DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

1 SEP 2011

FROM: AFCESA/CEO
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SUBJECT: **Engineering Technical Letter (ETL) 11-7: Nuclear Weapons-Capable Maintenance and Storage Facilities**

1. Purpose. This ETL provides criteria specific to new and existing (Attachment 1, Chapter 8 only) nuclear weapons-capable maintenance and storage facilities, including unique criteria that are related to (but not limited to) design, construction, sustainment, restoration, and modernization.

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

2. Application: Air Force installations with nuclear weapons-capable maintenance and storage facilities. The requirements in this ETL are mandatory.

2.1. Authority: Air Force policy directive (AFPD) 32-10, *Air Force Installations and Facilities.*

2.2. Coordination:

- Air Force Nuclear Weapons Center (AFNWC)
- Headquarters, Air Force Safety Center, Weapons Safety Division (HQ AFSC/SEW)
- Headquarters, Air Force Security Forces Center (HQ AFSFC/SFON)
- Major commands (MAJCOMs) fire protection engineers
- Headquarters, Global Strike Command (HQ AFGSC/A7P)
- Air Force Civil Engineer (HQ AF/A7CP)

2.3. Effective Date: Immediately.

2.4. Intended Users: MAJCOM engineers, base civil engineers (BCE), and other engineers responsible for design, construction, renovation, and maintenance of new and existing nuclear weapons-capable maintenance and storage facilities.

3. Referenced Publications: See Attachment 1, Appendix A, for a comprehensive list of references.

4. Acronyms and Terms: See the glossary in Attachment 1 for a comprehensive list of acronyms and terms.

5. Nuclear Weapons-Capable Maintenance and Storage Facility Design. Attachment 1 contains unique facility-related criteria specific to and required for new and existing nuclear weapons-capable maintenance and storage facilities within the Air Force. Use Attachment 1as a basis for the development of detailed design documents (including scope, basis of design, technical requirements, plans, drawings, specifications, cost estimates, request for proposals, and invitations for bids) used for the procurement of facilities, facility similar equipment, and other infrastructure systems. This attachment must be used as a reference document and requirement in the procurement of architectural and engineering services (A&E) and other consulting services to prepare detailed design documents, including those for design-build projects. It is not intended to be used in lieu of detailed design documents in the procurement of facility construction.

6. Waivers. See paragraphs 1-6.1 and 1-6.2 of Attachment 1 for equivalency and exemption criteria.

7. Point of Contact: Recommendations for improvements to this ETL are encouraged and should be furnished to the Chief Fire Protection Engineer, HQ AFCESA/CEOA. To reach the Chief Fire Protection Engineer, e-mail AFCESAR@tyndall.af.mil, call DSN 523-6995 or commercial (850) 283-6995, or mail to 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32403-5319.

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Chief, Operations and Programs Support Division

2 Atchs
1. Nuclear Weapons-Capable Maintenance and Storage Facilities
2. Distribution List

NUCLEAR WEAPONS-CAPABLE MAINTENANCE AND STORAGE FACILITIES

CONTENTS

CHAPTER 1

INTRODUCTION

1-1 SCOPE

This attachment provides criteria specific to new and existing (Chapter 8 only) nuclear weapons-capable maintenance and storage facilities, including unique criteria that are related to (but not limited to) design, construction, sustainment, restoration, and modernization. These facilities are relatively few in number and they are uniquely designed to protect the Air Force mission, ensure continuity of facility operations, limit property damage, and provide safety to life of on-site personnel.

1-2 PURPOSE

This attachment is prepared for the use and guidance of those charged with the design, construction, renovation, and maintenance of new and existing (Chapter 8 only) nuclear weapons-capable maintenance and storage facilities. The performance goals of this document are to ensure that:

- Lightning strikes to the facility will not result in a side flash inside the facility that will compromise the surety of nuclear weapons
- Facility power systems, including all auxiliary power systems, are adequate to supply power to facility systems required to maintain the surety of nuclear weapons
- Facility structural supports for hoists, cranes, and lifting devices are adequately rated for the design loads
- Security meets the requirements of Department of Defense (DOD) S-5210.41-M/Air Force manual (AFMAN) 31-108, Volumes 1–3
- Blast containment and isolation systems mitigate contamination of facilities and weapons by limiting radiation transport mechanisms such as explosions, blasts and fires
- Studies, including a fire hazard analysis (FHA), an electromagnetic radiation environment (EMRE) survey, and a facility characterization (if implemented), are conducted to support the adequate design and operational issues in these areas, ensure the safety of weapons, and provide baseline documentation
- Fire safety designs are implemented to ensure that:
  - Fire during any operational state will not prevent the facility plant from maintaining nuclear weapons in a safe, secure, and stable condition

- Fire will not result in a radiological release that adversely affects the public, facility personnel, or the environment

- Fire itself will not cause a loss of life to those not intimately exposed to the fire origin, and injuries are minimized for those that are intimately exposed

- A fire will be limited such that facility damage, economic loss, and interruption of support to DOD missions are limited to an acceptable level, as defined by the authority having jurisdiction (AHJ)

This document is intended to be used as a basis for the development of detailed design documents (including scope, basis of design, technical requirements, plans, drawings, specifications, cost estimates, request for proposals, and invitations for bids) used for the procurement of facilities, facility similar equipment, and other infrastructure systems. This attachment must be used as a reference document and requirement in the procurement of architectural and engineering services (A&E) and other consulting services to prepare detailed design documents, including those for design-build projects. It is not intended to be used in lieu of detailed design documents in the procurement of facility construction.

1-3 CRITERIA

This attachment describes unique facility-related criteria specific to and required for new and existing (Chapter 8 only) nuclear weapons-capable maintenance and storage facilities within the Air Force. These criteria include, but are not limited to, their design, construction, and maintenance. These facilities are relatively few in number and since they are uniquely designed for their mission, national consensus standards for certain criteria for these facilities are not available and in many cases not appropriate for use by the Air Force.

1-4 CONFLICTS WITH EXISTING CRITERIA

Topics and criteria not included in this attachment are those adequately addressed in the engineering criteria for DOD buildings as found in published UFC documents. In case of conflict with any UFC, the criteria in this document shall take precedence. In particular, specific fire protection and life safety criteria have been developed for nuclear weapons-capable maintenance and storage facilities that would not be appropriate for most DOD buildings. Consequently, in case of conflict with UFC-3-600-01, the criteria in this attachment shall take precedence.

1-5 AUTHORITY HAVING JURISDICTION (AHJ)

The acronym “AHJ” as used in the codes and standards referenced in this attachment mean the component office of responsibility. The following offices jointly serve in the role of component office of responsibility:

- Air Force Nuclear Weapons Center (AFNWC). Coordinates approvals with other offices of responsibility as appropriate.

- Headquarters, Air Force Civil Engineer Support Agency, Operations and

Programs Support Division (HQ AFCESA/CEO). Serves as preparing activity for this attachment and serves as office of responsibility for civil engineering-related issues.

- Headquarters, Air Force Safety Center, Weapons Safety Division (HQ AFSC/SEW). Serves as office of responsibility for safety-related issues.

- Headquarters, Air Force Security Forces Center (HQ AFSFC/SFON). Serves as office of responsibility for security-related issues.

1-6 EQUIVALENCIES AND EXEMPTIONS

1-6.1 Equivalencies

Equivalencies to established criteria may be approved by the AHJ if the alternate engineering design provides an equivalent level of protection to that intended by this attachment. Requests for approval shall be submitted to the AHJ and must include written justification, hazard analysis, cost comparisons, criteria used, and other pertinent data. Lack of funds is not considered sufficient justification for deviation from established criteria. Approved equivalencies and alternatives must apply only to the specific facility involved and do not constitute blanket approval for similar cases. For issues involving physical security, refer to DOD S-5210.41-M/AFMAN 31-108, Volumes 1–3.

1-6.2 Exemptions

Exemptions to established criteria must be submitted to the AHJ for determination. The exemption must demonstrate that the criteria cannot be technically executed, or execution of the criteria will increase a hazard or create a new hazard and no technical alternatives exist. Written request for exemptions must include justification, hazards analysis, cost comparison, alternatives considered, and other pertinent data. Lack of funds or cost savings are not considered sufficient justification for deviation from established criteria. Exemptions must apply only to the specific facility or project involved and do not constitute blanket approval for similar cases. Exemptions must follow the process outlined in MIL-STD-3007F. For issues involving physical security refer to DOD S-5210.41-M/AFMAN 31-108, Volumes 1–3.

1-7 RETROACTIVITY

1-7.1 Level of Protection

The provisions of this attachment are considered necessary to provide an acceptable level of protection against loss of life and property and to minimize impact to the facility mission.

1-7.2 Retroactivity

Unless specifically noted in this document, the provisions of this attachment shall not be applied retroactively unless determined by the FHAs or other approved documented analyses that the existing situation involves a distinct hazard to life, mission, property, or to the environment.

1-7.3 Alterations to Existing Facilities

Any alteration, installation of new equipment, or change in occupancy shall meet the requirements for new construction except where approved by the AHJ.

1-7.4 Limitations

This attachment applies to new and existing facilities. This attachment also applies when a facility is altered, renovated, or modernized. It is recognized that certain requirements within this attachment are not possible or practical in existing structures; therefore, a FHA or other documented evaluation shall be provided to the AHJ as a technical justification for the acceptability of the existing configuration. Such justifications must provide a sound technical basis for nonconformance that can include benefit to cost analysis.

1-8 SERVICES AND QUALIFICATIONS OF ENGINEERS

For the purposes of meeting these requirements, a qualified engineer is defined as an individual meeting one of the following conditions:

- A registered professional engineer (P.E.) who has passed the engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES) in his or her area of expertise. A registered P.E. who serves as a qualified engineer shall also have 5 years of experience in the nuclear weapons field.

- An engineer who is not registered but can demonstrate a minimum of 20 years of documented engineering experience, including 5 years in the nuclear weapons field, and who has been specifically approved to serve in the capacity of a qualified engineer by the AHJ.

CHAPTER 2

LIGHTNING PROTECTION SYSTEMS

2-1 SCOPE

This chapter provides the criteria necessary for adequate protection of weapons from the energy of lightning strikes to new and existing nuclear weapons-capable facilities.

2-2 APPLICATION

2-2.1 DOD Requirements

Lightning protection systems (LPS) for nuclear weapons-capable maintenance and storage facilities shall meet the requirements of:

- Department of Defense directive (DODD) 6055.9E
- DOD 6055.09-STD

2-2.2 Additional Air Force Requirements

Air Force LPSs shall also comply with the following:

All facilities, except for underground, shall be provided with a LPS in accordance with National Fire Protection Association (NFPA) 780, Air Force instruction (AFI) 32-1065, AFMAN 91-201, and UFC 3-520-01.

Underground facilities do not require a LPS. A counterpoise grounding system shall be provided that meets the requirements of NFPA 70, AFI 32-1065, UFC 3-520-01, and AFMAN 91-201.

2-3 REQUIREMENTS

2-3.1 Design Approaches

LPSs shall be designed to traditional LPS parameters. These systems shall be designed to meet the requirements of AFI 32-1065, AFMAN 91-201, and NFPA 780. Traditional LPS design consists of the use of strike termination means, low impedance paths to ground, and earth electrode systems, coupled with bonding of all conductive penetrations into the protected facility, surge suppression, and side flash protection.

2-3.2 Special Documentation of LPS

During construction, establish clear, comprehensive documentation (including photographs) of the as-built installation of the LPS counterpoise, connection to ground rods, and interconnection to other systems. The photos must be taken while the counterpoise and connections are still exposed and visible prior to the placement of backfill or other coverage material. Include distances from permanent reference points to enable base personnel to subsequently locate and uncover any connection point in the system. The installing contractor shall include this documentation with the project as-built submittals with written certification of its accuracy.

2-4 NUCLEAR WEAPONS SIDE FLASH PROTECTION REQUIREMENTS

2-4.1 Seven-Foot Rule

Nuclear weapons, during major maintenance operations, shall be protected from lightning side flash by maintaining a minimum 7-foot (2.1-meter) separation distance between the weapon and the walls, ceiling, structural supports, and all metallic conductors of the facility in accordance with AFMAN 91-201. This is commonly referred to as the “seven-foot rule.”

2-4.2 Metallic Cage (or Faraday Shield)

The required separation distance of the seven-foot rule can be significantly reduced by providing the design feature referred to as a metallic cage in NFPA 780 (hereafter referred to as a “Faraday shield”). The facility must be configured to enclose the space approved for maintenance with a properly configured Faraday shield. The Faraday shield must have proper and maintained electrical bonds on all penetrations. All electrical conductors entering the Faraday shield must have the appropriately sized and maintained surge suppression. In addition, the Faraday shield must be tested and analyzed to determine the effectiveness of the cage. Based on the documented specific test results, the safe separation distance needed for side flash protection may be reduced. This process is referred to as characterization (refer to section 2-5).

2-5 CHARACTERIZATION (ALTERNATIVE TO SEVEN-FOOT RULE)

NOTE: The measures taken to implement a Faraday shield approach for reducing the required lightning side flash or separation distance in a particular facility do not relieve the requirements to maintain a traditional LPS (refer to section 2-3).

2-5.1 New Metal Enclosed Facilities

Construct the building envelope or Faraday shield boundary encompassing the protected area in such a manner as to ensure a grounded, continuously conductive enclosure meeting the metallic cage descriptions of NFPA 780. Penetrations to the Faraday shield shall be bonded as described in section 2-5.4. Document the construction methods and materials used to construct the Faraday shield and bond the penetrations. Documentation shall include photos that show the connection method of the facility enclosure forming the Faraday shield and the bonding of the penetrations (refer to paragraph 2-3.2).

2-5.2 New Steel-Reinforced Concrete Facilities

The reinforcing steel shall be tied together throughout the structure or in the metallic cage boundary encompassing the protected area to ensure an electrically continuous grid having the minimum ground system resistance listed in NFPA 780. The techniques commonly used and approved in the construction industry to join or tie reinforcing steel are acceptable for this purpose.

Penetrations to the Faraday shield shall be bonded as described in section 2-5.4. Document the construction methods and materials used to construct the Faraday shield and bond the penetrations. Documentation shall include photos that show the

connection method of the facility rebar forming the Faraday shield and the bonding of the penetrations (refer to paragraph 2-3.2).

2-5.3 Existing Facilities

Determine, define, and document the boundary of the Faraday shield. The Faraday shield must be comprised of a metallic enclosure or a grounded, continuously conductive metallic enclosure or shield formed by the reinforcing steel as defined in NFPA 780. A rigorous examination of existing facility drawings coupled with on-site examination of the facility's physical features and construction is required to be assured that a Faraday shield exists.

2-5.4 Bonding Requirements

At a minimum, bonding shall be in accordance with AFI 32-1065, AFMAN 91-201, and NFPA 780. In addition, the criteria in paragraphs 2-5.4.1 through 2-5.4.4 apply to facilities being characterized.

2-5.4.1 Metallic Penetrations

Bond all metallic penetrations at the point of entry to the defined Faraday shield using the methodology approved by the AHJ prior to implementation. Bonds shall have a maximum resistance of 1 ohm across the connection to the Faraday shield to ground. Penetrations of the Faraday shield in new facilities shall be bonded and documented during construction as described in paragraph 2-3.2.

2-5.4.2 Conductor Length and Direction

The bond length shall be as short as practical and if possible shall go downward from the penetration to the Faraday shield; however, if any bond exceeds 4 inches (102 millimeters) in length, additional calculations of impedance, electrical potential, and side flash distance corresponding to the current of a worst case lightning strike traveling through these bonds will be required (refer to section 2-5.7).

NOTE: Safe separation distance (SSD) could be affected by these calculations.

2-5.4.3 Conductor Bends

Bends in the bonding conductor shall comply with NFPA 780 requirements for radius and arc.

2-5.4.4 Unique Identification

Each bond shall be given a unique identification number and shall be permanently tagged to display this number and the purpose of the bond, such as "FARADAY SHIELD BOND." Document the location, configuration, and identity of each bond in a permanently maintained drawing file.

2-5.5 Surge Suppression Requirements

2-5.5.1 Electrical Conductors

Surge protection having the capability to interrupt the energy levels of the established "1 percentile lightning strike" shall be installed on electrical conductors entering the Faraday shield. The 1 percentile lightning strike is defined as the 99 percent severity level in the Department of Energy (DOE) baseline stockpile-to-target sequence (STS). Testing and monitoring of the surge suppression shall be as defined by the AHJ.

2-5.5.2 Alternative Measures for Communications and Data Circuits

When it is not practical to install suppression capable of interrupting the energy levels of the established 1 percentile lightning strike on communications and data circuits, alternatives shall be in place to minimize the possibility of the lightning energy entering the facility through these conductors. Provide an evaluation and analysis of these alternatives to the AHJ for review and approval prior to implementation. Factors to consider in determining the practicality of installing the required surge suppression or the acceptability of alternatives shall include at least:

- The quantity and associated costs of installing the required surge suppressors for the number of conductors involved
- The volume of space necessary to install the required suppression units
- The exposure of the portions of the system that are external to the Faraday shield to lightning strikes
- The impact on system performance if installing the required suppression units
- The protection provided using standard commercial surge suppressors manufactured for the application

2-5.6 Testing

Side flash or safe separation distance reduction shall be based on Faraday shield transfer impedance evaluation, adequate bonding, and appropriate installation of surge suppression. Testing methodology shall be approved by the AHJ prior to implementation.

2-5.7 Calculations

If necessary, calculate the standoff or safe separation distance using bond path lengths in accordance with a methodology approved by the AHJ prior to implementation.

2-5.7.1 Calculation versus Testing

When penetrations are bonded to the Faraday shield (see section 2-5.4) and if any bond exceeds 4 inches (102 millimeters) in length, additional calculations are required for impedance, voltage, and side flash distance corresponding to the current of the worst case lightning strike traveling through such bonds. The final standoff or safe separation distance is derived from these calculations in lieu of the distance determined from the transfer impedance evaluation; however, this does not negate the need to accomplish the transfer impedance evaluation since it is required to establish the existence and effectiveness of the Faraday shield.

2-5.7.2 **Safe Separation Distance**
These calculations shall be performed for all bonds exceeding 4 inches (102 millimeters) in length. The largest standoff or safe separation distance calculated from these bonds will establish the facility standoff or safe separation distance within the defined boundaries of the Faraday shield.

2-5.8 **Application**
When implementing a Faraday shield to reduce the separation distance of the seven-foot rule, characterization is required as described in subparagraphs 2-5.8.1 to 2-5.8.3.

2-5.8.1 **Design of New Facilities**
Design new facilities to successfully complete the characterization process prior to activating the facility.

2-5.8.2 **Testing of New Facilities**
Complete the characterization and transfer impedance evaluation prior to activating the facility.

2-5.8.3 **Testing of Existing Facilities**
Complete the characterization and transfer impedance evaluation prior to reducing the required separation distances less than those required by the seven-foot rule.

2-5.9 **Update of Characterization**
If the Faraday shield or penetrations are modified, the characterization shall be reassessed for compliance with the requirements of section 2-5.

2-5.10 **Maintenance and Inspection**
Maintenance and inspection criteria, including retesting of bond resistance measurements and low impedance test measurements, shall be accomplished in accordance with the latest version of AFMAN 91-201.

2-5.11 **Documentation Retention**
The facility shall maintain documentation of the characterization process, including at least these items:

- AHJ requirements
- Testing methodology
- Transfer impedance evaluation results
- Bonding methodology
- Faraday shield bonding records
- Bonding length calculations

- Suppression alternatives and mitigation methods

CHAPTER 3

ELECTRICAL POWER AND LIGHTING SYSTEMS

3-1 SCOPE

This chapter provides the criteria for electrical power and lighting systems necessary to protect weapons from electrical energy and provide auxiliary power and lighting to maintain essential operations without impacting mission requirements.

3-2 ELECTRICAL SYSTEMS

3-2.1 Design Criteria

Electrical systems for nuclear weapons-capable maintenance and storage facilities shall be designed to meet the requirements of UFC 3-501-01, UFC 3-520-01, and UFC 3-550-01. Electrical systems shall comply with NFPA 70 and American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE) C2, except as modified by UFC 3-501-01, UFC 3-520-01, or UFC 3-550-01. Electrical systems shall comply with AFI 32-1063, AFI 32-1065, and AFMAN 91-201.

Facilities shall be provided with an auxiliary power system to supply electrical power to all facility subsystems that are necessary to maintain the safety and security of nuclear weapons in accordance with AFI 32-1063.

3-2.2 Special Documentation of Grounding System

During construction, establish clear, comprehensive documentation (including photographs) of the as-built installation of the facility's grounding electrode system, connection to ground rods, and interconnection to other systems. The photos must be taken while the grounding electrode system and connections are still exposed and visible, prior to the placement of backfill or other coverage material. Include distances from permanent reference points to enable base personnel to subsequently locate and uncover any connection point in the system. The installing contractor shall include this documentation with the project as-built submittals with written certification of its accuracy.

3-2.3 Transformers

3-2.3.1 Dry-type transformers shall be used wherever possible for indoor applications per UFC 3-520-01. If dry-type transformers are not suitable to meet load requirements, use transformers with less-hazardous dielectric fluids in place of hydrocarbon-based insulating oils. Polychlorinated biphenyl (PCB)-filled transformers shall not be used. Installation shall comply with NFPA 70 requirements for transformers located inside buildings. If non-dry-type transformers are used within a facility, the area where the transformers are located shall be provided with fire detection and fixed suppression. The room shall be separated from the remainder of the facility by 2-hour fire barrier walls with all penetrations and openings (e.g., fire doors, penetration seals, and fire dampers) properly protected.

3-2.3.2 Outdoor transformers shall meet the minimum separation distances from structures as specified in AFMAN 91-201 and UFC 3-600-01.

3-2.3.3 Outdoor transformers, other than dry-type transformers, shall contain insulating oils suitable for the cold weather conditions of the geographic location of the nuclear weapons-capable maintenance and storage area.

NOTE: Some dielectric fluids used as an alternative to hydrocarbon-based oils have significant changes in their dielectric properties when exposed to below freezing conditions. Although these fluids may function appropriately in a continuously energized transformer that keeps the fluids warm, the transformer must always remain energized. It may not be possible to safely reenergize these transformers from an extended shutdown period in cold environments.

3-2.3.4 Transformers containing insulating mineral oils shall be tested at least annually to the specifications of the American Society for Testing and Materials (ASTM). Testing shall include at least the following:

a. Dissolved gas-in-oil analysis (IEEE C57.104 and ASTM D3612)

b. Oil testing, including:

- Dielectric breakdown strength (ASTM D877 and D1816)
- Neutralization (ASTM D974)
- Interfacial tension (ASTM D971)
- Color (ASTM D1524)
- Moisture content (ASTM D1533)
- Specific gravity (ASTM D1298)
- Transparency and opacity (ASTM D1524)
- Sediment (ASTM D1698)
- Power factor (ASTM D924)

Results of the testing shall be evaluated to detect impending transformer breakdown and to permit corrective maintenance before a transformer failure causes an unplanned power outage.

3-2.3.5 If the FHA report identifies critical transformers that if lost would have a severe impact to the facility mission, and if these transformers have a long replacement time, the procurement of a spare transformer shall be evaluated by facility management.

3-2.4 Cabling

Cabling within nuclear weapons-capable maintenance and storage facilities shall meet the specifications in UFC 3-520-01. The specific areas that shall exceed the criteria within UFC 3-520-01 are addressed in paragraphs 3-2.4.1 through 3-2.4.5.

3-2.4.1 Combustible Cable Insulation and Jacketing Material

Combustible cable insulation and jacketing material shall meet the fire and flame test requirements of IEEE 383. Meeting the requirements of IEEE 383 shall not eliminate the need for other features of fire protection as specified in this attachment.

3-2.4.2 Fiber Optic Cable Insulation and Jacketing Material

Fiber optic cable insulation and jacketing material shall meet the fire and flame test requirements of IEEE 383.

3-2.4.3 Electrical Switchgear Rooms

Electrical switchgear rooms shall not be used for other purposes, e.g., storage of items not related to the switchgear. Combustible materials and containers shall not be stored in the switchgear room.

3-2.4.4 Wire Management Systems

All wiring, including power, signal, communication, and control, shall be installed in metallic conduit. Wireways or cable trays shall not be used without approval of the AHJ.

NOTE: Wireways and cable trays shall not be used to run cables through the boundary of a blast containment zone (refer to paragraph 7-4.1).

3-2.4.4.1 Raceways

If the use of raceways is approved by the AHJ, raceways shall be made of noncombustible materials.

3-2.4.4.2 Cable Trays

If the use of cable trays is approved by the AHJ, only metal shall be used for cable trays; e.g., fiberglass-reinforced plastics are not permitted.

If the use of cable trays is approved by the AHJ, cable tray fire breaks shall be installed every 20 feet (6.1 meters) for vertical cable trays that rise over 30 feet (9.1 meters), unless they are protected with a fire-resistive coating. Access to cable shafts shall be provided every 40 feet (12.2 meters), with the topmost access within 20 feet (6.1 meters) of the cable shaft ceiling. Automatic sprinkler protection and smoke detection shall be provided at the ceiling of the vertical shaft.

If the use of cable trays is approved by the AHJ, horizontal cable trays shall be provided with cable tray fire breaks every 50 feet (15.2 meters) unless the cable trays are protected with a fire-resistive coating.

3-2.4.5 **Conduits**

Conduits with an inside diameter larger than the trade size of 4 inches (103 millimeters) that pass through a fire barrier wall shall be provided with an internal fire seal that has a fire-resistive rating equivalent to that of the fire barrier, and the internal fire seal shall be permitted to be installed on either side of the barrier in a location that is as close to the barrier as possible. Blast walls shall also be provided with an explosion-proof conduit seal meeting the requirements of NFPA 70 for a Class I, Division 1 boundary (refer to paragraph 7-4.1).

Conduits with an inside diameter equal to or less than the trade size of 4 inches (103 millimeters) that pass through a fire barrier wall that is not also a blast wall shall be provided with a fire-rated internal seal unless the conduit extends greater than 5 feet (1.5 meters) on each side of the fire barrier. In this case, the conduit opening shall be provided with noncombustible material to prevent the passage of smoke and hot gases. The fill depth of the material packed to a depth of 2 inches (51 millimeters) shall constitute an acceptable smoke and hot gas seal in this application.

Conduits with an inside diameter equal to or less than the trade size of 4 inches (103 millimeters) that pass through a fire barrier wall that is also a blast wall shall be provided with an explosion-proof conduit seal meeting the requirements of NFPA 70 for a Class I, Division 1 boundary (refer to paragraph 7-4.1).

3-2.5 **Battery Rooms**

Battery rooms shall be provided with ventilation to limit the concentration of hydrogen to less than 1 percent by volume in accordance with NFPA 69. Loss of ventilation in a battery room shall cause an alarm to be received at a constantly attended location (e.g., in the security control room or munitions squadron control). The installation of an approved hydrogen detection system shall be in accordance with NFPA 70, Article 480, and evaluated by a qualified fire protection and electrical engineer. The room shall also be designed and constructed in accordance with Chapter 7 of NFPA 111.

Direct current switchgear and inverters shall not be located in battery rooms.

3-2.6 **Electrical System Analyses**

Current electrical coordination, short-circuit, and load flow analyses for the facility shall be maintained and kept with other facility records. These analyses shall be used to ensure that proposed system modifications will not adversely affect system reliability.

3-2.7 **Priority and Normal Electrical Power Loads**

Priority loads are designated as electrical system loads whose failure could result in loss of human life or serious injuries, or result in serious mission or security issues. Priority loads shall be served by a permanent emergency engine generator power system. These loads include, but are not limited to:

- Security systems
- Entry control systems

- Maintenance area lighting and power
- Storage area lighting
- Shelter-in-place (refuge area) lighting and power
- Egress lighting
- Life safety systems
- Mechanical systems associated with a blast containment management system (BCMS)
- Fire alarm and reporting systems

Normal loads are any electrical system loads not classified as a priority load.

3-2.8 Hardening of Electrical Power Systems

Electrical power systems located within and serving the controlled areas of nuclear weapons-capable maintenance and storage facilities shall be required to be hardened against unauthorized access and intentional acts that may result in damage to the systems. Hardening shall incorporate one or more of these features: location within secured facility boundaries, active surveillance, alarms, physical barriers, access controls, shock- or vibration-resistant equipment mounts, or other methods that will prevent unauthorized access and damage to the supply, distribution, or controls of the normal and emergency power systems.

3-2.9 Emergency Power Systems

Emergency power systems shall be capable of supporting all priority loads with a reserve capacity. Emergency power system types include at a minimum a real property installed equipment (RPIE) permanent engine-driven electric generator. In addition, other types of electrical power systems may be approved by the AHJ, such as uninterruptable power supplies (UPS) that use batteries as the source of emergency power.

3-2.9.1 Fuel Systems for Emergency Engine Generator Power Systems

Fuel systems for emergency engine generator power systems, including on-premise supply, shall be afforded the same level of hardness required for the emergency engine generator power system itself. Furthermore, the on-premise supply shall be sufficient to enable the emergency power systems to support all priority loads for at least 72 hours.

3-2.9.2 Automatic Transfer Switches (ATS)

Facilities using ATSs connected to normal power and emergency power supply breakers must be provided with 100 percent redundant breakers that allow any one breaker to be racked out to allow for annual inspection, calibration, and maintenance of equipment without requiring electrical system shutdown. The system design shall also incorporate an electrical power bypass feature to allow maintenance on the ATS without requiring an electrical system shutdown.

3-2.9.3 Tertiary Connection Point

Facilities shall be provided with a tertiary connection point for a mobile engine generator system independent of the permanently installed facility engine generator set. This connection point shall be capable of sustaining all priority loads, including a 50 percent reserve capability for future additional priority loads.

3-2.10 Surge Protection

3-2.10.1 Existing Facilities

For existing facilities, provide surge protection sized to reduce transient voltages, including those produced by lightning, to a harmless level on all entering or exiting metallic power, intrusion detection, communication antenna, and instrumentation lines in accordance with UFC 3-520-01. Install the surge protection as near as practical to where the conductor enters the interior of the facility. Surge protection for Faraday shield environments must be high capacity (refer to paragraph 2-5.5.1).

3-2.10.2 New Facilities

For all new facilities, surge protection must meet the requirements in Chapter 2 for a Faraday shield in addition to the requirements in UFC 3-520-01.

3-3 TEMPORARY ELECTRICAL WIRING

Comply with NFPA 70 and the requirements listed in Chapter 10.

3-4 LIGHTING

3-4.1 Normal Lighting

Normal lighting shall be provided as required by UFC 3-520-01.

3-4.2 Photoluminescent Egress Path Marking

Non-powered, luminescent path markings shall be provided for egress access routes and to areas of refuge in accordance with NFPA 101. The installation of luminescent path marking shall consider the amount of ambient lighting that is available throughout the day to ensure that the level is sufficient to keep the marking charged in accordance with the manufacturer’s requirements.

3-4.3 Photoluminescent Exit Door Marking

Exit doors and doors to areas of refuge shall be marked with non-powered photoluminescent signs that are unique to avoid confusion with normal egress doors. These signs shall be installed in accordance with the manufacturer’s requirements. Particular attention shall be given to the requirement for the level of background ambient lighting to ensure that the signs remain charged. If this criterion cannot be met, then electrically powered exit marking shall be used (e.g., light-emitting diode [LED] signs).

3-4.4 Emergency Lighting

Emergency lighting shall be provided for the egress access routes, security staging and operating locations, and firefighting staging and operating locations in accordance with NFPA 101. Emergency lighting for security staging and operating locations and

firefighting staging and operating locations may be required to be at a higher level. The required illumination shall be documented in the FHA.

3-4.4.1 Battery-Powered Hand Lights

Suitable battery-powered hand lights shall be provided for emergency use by security personnel and other personnel required to safeguard the facility. Their location shall be established by the cognizant security and building officials.

3-4.4.2 Testing

Permanently mounted emergency lighting units using batteries shall be tested and inspected to verify proper operation based on the requirements of NFPA 101.

3-5 SECURITY LIGHTING

Security lighting shall be in accordance with DOD S-5210.41-M/AFMAN 31-108, Volumes 1–3.

CHAPTER 4

STRUCTURAL SUPPORT FOR HOISTS, CRANES, AND LIFTING DEVICES

4-1 SCOPE

This chapter provides the criteria for the facility structural elements that directly support hoists, cranes, and lifting devices that fall under the requirements of AFMAN 91-118 to ensure that those elements are capable of supporting the devices to the full extent of the safety design criteria of the device itself.

4-2 STRUCTURAL LOAD DEFINITIONS

4-2.1 Rated Load

The rated load is the static load consisting of one or more weapons and the associated handling and restraint equipment, including the grounding equipment. The rated load is based on the combination of load forces that the basic equipment must support or resist in a static state.

4-2.2 Dynamic Load

The dynamic load is developed by applying factors from the loads and accelerations in all directions experienced during loading and unloading operations to the rated (static) load.

4-2.3 Design Load

The design load is the greater of the rated load multiplied by a factor as required in AFMAN 91-118. This design load is considered the minimum load for design of the facility structural elements required to support the hoist, crane, or similar device.

4-3 STRUCTURAL REQUIREMENTS

Ensure that items such as load frames, hoist trolleys, test and storage stands, and handling units provide at least the design load capability. See AFOSH 91-46 for additional requirements.

CHAPTER 5

PHYSICAL SECURITY

5-1 SCOPE

This chapter provides criteria for the physical security necessary to meet the applicable DOD nuclear weapon system safety standards and considers systems design, access analysis, and other features to ensure that the applicable standards have been met.

5-2 DESIGN CRITERIA

5-2.1 Minimum Physical Security Design

At a minimum, physical security design shall be in accordance with DOD S-5210.41-M/AFMAN 31-108, Volumes 1–3.

5-2.2 Systems Engineering Perspective

Physical security system designs shall be approached from a systems engineering perspective to identify potential impacts to the safety of nuclear weapons systems and to ensure compatibility (including an EMRE survey) with nuclear weapon systems.

CHAPTER 6

FACILITY AUTOMATA AND SOFTWARE

6-1 SCOPE

This chapter provides criteria for facility automata and software that is unique and developed or written specifically to control essential facility systems (EFS).

6-2 DEFINITION OF EFS

EFS are defined as those facility systems that directly impact the safe maintenance, handling, and storage of nuclear weapons. (Also see AFMAN 91-118.)

6-3 AUTOMATA AND SOFTWARE REQUIREMENTS

6-3.1 Software

All software (including facility security system software) that is unique and developed or written specifically to control EFS must meet the requirements of AFMAN 91-119.

6-3.2 Exempted Embedded Software and Firmware

Embedded software and firmware that is installed by the equipment manufacturer, is commercially available, is incapable of being modified without the manufacturer's authorization, and is common to all identical equipment without modification to the program itself does not fall under the requirements of AFMAN 91-119 and does not require separate nuclear safety certification for the software and firmware.

6-4 EFS DESIGN CONSIDERATIONS

6-4.1 Protection of EFS Interfaces

Control of EFS is nearly always accomplished by embedded software and firmware, or in some instances, by unique software written specifically for that purpose. Typically, EFS are interconnected and provide integrated systems operations. Interfaces between EFS must be designed to ensure that the nuclear surety environment is maintained. Design considerations may include, but are not limited to:

- Placing control panels and interface connections and equipment in locked secure cabinets and placing the cabinets in a secure environment
- Ensuring that the interconnections and equipment are passive in nature
- Minimizing exposure of interconnection wiring to unauthorized access (i.e., enclosing in conduit)

6-4.2 Protection from Power Fluctuations

All software and computer system hardware for EFS shall be robust and insensitive to normal power fluctuations, spikes, and dips. Hardware shall be provided with supplemental power such as battery backup or UPS, or be connected to a power supply that has reserve capabilities.

CHAPTER 7

BLAST CONTAINMENT AND ISOLATION SYSTEMS

7-1 SCOPE

This chapter provides criteria and requirements for blast containment and isolation systems for the purpose of mitigating contamination of facilities and weapons and limiting the spread of contamination and consequential damage to areas outside individual blast zones.

NOTE: Fire protection (e.g., automatic sprinklers) and fire detection (e.g., fire alarm systems) are to be configured to coincide with the blast zones and corresponding heating, ventilation, and air conditioning (HVAC) zones. This will reduce the penetrations through the blast walls by the fire protection equipment and will also improve the survivability of the systems (refer to Chapters 9 and 11). Life safety issues related to blast containment are discussed in subsequent chapters of this attachment.

7-2 REFERENCES

Guidance for blast containment and isolation systems is provided in the following documents:

- AFMAN 91-201
- DOD Directive 6055.9
- DOE M 440.1-1A

7-3 DESIGN FEATURES

Blast containment and isolation design features shall include as a minimum:

- The ability to mitigate contamination of facilities and weapons by limiting radiation transport mechanisms such as explosions, blasts and fires
- Incorporation of blast zones for the purpose of limiting the spread of contamination and consequential damage to the facility and stored critical assets
- Blast-resistant barriers separating blast zones that are capable of withstanding explosions commensurate with the maximum credible event of the zone
- Compatibility between factors such as site requirements, blast zones, blast pressures, isolation requirements, HVAC, and drainage requirements
- Mitigation of collateral damage from blast or contamination to the environment outside the facility

- Appropriate filtering capable of removing hazardous airborne materials from intake or exhaust air

- The capability for venting or isolating the facility with respect to environmental air

- The capability for monitoring the interior of the facility for specific types of radiation

- Integration with other systems, such as HVAC, fire alarm, and security, to achieve a coordinated and managed environment

NOTE: The integrated system is commonly referred to as the blast containment and management system (BCMS).

- The ability to accomplish remote control of systems through the BCMS by specific authorized personnel

- The capability to mitigate external, outside environmental hazards

7-4 SYSTEM ELEMENTS

Blast containment and isolation system elements include, but are not limited to: blast containment zones, blast-resistant barriers (i.e., walls, floors, and ceilings), blast doors, blast valves, HVAC systems, and plumbing systems.

7-4.1 Blast Containment Zones

Blast containment zones shall be arranged to coincide with HVAC zones and fire zones (as separated by rated fire barrier walls) to the maximum extent possible (see Chapter 11). Blast containment zones shall be constructed to be as gastight as possible. The construction of the area shall meet the gastight criteria, e.g., reinforced concrete, steel blast doors, pipes, valves, and seals. Each area shall be designed such that both during and after an explosive event, the gastight capability of the area will not be substantially lessened.

7-4.2 Blast-Resistant Barriers

Blast-resistant barriers, such as walls, floors, and ceilings, will be designed to resist blast loads in any area subject to accidental explosion. Concrete cracking shall be limited to discontinuous hairline-type cracks such that the migration of contaminants through these cracks will be severely limited. Spalling on the protected side of the wall shall be limited, and the integrity of the wall shall be maintained considering the combined fragment impact and blast pressure commensurate with the maximum credible event. Penetrations of the blast-resistant barriers shall be limited to only those services necessary to serve the blast zone encompassed by the blast-resistant barriers. The penetrations will be protected by blast valves, explosion-proof seals, or other such means necessary to maintain the integrity of the barrier. Where sprinkler piping penetrates a blast barrier, other means of protection shall be considered to ensure that

the system maintains NFPA code compliance. This may necessitate zoning the sprinkler systems such that a single sprinkler system would service a single blast zone.

7-4.3 Blast Doors

Blast doors shall meet the criteria in paragraphs 7-4.3.1 through 7-4.3.10 at a minimum.

7-4.3.1 Configuration

The preferred configuration is a single-leaf swing blast door; however, other configurations are acceptable (e.g., vertical sliding blast doors) providing that the blast doors will provide the required protection and blast containment.

7-4.3.2 Construction

The doors shall be constructed of material that will provide the required blast resistance and delay characteristics. There shall be specific and proven data that demonstrates the capability of the material selected to meet the required blast resistance and delay characteristics.

7-4.3.3 Blast Resistance

The door material shall be of sufficient thickness and strength to withstand the blast pressures imposed on it. At a minimum, it shall resist the blast pressure associated with the maximum credible event of the area being protected.

7-4.3.4 Door Operators

The door operating system shall include a stored energy system that shall be capable of operating through not less than two complete cycles without relying on external power. Furthermore, upon loss of power, the door operating system shall automatically cycle the doors to a failsafe position that meets the applicable security and safety requirements.

7-4.3.5 Door Control

Controls for the door operators shall be compatible with the physical security requirements mandated by the applicable criteria of DODD 5210.41 and DOD S-5210.41-M/AFMAN 31-108, Volumes 1–3. A manual means of opening the door from either side shall be provided.

7-4.3.6 Seals

Blast doors shall be provided with seals around the perimeter of the door. Blast door systems, including the seals, shall be gastight before and after an explosive detonation and fragmentation impact. The maximum leakage permitted around the seals is 1 cubic foot (28.3 liters) of air per hour per 1 linear foot (30.5 centimeters) of seal. Each blast door system shall be designed with the inherent capability to test leakage around the seals with the door and seals in place and without separate equipment or special procedures.

7-4.3.7 Hinge Requirements

The hinge design capacity shall be at least 150 percent of the calculated load to which the hinge will be subjected, including each component and mounting hardware. The life expectancy of the hinges shall be not less than 20 years with a normal number of

operating cycles per day based on a conservative evaluation of past facility operations (for existing facilities) or anticipated operations (for new facilities). The hinges shall allow the door to be adjusted in both the x- and y-axis of the door plane, which shall not require specialized tools, hinge disassembly, machining of hinge or door surfaces, cutting or welding, or any other such special procedures.

7-4.3.8 Equivalency to Fire Doors

In most cases, blast doors will be within fire-rated walls. Blast doors are not listed by nationally recognized testing laboratories as fire doors; however, based on their very massive construction, they likely meet most of the listing agencies' criteria for a fire door. In cases where a blast door is within a fire barrier wall, a qualified fire protection engineer shall evaluate the door and determine if it meets the intent and function of a fire-rated door. The evaluation should include at least the types and amount of combustible materials used in construction of the door, a qualitative consideration of the door's thermal transfer characteristics, the means of mounting the door into the blast wall and the door frame, and the size and means of sealing of gaps around the door when closed. The evaluation shall be reviewed and approved by the AHJ. If the evaluation proves that the door is not equivalent to a fire-rated door, other means shall be provided to ensure that the rating of the wall is maintained. Such configurations can include a fire-rated vestibule with fire-rated doors.

7-4.3.9 Communication Capability

Capability for communication by personnel shall be present on both sides of the blast doors.

7-4.3.10 Emergency Operation of Vertical Blast Doors

If vertical blast doors are used, they shall be evaluated and configured such that in the event of an explosion within the space, the damaged door can be operated from the exterior of the room by an emergency means (e.g., providing the door with the necessary hardware to permit the use of a forklift to lift the door after an explosive event).

7-4.4 Blast Valves

Blast valves shall be installed on HVAC hardened ducts and plumbing piping that penetrate blast-resistant barriers. These valves and their installation shall prevent over and under pressure blast waves from reaching the supply and exhaust airstreams. These valves shall be self-contained and be capable of automatically closing upon an explosive event.

7-4.5 HVAC Systems

7-4.5.1 Zones

HVAC zones will be arranged to coincide with blast zones and fire areas to the maximum extent possible (refer to Chapter 11).

7-4.5.2 Valves

Blast valves and gastight butterfly valves will be used to isolate each ventilation air pipe crossing blast-resistant barriers. Butterfly valves (Wafer-Sphere) shall be the quick

acting, gastight isolation type that are air driven, spring closed to isolate a zone immediately after an internal blast. Butterfly valves shall be triggered by blast detectors located within each contamination zone.

7-4.5.3 Hardened Duct

Hardened duct will be used for any duct penetrating a blast-resistant barrier or for any duct extending through a blast zone. Duct that remains entirely within a blast zone is not required to be a hardened duct.

7-4.5.4 Individual Air Handling Systems

Each blast protected containment zone will be served by an individual air handling system.

7-4.5.5 CBR Filters and Filter Systems

A chemical-biological-radiological (CBR) filter system will be provided to protect against contaminated air being supplied or vented.

7-4.5.6 Chemical-Biological (CB) Agents

In addition to the normal HVAC function, ventilation systems shall also protect against CB agents and maintain consistent building pressurization.

7-4.5.7 Mechanical Plenums

Ventilation air shall be supplied and exhausted from the mechanical plenums to each area in either steel ducts or welded Schedule 40 steel pipes in accordance with standard industry practices. The use of flexible ducts shall be permitted only with the approval of the AHJ.

7-4.5.8 Containment of Blast By-Products

The various weapon handling areas of the main facility will each be designed to contain the by-products of an accidental explosion entirely within themselves until these by-products can be vented safely to the outside.

7-4.6 Plumbing

Remotely air-operated quick acting isolation ball valves shall be placed on domestic water lines, sewer lines, fuel lines, and other plumbing lines to prevent blast contaminating particles from reaching the water source. These valves shall be configured to fail in the closed position. These valves shall also close at the same time as the blast valves.

7-4.7 Electrical

Explosion-proof conduit seals shall be provided for each conduit run passing through the boundary of a blast containment zone (refer to paragraph 3-2.4.5). Wireways and cable trays are not permitted to cross the boundary of a blast containment zone (refer to paragraph 3-2.4.4).

CHAPTER 8

STUDIES AND DOCUMENTATION

8-1 SCOPE

This chapter provides criteria and requirements for conducting the specified studies in sufficient detail to ensure the safety of weapons and to provide baseline documentation to the AHJ. The unique requirements for fire safety, including fire suppression systems and life safety components, are a key issue; however, principles of fire safety applicable to other types of facilities that handle special nuclear materials are available within certain national consensus standards and within the DOE. Such principles were considered in developing this attachment.

The principles of facility safety, life safety, and fire protection required for nuclear weapons-capable maintenance and storage facilities were developed by collecting and refining criteria from DOD fire protection guidance, munitions safety guidance, and national consensus fire safety standards, including NFPA 801, NFPA 804, and NFPA 805. Also considered were DOE criteria, including: DOE O 420.1B, DOE O 440.1B, and DOE-STD-1066-99.

NOTE: Specific and unique fire protection and life safety criteria have been developed for nuclear weapons-capable maintenance and storage facilities. These criteria would not be appropriate for most DOD buildings. Consequently, the criteria in this document shall take precedence in case of any conflict with UFC-3-600-01 (refer to paragraph 1-4).

8-2 APPLICATION

Studies shall be accomplished on all nuclear weapons-capable maintenance and storage facilities as described in the following sections. Following the initial study efforts, if any proposed facility change or modification involves, affects or impacts systems covered by the studies, they shall be updated to include the affect of the modification on the study conclusions and recommendations.

These studies, new or revised, shall be used to support or maintain facility certification actions. Facility certification actions shall be accomplished in accordance with AFI 63-125.

8-3 FIRE HAZARD ANALYSIS (FHA)

The purpose of a FHA is to comprehensively and quantitatively assess the risk from a fire originating from within individual fire areas in an Air Force facility to ascertain whether the Air Force fire safety objectives are being met.

NOTE: The FHA is typically funded by Civil Engineering.

8-3.1 General Requirements

8-3.1.1 Assessor Qualifications

The FHA shall be accomplished by qualified fire protection engineers to ensure compliance with the fire protection and fire prevention requirements of this standard (refer to paragraph 1-8).

8-3.1.2 New Facilities

A FHA shall be performed for all new facilities. The FHA shall be performed early in the design phase for new facilities to ensure that an acceptable level of protection is being incorporated into the design.

The FHA shall be updated when significant design changes occur within any individual fire area and shall serve as the basis for the post-construction FHA.

8-3.1.3 Existing Facilities

A FHA shall be performed for all existing facilities.

8-3.1.3.1 Existing Facilities with No Prior History of a FHA

On existing facilities that have no prior history of a FHA, an initial FHA shall be accomplished within 3 years from the issuance date of this attachment unless a later date has been approved by the AHJ.

8-3.1.3.2 Existing Facility with a Current FHA

For any existing facility with a current FHA, an updated FHA shall be accomplished when configuration changes are made to the facility structure or systems if the changes have, or may have, impacted the facility's compliance with the fire prevention and fire protection requirements of this attachment.

8-3.1.4 FHA Update Intervals

The FHA shall be updated and revised for all facilities no later than the end of the fifth calendar year after the date of the last FHA or annually if specifically required by the AHJ.

8-3.1.5 FHA Content

The FHA must include an assessment of the risk from fire and related hazards (e.g., direct flame impingement, hot gases, smoke migration, firefighting water damage and drainage) in relation to existing or proposed fire safety features to ensure that the facility can be safely controlled and stabilized during and after a fire. In accordance with the graded approach concept, the level of detail necessary for an acceptable FHA is directly related to the complexity of the facility and the potential risk to the public and facility personnel. The scope and content of a FHA shall be limited to those issues that are relevant to the facility. In general, the FHA shall comprehensively and qualitatively:

- Assess the potential for a fire within each individual fire area, or zone, within a facility

- Analyze the effects of a fire event within each fire area
- Assess the adequacy of facility fixed and portable fire protection and prevention systems and equipment
- Assess organizational response (both emergent and non-emergent) requirements, capabilities, training and procedures
- Assess operational procedures and practices as related to fire protection and response
- Assess programs for minimizing the effects of fire on personnel, facilities, equipment, and mission

8-3.2 **FHA References**

8-3.2.1 The FHA survey and analysis shall performed by a qualified fire protection engineer (refer to paragraph 1-8). The FHA should include appropriate requirements and guidelines from the most current editions of the following publications:

- UFC 3-600-01
- NFPA 801
- AFMAN 91-201
- AFI 91-202
- DOD instruction (DODI) 6055.06
- DODD 6055.9E
- DOD 6055.09-STD
- NFPA 550
- Society of Fire Protection Engineers (SFPE) *SFPE Handbook of Fire Protection Engineering*
- NFPA 13
- NFPA 14
- NFPA 72
- NFPA 101
- NFPA *Fire Protection Handbook*

NOTE: Other NFPA standards not included in this list should be considered when appropriate.

8-3.2.2 With respect to nuclear weapons safety, security, and control, the FHA shall be guided by the concepts and requirements contained in the most current edition of applicable publications, including but not limited to:

- AFI 90-201
- Air Force policy directive (AFPD) 91-1
- AFI 91-101
- AFI 91-102
- AFI 91-103
- AFI 91-107
- AFI 91-116
- AFMAN 91-118
- DODD 3150.2
- DODD 3150.2-M
- DOD S-5210.41-M/AFMAN 31-108, Volumes 1-3

8-3.3 **Qualifications of FHA Personnel**

8-3.3.1 The FHA shall be accomplished by qualified fire protection engineers (refer to paragraph 1-8). It is desirable that these qualified engineers be supported by an engineering firm having experience in performing FHAs for a wide range and type of facilities and hazards—especially nuclear hazards. These engineers shall be knowledgeable of facility operations, maintenance procedures, equipment design, training of facility personnel, and firefighting procedures. They must be sensitive to those issues unique to nuclear weapons-capable maintenance and storage facilities (e.g., security requirements versus life safety requirements).

8-3.3.2 The qualified fire protection engineers accomplishing the FHA shall solicit support from other appropriate engineering disciplines as needed, including but not limited to electrical, mechanical, civil, structural, chemical, and systems engineers.

8-3.3.3 When necessary, the qualified fire protection engineers accomplishing the FHA shall consult with appropriate national laboratory representatives who are knowledgeable of weapon design and weapon system responses to thermal changes.

8-3.3.4 When accomplishing the FHA for existing facilities, the qualified fire protection engineers shall contact facility personnel who are knowledgeable of facility maintenance, operations, equipment, training, and procedures.

8-3.4 Specific Requirements

8-3.4.1 Fire Risk Analysis

The FHA shall include a fire risk analysis. The fire risk analysis shall:

8-3.4.1.1 Evaluate the probability of fires in the facility and evaluate the probability of resultant injuries to people and damage to buildings or equipment.

8-3.4.1.2 Quantify the costs related to personnel injuries and equipment damage for the fires. Also, the fire risk analysis shall consider the impact on mission continuity from the fires.

8-3.4.1.3 Evaluate the effect of possible fires and related perils (e.g., direct flame impingement, hot gases, smoke migration, and firefighting water damage) in relation to the capabilities of existing fire safety features and fire department operations to ensure that the fire can be safely controlled and stabilized.

8-3.4.1.4 The fire risk analysis shall assume that all potentially vulnerable systems will be damaged within the fire area. Acceptable exceptions to this assumption are water-filled steel pipes, tanks, and similar components of superior structural integrity with welded fittings and adequate pressure relief. Passive fire protection features, such as blank fire-rated walls, floors, and ceilings, and continuous fire-rated cable wraps, are assumed to remain viable.

8-3.4.1.5 The fire risk analysis shall evaluate the effect of possible fires when any single automatic fire detection or fire suppression system is not available to perform its intended function. Active fire protection features, such as fire dampers, window shutters, and self-closing fire doors in fire barrier walls, shall also be evaluated using the criteria of a single fire protection feature not being available. This non-availability may result from an equipment failure (non-fire related) or because the fire occurs during a time the system has been disabled for routine maintenance. If redundant automatic fire protection systems are provided in the area, only the one system or component that causes the most vulnerable condition need be assumed to be unavailable. Passive fire protection features, such as blank fire-rated walls, floors, and ceilings, and continuous fire-rated cable wraps, are assumed to remain viable.

8-3.4.1.6 Determine the maximum credible fire loss (MCFL) and maximum possible fire loss (MPFL) with respect to facility function as well as value. In determining the value of the MPFL, which is used in part to assess the need for fire protection systems, the basic assumption shall be that there is no automatic or manual fire suppression. This loss determination shall include all direct and indirect costs associated with the fire and clean-up operations. Clean-up costs due to radioactive contamination shall be

based on service-specific historical data or estimated from other historical data (e.g., such as data used by the DOE).

8-3.4.2 Fire Areas

The focus of the FHA shall be the individual fire areas. Fire areas are those areas of the facility that are bounded by fire barriers. Where a facility is not subdivided by fire-rated construction, the exterior walls and roof of the facility shall define the fire area.

8-3.4.3 Conflicts

The FHA shall identify specific sections of national consensus codes and standards that might be considered in conflict with the nuclear safety and security requirements of the facility. These shall be documented within the FHA, and alternative measures to achieve fire protection objectives shall be recommended where appropriate.

8-3.4.4 Air Distribution Systems

The FHA shall consider fire propagation and the potential for fire-induced radiological dispersal through the facility's air distribution system. These effects shall be considered for both the normal operating mode of the air distribution system as well as operation in alternate modes, including system shutdown that may result from the fire.

8-3.4.5 Flammable and Combustible Materials

The quantity and associated hazards of flammable and combustible materials that can be expected to be found within the fire area shall be factored into the analyses. Consideration shall also be given to the presence of normal as well as unexpected transient combustible materials associated with the function and operation of the facilities.

8-3.4.6 High-Bay Locations

FHAs for high-bay locations shall consider the effects of smoke and hot gas stratification that may occur at some intermediate point below the roof or ceiling. Similarly, the effect of smoke movement through doors and dampers held open by fusible links shall be addressed. The impact of the height to automatic fire suppression and detection systems shall also be evaluated. A fire model may be necessary to evaluate the response time of the suppression and detection systems at the ceiling of high-bay areas.

8-3.4.7 Natural Hazards

The FHA shall consider natural hazards (e.g., earthquake, flood, wind, lightning, wild land fires) as related to their impact on fire safety.

8-3.4.8 Hostile Act Scenarios

The FHA shall consider certain hostile act scenarios (defined by the user) and their impact on fire-induced radiological dispersal.

8-3.4.9 Additional Considerations

The FHA shall examine compliance and noncompliance in existing facilities and shall include these elements:

- Recommendations for correction or mitigation of noncompliance. The recommendations shall identify specific mitigation strategies for the noncompliance (e.g., the need for a fire suppression system, the type of fire suppression needed, and the water requirement).

- For any noncompliance, the FHA shall include a risk assessment of the noncompliance in the case that the recommendations are not approved for implementation.

- Recommendations for improvement of features in compliance.

- For recommendations for improvement of features in compliance, the FHA shall include a qualitative risk assessment in the case that the improvement is not approved for implementation.

Once approved by the AHJ, the results of the FHA shall take precedence over previous or conflicting design criteria.

8-3.5 **FHA Report**

As a minimum, the FHA report shall contain and document these items:

- A description and assessment of general facility construction, including the type, location, ratings (in hours), and construction of fire barriers

- A description and assessment of fire detection and fire suppression systems, equipment, and related components (including but not limited to HVAC systems)

- A description and assessment of fire hazards from adjacent facilities and construction, as appropriate

- The fire risk analysis, including the MCFL and MPFL

- An inventory of all priority electrical loads (e.g., such as fire alarm, emergency power) within the fire area that are susceptible to fire damage, including mechanical and electrical systems, which must function effectively during and after a fire event. This shall also include an assessment of the adequacy and protection afforded these priority electrical loads.

- An evaluation of the potential for flame spread, fire spread, and smoke development due to cabling within the facility with respect to the requirements in CHAPTER 3

- An assessment of fire response and fire response plans, including organization, capabilities, training, and requirements

- An itemization of areas and issues of noncompliance, including the comprehensive and qualitative risk assessment of the noncompliance items if not accomplished
- An itemization of areas and issues in compliance that are recommended as candidates for improvement
- Recommendations for correction or mitigation of noncompliance
- Recommendations for action on candidates for improvement
- A description of any critical process equipment
- A description of any high value property
- The potential for a toxic, biological, or radiation incident due to fire
- Life safety considerations
- Emergency planning
- Recovery potential
- Exposure fire potential and the potential for fire spread between two fire areas

8-3.6 FHA Tools

8-3.6.1 Fire Models

Tools that may be used in the development of a FHA include fire models such as those developed by the National Institute of Standards and Technology (NIST); however, the use of such models is predicated on their being conservative and validated. Air Force acceptance of individual models will be considered on a case-by-case basis.

8-3.6.2 Fire Protection: Defense-In-Depth

The fire protection criteria are based on the principle of defense-in-depth. This attachment supplements and in some cases modifies the fire protection requirements of UFC 3-600-01 to meet the unique mission requirements of these facilities (refer to paragraph 1-4). Defense-in-depth is achieved when a balance of each of the following elements is provided in the facility:

- Preventing the initiation of fires
- Rapidly detecting all fires that do occur
- Controlling and promptly extinguishing fires to limit damage, personnel injury, and consequences to acceptable levels

- Providing a level of fire protection for structures, systems, and components so that a fire that is not promptly extinguished will not prevent essential facility functions from being performed

8-3.6.3 Life Safety Objectives

The life safety objectives are to be established to ensure that any occupants that are not within the affected fire area are protected to a level such that they can safely exit the facility. Occupants that are within the fire area shall be protected to a level such that they have a reasonable level of expectation to safely exit the facility, or be able to safely stay within a designated area of refuge. The life safety configurations shall also be arranged to provide adequate protection for essential and emergency response personnel.

8-3.7 FHA for Existing Buildings

Design requirements for existing buildings are developed based on the results of the FHA or other analyses preformed on existing structures and approved by the AHJ. To the greatest extent practical, the level of protection for existing and new structures should be identical; however, implementing current levels of protection into all existing structures will not be feasible. In these cases, the FHA or other approved analysis can provide to the AHJ a technical justification for the acceptability of the existing configuration (refer to section 1-7).

8-4 EMRE SURVEY

An EMRE survey is a comprehensive assessment of the EMRE within each facility to ensure that exposures of weapons systems to the EMRE from all equipment installed or used within the facility, individually and collectively, does not result in an overall EMRE that exceeds the weapon's STS levels.

NOTE: An EMRE survey is typically funded by the facility occupant.

8-4.1 General Requirements

8-4.1.1 Survey Personnel

The EMRE survey shall be accomplished by the 85th Engineering Installation Squadron (EIS) Specialized Engineering Flight, Keesler Air Force Base, Mississippi.

8-4.1.2 Survey Frequency

8-4.1.2.1 Existing Facilities

The EMRE survey shall be accomplished on any existing facility when configuration changes are made to the facility or facility systems or changes are made in the tools and equipment that impacts the EMRE. The EMRE survey will help ensure that the overall EMRE as a result of such changes does not exceed the weapon's STS levels.

On existing facilities with no prior history of an EMRE survey, the survey shall be accomplished within 3 years from the issuance date of this attachment unless a later date has been approved by the AHJ.

8-4.1.2.2 **New Facilities**
On all new facilities, the EMRE survey shall be accomplished at the beginning of the design process. In these cases, the survey will consist of an analysis of anticipated EMRE emitters using straw man data to project EMRE levels.

8-4.1.2.3 **Renewal**
The EMRE survey shall be updated on all facilities no later than the end of the fifth calendar year after the date of the last EMRE survey.

8-4.2 **EMRE Survey-Specific Requirements**

8-4.2.1 **EMRE Survey Elements**
The EMRE survey shall:

8-4.2.1.1 Accomplish discrete tests of all unintentional EMRE emitters used in close proximity to critical equipment within the facility. These unintentional EMRE emitters include but are not limited to: fluorescent lighting; motors; hand tools; computers and monitors; communication equipment such as phones and intercoms; entertainment devices such as televisions, MP3 players, and radios; and fire alarm control panels.

8-4.2.1.2 Accomplish discrete tests of all intentional EMRE emitters used in close proximity to critical equipment within the facility. These intentional EMRE emitters include but are not limited to: computers using wireless devices or networks; radio transmitters; motion sensors; and “lossy” antenna distribution systems.

8-4.2.1.3 Measure ambient levels in representative areas and measure specific classes of emitters used in close proximity to critical equipment.

8-4.2.1.4 Perform an external ambient survey outside of the facility to obtain an overview of the typical EMRE levels encountered in the nearby area.

8-4.2.1.5 Evaluate and analyze the results to determine compliance with AFMAN 91-201. Identify compatibility anomalies and make recommendations for mitigating these anomalies.

8-4.2.2 **New Facilities**
EMRE surveys for new facilities shall analyze anticipated EMRE emitters using straw man data to project anticipated EMRE levels and to adjust facility design, equipment selection, and procedures as necessary to reduce EMRE levels.

Conduct a complete EMRE survey upon activation of the facility to ensure that actual levels do not exceed maximum permitted EMRE values.

8-4.2.3 **EMRE Survey Report**
As a minimum, the EMRE survey report shall contain and document these items:

- A detailed list of test equipment with calibration dates

- A detailed list of the equipment tested (including locations if appropriate for the equipment)
- A testing strategy and survey plan
- A graphical comparison of EMRE from tested equipment in comparison to appropriate STS curves
- A simulated composite EMRE environment to determine the maximum practicable level that could be expected
- Conclusions on any findings and recommendations for corrective measures

8-4.3 **EMRE References**

The EMRE survey shall meet or exceed the requirements and guidelines of the most current edition of these publications. (Other publications may apply in addition.)

- AFMAN 91-201
- DODD 6055.9
- DOD 6055.09-STD

The EMRE survey shall consider the concepts and requirements with respect to nuclear weapons safety, security, and control as contained in the most current edition of these publications. (Other publications may apply in addition.)

- AFI 90-201
- AFPD 91-1
- AFI 91-101
- AFI 91-102
- AFI 91-103
- AFI 91-107
- AFI 91-116
- AFMAN 91-118
- DODD 3150.2
- DODD 3150.2-M

8-5 FACILITY CHARACTERIZATION

8-5.1 General Requirements

Facility characterization shall meet the criteria and requirements of Chapter 2 (refer to section 2-5).

NOTE: Facility characterization may be accomplished when deviation from the seven-foot rule as defined in AFMAN 91-201 is proposed. Facilities that have not been characterized must comply with the seven-foot rule. Any deviation from the seven-foot rule requires specific approval of the AHJ.

NOTE: Facility characterization is typically funded by the facility occupant.

8-5.2 Specific Requirements

Facility characterization shall be accomplished:

- By the 85 EIS Specialized Engineering Flight, Keesler Air Force Base, Mississippi
- On all new facilities upon completion of the facility construction
- On existing facilities when specifically approved by the AHJ
- On any facility that has been previously characterized and when configuration changes to the facility or facility systems are made that may have impacted the facility characterization requirements of this attachment. A qualified electrical engineer shall determine if a total or partial revision to the previous facility characterization is required.

Facility characterizations shall be updated on all facilities no later than the end of the tenth calendar year after the date of the last facility characterization.

On facilities that have been characterized, comply with the requirements in AFMAN 91-201, including the requirements for periodic maintenance and inspection. This shall include retesting of the Faraday shield, bonding, and surge suppression features.

8-6 FIRE DEPARTMENT BASELINE NEEDS ASSESSMENT

8-6.1 Baseline Needs Assessment

The base fire department shall have a baseline needs assessment that establishes the minimum required capabilities of base firefighting forces. This includes minimum staffing, apparatus, facilities, equipment, training, fire pre-plans, off-site assistance requirements, and procedures.

Information from this assessment shall be incorporated into the site emergency plan.

NOTE: The baseline needs assessment is typically funded by Civil Engineering.

8-6.2 Updates

Baseline needs assessments for firefighting forces are periodically performed through independent assessors that are regarded as experts in the field. Frequencies of updates are not formally established, but updates are performed when there is a significant change in base or facility mission, size, or hazards.

Baseline needs assessments are approved by the AHJ.

8-7 FIRE PREVENTION PROGRAMS

Nuclear weapons-capable maintenance and storage facilities shall implement fire prevention programs. Such programs can be part of an overall base fire prevention program or be established as a specialized program for the facility.

At a minimum, the fire prevention program shall include:

- Fire department inspections
- Combustible loading limitations and inspections
- Storage criteria
- Use and handling of flammable and combustible liquids
- Use of heat-producing appliances
- Hot work and hot work permits (refer to Chapter 13)
- Roofing operations permits
- Use of fuel-fired heaters and equipment

8-8 FIRE PROTECTION IMPAIRMENTS AND DEFICIENCIES

Nuclear weapons-capable facilities shall have implemented fire protection impairment and deficiency programs. These programs can be part of an overall base impairment and deficiency program or be established as a specialized program for the facility.

The programs shall include the identification, tagging, and tracking of impaired equipment, and the determination of compensatory fire protection and prevention measures.

The programs shall comply with AFI 32-10141.

8-8.1 Application

The programs shall apply to all active fire protection systems, including: automatic sprinkler systems, fire detection systems, filter plenum fire suppression, and special

hazard suppression systems. The application of the program to passive fire protection systems, including fire barriers, dampers, lightning protection components, and fire extinguishers, and to any work activities not directly related to active fire protection systems may be included at the discretion of the facility manager unless otherwise directed by the AHJ.

8-8.2 Tracking Requirements

A fire protection system impairments and deficiencies program shall be used to track and trend all system failures, planned outages, system minor discrepancies, or removal of systems from active service. Systems removed from service for the purpose of facility demolition shall be tracked until demolition completion.

8-8.3 Impairment Coordinator

The facility user shall designate an impairment coordinator to track impairments and deficiencies.

CHAPTER 9

FIREFIGHTING GUIDANCE

9-1 SCOPE

This chapter provides criteria and requirements for developing detailed pre-fire plans. Pre-fire plans are also known as pre-incident plans, and the terms can be used interchangeably.

9-2 DEVELOPMENT OF PRE-FIRE PLANS

Detailed pre-fire plans shall be developed for all facility areas. The plans shall detail the fire area configurations and fire hazards along with any nuclear weapon-related components and fire protection systems and features. Pre-fire plans shall be reviewed and, if necessary, updated at least every 2 years. Pre-fire plans shall be available in the security control room.

In developing a schedule for pre-fire plans, these items shall be considered:

- Potential life safety hazard
- Facility size and complexity
- Value
- Mission importance
- Presence of hazardous materials
- Susceptibility to natural phenomena

The emergency response organizations shall be trained to the pre-fire plan program as well as the individual pre-fire plans.

9-3 ELEMENTS OF PRE-FIRE PLANS

The physical elements of a pre-fire plan are addressed in paragraphs 9-3.1 through 9-3.9.9.

9-3.1 Internal Site Conditions

9-3.1.1 Construction and Building Features

Include information on these features:

- Construction, floor construction, construction of interior walls, suspended ceiling assemblies, raised floors, concealed spaces, windows for rescue, confined space, and fire resistance of structural members
- Area and height

- Building services, including utilities (electric, transformers, emergency power, domestic water, compressed and liquefied gases, steam, and fuels)

- Building features: the structural integrity of walls, roofs, and floors, including added live and dead loads; indications of deterioration and structural weakening and other conditions that would impact fire spread; ability of responding personnel to access the building; and the potential for falling debris

9-3.1.2 **Occupant Considerations**
The number and type of occupants in a facility will have a substantial impact on the pre-fire plan. Critical information to be gathered includes the expected number of occupants and their duties within the facility.

9-3.1.3 **Life Safety Considerations**
These are a priority that must be addressed to permit responding emergency service personnel to assist immediate and safe evacuation of facility personnel. Considerations must also be included on the actions of the facility security personnel and their duties during emergency events.

Unique life safety egress facility configurations shall be documented within the pre-fire plan.

9-3.2 **External Site Conditions**

9-3.2.1 **Fences**
The height and construction of fences shall be noted. Security measures for these fences shall also be included.

9-3.2.2 **Exposures**
The grounds surrounding the facility shall be evaluated to identify buildings, structures, equipment, and storage that could be exposed by an incident.

9-3.3 **Communications Impact**
Include the results of a functional test of the communications system as it shall be used in an emergency. This information is critical for many of the unique facilities across the Air Force.

Data regarding communications impact that shall be recorded include the following:

- Interference or poor coverage as a result of construction or radio system design, including coverage in below-grade and shielded areas, interiors of large structures, and the upper floors of high-rise buildings

- Assignment of radio channels

- Other supplemental communications available within or external to the facility

9-3.4 Security Data

Information about security measures shall be included to ensure prompt ingress to the facility at all times.

9-3.5 Personnel Interactions

The interaction between the firefighting personnel and the facility and external security personnel must be addressed within the pre-fire plan. In a number of situations, the fire forces and the security forces may have conflicting missions during an emergency. These situations shall be addressed within the pre-plan so that agreements between the two groups may be established in advance. It is also advisable to practice drills that implement these agreements to ensure that they can be carried out in the proper manner.

9-3.6 Defend-in-Place Methods

Methods that are to be used because complete evacuation is either impossible or impractical shall be noted within the pre-fire plan.

9-3.7 Hazards Information

9-3.7.1 Hazardous Materials Coordinator

If a facility has an individual or department that is responsible for maintaining material safety data sheets (MSDS) and inventories of hazardous materials, the pre-fire plan shall contain information on contacting this individual. If a facility or base has an internal computer-based hazardous materials system, means to access this system shall be detailed within the plan.

9-3.7.2 Special Hazards

Special hazards within the facility shall be documented. These hazards may include flammable and combustible liquids, explosives, toxic agents, radioactive materials (ionizing radiation and contamination), reactive chemicals, electrical and mechanical hazards, and special hazards.

9-3.8 Incident Operations

The plan shall address the standard response to the facility and the incident command system as it applies to the building.

9-3.9 Fire Protection Systems Information

Information on fire protection systems (detection and suppression) shall be determined in the development of the pre-fire plan. The required information is addressed in paragraphs 9-3.9.1 through 9-3.9.9.

9-3.9.1 Information on the Primary Water Supply

Included shall be the required fire flow for the building based on criteria developed in the approved FHA. Evaluation of the water supply may require testing of the water system or obtaining information from the engineering branch.

9-3.9.2 **Fire Department Connections (FDC)**
Data concerning the FDCs shall be included within the plan. The information required is the physical location, areas covered, and the type of system supplied.

9-3.9.3 **Fire Pumps**
Data regarding facility fire pumps shall be provided that includes the location, type of driver, capacity, water source, operation (automatic, manual, or remote manual), areas served, and contact information for the department responsible for maintenance and operation during an emergency.

9-3.9.4 **Fire Hydrants**
Data regarding the facility fire hydrants shall be provided that includes the location and type of each hydrant, number and diameter of each outlet, size of the water main location, and the approximate flow at 20 pounds per square inch gauge (psig) (138 kilopascal gauge).

9-3.9.5 **Automatic Sprinkler Systems**
Data concerning automatic sprinkler protection shall be documented, including the type of system (wet, dry, pre-action), hazard classification of the system and occupancy, location of all controlling valves for the system, location and identification of all risers, location of audible flow alarms, and extent of the sprinkler coverage.

9-3.9.6 **Standpipe System**
Data concerning standpipe systems shall be documented that includes the type of system, location and size of outlets, pressure available at the hose outlets, water supply, location of isolation valves, and the location and identification of all risers.

9-3.9.7 **Protective Signaling Systems**
Data for the fire alarm systems for the facility shall include the method of system activation, areas of coverage, location of the fire alarm control panel and the remote fire alarm panels, type of detectors, any public address system or voice alarm capability, and the method and extent of occupant notification. Information on the DOD-required mass notification system shall be included, including details on the configuration of the system (e.g., combination system with the fire alarm system or stand-alone system).

9-3.9.8 **Special Hazard Protection Systems**
Data for special hazard fire protection systems that shall be included within the pre-fire plan include the type of system, hazard or area protected by the system, location of control panels, activation method, personnel hazards of the protective agent (if any), and method and extent of occupant notification.

9-3.9.9 **Smoke Management**
Data regarding any smoke management systems shall be included. This may include the type of system, location of the areas served by the system, and location of the primary control panel for the system. This shall also include any portable ventilation equipment or systems (refer to Chapter 12).

9-4 ROBOTIC FIREFIGHTING RESPONSE VEHICLES

The use of robotic firefighting response vehicles located within areas capable of maintaining or storing nuclear weapons may be considered when necessary to reduce the response time to an incident. Use of such vehicles is not a general practice and shall not be implemented without prior approval of the AHJ. Requests to use robotic firefighting methods shall evaluate operational impacts such as training, staffing levels, initial and recurring equipment costs, required supplies and costs, environmental impacts, EMRE, and other related issues.

CHAPTER 10

TEMPORARY INTERIOR CONSTRUCTION

10-1 SCOPE

This chapter provides criteria and requirements for temporary interior construction. For the purposes of this attachment, temporary is defined as any structure in place for less than 12 months. Any temporary construction features that are not covered by this chapter shall, by default, be required to meet the criteria of permanent construction.

10-2 FIRE RETARDANT WOOD

If wood is used for interior temporary construction, the wood shall be noncombustible, limited-combustible, or fire retardant pressure-impregnated wood. Fire retardant coatings are not acceptable on walking surfaces or surfaces subject to mechanical damage. Industrial safety personnel shall be contacted prior to coating scaffolding with a fire retardant coating since the coating may have an effect to the wood that must be evaluated.

10-3 FIRE RETARDANT TARPAULINS

The use of interior temporary coverings shall be limited to special conditions for which interior temporary coverings are necessary, e.g., contamination control structures (interior tents). They shall be constructed of approved fire retardant plastics or tarpaulins and meet the testing requirements of NFPA 701.

10-4 FIRE EXTINGUISHERS

All interior temporary construction shall have the appropriate type and size of portable fire extinguisher, spaced in accordance with NFPA 10.

10-5 TEMPORARY ELECTRICAL WIRING

The potential for ignition of flammable materials shall be minimized by requiring that all temporary electrical wiring:

- Be kept to a minimum
- Be suitable for the location
- Be installed and maintained in accordance with NFPA 70 or ANSI C2, as appropriate
- Be arranged so that energy can be isolated by operation of a single switch
- Be arranged so that energy can be isolated when not needed

10-6 TEMPORARY HEATING APPLIANCES

10-6.1 Types Permitted

Only safely installed, approved, electrically powered heating devices shall be used in all locations. All heating devices shall comply with Air Force Occupational Safety and Health (AFOSH) Standard 91-501.

10-6.2 Automatic Shutdown Feature

Heating devices shall be situated so that they are not likely to overturn and shall be provided by the factory with an automatic shutoff feature per AFOSH 91-501.

10-6.3 Monitoring and Maintenance

Temporary heating equipment, when used, shall be monitored and maintained by properly trained personnel.

10-7 PLASTIC SHEATHING

If plastic sheathing is used for temporary construction or containment structures (plastic tents), it shall meet the testing requirements of NFPA 701.

CHAPTER 11

FIRE PROTECTION SYSTEMS

11-1 SCOPE

This chapter includes the criteria and requirements for fire detection, fire suppression, fire alarm, and mass notification systems applicable to nuclear weapons-capable maintenance and storage facilities.

11-2 GENERAL REQUIREMENTS

Fire protection systems shall be designed in accordance with UFC 3-600-01, except as modified in this attachment.

Fire suppression and fire detection systems shall be configured to coincide with the blast zones and corresponding HVAC zones whenever possible.

NOTE: This design requirement is intended to reduce the number of penetrations through the blast walls by the fire protection equipment and may also improve the survivability capability of the fire protection systems.

11-3 LISTED EQUIPMENT

Fire protection equipment shall be listed or approved for its intended service by a nationally recognized testing laboratory (NRTL), except for certain equipment for which such listing or approval is not practical because of the unique nature of nuclear weapons-capable facilities. For example, a blast door by nature of its construction might serve adequately as a fire door but has never been listed or approved for such a purpose. In these cases, the use of non-listed or non-approved equipment shall be approved by the AHJ.

11-4 WATER SUPPLIES

11-4.1 At least two independent sources of water shall be provided, each of not less than 300,000 gallons (1,135,500 liters). A water supply independent of the potable water supply is not required for the water-based fire suppression systems unless so specified in the FHA. Examples of independent water supply systems include:

- Elevated water tanks
- Ground level water tanks with dedicated fire pumps
- Pressure tanks internal to the facility (e.g., when the FHA permits a tank volume of less than 300,000 gallons [1,135,500 liters]).

11-4.2 The water supplies shall be interconnected such that if fire pumps are used, they can take suction from any source. A failure in one source shall not cause both sources to failure.

11-4.3 Water tanks shall be filled from a source capable of replenishing the supply for the fire protection needs within an 8-hour period.

11-4.4 If multiple water supplies are used, each water supply shall be connected to the fire main by a separate connection that is arranged and valve-controlled to minimize the possibility of multiple supplies being impaired simultaneously. Generally, the two supplies should be connected such that they are hydraulically remote from each other (e.g., at opposite ends of the system).

11-4.5 The tanks shall not be supplied by an untreated, raw water source.

NOTE: The intent of this paragraph is to provide a water supply that will not be susceptible to bio-fouling, scaling, microbiologically induced corrosion (MIC), or sedimentation.

11-4.6 The tanks shall be configured to permit ease of inspection and maintenance.

11-5 FIRE SUPPRESSION SYSTEMS

11-5.1 Water-Based Fire Suppression Systems

An automatic water-based suppression system shall be provided in all areas of the facility and meet the performance requirements established in the FHA.

NOTE: Based on the hazards generally found within nuclear weapons-capable maintenance and storage facilities, it is expected that a wet-pipe type of automatic sprinkler system or water mist fire suppression system will be needed in most areas, with a dry-pipe type of system used in those areas subject to temperatures below or approaching freezing (e.g., truck bays, earth-covered magazines). Firefighting foam-based fire suppression systems are not expected to be required except in special areas such as refueling areas and areas where the FHA identifies hazards from combustible or flammable liquids.

11-5.1.1 Suppression systems shall be hardened against possible internal or external damage to the building.

NOTE: Appendix B provides guidance on the selection and design of hardened fire protection systems.

11-5.1.2 Domestic water distribution systems that also serve fire protection requirements shall be designed to simultaneously meet the calculated fire protection demand (e.g., sprinklers and hose streams) and the peak domestic demand. When not otherwise identified, the peak domestic demand shall be calculated as 2.5 times the calculated average daily demand plus appropriate special demands. The domestic water distribution system shall be capable of meeting this combined demand at a

minimum residual pressure of 20 pounds per square inch (psi) (137.9 kilopascals) at ground elevation for a period of not less than 2 hours.

11-5.1.3 Water-based fire suppression systems shall be looped with at least two independent means of water supply into the fire suppression system. The supply points shall be separated so that external damage to one supply point (e.g., mechanical damage by a backhoe) shall not simultaneously damage other supply points.

11-5.1.4 Water supply piping shall not be located under buildings.

11-5.1.5 Sectional control valves shall be provided to automatically isolate damaged portions of the looped fire suppression system while permitting undamaged portions to remain in service.

NOTE: It is preferred that these control valves be mechanical-only in their design and operation, and not require pneumatic, electrical, or other external power supplies.

11-5.1.6 In addition to an exterior isolation valve, each system shall be equipped with an approved outside screw and yoke (OS&Y) gate valve or other approved interior isolation valve.

11-5.1.7 Sprinkler system risers and alarm valves shall be located as close as practical to a building entry point with regard to the zoning configuration of the suppression systems.

11-5.1.8 The piping serving each zone of an automatic water-based suppression system shall be independent from piping to other zones.

11-5.1.9 Each fire suppression system shall be equipped with approved alarming devices that will annunciate an alarm in a constantly attended area and activate internal and external fire alarms in the facility.

11-5.1.10 Within the facility, domestic water shall be supplied to the greatest extent practical by a separate service line and not be designed as a combined fire protection and potable water service or as a combined process and potable water service. Where combined fire and domestic-process water systems are necessary (e.g., to reduce penetrations through blast containment walls), the distribution piping shall be provided with isolation valves so that domestic or process systems can be isolated from the fire protection system.

11-5.2 Foam Fire Suppression Systems

High-expansion foam systems designed in accordance with NFPA 11 shall be used where flammable or combustible liquids are of significant concern and in other areas as specified in the FHA.

11-5.3 Water Mist Systems

Water mist systems designed in accordance with NFPA 750 shall be used in nuclear weapons-capable maintenance and storage facilities in lieu of automatic sprinklers when specified in the FHA.

11-5.4 Fire Suppression Systems for Specific Hazards

11-5.4.1 Oil Fired Boilers

Oil-fired boilers or boilers using oil ignition shall be protected with automatic sprinkler, water spray, water mist, or foam-water sprinkler systems covering the firing end of the boiler area at a minimum. Sprinkler and water spray systems shall be designed for a minimum density of 0.25 gallon per minute per square foot (10.2 liters per minute per square meter) over the entire area.

11-5.4.2 Vehicle Loading Tunnels

Vehicle loading tunnels shall be provided with automatic fixed water-based suppression systems. Automatic sprinkler systems shall be designed for a density of 0.30 gallon per minute per square foot (12.2 liters per minute per square meter).

NOTE: Generally, it is expected that these vehicle loading tunnels will be protected with dry-pipe sprinklers.

11-6 SEISMIC CAPABILITIES

The water supply systems shall be capable of supplying water to automatic water-based fire suppression systems, standpipes, and hose stations in all areas designated for the transportation, storage, and maintenance of nuclear weapons following a design basis earthquake.

The piping system and components of automatic water-based fire suppression systems, standpipes, and hose stations in all areas designated for the transportation, storage, and maintenance of nuclear weapons shall be analyzed for earthquake loading and shall be provided with supports that will ensure pressure boundary integrity. The piping and valves for the portion of the hose standpipe systems affected by this functional requirement shall, at a minimum, satisfy the requirements of ANSI B31.1.

The water piping shall, at a minimum, meet the seismic support criteria in the applicable NFPA standard. When specified in the FHA, the water piping shall be designed and installed exceeding these criteria, such as to meet the requirements for a design-basis earthquake for the specific locality. If the water piping system is designed exceeding the NFPA criteria, the design shall be completed under the supervision of a qualified structural engineer.

11-7 SUPPLY MAINS AND HYDRANTS

11-7.1 Yard Fire Main Loop

11-7.1.1 Design and Installation

An underground yard fire main loop designed and installed in accordance with NFPA 24 shall be installed. The loop shall be sized to accommodate emergent mission requirements.

Design of the pipe and provision for water treatment shall be consider the potential for tuberculation and MIC. Means for easily inspecting and flushing the systems shall be provided.

11-7.1.2 Isolation

Means shall be provided to isolate portions of the yard fire main loop for maintenance or repair without simultaneously shutting off both supplies to fixed fire suppression systems and fire hose stations. Approved visually indicating sectional control valves such as post-indicator valves shall be provided to isolate portions of the main for maintenance or repair. Isolation valves shall be configured so that no more than five connections (sprinkler systems, hydrants, or hose connections) are impaired at any one time.

11-7.1.3 Headers

Each automatic suppression system and standpipe shall be supplied from two physically separated headers supplied by the yard fire main loop. Schedule 40 or thicker steel piping and fittings meeting the requirements of ANSI B31.1 shall be used for the headers (up to and including the first valve) supplying the automatic suppression systems where such headers are part of the seismically analyzed hose standpipe system. Where provided, such headers shall be considered an extension of the yard main system. Each sprinkler and standpipe system shall be equipped with an OS&Y gate valve or other listed or approved shutoff valve.

11-7.2 Hydrants

11-7.2.1 Location

Hydrants shall be located every 250 feet (76 meters) apart on the yard main system when the yard loop also supplies water to above ground buildings that support the underground facility. Valves shall be installed to permit isolation of outside hydrants from the fire main for maintenance or repair without interrupting the water supply to automatic or manual fire suppression systems.

11-7.2.2 Compatibility

Threads compatible with those used by local fire departments shall be provided on all hydrants.

11-8 STANDPIPES AND HOSE STATIONS

11-8.1 Standpipe Locations

Class I standpipes designed in accordance with NFPA 14 shall be provided within each fire area and within each vehicle loading tunnel.

11-8.2 Standpipe Connections

Fire department connections to the standpipes shall be located near the locations of entry to the fire area that will be used by emergency responders. Connections shall be provided in stairwells in multi-story facilities. The size and type of threads on the standpipe connections shall be the compatible with the equipment used by the fire department.

11-8.3 Hose Station Locations

Hose stations or a mobile means of providing hose and associated equipment, such as hose carts or trucks, shall be provided in all fire areas designated for the transportation, storage, or maintenance of nuclear weapons.

11-8.4 Water Flow Rate and Nozzle Pressures

Water flow rate and nozzle pressures as determined in the FHA shall be provided to hose stations.

NOTE: Hose station pressure reducers may be needed for the safety fire department personnel as specified in the FHA.

11-8.5 Hose Nozzles

The types of hose nozzles to be located at each hose station shall be based on the fire area's particular fire hazards and on the operational requirements of the fire department. Hose nozzles shall have shutoff capability and be able to control water flow from fully open to fully shut. Hose and nozzles may be omitted at locations where so documented in the FHA.

NOTE: The commonly used combination spray and straight stream nozzle should not be used in areas where a straight stream could cause unacceptable damage or create an electrical hazard to firefighting personnel. Approved electrically safe, fixed, fog nozzles should be provided at locations where high-voltage electrical shock hazards could exist.

11-9 VALVES

11-9.1 Inspection and Supervision

All fire protection water supply and fire suppression system control valves shall be under a periodic inspection program and shall be supervised by one of the following methods:

- Electrical supervision with audible and visual signals in the security control room or other suitable constantly attended location.

- Locking valves in their normal position when so documented in the FHA. Keys shall be controlled and made available only to authorized personnel.

- Sealing valves in their normal positions when so documented in the FHA. This option shall be utilized only where valves are located within fenced areas or under the direct control of approved facility personnel.

11-9.2 Operators

Operators (e.g., hand wheels) of valves that require manual manipulation shall be readily accessible. If the hand wheel is located more than 5 feet (1.5 meters) above the floor or ground, the hand wheel shall be provided with either a chain operator or a permanent platform. The platform shall be of sufficient size to allow the operator to safely perform the manual action.

11-10 FIRE PUMPS

Fire pumps are not required for nuclear weapons-capable maintenance and storage facilities when reliable means of meeting the fire protection demands are provided and the omission of the fire pumps is approved by the AHJ.

11-10.1 Design and Installation

Fire pumps shall be designed and installed in accordance with NFPA 20 to ensure that 100 percent of the required flow rate and pressure are available assuming failure of the largest pump or pump power source. The flow requirements shall be met based on 100 percent of the capacity of the pump (not 150 percent as is commonly used in other types of facilities).

11-10.2 Configuration

11-10.2.1 Fire pumps may be configured to serve more than one nuclear weapons facility when approved by the AHJ.

11-10.2.2 For maximum reliability, three fire pumps shall be provided so that two pumps meet the maximum demand plus hose streams. When approved by the AHJ, use of two fire pumps is an acceptable alternate provided either of the fire pumps can supply the maximum demand plus hose streams at no more than 120 percent of the fire pump’s rated capacity.

11-10.2.3 Fire pumps shall be configured to permit ease of flow testing. Provide a test discharge header that is piped back into the tank or provide piping to a location where the test nozzles can be flowed with minimal operational impact (e.g., into a pond or open field).

11-10.2.4 Each pump and its driver and controls shall be separated from other fire pumps by 2-hour-rated fire barriers and also from the rest of the facility by 2-hour-rated fire barriers.

11-10.2.5 Fire pumps shall be provided with automatic start but only manual shutdown. The manual shutdown shall be located at the pump controllers. A remote manual start is permitted in addition to the automatic start.

11-10.2.6 Individual fire pump connections to the yard fire main loop shall be provided and separated with sectionalizing valves between connections such that loss of one fire pump connection to the loop can be isolated without isolating the other pumps.

11-10.2.7 A method of automatic pressure maintenance of the fire protection water system (commonly referred to as a jockey pump) shall be provided independent of the fire pumps.

11-10.2.8 Means shall be provided to immediately notify a constantly attended location of the operation, failure, or receipt of supervisory signals of the fire pumps.

11-11 GASEOUS FIRE SUPPRESSION SYSTEMS

An automatic total flooding or local application gaseous fire suppression system may be installed to supplement but not replace the required automatic water-based suppression system. The requirement for such a system shall be approved by the AHJ for the protection of unique situations or to address unique hazards. The system shall be designed and installed in accordance NFPA 2001.

11-11.1 Annunciation

Operation of gaseous fire suppression systems shall annunciate an alarm in a constantly attended location.

11-11.2 Ventilation System Design

Ventilation system design shall prevent space over-pressurization during agent injection and provide adequate sealing to prevent loss of agent and confine radioactive contaminants.

11-11.3 Disarming Device

Provisions for locally disarming automatic gaseous suppression systems shall be secured and maintained under strict administrative control. Activation of the disarming device shall initiate a supervisory alarm on the fire alarm control panel.

11-11.4 Prohibited Systems

Installation of carbon dioxide, Halon 1211, and Halon 301 systems are prohibited.

11-12 SMOKE DETECTION SYSTEMS

An approved smoke detection system shall be installed in all areas of nuclear weapons-capable facilities except that a smoke detection system is not required in support areas (e.g., offices, mechanical spaces, corridors) where an automatic water-based fire suppression system has been provided (refer to section 11-5). An approved smoke detection system is required in all areas of a facility where nuclear weapons are stored, inspected, or maintained in addition to the automatic suppression system. Also, smoke detection shall be provided in the security control room complex,

sleeping rooms, computer or information technology rooms, and in the vicinity of the fire alarm control panel (FACP) in addition to the automatic suppression system. Appliances and other smoke detection equipment shall be installed in accordance with NFPA 72 and UFC 3-600-01.

NOTE: An air-aspirating type of ultrasensitive smoke detection (i.e., very early smoke detection) or other smoke detection technology (e.g., open-area light scattering smoke detection) should be used in areas designated as approved for the storage of nuclear weapons when EMRE requirements can be met (refer to section 8-4).

11-13 FIRE ALARM SYSTEMS AND MASS NOTIFICATION SYSTEMS (MNS)

A combination system serving as the fire alarm system and MNS shall be installed in accordance with UFC 3-600-01, UFC 4-021-01, and UFC 4-010-01.

11-13.1 Voice Communication

Means shall be provided to allow a person observing a fire at any location in the plant to quickly and reliably alert the appropriate personnel using voice communication to the security control room or other suitable constantly attended location.

11-13.2 Signal Transmission

Signals shall be transmitted to a constantly attended location from which required notifications and emergency response can be initiated. All signals shall be permanently recorded in accordance with NFPA 72. These signals shall include fire, trouble, and supervisory signals, and include at least the following:

- Actuation of any fire detection device
- Actuation of any fixed fire suppression system
- Actuation of any manual fire alarm station
- Starting of any fire pump
- Actuation of any supervisory device or signal
- Indication of alarm system trouble condition

11-13.3 Fire Department Notification

Means shall be provided to promptly notify the fire department of any fire emergency in such a way as to allow the fire department to determine an appropriate course of action.

11-13.4 Security Forces Notification

Means shall be provided to promptly notify the security forces of the nuclear weapons-capable maintenance and storage facility of any fire emergency in such a way as to allow the security forces to determine an appropriate course of action.

CHAPTER 12

HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

12-1 SCOPE

This chapter includes the criteria and requirements for HVAC applicable to nuclear weapons-capable maintenance and storage facilities.

12-2 DESIGN CONSIDERATIONS

12-2.1 Design of the System

12-2.1.1 Suitable design of the ventilation system can limit the consequences of a fire by preventing the spread of the products of combustion to other fire areas. The design of the ventilation system shall provide a means to ventilate, exhaust, or isolate the fire area as necessary, and consideration shall be given to the consequences of failure of the ventilation system due to fire causing loss of control for ventilating, exhausting, or isolating a given fire area.

12-2.1.2 The capability to ventilate, exhaust, or isolate is particularly important in underground nuclear weapons-capable maintenance and storage facilities to ensure the habitability of rooms and spaces that shall remain occupied throughout the fire emergency (e.g., security, control rooms). Areas of refuge also require particular attention since these are designated locations designed to help occupants survive for a specified period of time if they become trapped by a fire.

12-2.1.3 Automatic damper closure or shutdown of ventilation systems shall be designed based on considerations of nuclear safety, nuclear security, and the life safety of personnel.

12-2.1.4 Facilities shall be provided with 100 percent redundant chiller systems. Additionally, quick disconnect points shall be provided for temporary portable chillers to be connected.

12-2.2 Balanced Air Differentials

Ventilation of a nuclear weapons-capable storage facility involves balanced air differentials between building or blast zones, comfort ventilation, and heat removal from areas where heat is generated by equipment. This need for ventilation also includes fire area isolation and smoke removal equipment, as well as equipment for high efficiency particulate air (HEPA) filtering of radioactive particulates.

12-2.3 Ventilation Design Standards

The design standards of the ventilation system shall be in accordance with UFC 1-200-01.

12-2.4 **Configuration**
HVAC zones, fire areas (or zones), and blast zones shall be arranged to coincide with each other (refer to Chapters 7 and 11).

12-3 **INTERCONNECTIONS**
Interconnections of individual fire areas via the ventilation system shall be kept to a minimum. If an interconnection is made, it shall be properly protected by fire stopping, fire and smoke dampers, and blast containment as appropriate.

12-4 **PORTABLE VENTILATION EQUIPMENT**
In the event that fixed ventilation systems malfunction or are damaged and are not capable of removing smoke and heat, portable ventilation equipment shall be available. This equipment shall be staged in the facility or be verified as readily available from the installation fire department. Sizing of the portable equipment and means to provide any required electrical power shall be considered in the FHA and documented within the fire pre-plan.

12-5 **HVAC INTAKE AND OUTLET LOCATIONS**
HVAC intakes shall be located and protected to prevent the accidental or intentional introduction of harmful gases or other materials.

Intakes and outlets for air-cleaning systems shall be located to reduce the potential for the spread of radioactive contamination during maintenance.

12-6 **FIRE, SMOKE, AND COMBINATION FIRE AND SMOKE DAMPERS**

12-6.1 Dampers shall be provided at those fire area boundaries required to have a fire resistance rating of greater than 1 hour for both ventilation duct penetrations and air transfer openings. Where shutdown of the ventilation system is not permitted due to operational or security requirements, fire dampers shall not be required for ventilation duct penetrations and an alternative means of protecting against fire propagation shall be provided.

NOTE: This paragraph is intended to address fire barriers within blast zones. Interconnections between blast zones are strongly discouraged (refer to section 12-3).

NOTE: The need for automatic dampers and ventilation system shutdown can be minimized by installing separate ventilation systems for each fire area and blast zone or by installing fire-resistive ducting enclosures that provide the required fire barrier while passing through adjacent areas. Other means of protecting the ductwork that penetrates rated fire barrier walls are available in other documents.

12-6.2 Dampers having a rating of 1.5 hours shall be installed where ventilation ducts penetrate fire barriers having a required fire resistance rating of 2 hours. Where ventilation ducts penetrate required 3-hour fire barriers, approved dampers having a fire protection rating of 3 hours shall be installed.

12-6.3 Access shall be provided to ensure that the damper can be properly and easily inspected, tested, and maintained, with particular consideration for the required periodic replacement of the damper's thermal elements.

12-6.4 Dampers shall be installed directly into the fire barrier wall in accordance with the manufacturer's requirements. Dampers shall be equipped with visible indicators to show damper position.

12-6.5 Dampers shall be designed and installed in accordance with their listing and, where possible, installed in a configuration such that air movement in the duct assists in closing the damper.

12-7 FILTERS

12-7.1 Pre-filters

Air pre-filters located upstream or as part of the final HEPA filter exhaust plenums shall be listed as Class 1 air filter units as tested in accordance with Underwriters Laboratories, Inc., (UL) Standard 900.

12-7.2 HEPA Filters

When used in nuclear ventilation exhaust systems, HEPA filters shall meet the requirements for HEPA filters in American Society of Mechanical Engineers (ASME) AG-1, Section FC, and be listed as a "high-efficiency, particulate, air filter unit" as tested in accordance with UL 586.

12-7.3 Self-Cleaning Filters

Self-cleaning filters are not permitted.

12-7.4 Spare Filters

At least a 100 percent supply of specialized spare filters, such as HEPA filters and CBR filters, shall be maintained.

12-7.5 Noncombustible Materials

Roughing or pre-filters, where necessary, shall be constructed of noncombustible materials.

12-7.6 Filter Framing Systems

Filter framing systems may be constructed of combustible material provided that the material has a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

12-7.7 Filter Plenum Fire Separation

Filter plenums located inside nuclear weapons-capable buildings shall be separated from all parts of the facility by 2-hour fire-rated construction.

12-7.8 Small Filter Plenums

Small filter plenums that serve as a final filter and have a leading surface area of 16 square feet or less need not be separated by fire-rated construction from other parts

of a facility or be located in a separate fire-rated enclosure if the filter plenum is located in an area provided with an automatic sprinkler system designed and installed in accordance with UFC 3-600-01.

12-7.9 Fire Suppression Systems

12-7.9.1 Fire suppression systems shall be installed to protect filters that collect combustible material.

12-7.9.2 Where combustible filters, combustible particulates or combustible ductwork (e.g., fiberglass-reinforced plastic) is present in the ventilation system, fire suppression systems shall be provided. Additional fire protection features shall be provided as appropriate for the fire hazard and the requirements documented in the FHA.

12-7.9.3 Fixed water spray systems shall be provided for charcoal absorber beds containing more than 100 pounds (45.4 kilograms) of charcoal.

12-7.9.4 Automatic and manual water deluge spray systems shall be provided inside all final filter plenums for protection of the filters where they have a leading filter surface area greater than 16 square feet (1.5 square meters).

12-7.9.5 Deluge spray sprinkler systems shall operate upon activation of the fire alarm system heat detectors or pilot sprinklers located in either the final ducting or filter plenum housing. Manual activation shall be provided as well.

12-7.9.6 The design of the water deluge spray systems shall reflect the potential for filter failure mechanisms, such as filter media damage resulting from weakened media due to water absorption and excessive differential pressures during water discharge.

NOTE: Such filter failure mechanisms can be significantly mitigated by throttling back fan controls to reduce filter pressure or by providing redundant filters.

12-7.9.7 Automatic deluge spray systems shall be designed per the applicable provisions of NFPA 13 and NFPA 15, and as follows:

- Water spray density shall be 0.25 gallon per minute per square foot (10.2 liters per minute per square meter) over the entire filter area or 1 gallon per minute (3.8 liters per minute) per 500 cubic feet per minute (14.2 cubic meters) of air flow, whichever is greater.

- Spray sprinklers shall be of the deluge type.

12-7.9.8 The spray pattern of the deluge sprinklers shall be in the form of a downward vertical water curtain approximately 6 inches (15 centimeters) in front of the pre-filter or demister. In addition, deluge sprinklers shall be spaced so that each sprinkler does not exceed 4 lineal feet (1.2 lineal meters) of curtain coverage.

12-7.9.9 Manual spray systems shall be designed per NFPA 15 with these specific requirements:

- Water spray density shall be 0.25 gallon per minute per square foot (10.2 liters per minute per square meter) over the entire filter area.
- Nozzles shall be deluge spray nozzles that form a full circle solid cone discharge.
- Spray nozzles shall be horizontally directed at the face of the first series of HEPA filters so that all areas of the first stage filters and framing support system are wetted.
- Activation shall be by activating the deluge valve or by opening a normally closed valve. Control devices to activate the manual spray system shall be provided in the process operator's control room or other locations accessible to emergency response personnel. When a deluge valve is used, manual activation may also be provided at the location of the deluge valve.

12-7.9.10 Water for the deluge spray systems shall be provided by two separate water supply connections for reliability.

12-7.9.11 Automatic and manual water spray system water supplies shall be hydraulically calculated. They shall be capable of supplying a simultaneous flow of water for 2 hours to the automatic and manual water spray systems as well as the overhead ceiling automatic sprinkler systems in the fire area providing air to the HVAC plenum.

12-7.10 **Demisters**

12-7.10.1 **Location**
Where automatic deluge spray systems are installed in filter plenum enclosures that do not contain pre-filters, metal demisters shall be installed downstream of the automatic deluge spray sprinklers and upstream of the first series of HEPA filters.

Where automatic deluge spray systems are installed in the final filter plenum enclosures that contain pre-filters, water spray deluge sprinklers shall be located upstream from the pre-filters. **NOTE:** In this configuration, the pre-filters act as a demister.

Demisters shall be located as far away as practical from HEPA filters but no closer than 36 inches (91 centimeters), and at approximately 6 inches (15.2 centimeters) from the deluge spray sprinklers.

12-7.10.2 **Efficiency**
Demisters shall have an approximately 100 weight percent efficiency for water drops 50 microns and larger. They shall have efficiency greater than 99 weight percent for 1 to 50 microns when air flow velocities are present of 500 to 600 feet per minute (150 to

185 meters per minute) , or at operating air flow velocities with the deluge system operating water flow delivery rate.

12-7.11 Fire Screens

Fire screens shall be located upstream from the pre-filters and final filter plenums. Fire screens with metal meshes from 8 to 16 openings per inch (3 to 6 openings per square centimeter) shall be provided and located at least 4 to 5 feet (1.2 to 1.5 meters) upstream from all pre-filters and at least 20 feet (6.1 meters) upstream from all final filter plenum enclosures. Where pre-filters are located in final filter enclosures, fire screens shall be located at least 20 feet (6.1 meters) upstream from the pre-filters.

12-7.12 Heat Detection

Heat detectors or pilot sprinklers, when required to comply with section 12-7.9, shall be provided in ducting prior to final filter enclosures. Airflow shall be considered when determining detector or pilot sprinkler location. Heat detectors or pilot sprinklers shall also be provided in the final filter enclosures. If filter plenum automatic deluge spray systems are actuated by pilot sprinklers, heat detectors are not required in the ducting or the final filter enclosure unless specified in the FHA.

12-7.13 Fire Alarm

The detection system or pilot sprinkler system shall be arranged to detect a rise in airflow temperatures, actuate automatic fire suppression systems, and transmit an alarm to a constantly attended location (refer to paragraph 11-13.2). A pilot-operated system shall be used only when an automatic water deluge spray system is installed.

12-7.14 Fire Detector Configuration for Testing

12-7.14.1 Fire detectors shall be engineered and installed so that they can be tested during the life of the detector. Easily removable panels shall be provided to allow access for inspection and maintenance.

12-7.14.2 Where radiological contamination is not a concern, fire detectors may be installed such that the fire detector can be removed from the plenum enclosure and tested externally.

12-7.14.3 Remote testing shall be provided for detectors that are not accessible due to facility configurations or personnel hazards.

12-7.14.4 If line-type heat detection is used, a heat testing pad shall be provided outside of the plenum for operability testing of the system.

12-7.15 Lighting

Lighting shall be provided inside the filter plenum in front of or between the filter banks in the area where the automatic and manual sprinklers and nozzles are located. Such lighting may be provided with an on-and-off switch provided the switch is located outside the plenum at an accessible location.

12-7.16 **Viewing Ports**

Window viewing ports constructed of either wire glass, laminated lead safety glass, or fire-rated glass shall be provided for viewing inside the filter plenum. The window viewing ports shall be provided at each location where fire protection spray system sprinklers and nozzles are located and shall be placed such that all sprinklers and nozzles are visible from the outside of the plenum to facilitate flow testing of the system.

12-8 **DUCTWORK**

Ductwork from areas containing radioactive materials that passes through nonradioactive areas shall be of noncombustible construction and shall be protected from possible exposure fires by materials having a fire resistance rating as approved by the AHJ. For blast zones, this includes a requirement for hardened ductwork (i.e., steel piping).

Where the corrosive nature of the effluents conveyed precludes the use of metallic ducts, other materials shall be permitted as approved by the AHJ.

12-9 **SMOKE CONTROL**

12-9.1 Smoke control systems shall be provided.

12-9.2 Smoke, corrosive gases, and the non-radioactive substances that are released by a fire shall be vented from their place of origin directly to a location outside of the facility where these substances will have the minimum potential to affect personnel who are located outside of the facility.

12-9.3 The smoke control system shall be designed, located, and protected such that airborne corrosive products or contamination are not circulated (e.g., once-through ventilation systems).

12-9.4 Radioactive materials that are released by fire shall be confined or removed and filtered from the exhaust ventilation airstream. Smoke exhaust from areas that contain radioactive substances shall not be ventilated outside the building unless filtered through at least two stages of HEPA filters. Smoke control systems for such areas shall be connected to treatment systems to preclude release of radioactive substances, including tritium.

12-9.5 The possible release to the environment of smoke containing radioactive materials shall be monitored and modeled in accordance with emergency plans.

12-9.6 Fresh air inlets shall be located where contaminants are least likely to be present to reduce the potential of introducing smoke, toxic materials, or radioactive contaminants into the facility.

12-9.7 Enclosed stairwells shall be designed to minimize smoke infiltration during a fire via stairwell pressurization systems.

12-9.8 Where natural convection ventilation is approved by the AHJ, the smoke and heat ventilation shall provide a minimum ratio of vent area to floor area of at least 1 to 200, except in oil hazard areas, where at least a 1 to 100 ratio shall be provided.

12-9.9 To facilitate manual firefighting, a method of operation of the smoke control systems shall be provided for local control in switchgear rooms, battery rooms, emergency power generation areas, fuel oil storage areas, and other areas where the potential exists for heavy smoke and heat conditions.

12-10 LEAK TESTING

Open flame or combustion generated smoke shall not be used for leak testing.

12-11 POWER SUPPLIES AND CONTROLS

The power supply and controls for a HVAC system shall be located outside the fire area served by the system. The security control room, facility control room, or other designated control location shall be capable of remote monitoring and control of every ventilation system.

CHAPTER 13

HOT WORK

13-1 SCOPE

Hot work includes any temporary operation involving open flames or that produces heat or sparks, including brazing, cutting, grinding, soldering, arc welding, work on a pipe that would conduct heat through a wall or in contact with a wall, or torch-applied roofing. Non-powered (i.e., manual) cutting and grinding that do not generate sufficient heat or sparks to be considered a significant source of ignition to surrounding combustible materials do not require a permit.

13-2 PERMITS

Hot work must be coordinated and permitted through the appropriate local or base fire department.

CHAPTER 14

UNDERGROUND FACILITIES

14-1 SCOPE

This chapter includes requirements in addition to the requirements of Chapters 1 through 13 that are applicable to facilities where nuclear weapons-capable maintenance and storage areas are located underground.

14-2 ARCHITECTURAL REQUIREMENTS

Architectural requirements are provided in UFC-1-200-01.

14-2.1 Construction Type

Buildings shall be constructed to be fire resistant or noncombustible (Type I or Type II in accordance with the International Building Code [IBC]). All walls, floors, and structural components, except interior finish materials in office and support areas, shall be of noncombustible construction. Use of combustible interior finishes shall be minimized.

14-2.2 Hardened Fire Protection Systems

Buildings shall be provided with hardened fire suppression systems in all areas and smoke detection systems (refer to CHAPTER 11 and see Appendix B).

14-2.3 Faraday Shield

Buildings shall be constructed using the Faraday shield (i.e., metallic cage) approach for reducing the required lightning side flash or separation distance (refer to section 2-5).

14-2.4 Fire Areas

Facilities capable of storing nuclear weapons components shall be subdivided into separate fire areas to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat, radioactive contamination, and firefighting activities. In addition, the subdivision into fire areas shall allow adequate access for manual fire suppression activities, and be as consistent as possible with the blast zones.

14-2.4.1 Establishment of Boundaries

The boundaries of fire areas shall be as established in the FHA based on general fire protection criteria that include these elements:

- Types, quantities, density, and locations of combustible materials and radioactive materials
- Location of blast doors and security access portals
- Location and configuration of equipment
- Consequences of inoperable equipment

- Location or zoning of fire detection and suppression systems
- Personnel safety, exiting, area of refuge requirement

14-2.4.2 **Boundary Objectives**

In underground facilities, fire area boundaries shall accomplish fire protection objectives, including:

- To separate all contiguous buildings or portions thereof serving different purposes, such as storage, maintenance, service, administration, and other occupancy designations
- To separate weapons maintenance areas and weapons storage areas from each other and from adjacent areas
- To separate other types of maintenance areas from adjacent areas
- To separate security and other control rooms, computer rooms, and combined control and computer rooms from adjacent areas
- To separate rooms with major concentrations of electrical equipment, such as switchgear rooms and relay rooms, from adjacent areas
- To separate battery rooms from adjacent areas
- To separate each fire pump its associated equipment from all other pumps in the same room or pump house
- To separate each fire pump from adjacent areas
- To separate warehouse areas and combustible storage areas from adjacent areas
- To separate standby or emergency power generators from each other and from adjacent areas
- To separate fan rooms and plenum chambers from adjacent areas
- To separate office areas from adjacent areas

14-2.4.3 **Fire Barriers Separating Fire Areas**

Fire barriers separating fire areas shall have a minimum 3-hour fire resistance rating with listed 3-hour-rated penetration seals.

14-2.4.4 Fire Doors and Fire Windows in Fire Barriers

Fire doors and fire windows used in fire barriers shall be installed and maintained in accordance with NFPA 80. In the case of blast doors in fire barriers, refer to paragraph 7-4.3.8 of this attachment.

Normally, closed fire doors in fire barriers shall be identified with a sign indicating “Fire Door — Keep Closed.”

Windows in fire barriers, such as for a security control room or computer room, shall be provided with a listed or approved fire shutter, automatic wall curtain, or fire resistance glazing.

14-2.5 Vertical Shafts and Plenums

To prevent vertical spread of fire, all stairways, elevator shafts, escape ladders, and other vertical shafts and plenums shall be enclosed with barriers having a fire resistance rating of at least 2 hours. Openings in such barriers shall be protected with listed automatic or self-closing fire doors having a fire protection rating of at least 1.5 hours.

14-3 NUCLEAR CRITICALITY HAZARDS

Nuclear weapons-capable storage and maintenance areas shall be designed to be criticality safe with automatic sprinklers included. Floor drains shall be provided regardless of the inclusion of sprinklers. Appropriate drain lines and storage and handling systems capable of handling potentially contaminated water shall be provided.

14-4 COMBUSTIBLE MATERIALS AND FINISHES

14-4.1 Weapons Storage Areas

Combustible materials shall be excluded from fire areas designated for weapon storage, except for incidental amounts of combustible materials as determined by the FHA. Such incidental amounts might include solid wood blocks that serve as chocks for weapons support or small amounts of solvent used for weapons maintenance in the storage location.

14-4.2 Blast Shielding Materials

Permanent and temporary shielding materials shall be noncombustible or limited combustible, based on:

- ASTM E 84
- NFPA 253
- NFPA 255
- UL 94

Polystyrene used for sand walls is not required to be encased with fire-resistant materials.

14-4.3 Interior Finishes

14-4.3.1 Interior Wall and Ceiling Finish

Interior wall and ceiling finish in areas processing or storing radioactive materials shall be Class A in accordance with NFPA 255.

NOTE: The design should consider a potential radiation contamination incident and include wall and ceiling finishes that are easy to clean.

14-4.3.2 Interior Floor Finish

Interior floor finish in areas processing or storing radioactive materials shall be Class I in accordance with NFPA 253.

NOTE: The design should consider a potential radiation contamination incident and include floor finishes that are easy to clean.

14-4.4 Other Materials

Thermal insulation materials, radiation shielding materials, ventilation duct materials, soundproofing materials, and suspended ceilings, including light diffusers and their supports, shall be noncombustible or limited combustible. If polypropylene or polyethylene is required for neutron shielding, it shall be totally encased with a noncombustible material such as steel or 5/8-inch (16-millimeter) type X gypsum board. Approximately 3/8-inch (10-millimeter) vent holes shall be provided within the encasement to permit the venting of gasses from the poly material.

NOTE: Encasement is required because many plastic materials, including flame- and fire-retardant materials, will burn with an intensity and energy production in the range similar to that of ordinary hydrocarbons. When burning, they produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and HEPA filters. When burning, halogenated plastics also release free chloride and hydrogen chloride. These gases are toxic to humans and corrosive to equipment.

14-5 HAZARD CONTROL

14-5.1 Flammable and Combustible Liquids

14-5.1.1 Bulk storage of flammable and combustible liquids shall not be permitted inside structures capable of storing nuclear weapons.

14-5.1.2 Flammable and combustible liquid storage and use shall be in accordance with NFPA 30.

14-5.1.3 Where oil-burning equipment, stationary combustion engines, or gas turbines are used, they shall be installed and used in accordance with NFPA 31 or NFPA 37, as appropriate.

14-5.1.4 Flammable and combustible liquid and gas piping shall be in accordance with ANSI B31.1 or the ASME *Boiler and Pressure Vessel Code*, Section III, as applicable.

14-5.2 Hydraulic Systems

Hydraulic systems shall use only listed fire-resistant hydraulic fluids.

14-5.3 Solvents

Where a flammable or combustible solvent is used, it shall be handled such that the uncontrolled release of vapors is not permitted.

14-5.4 Gases

Flammable and combustible gases shall be stored and handled in accordance with NFPA 54, NFPA 55, and NFPA 58.

Bulk flammable gas storage, either compressed or cryogenic, shall not be permitted inside structures capable of storing nuclear weapons.

Storage of flammable gas, such as hydrogen, shall be located outdoors or in separate detached buildings so that a fire or explosion will not adversely affect any nuclear weapons storage facility systems or equipment.

14-6 LIQUID RUN-OFF CONTROL

Drainage shall be provided in all areas of the facility for the removal of all liquids directly to safe areas, or for containment in the area without adverse flooding of equipment and without endangering other areas.

14-6.1 Methods

Drainage and the prevention of equipment water damage shall be accomplished by one or more of these methods:

- Floor drains
- Floor trenches
- Open doorways or other wall openings
- Curbs for containing or directing drainage
- Equipment pedestals
- Pits, sumps, and sump pumps

14-6.2 Sump Pump Systems

Waste and drainage sump pump systems shall be provided with 100 percent redundant pumps.

14-6.3 **Drainage and Drainage Facility Size**

Drainage and any associated drainage facilities for a given area shall be sized to accommodate the volume of liquid produced by all of these sources:

- The spill of the largest single container of any flammable or combustible liquids in the area.
- The credible volume of discharge (as determined by the FHA) released by the automatic suppression system operating for a period of 30 minutes unless the approved FHA authorizes use of a different flow rate and duration.
- The contents of piping systems and containers that could fail in a fire.
- The volume of water discharged based on a manual firefighting flow rate of 500 gallons per minute (1,890 liters per minute) for 30 minutes unless the approved FHA authorizes use of a different flow rate and duration.
- For areas open to the outside, such as underground loading docks, credible environmental factors such as rain and snow.

14-6.4 **Staging Equipment**

Necessary equipment shall be staged to assist with routing water from the affected area. The use of the staging equipment shall be addressed in the fire department pre-fire plan.

14-6.5 **Floor Drainage**

Floor drainage from areas containing flammable or combustible liquids shall be trapped to prevent the spread of burning liquids beyond the fire area.

14-6.5.1 **Areas with Radioactive Materials**

Floor drainage from areas containing nuclear weapons components shall be trapped to prevent the spread of radioactive materials beyond the facility's controlled boundaries. If the drainage system leads to tanks, the tanks shall be designed to be criticality safe.

Water drainage from areas that might contain radioactivity shall be collected, sampled, and analyzed before discharge to the environment or outside the boundaries of the facility.

Water released during fire suppression operations in areas containing radioactivity shall be drained to a location that would be acceptable for the containment of radioactive materials.

14-6.5.2 **Facilities with Gaseous Fire Suppression Systems**

Where gaseous fire suppression systems are installed, floor drains shall be provided with adequate seals, or the fire suppression system shall be sized to compensate for the loss of the gaseous fire suppression agent through the drains.

14-7 THROUGH PENETRATION FIRE STOPS

14-7.1 Where Required

14-7.1.1 Fire stops for penetrations such as pipes, conduits, bus ducts, cables, wires, pneumatic tubes and ducts, and similar building service equipment that passes through fire barriers shall be provided to prevent the spread of fire using listed or approved materials (caulking) or devices (sleeves).

14-7.1.2 If the fire barriers coincide with or are also serving as a blast-resistant barrier, these penetrations shall also require blast-resistant devices (refer to CHAPTER 7).

If the blast-resistant device is sufficient to serve as protection from the spread of fire, no additional protection is necessary.

If the blast-resistant penetration device is not listed or approved for fire penetrations, it can be evaluated by a qualified fire protection engineer and accepted as a fire barrier product by the AHJ.

14-7.2 Annular Spaces

The annular space between the penetrating item and the through opening in the fire barrier shall be filled with a qualified (listed or approved) fire-resistive penetration seal assembly capable of maintaining the fire resistance of the fire barrier. The assembly shall be qualified by tests in accordance with fire test protocols or be protected by a listed fire-rated device for the specified fire-resistive period. Penetration seals provided for electrical and mechanical openings shall be listed as meeting the requirements of ASTM E814 or UL 1479.

14-7.3 Conduit Seals

Refer to section 3-2.4.

14-7.4 Leak Testing

Open flame- or combustion-generated smoke shall not be used for leak testing.

14-8 COMMUNICATIONS

Communication systems using a commonly described “lossy” antenna distribution system within the facility shall be limited as much as possible and shall be within the allowable electromagnetic radiation (EMR) limits of the applicable STS.

All electrical equipment and devices are either intentional or unintentional EMR emitters as defined in Chapter 8 of this attachment (refer to section 8-4). All such equipment to be used in close proximity to critical equipment interior to the facility shall not exceed the allowable EMR limits of the applicable STS. Anticipated EMR emitters shall be analyzed to evaluate anticipated EMRE levels. If the EMRE levels exceed allowable limits, facility design, equipment selection, or procedures must be adjusted to mitigate EMRE levels.

14-9 LIFE SAFETY AND MEANS OF EGRESS

14-9.1 Life Safety Performance Criteria

The following performance criteria shall be met during all operational modes and plant configurations:

- Provide safe egress or areas of refuge for all occupants of the facility.
- Provide adequate protection, including emergency lighting and communication, for essential personnel to perform necessary weapons safety and security functions in case of a fire event.
- Provide adequate protection (e.g., self contained breathing apparatus (SCBA) units, supplied air connections) for other facility personnel designated to provide emergency response services during or following a fire.

14-9.2 Occupancy Classification

14-9.2.1 Storage

Those areas involved in the storage of nuclear weapons shall be considered special purpose industrial occupancies and as underground spaces as defined in NFPA 101.

Warehouses and storage areas designated for the storage of materials *other than nuclear weapons* shall conform to the ordinary hazard storage occupancy (refer to Chapters 6 and 42 of NFPA 101) and underground space requirements in NFPA 101.

14-9.2.2 Maintenance

Those areas involved in the maintenance of nuclear weapons shall be considered special purpose industrial occupancies and as underground spaces as defined in NFPA 101.

14-9.2.3 Other Areas

General office areas, break rooms, security control rooms, office buildings, and training facilities shall conform to the business occupancy and underground space requirements in NFPA 101.

14-9.3 Occupant Load

In determining the exiting requirements for a nuclear weapons-capable maintenance and storage facility, the actual number of assigned personnel and expected number of visitors during operations, maintenance, and testing with an added safety factor of 20 percent shall be used to determine the occupant load in lieu of other criteria within NFPA 101.

14-9.4 Number of Means of Egress

Fire areas shall have at least one means of egress for those facilities protected throughout by an automatic fire suppression system. When nuclear security requirements prohibit the use of approved egress components (such as a listed fire door

meeting the requirements of NFPA 101) for the means of egress, an area of refuge shall also be provided within the fire area (refer to paragraph 14-9.6).

Two means of egress out of the fire area shall be provided for facilities not protected throughout by a fire suppression system. One of these means of egress may be an area of refuge. When nuclear security requirements prohibit the use of approved egress components (such as a listed fire door meeting the requirements of NFPA 101) for the means of egress, an area of refuge must be provided within the fire area (refer to paragraph 14-9.6).

14-9.5 Horizontal Exit

A horizontal exit shall be considered to be any adjacent fire area separated by at least 3-hour fire-rated construction and accessible through listed fire doors meeting the requirements of NFPA 101 and NFPA 80.

14-9.6 Area of Refuge

An area of refuge shall:

- Be separated from adjacent areas by at least 3-hour fire-rated construction
- Minimize the entrance of smoke
- Be protected throughout by automatic sprinklers
- Be provided with two-way communication (including instructions on the operation of the equipment)

Areas of refuge shall be provided with protective heat-resistant clothing, emergency drinking water, and sufficient breathing air to permit survival for at least 72 hours based on the expected occupant load. The occupant capacity for the area of refuge shall be established in the FHA.

NOTE: When possible, the area of refuge within a fire area should be located near to the nuclear security access doors into the fire area.

14-9.7 Travel Distances

14-9.7.1 Weapon Storage Areas

For weapon storage areas, travel distances to an exterior exit, horizontal exit, or area of refuge within the fire area shall not exceed 400 feet (122 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, these travel distances shall not exceed 200 feet (61 meters).

14-9.7.2 All Other Areas

For all other areas, travel distances to an exterior exit, horizontal exit, or area of refuge within the fire area shall not exceed 300 feet (91 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected

throughout by an automatic fire suppression system, these travel distances shall not exceed 200 feet (61 meters).

14-9.8 Common Path of Travel

14-9.8.1 Weapon Storage Areas

For weapon storage areas, common path of travel distances are not limited, provided the areas are protected with an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, common path of travel shall not exceed 75 feet (23 meters).

14-9.8.2 All Other Areas

For all other areas, common path of travel shall not exceed 100 feet (30 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, common path of travel shall not exceed 75 feet (23 meters).

14-9.9 Dead-End Corridors

14-9.9.1 Weapon Storage Areas

For weapon storage areas, dead-end corridors distances are not limited provided travel distances and common path of travel distances are not exceeded (see Sections 14-9.7 and 14-9.8).

14-9.9.2 All Other Areas

For all other areas, dead-end corridors shall not exceed 50 feet (15 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, dead-end corridors shall not exceed 20 feet (6.1 meters).

14-9.10 Special Locking Devices

Special locking devices (such as dead bolts and slide bolts) may be installed and left engaged on exit doors during periods of occupancy in addition to the normal door locking devices, provided that the devices are required by security and that they are clearly visible to the building occupants and the building occupants are advised of their presence.

NOTE: Such locking devices should be marked or painted with a bright contrasting color (e.g., orange, yellow, red) to be clearly visible to the occupants.

14-10 FIRE HYDRANTS IN VEHICLE LOADING TUNNELS

Hydrants shall be installed within approximately 50 feet (15 meters) of each end of each vehicle loading tunnel provided for the underground structures.

14-11 SECURITY CONTROL ROOM COMPLEX

14-11.1 Physical Separation

The security control room complex shall be protected against exposure fire damage and shall be separated from other fire areas of the plant by floors, walls, doors, and ceilings having a minimum fire resistance rating of 3 hours.

14-11.1.1 Windows

Windows in fire barriers for the security control room complex shall be provided with a listed or approved fire shutter or automatic wall curtain having a minimum fire resistance rating of 3 hours.

14-11.1.2 Peripheral Rooms

Peripheral rooms supporting the security control room complex but within the same fire area shall have an automatic water-based suppression system, and shall be separated from the control room by noncombustible construction with a minimum fire resistance rating of 1 hour.

14-11.1.3 Ventilation System Openings

Ventilation system openings between the control room and the peripheral rooms shall have automatic smoke or combination fire and smoke dampers installed that will close on operation of the fire detection or fire suppression systems.

14-11.2 Manual Firefighting

Manual firefighting capability shall be provided for:

- Fires originating within a cabinet, console, or connecting cables
- Exposure fires involving combustible materials in the general surrounding room areas

14-11.3 Portable Fire Extinguishers

Portable Class A and Class C fire extinguishers shall be located in the security control room. A fire hose station shall be installed immediately outside of the security control room. Clean agent or carbon dioxide (CO2) portable fire extinguishers shall be used for electrical hazards.

14-11.4 Smoke Detection

Smoke detectors shall be provided in the control room complex, including the interior of electrical cabinets and consoles (refer to CHAPTER 11).

14-11.5 Breathing Apparatus

Breathing apparatus for the security control room operators shall be readily available with a minimum of 72 hour capacity.

14-11.6 Smoke Venting

Manually operated smoke venting of the security control room shall be available to the control room personnel (refer to CHAPTER 11).

14-11.7 **Electrical Cables**

All electrical cables that enter the control room shall terminate in the control room. No cabling shall be routed through the control room from one area to another. Fully enclosed electrical raceways located in such under-floor and ceiling spaces, if over 1 cubic foot (0.03 cubic meter), shall have automatic fire suppression internally. Area automatic fire suppression shall be provided for under floor and ceiling spaces if used for cable runs unless all cable is located in 4-inch (103-millimeter) or smaller steel conduit, or unless cables are fully enclosed within raceways internally protected by automatic fire suppression. See CHAPTER 3 regarding the use of wireways or raceways and for requirements for conduit seals.

14-11.8 **Air Handling**

Air handling functions shall be ducted separately from cable runs. If cables are routed in under-floor or ceiling spaces, these spaces shall not be used as air plenums for ventilation of the control room.

14-12 **COMMUNICATIONS**

For all communication systems that are wireless or EMR emitting devices, the criteria within section 8-4 shall be implemented as appropriate.

CHAPTER 15

INDUSTRIAL FACILITIES

15-1 SCOPE

This chapter includes requirements in addition to the requirements of Chapters 1 through 13 that are applicable to industrial facilities where nuclear weapons-capable activities such as inspection, testing, and maintenance take place. For underground facilities, comply with Chapter 14 in lieu of this chapter.

15-2 ARCHITECTURAL REQUIREMENTS

Architectural requirements are provided in UFC 1-200-01.

15-2.1 Construction Type

Buildings shall be constructed to be fire resistant or noncombustible (Type I or Type II in accordance with the International Building Code [IBC]). All walls, floors, and structural components, except interior finish materials in office and support areas, shall be of noncombustible construction. Use of combustible interior finishes shall be minimized.

15-2.2 Hardened Fire Protection Systems

Buildings shall be provided with hardened fire suppression systems in all areas and smoke detection systems (refer to CHAPTER 11 and see Appendix B).

15-2.3 Faraday Shield

Buildings shall be constructed using the Faraday shield (i.e., metallic cage) approach for reducing the required lightning side flash or separation distance (refer to section 2-4).

15-2.4 Fire Areas

Facilities capable of inspecting, maintaining or storing nuclear weapons components shall be subdivided into separate fire areas to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat, radioactive contamination, and firefighting activities. In addition, the subdivision into fire areas shall allow adequate access for manual fire suppression activities, and be as consistent as possible with the blast zones.

15-2.4.1 Establishment of Boundaries

The boundaries of fire areas shall be established in the FHA based on general fire protection criteria that include these elements:

- Types, quantities, density, and locations of combustible materials and radioactive materials
- Location of blast doors and security access portals
- Location and configuration of equipment
- Consequences of inoperable equipment

- Location or zoning of fire detection and suppression systems
- Personnel safety, exiting, area of refuge requirements
- Building separations and occupancy separation requirements

15-2.4.2 **Boundary Objectives**

In industrial facilities, fire area boundaries shall accomplish fire protection objectives, including:

- To separate all contiguous buildings or portions thereof serving different purposes, such as storage, maintenance, service, administration, and other occupancy designations
- To separate weapons maintenance areas from adjacent areas
- To separate fueling areas from adjacent areas
- To separate security and other control rooms, computer rooms, or combined control and computer rooms from adjacent areas
- To separate rooms with major concentrations of electrical equipment, such as switchgear rooms and relay rooms, from adjacent areas
- To separate battery rooms from adjacent areas
- To separate each fire pump and its associated equipment from all other pumps in the same room or pump house
- To separate each fire pump from adjacent areas
- To separate warehouse areas and combustible storage areas from adjacent areas
- To separate standby or emergency power generators from each other and from adjacent areas
- To separate fan rooms and plenum chambers from adjacent areas
- To separate office areas from adjacent areas

15-2.4.3 **Fire Barriers Separating Fire Areas**

Fire barriers separating fire areas shall be of a minimum of 2-hour fire resistance rating with listed 2-hour-rated penetration seals.

15-2.4.4 Fire Doors and Fire Windows in Fire Barriers

Fire doors and fire windows used in fire barriers shall be installed and maintained in accordance with NFPA 80. In the case of blast doors in fire barriers, refer to paragraph 7-4.3.8 of this attachment.

Normally, closed fire doors in fire barriers shall be identified with a sign indicating “Fire Door — Keep Closed.”

Windows in fire barriers, such as for a security control room or computer room, shall be provided with a listed or approved fire shutter, automatic wall curtain, or fire resistance glazing.

15-2.5 Vertical Shafts and Plenums

To prevent vertical spread of fire, all stairways, elevator shafts, escape ladders, and other vertical shafts and plenums shall be enclosed with barriers having a fire resistance rating of at least 2 hours. Openings in such barriers shall be protected with listed automatic or self-closing fire doors having a fire protection rating of at least 1.5 hours.

15-3 NUCLEAR CRITICALITY HAZARDS

Nuclear weapons-capable maintenance areas shall be designed to be criticality safe with automatic sprinklers included. Floor drains shall be provided regardless of the inclusion of sprinklers. Appropriate drain lines, storage, and handling systems capable of handling potentially contaminated water shall be provided.

15-4 COMBUSTIBLE MATERIALS AND FINISHES

15-4.1 Blast Shielding Materials

Permanent and temporary shielding materials shall be noncombustible or limited combustible, based on:

- ASTM E84
- NFPA 253
- NFPA 255
- UL 94

Polystyrene used for sand walls is not required to be encased with fire-resistant materials.

15-4.2 Interior Finishes

15-4.2.1 Interior Wall and Ceiling Finish

Interior wall and ceiling finish in areas processing or storing radioactive materials shall be Class A in accordance with NFPA 255.

NOTE: The design should consider a potential radiation contamination incident and include wall and ceiling finishes that are easy to clean.

15-4.2.2 **Interior Floor Finish**
Interior floor finish in areas processing or storing radioactive materials shall be Class I in accordance with NFPA 253. If required to meet weapon maintenance environmental conditions, anti-static flooring having less than a Class I fire rating is permitted when approved by the AHJ.

NOTE: The design should consider a potential radiation contamination incident and include floor finishes that are easy to clean.

15-4.3 **Other Materials**
Thermal insulation materials, radiation shielding materials, ventilation duct materials, soundproofing materials, and suspended ceilings, including light diffusers and their supports, shall be noncombustible or limited combustible. If polypropylene or polyethylene is required for neutron shielding, it shall be totally encased with a noncombustible material such as steel or 5/8-inch (16-millimeter) type X gypsum board. Approximately 3/8-inch (10-millimeter) vent holes shall be provided within the encasement to permit the venting of gasses from the poly material.

NOTE: Encasement is required because many plastic materials, including flame- and fire-retardant materials, will burn with an intensity and energy production in the range similar to that of ordinary hydrocarbons. When burning, these materials produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and HEPA filters. When burning, halogenated plastics also release free chloride and hydrogen chloride. These gases are toxic to humans and corrosive to equipment.

15-5 **HAZARD CONTROL**

15-5.1 **Flammable and Combustible Liquids**

15-5.1.1 Bulk storage of flammable and combustible liquids shall not be permitted inside structures capable of maintaining nuclear weapons.

15-5.1.2 Flammable and combustible liquid storage and use shall be in accordance with NFPA 30.

15-5.1.3 Where oil-burning equipment, stationary combustion engines, or gas turbines are used, they shall be installed and used in accordance with NFPA 31 or NFPA 37, as appropriate.

15-5.1.4 Flammable and combustible liquid and gas piping shall be in accordance with ANSI B31.1 or the ASME *Boiler and Pressure Vessel Code*, Section III, as applicable.

15-5.2 **Hydraulic Systems**
Hydraulic systems shall use only listed fire-resistant hydraulic fluids.

15-5.3 Solvents

Where a flammable or combustible solvent is used, it shall be handled such that the uncontrolled release of vapors is not permitted.

15-5.4 Gases

Flammable and combustible gases shall be stored and handled in accordance with NFPA 54, NFPA 55, and NFPA 58.

Bulk flammable gas storage, either compressed or cryogenic, shall not be permitted inside structures capable of maintaining nuclear weapons.

Storage of flammable gas, such as hydrogen, shall be located outdoors or in separate detached buildings so that a fire or explosion will not adversely affect any nuclear weapons maintenance facility systems or equipment.

15-6 REFUELING AREAS

15-6.1 Automatic Fire Suppression

Automatic fire suppression systems that use high-expansion foam shall be provided. The systems shall protect the area from the hazards defined within the FHA and be designed in accordance with NFPA 11.

15-6.2 Electrical Equipment

Electrical equipment shall comply with NFPA 70, including Chapter 5, “Special Occupancies,” and other NFPA 70 requirements related to hazardous locations.

15-6.3 Fuel Transfer Pumps

Where pumps are used for liquid fuel transfer, means shall be provided to shut down liquid transfer in the event of a spill or fire.

15-6.4 Fuel Storage Tanks

Fuel storage (i.e., day tanks) located within refueling areas shall not exceed 200 gallons (757 liters).

Fuel storage tanks shall be equipped with overfill protection.

15-6.5 Fuel Line Shutoff

Fuel supply lines entering refueling areas shall be arranged with a spring-loaded automatic shutoff valve that is activated via a fusible link.

15-6.6 Curbing in Refueling Areas

Refueling areas shall be provided with curbing designed to capture the entire contents of the fuel within the facility and the discharge of the fire suppression system for 30 minutes.

15-6.7 **Ventilation**

15-6.7.1 Refueling areas shall be provided with either a gravity system or a continuous mechanical exhaust ventilation system.

15-6.7.2 Exhaust air shall be taken from a point near a wall on one side of the room and within 12 inches (30.5 centimeters) of the floor, with one or more make-up inlets located on the opposite side of the room within 12 inches (30.5 centimeters) of the floor.

15-6.7.3 The location of both the exhaust and inlet air openings shall be arranged to provide air movement across all portions of the floor to prevent the accumulation of vapors.

15-6.7.4 Exhaust from the room shall be conducted directly to the exterior of the building and shall not be recirculated.

15-6.7.5 If ducts are used, they shall not be used for any other purpose and shall comply with NFPA 91.

15-6.7.6 If make-up air to a mechanical system is taken from within the building, the opening shall be equipped with a fire door or damper as required in NFPA 91.

15-6.7.7 For gravity systems, the make-up air shall be supplied from outside of the building.

15-6.7.8 Mechanical ventilation systems shall provide at least 1 cubic foot per minute (28.3 liters per minute) of exhaust air for each square foot (0.09 square meter) of floor area, but not less than 150 cubic feet per minute (4,248 liters per minute).

15-6.7.9 The mechanical ventilation system for dispensing areas shall be equipped with an airflow switch or other equally reliable method that is interlocked to sound an audible alarm upon failure of the ventilation system.

15-6.7.10 The minimum height of air intakes in these areas shall be in accordance with UFC 4-010-01.

15-6.8 **Static Electricity**

Means shall be provided to minimize the generation of static electricity in the refueling area.

15-7 **LIQUID RUN-OFF CONTROL**

Drainage shall be provided in all areas of the facility for the removal of all liquids directly to safe areas, or for containment in the area without adverse flooding of equipment and without endangering other areas.

15-7.1 **Methods**

Drainage and the prevention of equipment water damage shall be accomplished by one or more of these methods:

- Floor drains
- Floor trenches
- Open doorways or other wall openings
- Curbs for containing or directing drainage
- Equipment pedestals
- Pits, sumps, and sump pumps

15-7.2 **Sump Pump Systems**

Waste and drainage sump pump systems shall be provided with 100 percent redundant pumps.

15-7.3 **Drainage and Drainage Facility Size**

Drainage and any associated drainage facilities for a given area shall be sized to accommodate the volume of liquid produced by all of these sources:

- The spill of the largest single container of any flammable or combustible liquids in the area
- The credible volume of discharge (as determined by the FHA) released by the automatic suppression system operating for a period of 30 minutes, unless the approved FHA authorizes use of a different flow rate and duration
- The contents of piping systems and containers that could fail in a fire
- The volume of water discharged based on a manual firefighting flow rate of 500 gallons per minute (1,890 liters per minute) for 30 minutes unless the approved FHA authorizes use of a different flow rate and duration
- For areas open to the outside, such as underground loading docks, credible environmental factors such as rain and snow

15-7.4 **Staging Equipment**

Necessary equipment shall be staged to assist with routing water from the affected area. The use of the staging equipment shall be addressed in the fire department pre-fire plan.

15-7.5 **Floor Drainage**

Floor drainage from areas containing flammable or combustible liquids shall be trapped to prevent the spread of burning liquids beyond the fire area.

15-7.5.1 **Areas with Radioactive Materials**

Floor drainage from areas containing nuclear weapons components shall be trapped to prevent the spread of radioactive materials beyond the facility's controlled boundaries. If the drainage system leads to tanks, the tanks shall be designed to be criticality safe.

Water drainage from areas that might contain radioactivity shall be collected, sampled, and analyzed before discharge to the environment or outside the boundaries of the facility.

Water released during fire suppression operations in areas containing radioactivity shall be drained to a location that would be acceptable for the containment of radioactive materials.

15-7.5.2 **Facilities with Gaseous Fire Suppression Systems**

Where gaseous fire suppression systems are installed, floor drains shall be provided with adequate seals, or the fire suppression system shall be sized to compensate for the loss of the gaseous fire suppression agent through the drains.

15-8 **THROUGH PENETRATION FIRE STOPS**

15-8.1 **Where Required**

15-8.1.1 Fire stops for penetrations such as pipes, conduits, bus ducts, cables, wires, pneumatic tubes and ducts, and similar building service equipment that passes through fire barriers shall be provided to prevent the spread of fire using listed or approved materials (caulking) or devices (sleeves).

15-8.1.2 If the fire barriers coincide with or are also serving as a blast-resistant barrier, these penetrations shall also require blast-resistant devices (refer to CHAPTER 7).

If the blast-resistant device is sufficient to serve as protection from the spread of fire, no additional protection is necessary.

If the blast-resistant penetration device is not listed or approved for fire penetrations, it can be evaluated by a qualified fire protection engineer and accepted as a fire barrier product by the AHJ.

15-8.2 **Annular Spaces**

The annular space between the penetrating item and the through opening in the fire barrier shall be filled with a qualified (listed or approved) fire-resistive penetration seal assembly capable of maintaining the fire resistance of the fire barrier. The assembly shall be qualified by tests in accordance with fire test protocols or be protected by a listed fire-rated device for the specified fire-resistive period. Penetration seals provided for electrical and mechanical openings shall be listed as meeting the requirements of ASTM E814 or UL 1479.

15-8.3 Conduit Seals

Refer to section 3-2.4.

15-8.4 Leak Testing

Open flame- or combustion-generated smoke shall not be used for leak testing.

15-9 COMMUNICATIONS

Communication systems using a lossy antenna distribution system within the facility shall be limited as much as possible and shall be within the allowable EMR limits of the STS.

All electrical equipment and devices are either intentional or unintentional EMR emitters as defined in Chapter 8 of this attachment (refer to section 8-4). All such equipment to be used in close proximity to critical equipment interior to the facility shall not exceed the allowable EMR limits of the STS. Anticipated EMR emitters shall be analyzed to evaluate anticipated EMRE levels. If the EMRE levels exceed allowable limits, facility design, equipment selection, or procedures must be adjusted to mitigate EMRE levels.

15-10 LIFE SAFETY AND MEANS OF EGRESS

15-10.1 Life Safety Performance Criteria

The following performance criteria shall be met during all operational modes and plant configurations:

- Provide safe egress or areas of refuge for all occupants of the facility.
- Provide adequate protection, including emergency lighting and communication, for essential personnel to perform necessary weapons safety and security functions in case of a fire event.
- Provide adequate protection (e.g., SCBA units, supplied air connections) for other facility personnel designated to provide emergency response services during or following a fire.

15-10.2 Occupancy Classification

Industrial facilities involved in the inspection, testing, and maintenance of nuclear weapons shall be considered special purpose industrial occupancies as defined in NFPA 101.

General office areas, break rooms, security control rooms, office buildings, and training facilities shall conform to the business occupancy requirements in NFPA 101.

Warehouses and storage areas designated for the storage of materials other than nuclear weapons shall conform to the ordinary hazard storage occupancy requirements in NFPA 101 (refer to Chapters 6 and 42 of NFPA 101).

15-10.3 **Occupant Load**

In determining the exiting requirements for a nuclear weapons-capable maintenance and storage facility, the actual number of assigned personnel and expected number of visitors during operations, maintenance, and testing with an added safety factor of 30 percent shall be used to determine occupant load in lieu of other criteria within NFPA 101.

15-10.4 **Number of Means of Egress**

15-10.4.1 Fire areas shall have at least two means of egress, including those facilities protected throughout by an automatic fire suppression system.

15-10.4.2 A single means of egress shall be permitted from any story or section of an industrial facility, provided that the exit can be reached within 100 feet (30 meters) for a sprinklered facility (50 feet [15 meters] for a nonsprinklered facility), and when the single means of egress is approved by the AHJ.

15-10.4.3 Refueling areas shall have not less than two means of egress, one of which shall include an exit directly to the exterior of the facility.

15-10.4.4 When nuclear security requirements prohibit the use of approved egress components (such as a listed fire door meeting the requirements of NFPA 101) in the means of egress, an area of refuge shall be provided within the fire area (refer to paragraph 15-11.7).

15-10.5 **Horizontal Exit**

A horizontal exit shall be considered to be any adjacent fire area separated by at least 2-hour fire-rated construction and accessible through listed fire doors meeting the requirements of NFPA 101 and NFPA 80.

15-10.6 **Area of Refuge**

An area of refuge shall:

- Be separated from adjacent areas by at least 3-hour fire-rated construction
- Minimize the entrance of smoke
- Be protected throughout by automatic sprinklers
- Be provided with two-way communication (including instructions on the operation of the equipment)

An area of refuge shall be provided with protective heat-resistant clothing, emergency drinking water, and sufficient breathing air to permit survival for at least 72 hours based on the expected occupant load. The occupant capacity for the area of refuge shall be established in the FHA.

NOTE: When possible, the area of refuge within a fire area should be located near to the nuclear security access doors into the fire area.

15-10.7 Travel Distances

Travel distances to an exterior exit, horizontal exit, or area of refuge within the fire area shall not exceed 400 feet (122 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, travel distances to an exterior exit, horizontal exit, or area of refuge within the fire area shall not exceed 200 feet (61 meters).

For refueling areas, travel distances to an exterior exit shall not exceed 75 feet (23 meters).

15-10.8 Common Path of Travel

The common path of travel shall not exceed 100 feet (30 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, the common path of travel shall not exceed 75 feet (23 meters).

15-10.9 Dead-End Corridors

Dead-end corridors shall not exceed 50 feet (15 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, dead-end corridors shall not exceed 20 feet (6.1 meters).

15-10.10 Special Locking Devices

Special locking devices (such as dead bolts and slide bolts) may be installed and left engaged on exit doors during periods of occupancy in addition to the normal door locking devices, provided that the devices are required by security and that they are clearly visible to the building occupants and the building occupants are advised of their presence.

NOTE: Such locking devices should be marked or painted with a bright contrasting color (e.g., orange, yellow, red) to be clearly visible to the occupants.

15-11 SECURITY CONTROL ROOM COMPLEX

15-11.1 Physical Separation

The security control room complex shall be protected against exposure fire damage and shall be separated from other fire areas of the plant by floors, walls, doors, and ceilings having a minimum fire resistance rating of 3 hours.

15-11.1.1 Windows

Windows in fire barriers for the security control room complex shall be provided with a listed or approved fire shutter or automatic wall curtain having a minimum fire resistance rating of 3 hours.

15-11.1.2 **Peripheral Rooms**
Peripheral rooms supporting the security control room complex but within the same fire area shall have an automatic water-based suppression system, and shall be separated from the control room by noncombustible construction with a minimum fire resistance rating of 1 hour.

15-11.1.3 **Ventilation System Openings**
Ventilation system openings between the control room and the peripheral rooms shall have automatic smoke or combination fire and smoke dampers installed that will close on operation of the fire detection or fire suppression systems.

15-11.2 **Manual Firefighting**
Manual firefighting capability shall be provided for:

- Fires originating within a cabinet, console, or connecting cables
- Exposure fires involving combustible materials in the general surrounding room areas

15-11.3 **Portable Fire Extinguishers**
Portable Class A and Class C fire extinguishers shall be located in the security control room. A fire hose station shall be installed immediately outside of the security control room. Clean agent or CO2 portable fire extinguishers shall be used for electrical hazards.

15-11.4 **Smoke Detection**
Smoke detectors shall be provided in the control room complex, including the interior of electrical cabinets and consoles (refer to CHAPTER 11).

15-11.5 **Breathing Apparatus**
Breathing apparatus with a minimum of 72-hour capacity shall be readily available for the security control room operators.

15-11.6 **Smoke Venting**
Manually operated smoke venting of the security control room shall be available to the control room personnel (refer to CHAPTER 11).

15-11.7 **Electrical Cables**
All electrical cables that enter the control room shall terminate in the control room. No cabling shall be routed through the control room from one area to another. Fully enclosed electrical raceways located in such under-floor and ceiling spaces, if over 1 cubic foot (0.03 cubic meter), shall have automatic fire suppression internally. Area automatic fire suppression shall be provided for under-floor and ceiling spaces if used for cable runs unless all cable is located in 4-inch (103-millimeter) or smaller steel conduit, or unless cables are fully enclosed within raceways internally protected by automatic fire suppression. See CHAPTER 3 regarding the use of wireways or raceways, and for requirements for conduit seals.

15-11.8 Air Handling

Air handling functions shall be ducted separately from cable runs. If cables are routed in under-floor or ceiling spaces, these spaces shall not be used as air plenums for ventilation of the control room.

15-12 COMMUNICATIONS

15-12.1 Wireless Communications

For all communication systems that are wireless or EMR emitting devices, the criteria in section 8-4 shall be considered and implemented as appropriate.

15-13 ELECTROEXPLOSIVE DEVICES (EED)

15-13.1 Storage and Testing Area Criteria

Areas where EEDs are stored or tested shall meet the following criteria:

15-13.1.1 Separation

EED areas shall be separated from the remainder of the industrial facility by not less than 3-hour-rated walls.

15-13.1.2 Seals

All permanent penetrations into and out of the room shall be sealed by a listed or approved means (i.e., penetration seals, fire and smoke dampers).

Penetrations that are provided for use in remote testing or remote electrical testing may be covered with a movable steel door or “flap” that is configured with a small slit that allows temporary wiring needed for the testing to penetrate the wall.

15-13.1.3 Ventilation Ductwork

Ventilation ductwork that penetrates the room shall be equipped with fire or combination fire and smoke dampers with at least a 3-hour fire rating. Alternate means of protection of the ductwork (i.e., without dampers) are not permitted.

15-13.1.4 Blast Doors

Blast doors into the rooms shall be evaluated by a qualified fire protection engineer to determine if the door may be considered as equivalent to that of a 3-hour-rated fire door. Use of the blast doors for this purpose shall be approved by the AHJ.

15-13.1.5 Fire Suppression

The room shall be protected by an automatic sprinkler fire suppression system.

NOTE: The sprinklers should be supplied from above the ceiling and also provided with sprinkler guards. These features will help reduce damage to the sprinkler system due to explosion.

15-13.1.6 Grounding

Grounding or bonding to an earth ground shall be provided (refer to CHAPTER 3).

15-13.2 **Deflagration Venting**

Areas where EEDs are stored or tested shall be provided with deflagration venting in accordance with NFPA 68. The following features shall be provided:

NOTE: According to the NFPA *Fire Protection Handbook*, industry experience shows that detonations cannot be adequately vented; however, deflagration venting should still be provided as a best management practice.

15-13.2.1 The vent area shall be located in an exterior wall.

15-13.2.2 The vent area shall be distributed symmetrically and evenly on the external wall.

15-13.2.3 The types of building vent closures permitted include:

- Hinged doors
- Windows and panel closures that swing in the outward direction and have latches or similar hardware that automatically release under calculated release pressure
- Friction, spring-loaded, or magnetic latches of the type used for doors on industrial ovens

15-13.2.4 Shear and pull-through fasteners are permitted to be used where the vent design requires large areas, such as the entire wall of an EED room.

15-13.2.5 The means of restraining large panels shall be documented in the FHA.

15-13.2.6 No restraint for any vent closure shall result in restricting the vent area.

15-13.2.7 Any hardware added to a vent closure shall be included when determining the total mass of the closure.

15-13.2.8 Hinged doors or covers shall be permitted to be designed to function as vent closures. The hinge shall be designed to ensure that the closure device remains intact during venting.

15-13.3 **Inspection**

Explosive venting systems shall be inspected annually and the inspection shall include at least these system conditions:

- The opening is clear of obstructions on both sides.
- The exhaust from the opening does not discharge to an occupied area.
- Changes made to the venting system installation since the last inspection.

- The venting system is not corroded or otherwise damaged.
- The explosive venting configuration is clearly identified.
- The explosive venting configuration is not damaged and will not be obstructed by snow, ice, insects, animals, plant growth or other environmental conditions.
- The explosive venting device will not be impeded in its operation.

15-14 ARMORIES

15-14.1 Armories shall be separated from the remainder of the facility by a minimum of 2-hour fire-rated walls and 1.5-hour-rated fire doors.

15-14.2 Penetrations into armories shall be fire stopped (e.g., fire dampers, penetration seals) in addition to security requirements.

15-14.3 Armories shall be protected with automatic sprinklers. The sprinkler piping into an armory may be valved to permit isolation of the system in the event of an emergency when approved by the AHJ.

15-14.4 Security doors into armories shall be evaluated by a qualified fire protection engineer to determine if a door may be considered as equivalent to that of a 3-hour-rated fire door. Use of the security doors for this purpose shall be approved by the AHJ.

CHAPTER 16

EARTH-COVERED MAGAZINE (ECM) STRUCTURES

16-1 SCOPE

This chapter includes requirements in addition to the requirements of Chapters 1 through 13 that are applicable to ECM structures where nuclear weapons are authorized to be stored.

16-2 ARCHITECTURAL REQUIREMENTS

16-2.1 Uniform Minimum Ammunition and Explosive (AE) Safety Standards

Uniform minimum AE safety standards established by the Department of Defense Explosives Safety Board (DDESB) shall be incorporated.

NOTE: The DDESB has established uniform minimum AE safety standards for personnel and property that have the potential of being exposed to the effects of an accidental explosion. These standards govern the design, construction, and use of all AE storage magazines within the DOD.

16-2.2 ECM Siting

ECM structures shall be sited using DDESB uniform minimum AE safety standards.

16-2.3 Hardened Fire Protection Systems

Buildings shall be provided with hardened fire suppression systems in all areas and smoke detection systems (refer to CHAPTER 11 and see Appendix B).

NOTE: ECM structures are built to store AE. ECM structures are not necessarily designed to contain the damaging effects from an internal explosion, although these structures will usually contain the effects of a very small quantity of AE. Instead, ECMs are intended to protect their contents from an explosion that may occur in an adjacent structure, such as another ECM, piers, aboveground magazines, rail sidings, or classification yards. The ECM may not be adequate to prevent damage to its contents from all external events. Protection from such events should be addressed in the FHA.

16-2.4 Faraday Shield

Buildings shall be constructed using the Faraday shield (i.e., metallic cage) approach for reducing the required lightning side flash or separation distance (refer to section 2-5).

16-3 APPROVAL REQUIREMENTS

16-3.1 DDESB Review

Plans for ECM structures shall be reviewed and approved by the DDESB to ensure that minimum DOD explosive safety considerations have been addressed. Situations requiring approval include:

- New construction or major modification

- Changes in use of facilities that affect the siting separation distances

16-3.2 Pre-approved ECM Designs

If pre-approved ECM designs are used, the project site plan along with the drawing numbers of the ECM design must be submitted for approval. All new 7- and 3-bar ECM designs must be approved by the DDESB before they may be used. The approval will require the submission of test results or detailed structural calculations.

16-3.3 Undefined ECM Designs

All new, undefined ECM designs require prior approval from the DDESB to ensure that minimum design and construction criteria are met.

16-4 LIFE SAFETY AND MEANS OF EGRESS

16-4.1 Life Safety Performance Criteria

These performance criteria shall be met during all operational modes and ECM configurations:

- Provide safe egress for all occupants of the facility.
- Provide adequate protection, including emergency lighting and communication, for essential personnel to perform necessary weapons safety and security functions in case of a fire event.

NOTE: Typical DOD ECMs are small structures that are occupied only for brief periods to permit the addition or removal of weapon systems from the structure. The weapons systems are then transported to an industrial facility (refer to CHAPTER 15) or an underground facility (refer to Chapter 16), or transported off the DOD installation. The only other expected periods of occupancy will be temporary access by a limited number of personnel to perform maintenance on the ECM's infrastructure systems. Otherwise, security measures will effectively prevent access by all personnel to the ECM. Life safety performance criteria provided in the FHA should incorporate such operational considerations.

16-4.2 Occupancy Classification

ECM structures used for the storage of nuclear weapons shall be considered special purpose industrial occupancies.

16-4.3 Occupant Load

In determining the exiting requirements for a nuclear weapons-capable maintenance and storage facility, the actual number of assigned personnel and expected number of security personnel during operations in the ECM with an added safety factor of 20 percent shall be used to determine occupant load in lieu of other criteria within NFPA 101.

16-4.4 Number of Means of Egress

One means of egress from an ECM is permitted.

16-4.5 **Travel Distances**

Travel distances to an exterior exit shall not exceed 400 feet (122 meters) for facilities protected throughout by an automatic fire suppression system. For facilities not protected throughout by an automatic fire suppression system, travel distances to an exterior exit shall not exceed 200 feet (61 meters).

16-4.6 **Common Path of Travel**

The common path of travel distance is not limited.

16-4.7 **Dead-End Corridors**

Dead-end corridors are not permitted.

GLOSSARY

Acronyms and Abbreviations

A&E—architectural and engineering

AE—ammunition and explosive

AFFF—aqueous film-forming foam

AFI—Air Force instruction

AFMAN—Air Force manual

AFNWC—Air Force Nuclear Weapons Center

AFOSH—Air Force Occupational Safety and Health

AFPD—Air Force policy directive

AHJ—authority having jurisdiction

ANSI—American National Standards Institute

ASME—American Society of Mechanical Engineers

ASTM—American Society for Testing and Materials

ATS—automatic transfer switch

BCE—base civil engineer

BCMS—blast containment management system

CB—chemical-biological

CBR—chemical-biological-radiological

cfm—cubic foot per minute

CO2—carbon dioxide

DDESB—Department of Defense Explosives Safety Board

DOD—Department of Defense

DODD—Department of Defense directive

DOE—Department of Energy

ECM—earth-covered magazine

EEDS—electro-explosive device

EFS—essential facility systems

EIS—Engineering Installation Squadron

EMR—electromagnetic radiation

EMRE—electromagnetic radiation environment

ETL—Engineering Technical Letter

FACP—fire alarm control panel

FDC—fire department connection

FHA—fire hazard analysis

ft—feet

HEPA—high efficiency particulate air

HQ AFCESA—Headquarters, Air Force Civil Engineer Support Agency

HQ AFCESA/CEO—HQ AFCESA Operations and Programs Support Division

HQ AFSC/SEW—Headquarters, Air Force Safety Center, Weapons Safety Division

HQ AFSFC/SFON—Headquarters, Air Force Security Forces Center

HVAC—heating, ventilation, and air conditioning

IEEE—Institute of Electrical and Electronics Engineers

IBC—International Building Code

LED—light-emitting diode

LPS—lightning protection system

m—meter

MAJCOM—major command

MCFL—maximum credible fire loss

MIC—microbiologically induced corrosion

MNS—mass notification system

MPFL—maximum possible fire loss

MSDS—material safety data sheets

NCEES—National Council of Examiners for Engineering and Surveys

NFPA—National Fire Protection Association

NIST—National Institute of Standards and Technology

NNSA—National Nuclear Security Agency

NRTL—nationally recognized testing laboratory

OS&Y—outside screw and yoke

PCB—polychlorinated biphenyl

P.E.—professional engineer

psi—pounds per square inch

psia—pounds per square inch absolute

psig—pounds per square inch gauge

RPIE—real property installed equipment

SCBA—self contained breathing apparatus

SSD—safe separation distance

STS—stockpile-to-target sequence

UFC—Unified Facilities Criteria

UL—Underwriters Laboratories, Inc.

UPS—uninterruptable power supply

Terms

Area of Refuge: A room or space that is designated, marked, and suitably equipped to provide a temporary place of safety for building occupants while awaiting rescue during a fire emergency.

Characterization: The process that includes: testing and analyzing a facility to determine the effectiveness of a Faraday shield (also known as low impedance testing); electrically bonding metallic penetrations to the Faraday shield; installing appropriate surge suppression; and establishing a reduced SSD based on specific test results and analyses.

Combustible: Capable of undergoing combustion.

Combustible Liquid: A liquid that has a closed-cup flash point at or above 100 degrees Fahrenheit (37.8 degrees Celsius).

Criticality: The state of sustaining a chain reaction, as in a nuclear reactor.

Criticality Incident: An accidental, self-sustained nuclear fission chain reaction.

Defense in Depth: A principle aimed at providing a high degree of fire protection by achieving a balance of preventing fires from starting; detecting fires quickly and suppressing those fires that occur, thereby limiting damage; and designing a nuclear facility to limit the loss of life, property, and environment to fire and to ensure continuity of facility operation and safety.

Deflagration: Propagation of a combustible zone at a velocity that is less than the speed of sound in the unreacted medium.

Detonation: Propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium.

Electromagnetic Radiation (EMR): EMR is a ubiquitous phenomenon that takes the form of self-propagating waves in a vacuum or in matter. It consists of electric and magnetic field components that oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation. Electromagnetic radiation is classified into several types according to the frequency of its wave; these types include (in order of increasing frequency and decreasing wavelength) radio waves, microwaves, terahertz radiation, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

Fire Area: An area that is physically separated from other areas by space, barriers, walls, or other means to contain fire within that area.

Fire Barrier: A continuous vertical or horizontal construction assembly designed and constructed to limit the spread of heat and fire and to restrict the movement of smoke.

Fire Door: A door assembly rated in accordance with NFPA 252 and installed in accordance with NFPA 80.

Fire Hazard Analysis (FHA): An analysis that evaluates potential fire hazards and appropriate fire protection systems and features to mitigate the effects of fire in any area.

Fire Model: Mathematical prediction of fire growth, environmental conditions, and potential effects on structures, systems, or components based on the conservation equations or empirical data.

Fire Prevention: Measures directed toward avoiding the inception of fire.

Fire Protection: Methods of providing fire detection, control, and extinguishment.

Fire-Rated Cables: Cables with an hourly fire resistance rating based on maintaining functionality when exposed to the fire tests in NFPA 251.

Fire-Rated Internal Seal: A conduit seal that is a tested and approved hourly rated fire seal in accordance with ASTM E814.

Fire-Rated Penetration Seal: An assembly provided in a fire barrier opening for the passage of pipes, cable trays, and so forth, to maintain the fire resistance rating of the fire barrier.

Fire-Resistant Hydraulic Fluid: A listed hydraulic fluid or lubricant that is difficult to ignite due to its high fire point and auto-ignition temperature and that does not sustain combustion due to its low heat of combustion.

Fire Resistance Rating: The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with an approved test procedure appropriate for the component under consideration.

Fire Watch: The act of observing field conditions that are indicators of initial stage fire development and initiating specified actions to mitigate the situation.

Fire Watcher: An individual assigned the duties of a fire watch. The fire watcher shall have hands-on training in the use of portable fire extinguishers.

Fissionable Materials: Materials that are capable of being induced to undergo nuclear fission by slow neutrons.

Flame Spread Rating: A relative measurement of the surface burning characteristics of building materials when tested in accordance with NFPA 255.

Flammable Liquid: A liquid that has a closed-cup flash point that is below 100 degrees Fahrenheit (37.8 degrees Celsius) and a maximum vapor pressure of 40 pounds per square inch absolute (psia) (2,069 Torr) at 100 degrees Fahrenheit (37.8 degrees Celsius).

Hot Work: Any temporary operation involving open flames or producing heat or sparks, including brazing, cutting, grinding, soldering, arc or gas welding, plasma welding, or torch-applied roofing. Cutting and grinding classified as hot work is limited to operations that produce significant sources of heat or spraying sparks such that they are considered ignition sources to surrounding combustible materials.

Hot Work Permit: A daily or weekly authorization document provided by the fire department for performing hot work outside of an established permissible welding area.

Limited-Combustible: A building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3,500 Btu/lb (8,141 kJ/kg) where tested in accordance with NFPA 259 and complies with (a) or (b) below. Materials subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible. (a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 inch (3.2 millimeters) that has a flame spread index not greater than 50. (b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion.

Mass Notification System: A system that provides real-time information to all building occupants or personnel in the immediate vicinity of the building during emergency situations.

Maximum Credible Fire Loss (MCFL): A worst case fire scenario in which all installed fire protection features operate as designed.

Maximum Possible Fire Loss (MPFL): A worst case fire scenario in which all fire protection features are not operable and the fire is involved within the entire fire area that is bounded by not less than 3-hour fire barrier walls.

Noncombustible: Not capable of supporting combustion.

National Consensus Standards: Standards, such as those by NFPA, that are consensus by preparation and approval, based on a very specific set of regulations. Generally these standards are only mandatory when adopted.

National Nuclear Security Agency (NNSA): A unit within the DOE that has overall responsibility for the DOE’s nuclear weapon programs.

Nationally Recognized Testing Laboratory (NRTL): A laboratory that provides fire testing and labeling services to list or approve products. Generally such laboratories are certified by a national laboratory certification agency.

Occupancy: The purpose for which a building or portion thereof is used or intended to be used.

Radiation: The emission and propagation of energy through matter or space by means of electromagnetic disturbances that display both wave-like and particle-like behavior.

Radioactivity: The spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation.

Redundant Component, System, or Subsystem: A component, system, or subsystem that independently duplicates the essential function of another component, system, or subsystem.

Self-Contained Breathing Apparatus (SCBA): An approved device that provides the user with a safe supply of breathing area via a compressed air cylinder, positive pressure regulator, and full face mask. The air supply is generally 30 to 45 minutes.

Through-Penetration Firestop: A tested, fire-rated construction consisting of the materials that fill the openings through the wall or floor around penetrating items such as cables, cable trays, conduits, ducts, and pipes and their means of support to prevent the spread of fire.

APPENDIX A

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APPENDIX B

GUIDELINES FOR POTENTIALLY SURVIVABLE FIRE PROTECTION SYSTEM ARCHITECTURES

B-1 INTRODUCTION

This attachment defines a spectrum of facility-related requirements for nuclear weapons-capable maintenance and storage facilities. These requirements include, but are not limited to, requirements for design, construction, and maintenance. There are relatively few of these facilities and since they have unique design features, national consensus standards are either not available or are not applicable to these facilities.

The principles of fire safety required for nuclear weapons-capable maintenance and storage facilities documented in this attachment were developed by collecting and refining criteria from the DOD, fire protection and munitions safety experts, and national consensus fire safety standards. The attachment requires that an approved fire detection system and suppression system (e.g., automatic sprinkler system, water mist system, or foam-water system) be installed in all areas of the facility unless shown to be unnecessary in the FHA. The automatic sprinkler system must be designed and installed in accordance with NFPA 13 and UFC 3-600-01.

Water-based fire suppression systems are required to be hardened against possible internal or external damage. This appendix describes different approaches to increase the survivability of a required suppression system, and increase the capabilities of a suppression system in a damaged area. Less conventional, alternative survivable systems for meeting the attachment's hardening requirements are also described.

B-2 OBJECTIVE

The objective of these guidelines is to identify potential approaches to increase the survivability of required water-based fire suppression systems and to identify other, potentially more survivable systems for weapons storage facilities.

B-3 FACILITY TYPES AND DESCRIPTIONS

B-3.1 Facility Types

Three types of nuclear weapons-capable maintenance and storage facilities are discussed in this attachment: ECMs, industrial facilities, and underground facilities. ECMs and underground storage areas are used primarily for storage of various munitions. These facilities typically consist of a large, open area with little, if any, floor-to-ceiling compartmentalization. Industrial facilities and parts of underground storage are used for such activities as inspection, maintenance, and testing of munitions. These facilities consist of separated use areas, including administration portions (office spaces), maintenance bays, and mechanical rooms.

B-3.2 Compartmented Areas

Facilities capable of storing nuclear weapons and components must be subdivided into separate fire areas to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat, radioactive contamination, and to aid in firefighting activities. Fire area boundaries must be provided to separate contiguous buildings or portions thereof serving different purposes, such as storage, maintenance, service, administration, and other occupancy areas as dictated by the facility design.

B-3.3 Open Areas

ECMs and underground storage areas typically consist of a limited number of large weapon storage areas. These areas can potentially have relatively large footprints.

B-4 PERFORMANCE OBJECTIVES

The system can be designed to meet three performance objectives:

1. Maintaining capabilities of the system in undamaged areas.
2. Containing the fire to the damaged area.
3. Controlling or suppressing the fire in the damaged area.

Section B-5 identifies approaches and techniques to configure the system to meet some or all of these objectives.

B-5 SURVIVABLE ARCHITECTURES

The performance objectives of the system will dictate the required architecture. The systems with the greatest capabilities would be the most complex and expensive. Conversely, systems with reduced capabilities would be the simplest and most economical to design and install. The approaches addressed in this section progress from simple to more complex (i.e., in the order of the performance objectives listed in paragraph B-4).

B-5.1 Architectures for Maintaining Capabilities in Undamaged Areas

To maintain the capabilities in the undamaged areas, the system must be segregated into fire zones (referred to in this attachment as fire areas). At a minimum, a reliable water supply must be provided. Also, rupture isolation for installed agent piping must be provided. This can be accomplished using flow control valves located within each fire zone boundary.

B-5.1.1 Simplest Approach

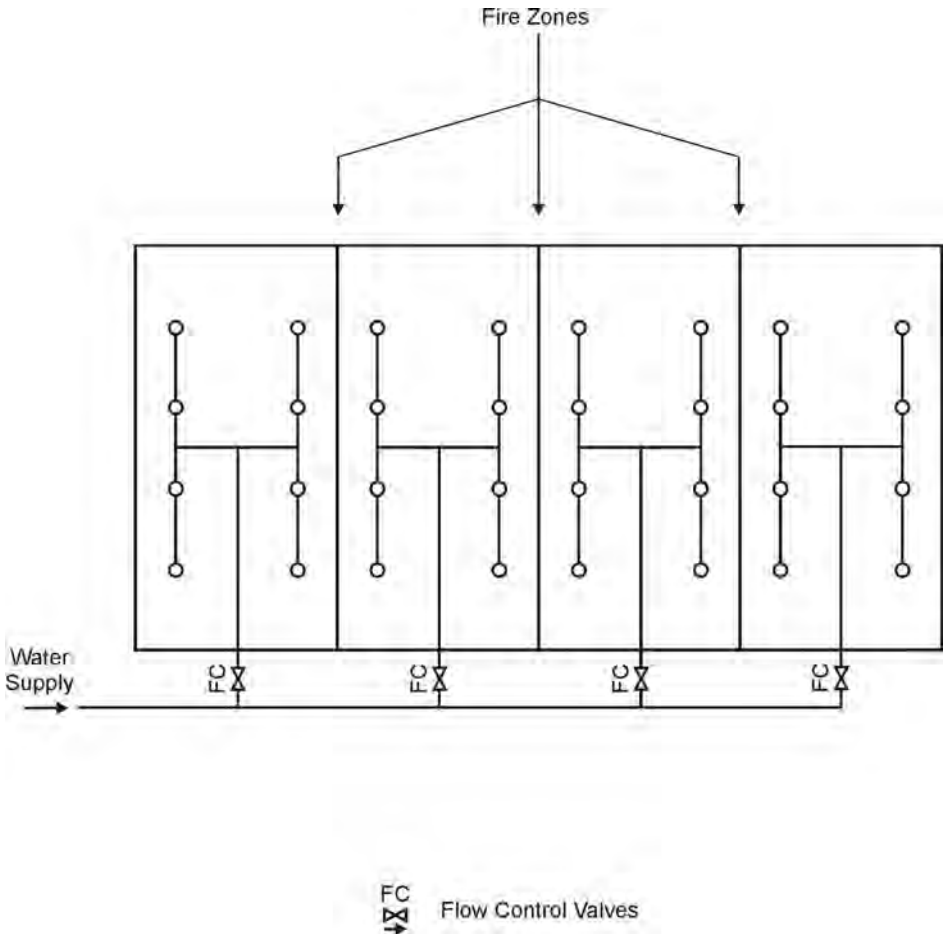
The simplest approach is to install the distribution main and control valves for each zone at a survivable location. These are potentially survivable locations:

- Low in the facility at the junction between the wall and the floor (baseboard)
- Any area that runs the length of the facility that is outside of the potential damage area from the initiating event

Installing the main in the concrete floor slab or even below grade just outside the building may also be options.

Figure B-1 shows a single survivable distribution main located outside of the facility supplied from one end with only a single control valve for each fire zone. Rupture isolation is provided by the control valves for each zone. This approach is adequate only if the distribution main and control valves are outside the damaged area.

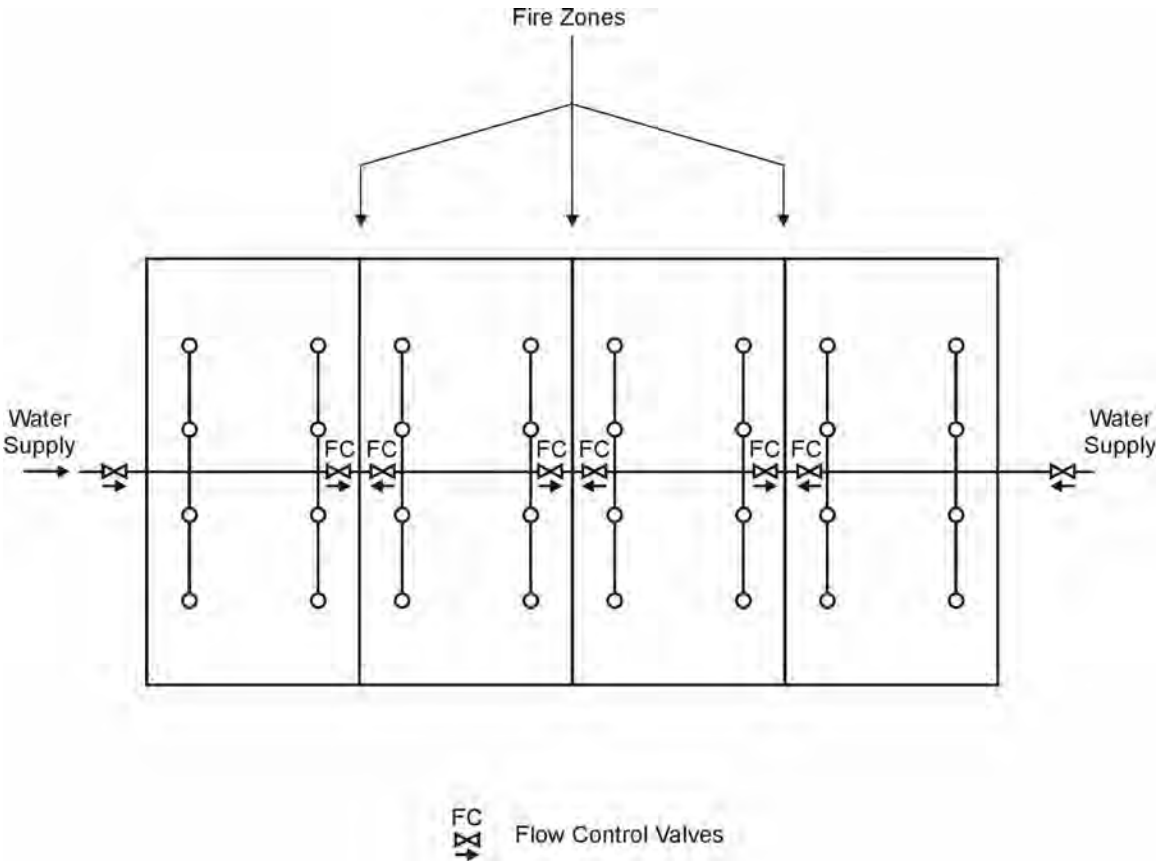
Figure B-1. Survivable Distribution Main Architecture



B-5.1.2 **Alternate Approach**

A second approach would be to provide redundant water supplies that enter from opposite ends of the facility. These supplies would feed into opposite ends of a distributed fire main supplying all of the fire suppression systems in the facility. Figure B-2 shows a single distribution main supplied from opposite ends of the building with control valves located on both sides of each fire zone boundary.

Figure B-2. Basic Survivable Architecture



B-5.1.2.1 **Flow Control Valves**

These flow control valves can be either manually operated or automatic. Manually operated flow control valves are the simplest and the easiest to install, but require a manned response for the system to operate properly. Automatic valves have the advantage of not requiring a manned response but are more expensive. Automatic valves can be either self contained mechanical or electrical valves (referred to as excess flow valves).

B-5.1.2.2 **Excess Flow Valves**

Excess flow valves automatically close if the flow through the system exceeds a preset value. The simplest type of excess flow valve is a mechanical valve (a spring-loaded piston or flapper) that is pushed closed by the friction produced by the higher flow rates. Electrical excess flow valves (sometimes referred to as smart valves) are equipped with either flow or pressure sensors that are used to assess the flow condition through the valve and automatically secure the valve if the preset value is exceeded. These valves are expensive and require power to be run to each valve. A backup power supply (i.e., battery) may also be required depending on the reliability of the primary power supply. These valves are not standard fire protection system components and have been developed and tested by the U.S. Navy as well as the petroleum industry.

B-5.1.2.3 **Fully Automated System**

A fully automated system is the most complex and expensive. This system consists of electrical valves operated by a separate computerized control system. In addition to the control valves, the pipe network must be instrumented to provide information to the control system. An industrial flow control system used in processing-type facilities could be adapted for this application. In addition, many of the commercially available fire detection and alarm panels can be programmed to control a simple automated system.

B-5.2 **Architectures for Containing and Combating Fire in the Damaged Area**

Maintaining the capabilities of the system in the undamaged zones is the first step in containing the fire to the damaged area. The surviving parts of the system in the undamaged area may not prevent the fire from spreading into the undamaged areas. Specifically, the surviving adjacent zones may not activate until fire has spread into that area.

As currently designed, the adjacent zones have no capabilities against the fire in the damaged area. To obtain these capabilities (containment or suppression of the fire in the damaged area), the system would need to be modified to include additional nozzles, or a new or different system would need to be considered.

B-5.2.1 **Detection and Control System**

Modifying the existing sprinkler system or selecting a new system for this application would result in a more sophisticated and complex system than the conventional sprinkler systems commonly in use. Specifically, the modified or new systems would need to be controlled by a separate detection and control system. This is required since the added component or new system used to combat the fire in the damaged area must be located away from the damage. The fire detection system required in CHAPTER 11 of this attachment could be used to control this more sophisticated system, minimizing the cost to obtain these additional capabilities. All of the architectures and systems discussed in the following sections would incorporate the required fire detection system to control the fire suppression system.

B-5.2.2 **Applicability**

The discussion in sections B-5.2.3 through B-5.2.5 applies only to open areas within the facility. Compartmented areas (office-type spaces, shops, and services areas) are difficult to protect from adjacent zones. This is normally acceptable since the open storage areas are a primary hazard of concern.

As a final point, a conventional automatic sprinkler system may not be the best choice for protecting large, open spaces. Namely, larger fires are required to activate the automatic sprinkler system in open storage areas. This may justify the need for a more sensitive detection system that could be used to control the fire suppression system.

The following sections identify two approaches that can be used to increase the capabilities of the required automatic sprinkler system against a damage scenario. Both require modification of the required system. Completely new systems are discussed in section B-5.4.

B-5.2.3 **Approach 1: Switch to Deluge Sprinkling**

Since larger fires are typically required to activate automatic sprinklers in large, open areas, deluge sprinkling may be a better option than thermally activated heads.

B-5.2.3.1 **System Activation**

The detection system installed in the space would be used to activate the system. The activation criteria (for the undamaged system) can be selected based on the ambient conditions in the facility and the nature of the hazard. For example, a default can be to activate the system using 135 degrees Fahrenheit (57 degrees Celsius) intrinsically safe heat detectors. If a more sensitive detection system is required, cross zoned smoke detectors are an option.

B-5.2.3.2 **Adjacent Zones**

The system can be programmed to automatically discharge water in the zones adjacent to the damaged area. This will help prevent fire spread into these zones or areas by pre-wetting any combustible materials located in these areas.

B-5.2.3.3 **Flow Rates**

Electrical excess flow valves would need to be used for this application (controlled by the detection system) due to the higher flow rates associated with the deluge sprinkling zones. The flow rates of a deluge sprinkling zone may be similar to a damaged system in many scenarios.

B-5.2.4 **Approach 2: Add Nozzles or Monitors to the Existing System**

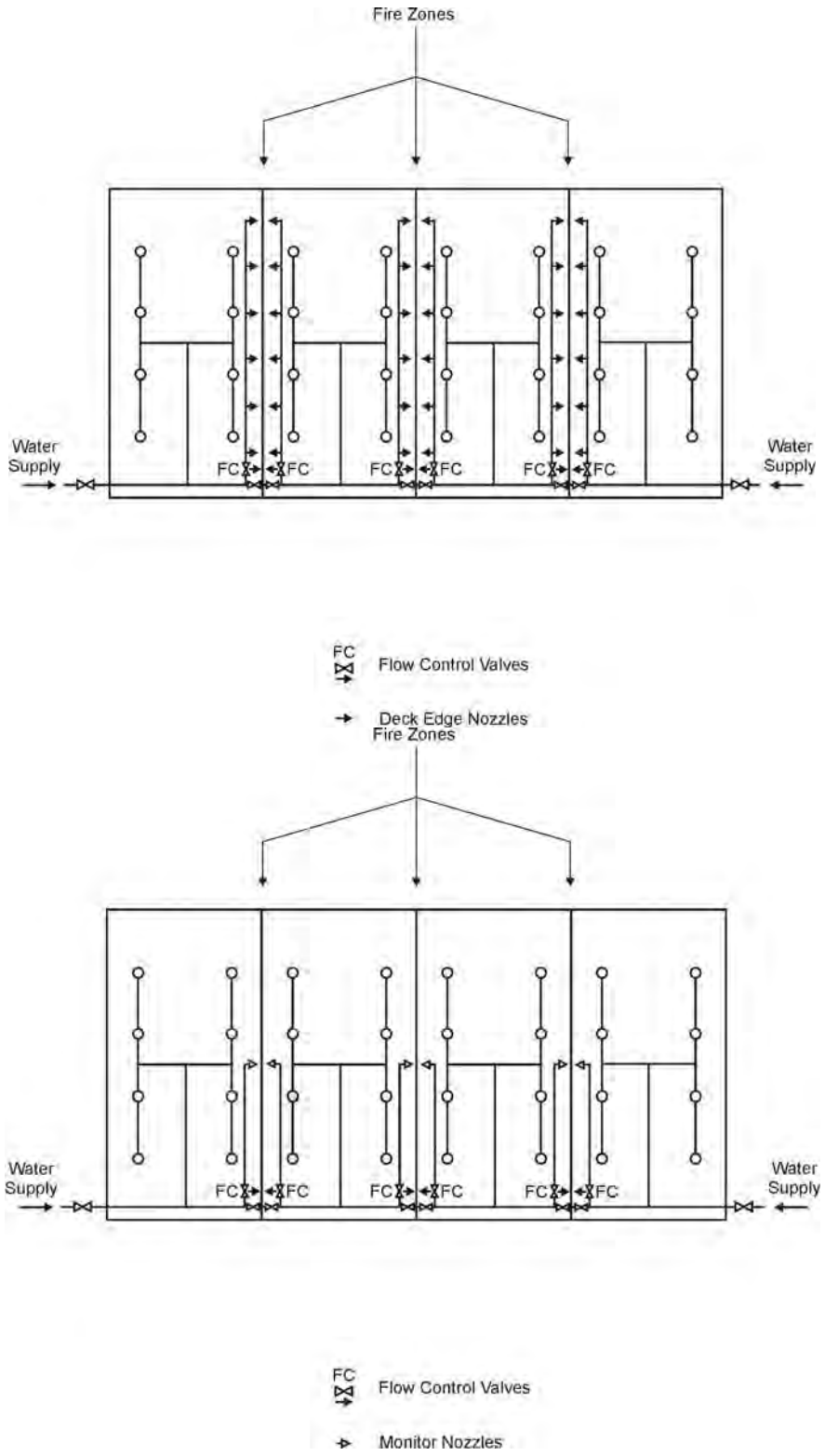
To combat the fire in the damaged area, additional nozzles or monitors would need to be added to the system. These nozzles or monitors would be installed high in the adjacent zones, spraying into the damaged area or zone. If the damaged area or zone is separated from the adjacent zone by a wall, the nozzles or monitors can be installed in the boundary to spray into the damaged area. Acceptability of penetrating the zone boundary must be considered since this is a violation of fundamental zone integrity criteria (i.e., zones are not normally penetrated).

The simplest approach would be to add a line of nozzles on both sides of each fire zone boundary, spraying into the adjacent zone. An approved “deck edge”-type system (the nozzle arrangements used to protect the flight decks of U.S. Navy surface combatants but installed high in the space) is recommended for this application. Another approach would be to provide one or more 125 gallons per minute (473 liters per minute) monitors (depending on the size of the fire zone) on both sides of each fire zone boundary, spraying into the adjacent zone. The monitors must be located at a place that is least likely to be obstructed by the contents in the space. A drawing of the two approaches is provided in Figure B-3.

The branch line containing the supplemental nozzles or monitors would be equipped with an electrically operated valve controlled by the installed fire detection system. The system can be programmed to automatically discharge water into the damaged zone if any or all of the detectors in that zone are reported as damaged (each detector is in

FAULT). This approach provides the potential to combat the fire in the damaged area.

Figure B-3. Systems That Discharge Water in the Damaged Area



B-5.2.5 **Aqueous Film-Forming Foam (AFFF)**

The default for the two systems (nozzles or monitors) would be to discharge water since they are basically add-ons to the automatic sprinkling system; however, water has only limited capabilities against a potential Class B fire. Specifically, the water would have some effect in controlling the fire but would not be able to suppress or extinguish the fire. To suppress or extinguish the fire, the system would need to discharge aqueous film-forming foam (AFFF).

To add the ability to discharge AFFF, proportioning systems would need to be added to both ends of the distributed fire main. The system would be designed to discharge water in the sprinkler mode but would switch to AFFF when the valves to the branch lines containing the additional nozzles or monitors are opened.

The previous two approaches can be used to supplement either the automatic (a system with thermally activated heads) or deluge sprinkler systems.

B-5.3 **Alternative Systems for Containing and Combating Fire in the Damaged Area**

The two systems described in this section could be installed as a substitute for the required automatic sprinkler system. Both systems would incorporate a supply main capable of rupture isolation as described in section B-5.1. Both systems would also be controlled by the fire detection system installed in the space (required in CHAPTER 11 of this attachment or added to control the hardened system). The activation criteria (for the undamaged system) can be selected based on the ambient conditions in the facility and the nature of the hazard. The default can be to activate using 135 degrees Fahrenheit (57 degrees Celsius) intrinsically safe heat detectors. If a more sensitive detection system is required, cross-zoned smoke detectors may be an option. The system would activate when one or a group of detectors are damaged (the detector is in “FAULT”).

B-5.3.1 **Approach 1: Replace the Sprinkler System with Monitors**

One approach would be to replace the required automatic sprinkler system with one consisting solely of monitors. A system produced using monitors has a better chance of being survivable due to the stream reach characteristics of the device (i.e., the monitor can be located away from the damage) and the reduced amount of piping (no overhead nozzle grid). The system will be designed to provide the same application density (water flow rate per unit area) as the automatic sprinkler system that is being replaced. In addition, the system would be sized for the simultaneous discharge of the two largest fire zones. An example of a system with monitors is shown in Figure B-4.

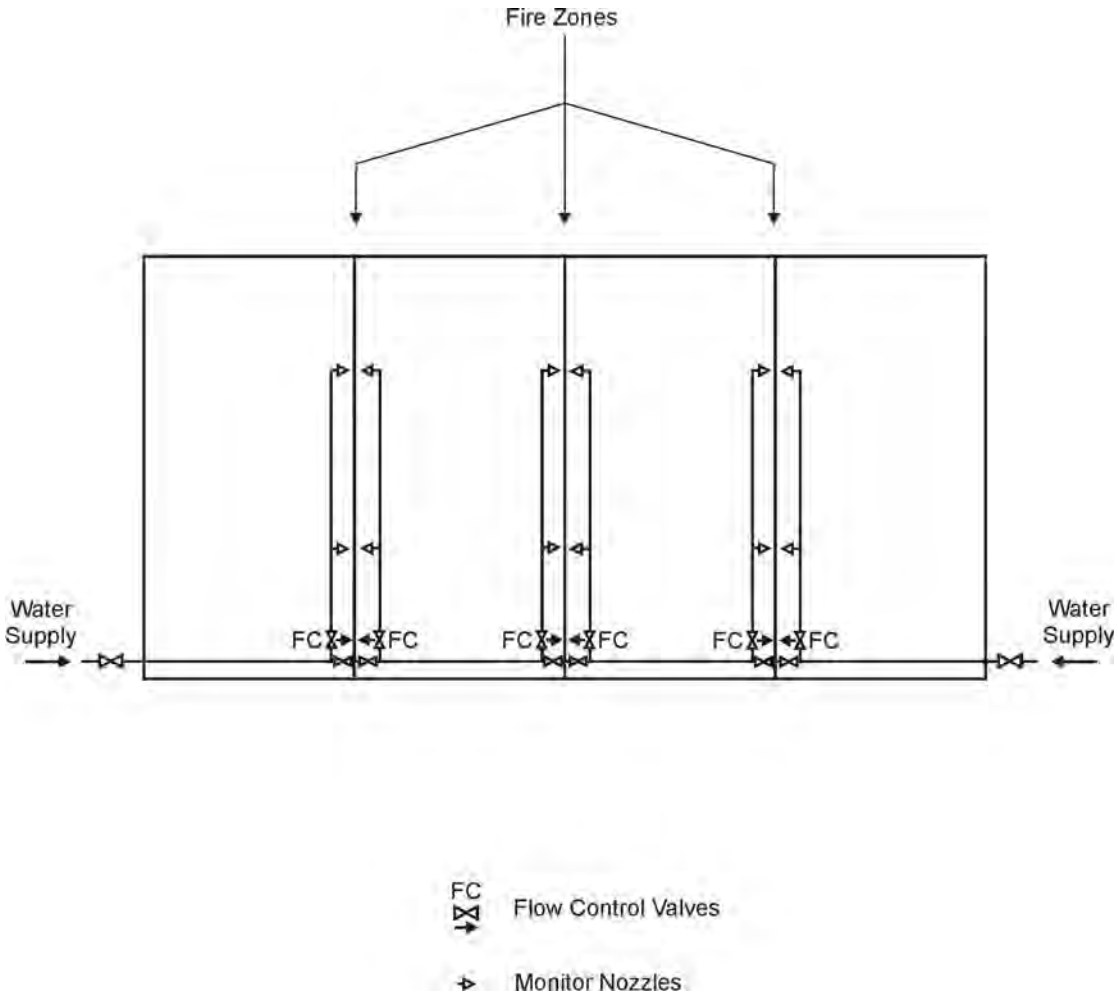
B-5.3.1.1 **Configuration**

As shown in Figure B-4, the monitors are located outside of the zone that they are protecting. If the damaged area or zone is separated from the adjacent zone by a wall, the monitors would be installed in the boundary, spraying into the damaged area.

Each zone contains two monitors (or more depending on the size of the zone) located adjacent to the protected area. This approach can work only if there is an uncluttered

and unobstructed space for the monitors to be installed with direct coverage of the protected area. The branch line containing the monitors would be equipped with an electrically operated valve controlled by the installed fire detection system. The monitors would be set to automatically oscillate through the protected zone (bounded by limit switches).

Figure B-4. System Consisting of Monitors



B-5.3.1.2 **AFFF Capability**

Since water has only limited capabilities against a potential Class B fire, the system would also be capable of discharging AFFF. To add this capability, proportioning systems would need to be added to both ends of the distributed fire main. The system would be designed to discharge water when the detectors go into ALARM but would switch to AFFF when the detectors have been damaged (show a FAULT). This system is a cost-effective option that provides protection against an incipient-type fire as well as more damaging incidents.

B-5.3.1.3 **Disadvantages**

The primary disadvantage of the system is that monitors require more maintenance than a fixed overhead nozzle grid. There is also a greater chance of “false positive” actuations, i.e., operation of the fire suppression system due to a false detection signal.

B-5.3.2 **Approach 2: Replace the Sprinkler System with High-Expansion Foam**

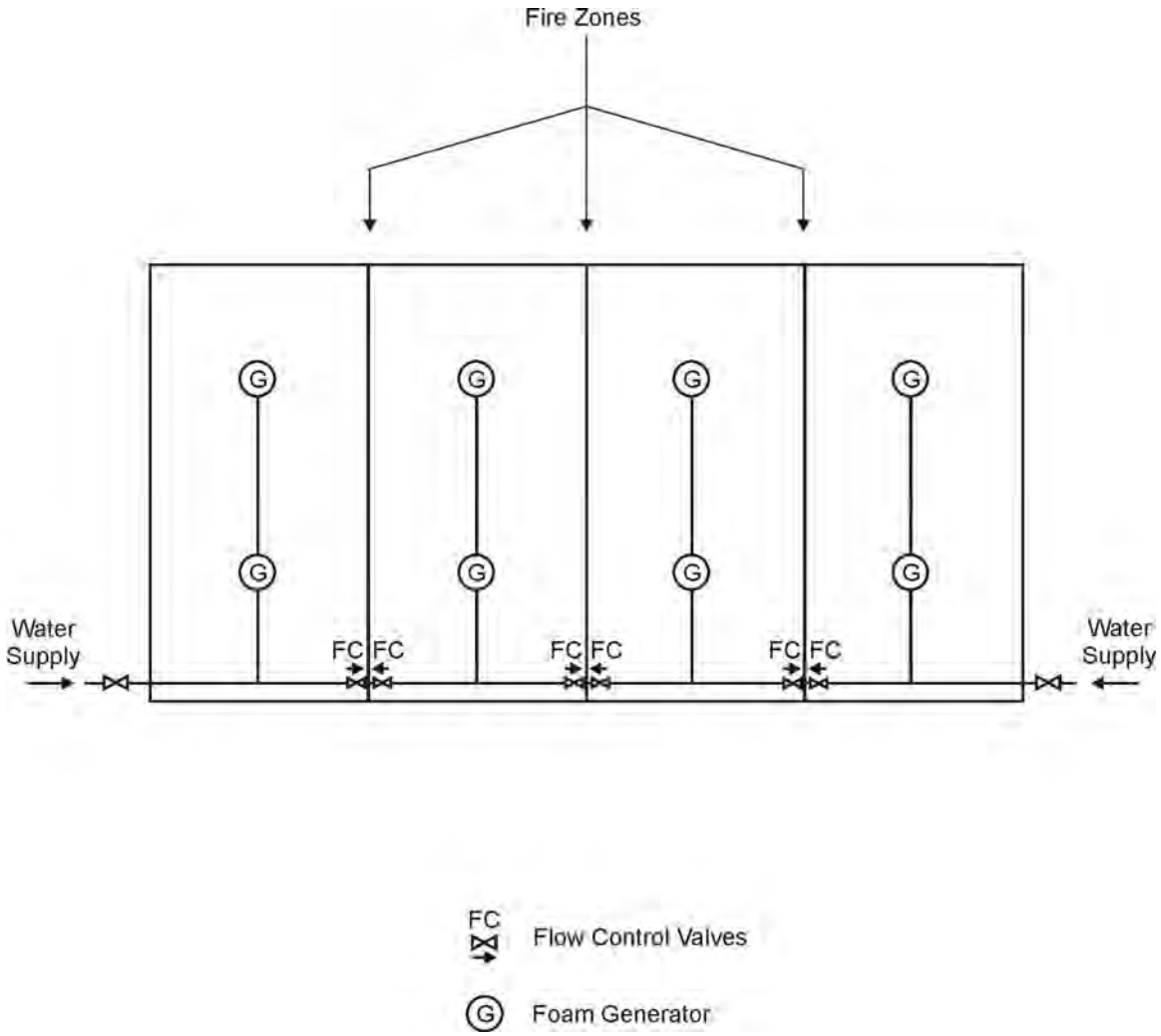
A significantly different approach would be to replace the automatic sprinkler system with a high-expansion foam system. A high-expansion foam system has potentially better capabilities in a damage scenario than an automatic sprinkler system. This is primarily due to the flow characteristics of the foam; i.e., foam would flow from adjacent zones through any penetrations into the damaged area. Another significant advantage of the system is that it has good capabilities against Class B fires. Automatic sprinkler systems have very limited capabilities against Class B fires. The disadvantage of high-expansion foam is that the system needs to be designed to fill the entire enclosure; i.e., high-expansion foam systems can be zoned properly only if the zones are separated by physical barriers to confine the foam in the protected area. Discharging foam throughout the entire area is a major disadvantage for the system during an inadvertent activation or during a smaller, incipient fire scenario (due to clean-up and potential collateral damage issues).

B-5.3.2.1 **Requirements**

The system would be designed to meet the requirements of NFPA 11. For large, open areas or facilities, the system would be designed to uniformly discharge foam throughout the entire area containing the ordnance; however, the system architecture would be designed with zones—but only for rupture isolation purposes because the rupture isolation would allow the undamaged generators in the space to operate properly. For facilities that have fire zones segregated by walls, the system would be designed similar to the system containing monitors, with the foam generators installed in the adjacent zone spraying through the fire zone boundary into the damaged area or zone.

NFPA 11 requires that the system fill the enclosure to a minimum depth of 10 percent above the height of the highest combustible material or 2 feet (0.6 meter) above the highest combustible, whichever is greater. This must occur in a specified maximum time period ranging from 2 to 8 minutes, depending on the type of construction, the presence of an automatic sprinkler system, and the type of materials stored in the space. For this application, it is recommended that the system fill the space to the required depth in less than 2 minutes. The concentrate and water supplies should have a minimum capacity of 15 minutes. An example of a high-expansion foam system for a large, open area or facility is shown in Figure B-5.

Figure B-5. Example High-Expansion Foam System



B-5.3.2.2 **Configuration**

As shown in this figure, the system supply lines or mains are similar to the automatic sprinkler system described in section B-5.1. As with the automatic sprinkler system, the system would be supplied from opposite ends of the facility. A bladder tank proportioning system would be required at both supply points (not shown in the drawing). Rupture isolation is accomplished using flow control valves located on both sides of each fire zone boundary. Mechanical excess flow valves are recommended for this application (most cost-effective and simplest to install).

Due to the simple architecture of the system, only two control valves are required (one at each end of the system). These valves would both be activated by the fire detection system in the event of a fire. Any damaged piping would automatically be isolated and foam would flow from the remaining generators in the space.

B-6 **SUMMARY AND CONCLUSIONS**

The performance objectives of the system will dictate the required architecture. The

systems with the greatest capabilities would be the most complex and expensive. Conversely, systems with reduced capabilities would be the simplest and most economical to design and install.

B-6.1 Simplest Approach

Maintaining the capabilities of the water-based fire suppression system in the undamaged area is the first step in preventing significant fire spread to adjacent areas. The suppression system must be segregated into fire zones (referred to in this attachment as fire areas). A reliable water supply must be provided. The easiest approach is to supply the system with redundant water supplies at opposite ends of the facility. Rupture isolation must also be provided. Rupture isolation can be accomplished using flow control valves located on both sides of each fire zone boundary. Mechanical excess flow valves are recommended for this application because these valves are the most cost-effective and simplest to install.

In this design, the adjacent zones have no capabilities against the fire in the damaged area. To combat the fire in the damaged area, the suppression system would need to be modified to include additional nozzles, or a new or different system would need to be considered.

B-6.2 More Complex Approaches

Modifying the existing sprinkler system or selecting a new system for this application would result in a more sophisticated and complex system than the conventional automatic sprinkler systems commonly in use. Specifically, these modified or new systems would need to be controlled by a separate detection and control system. The fire detection system required in CHAPTER 11 of this attachment can be used to control this more sophisticated system, minimizing the cost to obtain these additional capabilities.

Alternative modifications, such as installing additional nozzles or monitors in the adjacent zones that project into the damaged area, would increase the capabilities of the existing system in the damaged area. A line of nozzles similar to a “deck edge”-type system but installed high in the space could be used for this application. Another approach would be to install monitors that automatically oscillate through the damaged area. The monitors would need to be located at a place that is least likely to be obstructed by the contents in the space for the system to be effective and reliable. For these two systems to be effective against a potential Class B fire, the systems would need to be capable of discharging AFFF.

Two less conventional systems have the capability to combat the ensuing fire in a damage scenario: a system consisting solely of monitors and a high-expansion foam system. Monitors can be located outside the zone they are protecting, allowing the system to maintain some capabilities in the damaged area. To be effective against a potential Class B fire, the system consisting of monitors would need to be capable of discharging AFFF. High-expansion foam has good capabilities against Class B fires and would flow foam into the damaged areas from adjacent zones. High-expansion foam has the disadvantage of needing to fill the entire open area. (High-expansion foam can be zoned only if the protected area is bounded by physical barriers). Either system could be used as a substitute for an automatic sprinkler system.

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