST | | Project: | | |
|---------------------------------------|--|---|--------------------------|--------------------------|
| Element | Requirement | Section | | |
| Exhibit Design Drawings | General Show project area in relation to building floor plan. | 8.2.A.1 | <input type="checkbox"/> | |
| | General Show new, relocated, and existing equipment on demolition and new work plans. | 8.2.C.3 | <input type="checkbox"/> | |
| | General Adequate Exhibited Object information included on drawings. | 8.2.F.1 | <input type="checkbox"/> | |
| Exits | General Gallery has minimum two exits arranged to be remote from one another. | 8.3.A.1 | <input type="checkbox"/> | |
| | General Clear width along primary egress path is minimum 60". | 8.3.A.2 | <input type="checkbox"/> | |
| | General Clear width along secondary egress path is minimum 44". | 8.3.A.3 | <input type="checkbox"/> | |
| | Signs | Exits properly identified by exit signs. | 8.3.B.1.i | <input type="checkbox"/> |
| | | No display, object, or bright illumination obstructs exit sign line of vision. | 8.3.B.1.ii | <input type="checkbox"/> |
| | | Exit signs illuminated with integral light source or continuous external 5 foot-candle minimum. | 8.3.B.3.i | <input type="checkbox"/> |
| | Stairs and Steps | Elevation changes made obvious for stairs less than 3 risers. | 8.3.C.1.i | <input type="checkbox"/> |
| | | Stairs minimum 44" wide and clear of obstructions. | 8.3.D.2.i | <input type="checkbox"/> |
| | | Minimum headroom is 6'8" at doors and stairwells. | 8.3.C.2.i | <input type="checkbox"/> |
| | | Stairs and ramps have handrails 34" to 38" above leading edge of tread. | 8.3.D.4.i | <input type="checkbox"/> |

| | | | | |
|----------------------------------|---|--|--------------------------|--------------------------|
| | | Handrails offer no obstruction to smooth handhold surface. | 8.3.D.4.iv | <input type="checkbox"/> |
| | | Handrails have a circular cross section with an outside diameter between 1-1/4" and 2". | 8.3.D.4.v | <input type="checkbox"/> |
| | Guard Rails | Guardrails are provided at floor openings, open-sided floors, platforms 30" or more above floor level, ramps, etc. on all open sides except entrances to ramps or stairways. | 8.3.D.5.i | <input type="checkbox"/> |
| | | Guardrails have a vertical height of 42" measured from the upper surface. | 8.3.D.5.ii | <input type="checkbox"/> |
| | | Guardrails are capable of withstanding 200 pounds applied in any direction at any point on the top rail. | 8.3.D.5.iii | <input type="checkbox"/> |
| Fire Rated Construction | General | Penetrations other than fire dampers through fire-rated construction are sealed with an approved firestop material. | 8.4.A.1 | <input type="checkbox"/> |
| | | Details provided of new fire door assemblies showing area of glass and construction material. | 8.4.A.2 | <input type="checkbox"/> |
| Materials of Construction | General | All materials of construction are noncombustible or inherently fire retardant. | 8.5.A.2 | <input type="checkbox"/> |
| | | Proof of fire test performance for all materials of construction have been submitted to OSHEM and approved. | 8.5.B.3 | <input type="checkbox"/> |
| | Wall and Ceiling Materials | Materials have a flame spread index less than 25 in unsprinklered exhibits or 75 in sprinklered exhibits. | 8.5.C.1 & 3 | <input type="checkbox"/> |
| | | Materials have a smoke developed index less than 450. | 8.5.C.1 | <input type="checkbox"/> |
| | | Wall mounted materials exceeding either 10% of wall area or single pieces greater than 100 ft ² comply with above. | 8.5.C.5 | <input type="checkbox"/> |
| Wood | Wood used for walls, platforms, dioramas, blocking, furring, cases over 100 ft ³ , and similar | 8.5.D.1 | <input type="checkbox"/> | |

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|--|--|--|--------------------------|--------------------------|
| | | is Fire Retardant Pressure Impregnated (does not apply to cabinets, showcases, or finish trim). | | |
| | Carpeting, Draperies, Bunting and Decorative Textiles | Carpeting has a minimum critical radiant heat flux of 0.45 watts/cm ² . | 8.5.E.1 | <input type="checkbox"/> |
| | | Carpeting has passed the Methanamine Pill Test. | 8.5.E.2 | <input type="checkbox"/> |
| | | Carpeting and textiles installed on walls have a Class A rating and is not installed in unsprinklered room. | 8.5.E.3 | <input type="checkbox"/> |
| | | All materials intended for decorative purposes have passed testing in accordance with NFPA 701. | 8.5.F.1 | <input type="checkbox"/> |
| | Plastics | Plastics, exposed foam plastics, and materials containing foam plastics are not used in exhibits unless Life Safety Code and IBC Interior Finish requirements are met. | 8.5.G.1 | <input type="checkbox"/> |
| | | Vitrine materials other than glass do not exceed 100 ft ² exposed vertical surface area. | 8.5.G.3 | <input type="checkbox"/> |
| Fiberglass uses a fire-retardant resin and complies with Class A or B interior finish tests in the design thickness. | | 8.5.G.4 | <input type="checkbox"/> | |
| Aluminum Composite Materials used only for standalone signage or vitrine backing. It must pass ASTM E84 Class A. | | 8.5.G.5 | <input type="checkbox"/> | |
| | Desiccant chambers may be constructed of acrylic only in cases smaller than 100 ft ³ . Aluminum composite material may be used in larger cases. ACM must pass ASTM E84 Class A. | 8.5.G.6 | <input type="checkbox"/> | |
| Fire Detection and Alarm Systems | General | Manual pull stations and fire alarm notification devices are not obstructed from view or access by exhibit construction. | 8.6.B.1 | <input type="checkbox"/> |

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|------------------------------------|----------------|---|------------|--------------------------|
| | | Smoke, heat, and other detectors are not field painted. | 8.6.A.3 | <input type="checkbox"/> |
| Automatic Sprinkler Systems | General | Sprinkler system has been hydraulically designed for Ordinary Hazard Group II occupancies. | 8.7.B | <input type="checkbox"/> |
| | | Sprinkler heads are not field painted. | 8.7.C | <input type="checkbox"/> |
| | | Cases over 150 sq. ft. in size are provided with sprinkler protection unless approved by OSHEM. | 8.7.D | <input type="checkbox"/> |
| Emergency Lighting | General | Emergency lighting provided in all main circulation and egress paths, corridors, and stairs. | 8.8.A.1 | <input type="checkbox"/> |
| | | Emergency lighting is supplied by a continuous fixed wiring power source with battery pack or generator backup. | 8.8.B.1 | <input type="checkbox"/> |
| | | Emergency lighting average illumination levels are a minimum 1 foot-candle measured at the floor. | 8.8.C.1 | <input type="checkbox"/> |
| | | Dimming control is connected to emergency power and cannot provide less than the required 1 foot-candle illumination. | 8.8.C.2.ii | <input type="checkbox"/> |
| Portable Fire Extinguishers | General | Water-mist extinguishers provided in all exhibit halls with exposed collections. | 8.9.B | <input type="checkbox"/> |
| | | Maximum travel distance to an extinguisher is 75'. | 8.9.D | <input type="checkbox"/> |
| | | Extinguishers mounted on hangers, brackets, shelves, or in cabinets so that the top is no more than 5' above the floor. | 8.9.E | <input type="checkbox"/> |
| | | Cabinets recessed into walls are labeled "FIRE EXTINGUISHER" in appropriately sized lettering. | 8.9.F | <input type="checkbox"/> |
| | | Extinguishers are readily accessible and not hidden from view. | 8.9.H | <input type="checkbox"/> |

| | | | | |
|-------------------------------|--|---|--------------------------|--------------------------|
| Audio Visual Equipment | Open A/V Areas | Shelves and mounts are constructed of non-combustible materials. | 8.11.A.2 | <input type="checkbox"/> |
| | | Clearance to any combustible materials is at least 1' horizontally and 2' vertically. | 8.11.A.3 | <input type="checkbox"/> |
| | Enclosed A/V Areas | Enclosure is constructed of fire resistant materials approved by OSHEM. | 8.11.B.2 | <input type="checkbox"/> |
| | | Shelves and mounts are constructed of non-combustible materials. | 8.11.B.3 | <input type="checkbox"/> |
| | | Projection enclosures are provided with smoke detectors. | 8.11.B.4 | <input type="checkbox"/> |
| | | Projection enclosures are provided with mechanical ventilation. | 8.11.B.5 | <input type="checkbox"/> |
| | A/V Control Rooms | A/V control rooms are of 1-hr rated construction. | 8.11.C.2 | <input type="checkbox"/> |
| | | A/V control rooms are provided with smoke detectors. | 8.11.C.3 | <input type="checkbox"/> |
| Equipment Shutdown | A/V equipment is provided with hard or soft shutdown designed to cease operation upon fire alarm activation. | 8.11.D | <input type="checkbox"/> | |

APPENDIX B - GUIDE SPECIFICATIONS

| | | |
|---------|--------|---|
| SECTION | 078100 | SPRAYED FIRE-RESISTANT MATERIALS |
| SECTION | 078413 | PENETRATION FIRESTOPPING |
| SECTION | 081173 | ROLLING FIRE DOORS |
| SECTION | 104400 | FIRE EXTINGUISHERS, CABINETS, AND ACCESSORIES |
| SECTION | 211313 | WET PIPE SPRINKLER SYSTEMS |
| SECTION | 211316 | DRY PIPE AND PREACTION SPRINKLER SYSTEM |
| SECTION | 213110 | FIRE PUMP SYSTEM |
| SECTION | 283111 | ADDRESSABLE FIRE ALARM SYSTEM |
| SECTION | 283112 | ZONED FIRE ALARM SYSTEM |
| SECTION | 331615 | WATER STORAGE STEEL TANKS |

APPENDIX C – FIRE PROTECTION COMMISSIONING STANDARDS

CLEAN AGENT EXTINGUISHING SYSTEMS

EMERGENCY POWER AND STANDBY SYSTEMS

FIRE ALARM SYSTEMS

FIRE AND SMOKE DAMPERS

KITCHEN SYSTEMS

SMOKE CONTROL SYTSEMS

APPENDIX D – SUMMARY OF ENCLOSURE REQUIREMENTS FOR COMMON USE
AREAS

| Area | Minimum Fire Barrier Requirements ^{1, 2} | Commentary |
|---|---|---|
| Trash storage and recycling rooms | 2-hour | IBC Table 509 requires 1-hr fire resistance rated separation or a smoke partition with sprinkler protection between rooms used to store combustible trash materials and the remainder of the building. SI requires 2-hr fire resistance rated separation for trash storage and recycling rooms within all occupancies due high density of trash within these rooms. |
| Laundry rooms over 100 sq ft | 1-hour | IBC Table 509 requires that laundry and linen collection areas that are a higher hazard than the general building occupancy classification are separated from the building by fire resistance rated construction or have sprinkler protection. The 100 sq ft allowance accounts for the difference in fuel load between a smaller laundry room and a larger laundry room. The larger room has more combustible material and is therefore a higher hazard. Accordingly, SI requires that such laundry rooms are enclosed by 1-hr construction. |
| Incidental storage rooms over 100 sq ft | 1-hour | IBC Table 509 requires that storage areas that serve industrial and ambulatory occupancies are separated from the building by fire resistance rated construction. The 100 sq ft allowance accounts for the difference in fuel load between a smaller storage room and a larger storage room. The larger room has more combustible material and is therefore a higher hazard. Accordingly, SI requires that such storage rooms are enclosed by 1-hr construction. |
| Collections storage rooms | 2-hour rated fire/smoke barriers | NFPA 909 Section 9.12.23 requires that collections storage rooms are enclosed by a minimum of 1-hr fire resistance rating. Due to the value and vulnerability of the Smithsonian's stored collections, SI's collections storage rooms are required to be 2-hr fire resistance rated construction for protection from the remainder of the building. Additionally, the separation must be a smoke barrier to ensure that artifacts are not damaged by smoke infiltration if there is an incident outside of the storage room. |

| Area | Minimum Fire Barrier Requirements ^{1,2} | Commentary |
|------------------------------------|--|--|
| Collections processing areas | 1-hour rated fire/smoke barriers | NFPA 909 Section 9.12.23 requires that collections storage rooms are enclosed by a minimum of 1-hr fire resistance rating. Processing areas have collections that remain in the space for less than 24 hours. Although these items are temporarily located within the room, these temporarily stored collections still require protection. These spaces typically have a lower collection density than storage spaces. Accordingly, SI requires 1-hr fire resistance rated construction for protection from the remainder of the building. Additionally, the separation must be a smoke barrier to ensure that artifacts are not damaged by smoke infiltration if there is an incident outside of the processing room. |
| Wet collections spaces < 500 sq ft | Per NFPA 30 | NFPA 909 refers to NFPA 30 for the protection of wet collection storage. NFPA 30 Table 9.9.1 defines the fire resistance ratings for liquid storage rooms based on area of the room. In accordance with this table, wet collections spaces greater than 150 sq ft but less than 500 sq ft are required to have 2-hr fire resistance rated enclosure. Wet collections spaces less than 150 sq ft are required to have 1-hr fire resistance rated enclosure. |
| Wet collections space ≥ 500 sq ft | 4-hour fire wall | In accordance with NFPA 30 Table 9.9.1, a liquid warehouse type storage area is required for wet collections spaces greater than 500 sq ft. A 4-hr fire wall separation from non-liquid storage areas is required for such warehouses. The intermediate floors are required to have a 4-hr fire rating. NFPA 30 references NFPA 221, <i>Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls</i> for firewall design. The design of a firewall is much more stringent than a fire barrier enclosure since firewalls are required to remain stable after collapse of the structure due to fire on either side of the wall [NFPA 221, Section 6.2]. |

| Area | Minimum Fire Barrier Requirements ^{1, 2} | Commentary |
|--|---|---|
| Bulk alcohol storage for wet collections | 3-hour | This requirement originated from the Recommended Fire Protection Practices for Distilled Spirits Beverage Facilities standard. Section 3-8.4 requires that storage areas used for draining and filling bulk amounts of alcohol exist within a 2-hour fire resistance rated room separated from the remainder of the building. SI staff perform similar drainage and filling operations to examine samples stored in alcohol. Often, drums of alcohol are stored to complete this operation. SI recognizes that these bulk alcohol storage rooms are a higher level of hazard than the general occupancy classification of SI assembly and business occupancies and therefore, bulk alcohol storage rooms are required to be separated with 3-hour fire resistance rated construction. |
| Electric closets | 1-hour ³ | NFPA 70 is commonly referred to as The National Electrical Code (NEC). NEC Article 450.21 requires that indoor dry-type transformers exceeding 112½ kVA must be installed in a room of 1-hr fire-resistant construction. Electrical equipment, such as transformers, are often added post occupancy to electrical closets. To provide the most flexibility for use of these electrical closets by Smithsonian's maintenance staff once the building is occupied, SI requires that all electrical closets to have a 1-hr fire resistance rating to ensure the critical equipment in these spaces is protected and remains operational for business continuity. |

| Area | Minimum Fire Barrier Requirements ^{1,2} | Commentary |
|--|--|---|
| Mechanical and refrigerant machinery rooms | 1-hour ³ | IBC Table 509 requires that furnaces and boilers with equipment over 15 psi and 10 hp must be installed in a room of 1-hr fire-resistant construction. IBC Table 509 also requires 1-hr construction or a smoke partition with sprinkler protection for refrigerant machinery rooms. Mechanical equipment, such as furnaces and boilers, are often added or replaced with larger versions post occupancy within the mechanical rooms. To provide the most flexibility for use of these rooms by Smithsonian's maintenance staff once the building is occupied, SI requires that all mechanical and refrigerant machinery rooms have a 1-hr fire resistance rating to ensure the critical equipment in these spaces is protected and remains operational for business continuity. |
| Communication closets (telephone and non-mission critical IT spaces) | 1-hour ³ | NFPA 76, <i>Standard for the Fire Protection of Telecommunications Facilities</i> , Section 8.3 requires that telecommunications rooms are separated from the remainder of the building by 1-hr fire resistance rated construction. Communications closets are typically single rooms of dedicated space that are occupied by a telecommunications service company to provide voice calls and internet connectivity for the public while they are within Smithsonian buildings. NFPA 75 Section 5.1.3 requires that information technology (IT) equipment rooms are separated from the remainder of the building by fire resistance rated construction. Non-mission critical IT closets are those that are not vital to the operation of the Smithsonian and its ability to serve the public. Typically, these non-critical spaces are small closets distributed on several floors within the building. |

| Area | Minimum Fire Barrier Requirements ^{1,2} | Commentary |
|------------------------------|--|--|
| IT spaces (mission critical) | 2-hour | NFPA 75 Section 8.3 requires that telecommunications rooms are separated from the remainder of the building by fire resistance rated construction. Mission critical IT spaces are those that are not able to shut down without affecting the operations of the Smithsonian and its ability to serve the public. Mission critical IT spaces include rooms housing equipment, the loss of which would adversely affect operations in more than one facility, rooms housing collection-based servers not backed up off-site, and rooms containing the fiber entrance(s) for the facility. |
| Maintenance shops | 1-hour | IBC Table 509 requires that maintenance shops within institutional facilities are separated from the building by fire resistance rated construction. SI recognizes that these rooms are a higher level of hazard than the general occupancy classification of SI assembly and business occupancies and therefore, maintenance shops within all SI buildings are required to be separated with fire resistance rated construction. |
| Loading Docks | 2-hour | NFPA 909 Section 11.4.11 requires that loading docks are separated from the remainder of the building by 2-hr fire rated construction. Loading docks can be used for unloading of any type of material and often contain an interior trash dumpster. NFPA 909 indicates that where sprinkler protection is provided, the loading dock can be separated from the rest of the building by 1-hr fire rated construction; however, SI requires 2-hr construction for all loading docks to further protect occupants and our collections. |
| Fire Pump Room | 2-hour | IBC 913.2 requires fire resistance rated fire pump enclosures. High-rise buildings or buildings that are not fully sprinkler protected are required by IBC 913.2 to have a 2-hr fire resistance rating. Buildings that are not high-rise buildings and buildings that are not fully sprinkler protected are required by IBC 913.2 to have a 1-hr fire resistance rating; however, SI requires 2-hr fire resistance rated enclosures for fire pump rooms since this is a critical component of the fire suppression system. |

Notes:

1. This table is not intended to be comprehensive. The Design Engineer/Architect is required to confirm these ratings and other special requirements based on the applicable codes and standards.
2. The requirements listed here are for fire resistance ratings. Automatic sprinklers or other type of fire suppression system will be required in accordance with Chapters 5 and 7 of this Fire Protection and Life Safety Design Manual.
3. This assumes that these spaces are not located within a shaft connecting 4 or more stories.

APPENDIX E – COMPACT STORAGE UNITS (MOBILE SHELVING) DESIGN
SUPPLEMENT

This design supplement provides detailed requirements for the design and installation of compact shelving and automatic sprinkler systems. The information below identifies those designs that are appropriate for archival and collection storage.

- 1) *Enclosed shelving*. Provide fully enclosed metal cabinet-style compact shelving for all compactors. This effectively eliminates the hazard by compartmentalizing the large, continuous fuel load. Standard SI sprinkler system water density requirements are adequate. Clearance between compactors may be reduced to zero.
- 2) *Moderate-density sprinkler system with wide spacing*. Provide the following sprinkler system capability and shelving design
 - a. Limitations.
 - i. This arrangement is only suitable for books, files, and other similar archival paper-type storage.
 - ii. Minimum clearance of 24” between top of shelving and ceiling (23” from sprinkler deflector to top of shelving).
 - b. Sprinkler system
 - i. Sprinkler density of 0.3 gpm/ft² over 1500ft².
 - ii. Quick-response, 165°F sprinklers
 - iii. Maximum 10 ft. x 10 ft. spacing.
 - iv. Hose stream allowance of 250gpm
 - c. Shelving system
 - i. Steel construction, 18 ga. minimum
 - ii. Longitudinal vertical divider (18 ga. steel, minimum) along entire length and height of each compactor. May be at the center of each compactor (preferred) or along one face, if the entire width of the shelf is needed for storage. This barrier will slow the progression of fire from one compactor to the next.
 - iii. Transverse vertical divider (18 ga. steel, minimum), along the entire width of each compactor spaced at intervals no greater than 20 ft. If the length of the shelving unit is less than 20 ft., transverse dividers need not be provided. Similar to the longitudinal divider, this divider will slow the progression of fire within a compactor unit.
 - iv. Solid metal canopy tops on each compactor (18 ga. steel, minimum).
 - v. Minimum 4” spacing between compactors in the closed position. Permanent bumpers must be installed to maintain the spacing.
 1. As an alternative to permanent 4” spacing between compactor units (which usually leads to some loss in storage capacity), electric compactor units may be provided that are interfaced with the fire alarm system. When the fire alarm activates, a signal is sent to the electric compactor units which causes them to automatically space themselves apart (to a minimum of 4”). Under normal conditions, the clearance between compactors may be zero.
- 3) *High-density sprinkler system with close spacing*. Provide the following sprinkler system capability and shelving design.
 - a. Limitations.
 - i. This arrangement is only suitable for books, files, and other similar archival paper-type storage.

- ii. No loose storage of paper is permitted (e.g. newspaper stacks)
 - iii. Ceiling height 7 ft. to 10.5 ft.
 - b. Sprinkler system
 - i. Sprinkler density of 0.7 gpm/ft² over the shelving area.
 - ii. Sprinkler density of 0.3 gpm/ft² over 1500 ft² (over the aisle area adjacent to the shelving)
 - iii. Shelving area must be separated from aisle area at ceiling by a draft curtain.
 - iv. Quick-response, 165°F sprinklers
 - v. Maximum 10 ft. x10 ft. spacing (with 18 in. of clearance, minimum)
 - 1. For areas of reduced clearance, quick response sidewall sprinklers may be used (clearance from top of shelving to ceiling greater than or equal to seven in.).
 - a. Distance of sprinkler deflector below ceiling is 4 inches.
 - b. Maximum width of coverage is 15 ft.
 - c. Sidewall sprinklers must be spaced at intervals of 8.5 ft. along each side of the protected area. Positioning must be staggered from one side to another, such that sprinklers opposite each other do not line up (i.e. offset by 4.25 ft.)
 - vi. Hose stream allowance of 250gpm
 - c. Shelving system
 - i. Steel construction, 18 ga. minimum
 - ii. Open cantilever-style shelving.
 - iii. Longitudinal vertical divider (18 ga. steel, minimum) along entire length and height of each compactor. May be at the center of each compactor (preferred) or along one face, if the entire width of the shelf is needed for storage. This barrier will slow the progression of fire from one compactor to the next.
 - iv. Transverse vertical divider (18 ga. steel, minimum), along the entire width of each compactor spaced at no greater than 15 ft. intervals. If the length of the shelving unit is less than 15 ft., transverse dividers need not be provided. Similar to the longitudinal divider, this divider will slow the progression of fire within a compactor unit.
 - v. No canopy tops on each compactor.
 - vi. Minimum 1" spacing between compactors in the closed position. Permanent bumpers must be installed to maintain the spacing.
- 4) *Ultra high-density sprinkler system with close spacing and no longitudinal or transverse dividers in compact shelving.*
 - a. Limitation. This arrangement is only suitable for storage that is not considered as collections. This arrangement provides only life safety and possibly building protection. A fire could spread throughout the entire compact shelving array without longitudinal or transverse dividers in the storage system. This is unacceptable for collections.
 - b. Sprinkler system
 - i. Design sprinkler system according to Factory Mutual Data Sheet 8-9 for solid-pile storage of the appropriate type.
 - 1. The minimum design criteria shall be for Class 4 commodities.
 - 2. For ceilings less than 15 ft., the minimum design criteria shall be for cartoned, expanded plastic commodities.
 - ii. Sprinkler densities will vary depending on conditions, but will be in the general range of 1 to 2 gpm/ft².
 - iii. Quick-response, 165°F sprinklers
 - iv. Maximum 10 ft. x10 ft. spacing.
 - v. Minimum spacing of 8 ft. x 8 ft. spacing.
 - vi. Hose stream allowance of 250gpm
 - c. Shelving system

- i. Steel construction, 18 ga. minimum
- ii. No canopy tops on each compactor.
- iii. Shelving must be at least 50% open.
- iv. Minimum 1” spacing between compactors in the closed position. Permanent bumpers must be installed to maintain the spacing.

APPENDIX F – GENERAL NOTES FOR EXHIBIT DESIGNS

1. Penetrations through fire-rated construction (i.e. walls, floors, etc.), not protected by fire dampers or combination fire/smoke dampers, shall be sealed with an approved penetration firestop material that maintains the fire rating.
2. Wall and Ceiling Materials
 - A. Wall and ceiling materials that are used in exhibit spaces or the means of egress such as paneling or acoustical tiles; shall have a flame spread rating of 25 or less, and a smoke developed index of 450 or less, as measured in accordance with ASTM E-84, Surface Burning Characteristic of Building Materials.
 - B. For exhibit spaces protected by an automatic sprinkler system, these materials shall have a flame spread rating of 75 or less.
 - C. Materials that are not appropriate for testing to ASTM E84 (those that melt or drip) shall be tested to NFPA 286.
 - D. Wall mounted materials that have a surface area exceeding 10% of the wall area, and single pieces over 100 sq. ft. (9.3 sq. m) shall comply with the above requirements for wall and ceiling materials.
3. Wood
 - A. Wood used for walls, platforms, dioramas, blocking, furring, cases over 100 cubic feet (2.8 cubic m), light attics with electric lighting, and similar applications shall be fire retardant, pressure impregnated.
 - i. Fire retardant coatings of intumescent paint are not acceptable in lieu of fire retardant treatment.
 - ii. This requirement shall not apply to cabinets, showcases or finish trim.
 - iii. Unenclosed spaces beneath table-style cases shall not contribute to overall case volume when considering the 100 cubic foot (2.8 cubic m) limit.
4. Carpeting
 - A. Flooring materials shall have a minimum critical radiant flux of 0.45 watts/ cm², when tested in accordance with ASTM E-648, Standard Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source.
 - B. Carpeting shall also pass the Methanamine Pill Test, Federal Flammability Standard FF-1-70 (ASTM D-2859).
 - C. For installations specifying carpeting on walls:
 - i. The room shall be protected by an automatic sprinkler system.
 - ii. Materials shall have a Class A rating (flame spread 25 or less and smoke development factor less than 450), as measured by ASTM E-84.
5. Draperies, Bunting or Decorative Textiles
 - A. All material intended for decorative purposes, such as draperies, scrim or bunting shall be certified flame resistant in accordance with the criteria contained in the

current edition of NFPA 701, Methods of Fire Tests of Flame-Resistant Textiles and Films. Samples and fire test data shall be submitted to OSHEM for evaluation and approval.

6. Plastics, fiberglass, exposed foamed plastics, materials containing foamed plastics
 - A. Plastics, exposed foamed plastics, and materials containing foamed plastics are prohibited from being used in the exhibit unless the specific criteria in the Life Safety Code and the IBC for Interior Finish and Furnishings, Decorations, and Scenery have been met.
 - B. Samples and fire test data shall be submitted to OSHEM for evaluation and approval.
 - C. Vitrines materials with more than 100 sq. ft. (9.3 sq. m) of exposed vertical surface area shall comply with the interior finish requirements for walls and ceiling materials.
 - D. Fiberglass must use a fire-retardant resin and pass Class A or B interior finish requirements when tested in accordance with ASTM E-84 in the design thickness.
 - E. Aluminum Composite Materials (ACM) (e.g. di-bond) may be used for standalone signage and the backing of cases when the material does not exceed 100 sq. ft. in area. This material may not be used to construct casework.
 - F. Desiccant chambers within cases less than 100 ft³ in size may be constructed of acrylic. Aluminum Composite Material may be used in larger cases for this purpose.
7. Glass
 - A. Glass used in vitrines or displays that exceeds 48 inches (1219 mm) in any dimension shall be laminated safety glass.

APPENDIX G – FREQUENTLY ASKED QUESTIONS ABOUT EXHIBITS MATERIALS

The following questions have been generated from past conversations with exhibits staff and from previous projects that were approved after collaboration with OSHEM. They represent suggested paths forward for several types of exhibitry. Exhibits staff are encouraged to contact their OSHEM representative early when an exhibit will involve combustible materials of any type.

- A. What are the various fire tests used to evaluate construction materials?
1. ASTM E84 – Steiner Tunnel Test
 - i. This is a test for wall and ceiling finishes. It evaluates how far flames spread across a surface material and how much smoke is produced when it is burned.
 - ii. Results are dimensionless numerical scores. Lower numbers are better for both flame spread and smoke development. The ratings are as follows:
 - (a) Class A – Flame Spread 0-25. Smoke Developed 0-450.
 - (b) Class B – Flame Spread 26-75. Smoke Developed 0-450.
 - (c) Class C – Flame Spread 76-200. Smoke Developed 0-450.
 - iii. Most materials for SI projects must meet Class A for unsprinklered spaces, and Class B for sprinklered spaces.
 - iv. Materials that melt and drip cannot be tested to ASTM E84.
 2. NFPA 286 – Room Corner Test
 - i. This is a full-scale test for wall and ceiling finishes. It evaluates the contribution of a finish to fire growth.
 - ii. Materials tested to NFPA 286 (like some plastic panels) must pass the test to be used at SI.
 3. ASTM E648 – Floor Covering Test
 - i. This is a test for floor covering systems such as carpeting and vinyl flooring.
 - ii. Results are based on how much radiant heat it takes to ignite a sample of the material. The ratings are as follows:
 - (a) Class I – Not less than 0.45 W/cm².
 - (b) Class II – Not less than 0.22 W/cm² but less than 0.45 W/cm².
 - iii. Flooring materials must meet Class I to be used at SI.
 4. NFPA 701 – Textiles and Films
 - i. This is a test for textiles, fabrics, and films without a solid backing.
 - ii. Results are based on whether flame spreads across a fabric and whether flaming drips result from the test.
 - iii. Fabrics and textiles must pass this test to be used at SI.

- B. What documentation do you need for materials of exhibit construction?
1. Product data sheets for the product in question
 2. Results for all applicable fire tests. (See below for each type of material) What OSHEM requires is the fire test report from the independent testing lab used by manufacturer. A product data sheet stating “Passes ASTM E84 Class A” or “Fire Retardant” is not enough information to verify the fire performance of a material.
 3. Samples must be provided to OSHEM upon request, in the configuration and thickness that will be used.
- C. Is there a list of approved exhibit fabrication materials?
1. As of the writing of this version (1/29/2018), there is not. OSHEM is planning to develop such a list and will be polling the exhibits community on how to best document such information.
- D. Can I use plaster/gypsum/sand/concrete?
1. No restrictions are placed on these types of material. While heavy, these materials are preferable since they are not combustible.
 2. Newer, moldable versions of the above materials allow for construction of artificial environments. These are preferable to using a foam substrate to shape scenery.
- E. Can I use metal?
1. There are no restrictions on metal. Metal framing for larger models is preferred over wood.
- F. Can I use wood?
1. As stated elsewhere in this manual, casework over 100 ft³ must be constructed of fire-retardant, pressure impregnated (FRPI) wood.
 2. Similarly, wood used in models over 100 ft³ must be fire retardant, pressure impregnated. Steel or aluminum is preferred, however.
 3. Fire retardant, pressure impregnated wood must pass ASTM E84 Class A.
- G. Can I use a surface coating (intumescent paint) to make wood fire retardant?
1. No. Surface coatings do not get absorbed into the wood, and hence fade over time, can be chipped off, and do not offer the same level of fire performance as FRPI wood.
- H. How is the volume of casework calculated?
1. To determine if a case exceeds the 100 ft³ limit, the case length is multiplied by its width and height. Open space between the legs/supports is not counted in the volume. The vitrine is not counted in the volume.
- I. Can I install a scrim ceiling as long as the fabric used passes NFPA 701?
1. No. Scrim ceilings will block the fire sprinklers above, which is not permitted.
- J. How is the 100 ft² surface area limit calculated for restrictions on using acrylic for vitrines?
1. Only the walls of the vitrine are counted. The lid (top) does not count towards the 100 ft².
- K. Can I use fiberglass?

1. Fiberglass is permitted so long as the resin component passes ASTM E84 with a Class A rating. Like wood, the fire retardant component must be mixed/impregnated into the resin. Surface coatings are not permitted. As they will not absorb into the material.
 2. Some plastic resins allow the addition of fiberglass meshes/flakes. Adding this material provides additional strength to the material as well as some fire resistance. However, noncombustible materials are always preferred.
- L. Can I use fabrics?
1. Yes. However, the fabric in question must be fire retardant from the factory and must pass NFPA 701. Fabrics coated in the field with a spray on fire retardant are generally not an acceptable substitute for long-term exhibits.
 2. Spray-on additives are only acceptable in situations where it is not possible to obtain fabrics that come with the fire retardant from the factory. An example would be custom-fabricated artwork.
- M. Can I use plastic resin?
1. Plastic resin is a very broad category, and different mixes/products perform different functions for fabricating artwork, dioramas, and casts. The majority of these resins do not pass ASTM E84, especially if they are clear. Even when they are marketed as being fire retardant (Class A), they produce a large amount of thick, black smoke when burned. Some varieties can be lit with a household lighter and sustain a fire afterwards. OSHEM has recently permitted a small number of Class A materials that classify as plastic resins, but perform more closely to plaster, in that they do not burn and do not produce much smoke.
 2. OSHEM often has a number of questions regarding the use of plastic resins before proceeding:
 - i. How large is the model in question?
 - ii. Have other material options been exhausted? (See above.) The engineer will want to know any extenuating circumstances as to why plastic must be used.
 - iii. Will the casted object/model in question be within an enclosed case? Smaller objects within a case present less of a fire risk.
 - iv. Is the model touchable/interactive or otherwise accessible to visitors? An object out in the open represents an increased risk.
 - v. Are there electrical sources in the case? The lack of ignition sources within the case goes a long way to reducing the fire risk.
 3. Plastic resins proposed for exhibit installation require fire testing. A minimum of an ASTM E84 Fire Test Report with a passing score of Class A is required. E84 test results that indicate melting, dripping, or loss of structural integrity, are not acceptable, since they do not provide an accurate measurement of flame spread. Dripping, melting, and residual flaming at the bottom of the test apparatus is considered a fail, regardless of the test result. Untested plastics cannot be used.
 4. For small cast objects (e.g. shark teeth, a skull) present within an enclosed case without internal lighting:
 - i. Confirm with OSHEM before proceeding.
 5. For a larger diorama within a case, or larger objects:

- i. Ensure that no ignition sources are present within the case.
 - ii. Minimize the amount of plastic that will be used. Can the cast be hollow? Is the plastic being used as a thin topcoat?
 - iii. Can fiberglass mesh or flakes be added to the model?
 6. Larger models (e.g. skeletons)
 - i. Plastic resin is not recommended, even as a topcoat.
- N. Can I use plastic foam?
 1. The answer to this question is, more often than not, no. Foam is extremely flammable, and burns more readily than resin due to the air in its structure. Any project considering the use of this material must be thoroughly vetted. It is not uncommon for detailed discussions to occur several times before a solution is reached.
 2. Please see item B.2 above for information that will be required by OSHEM.
 3. Foam is not permitted to be used as a wall or ceiling finish.
 4. Foam use for models is only permitted in rare cases, where the scope of the project is such that no other materials can be used and an equivalent level of safety can be achieved. An example is the Right Whale present in the Oceans Hall of the National Museum of Natural History. For that model, the following methodology was used:
 - i. The model was out of reach of the public.
 - ii. Metal structure was used for stability.
 - iii. The foam model was not solid. It was hollow to the maximum extent possible without compromising structural integrity. The extent of hollowing will depend on the shape and size of the model.
 - iv. The foam passed ASTM E84, Class A. Having a material that passes NFPA 286 is preferable.
 - v. Each piece of the model was encapsulated completely with an intumescent fire retardant barrier. The barrier was ignition-resistant for 15 minutes as described in NFPA 286.
 - vi. The sprinkler system above was not compromised by the presence of the foam model.
 - vii. The amount of foam present did not overwhelm the sprinkler system as installed.
 - viii. Lighting was not placed directly above the model.

APPENDIX H – APPROVED/PROHIBITED EXHIBIT MATERIALS (RESERVED)

OSHEM is in the process of developing a database of approved exhibit materials. Information will be placed here when it is complete.