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DOE-STD-1066-2012

December 2012

Supersedes
DOE-STD-1066-99

DOE STANDARD

FIRE PROTECTION



U.S. Department of Energy
Washington, DC 20585

AREA FIRP

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FOREWORD

This Department of Energy (DOE) Standard (STD) supersedes DOE-STD-1066-99¹ and is approved for use by DOE and its contractors. The following fire protection standard is canceled with the issuance of this Standard and appropriate technical content was incorporated into this Standard:

- DOE-STD-1088-95, *Fire Protection for Relocatable Structures*

Furthermore, applicable technical content in the following canceled directives was incorporated into this standard:

- DOE Guide (G) 420.1-3, Implementation Guide for DOE Fire Protection and Emergency Services Programs for Use with DOE O 420.1B, Facility Safety; and,
- DOE G 450-1.4 Implementation Guide: Wildland Fire Management Program for Use with DOE 450.1, *Environmental Protection Program*.

This Standard now serves as the single document for criteria and guidance for fire protection programs supporting implementation of DOE Order (O) 420.1C, *Facility Safety*. Other information supporting DOE's fire protection programs such as, past guidance, models and sample reports is available through the DOE Fire Protection Program website:

<http://www.hss.doe.gov/nuclearsafety/nfsp/fire/>

This Standard was developed because national consensus standards and other design criteria do not comprehensively or, in some cases, adequately address special or unique fire protection issues at DOE facilities. A working group comprised of subject matter experts drawn from DOE, contractors, and industry was used to prepare this Standard. Beneficial comments (recommendations, additions, deletions) and any pertinent data that may improve this document should be sent to:

U.S. Department of Energy
Office of Nuclear Safety (HS-30)
1000 Independence Avenue SW
Washington, DC 20585.

DOE technical standards, such as this Standard, do not establish requirements. However, all or part of the provisions in a DOE standard can become requirements under the following circumstances:

- They are explicitly stated to be requirements in a DOE requirements document; or,
- The organization makes a commitment to meet a standard in: 1) a contract or 2) an implementation plan or program plan of a DOE requirements document.

Throughout this Standard, the word "shall" is used to denote a requirement; the word "should" is used to denote a recommendation; and, the word "may" is used to denote permission, but not a requirement or a recommendation. To satisfy this Standard, all applicable "shall" statements need to be met. Alternate approaches that demonstrate an equivalent level of safety are also acceptable, if approved by the DOE field element.

¹ DOE-STD-1066-99 is available for reference in the Technical Standards Program archive at <http://www.hss.doe.gov/nuclearsafety/techstds/archive.html>

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TABLE OF CONTENTS

| | | |
|-----|----------------------------------------------------------------|----|
| 1 | INTRODUCTION | 1 |
| 1.1 | Purpose | 1 |
| 1.2 | Applicability | 1 |
| 1.3 | Overview of Standard | 2 |
| 1.4 | Referenced Documents | 2 |
| 1.5 | Definitions | 6 |
| 2 | GENERAL FIRE PROTECTION REQUIREMENTS | 10 |
| 2.1 | Fire Protection Policy Statement | 10 |
| 2.2 | Use of National Codes and Standards | 10 |
| 2.3 | Improved Risk Criteria | 11 |
| 3 | FIRE PROTECTION PROGRAM ADMINISTRATION | 12 |
| 3.1 | Documentation | 12 |
| 3.2 | Program Self-Assessments | 12 |
| 4 | FIRE PROTECTION DESIGN | 13 |
| 4.1 | Design Process | 13 |
| 4.2 | General Design Criteria | 13 |
| 4.3 | Process Fire Safety | 18 |
| 4.4 | DOE-Specific Facilities and Systems | 19 |
| 5 | OPERATIONS | 26 |
| 5.1 | Criteria and Procedures | 26 |
| 5.2 | Implementation | 27 |
| 5.3 | Leased Facilities | 29 |
| 5.4 | Transitional Facilities | 30 |
| 6 | EMERGENCY RESPONSE | 31 |
| 6.1 | Baseline Needs Assessment | 31 |
| 6.2 | DOE Fire Department Resources | 32 |
| 6.3 | Pre-Incident Planning | 33 |
| 6.4 | Firefighting Activities Involving Special Considerations | 33 |
| 7 | FACILITY FIRE PROTECTION EVALUATIONS | 34 |
| 7.1 | Fire Hazard Analysis | 34 |
| 7.2 | Facility Fire Protection Assessments | 35 |
| 7.3 | Compensatory Measures | 35 |
| 8 | WILDLAND FIRE MANAGEMENT | 37 |
| 8.1 | Wildland Fire Management Program | 37 |
| 8.2 | Land Management Program | 37 |

| | |
|-----------------------------------------------------------------------------------------------|-----|
| APPENDIX A SAFETY SIGNIFICANT AND SAFETY CLASS FIRE PROTECTION SYSTEM SPECIFICATIONS | A-1 |
| APPENDIX B FIRE HAZARD ANALYSIS | B-1 |
| APPENDIX C RELOCATABLE STRUCTURES | C-1 |
| APPENDIX D TRANSITIONAL FACILITIES | D-1 |
| APPENDIX E SAMPLE QUALIFICATION TEMPLATE FOR LEAD FIRE PROTECTION ENGINEERS | E-1 |
| APPENDIX F EXPLANATORY MATERIAL | F-1 |

1 INTRODUCTION

1.1 Purpose

The purpose of this Standard is to facilitate implementation of requirements in Department of Energy (DOE) Order (O), 420.1C, *Facility Safety*, by providing criteria and guidance for a standard and acceptable approach to meet the DOE O 420.1C requirements for fire protection programs.

This Standard was developed to provide acceptable methods and approaches for meeting DOE fire protection program and design requirements and to address special or unique fire protection issues at DOE facilities that are not comprehensively or adequately addressed in national consensus standards or other design criteria.

1.2 Applicability

The provisions of this Standard apply to the following:

- All departmental elements as identified in the scope of DOE O 420.1C and its respective contractor requirements document (CRD); and,
- The purchase and lease, as well as the design and construction, of all DOE facilities erected, modified, or renovated after the effective date of this Standard whether located on or off a DOE site.

Appendix A of this Standard describes an acceptable approach for implementing the design and operational requirements specified in DOE O 420.1C for new safety significant (SS) and safety class (SC) fire protection systems, specifically, wet pipe automatic sprinklers, water supplies, and fire barrier systems. Appendix A may also apply to situations where DOE decides to modify the safety basis for an existing hazard category 1, 2, or 3 nuclear facility such that an existing fire protection system is reclassified to perform a SC or SS function.

Other Departmental documents contain requirements and guidance pertaining to the protection of personnel and facilities from fire hazards. These include, but are not limited to:

- 10 Code of Federal Regulations (C.F.R.) Part 851, *Worker Safety and Health Program*;
- DOE O 440.1B, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*; and,
- DOE O 151.1C, *Comprehensive Emergency Management System*.

The above documents are available at the DOE Fire Protection website:

<http://www.hss.doe.gov/nuclearsafety/nfsp/fire/> and at the DOE Directives website:
<http://www.directives.doe.gov/>

This Standard may not apply to non-government facilities or to facilities of other agencies on DOE sites where fire protection requirements are enforced by other government agencies.¹ Unless specifically required by a DOE contract, directive, or regulation, provisions of this Standard provide guidance on acceptable methods to meet DOE requirements. Nothing in this Standard is intended to limit the application of other fire protection methods when unique situations or hazards warrant an alternate approach. Any alternate approach should provide a level of safety equal to or greater than that achieved by conformance with this Standard. Such alternate approaches should be documented as required by the authority having jurisdiction (AHJ).

1.3 Overview of Standard

This Standard is structured to be consistent with the organization of DOE O 420.1C as follows:

Section 2, General Fire Protection Requirements

Section 3, Fire Protection Program Administration

Section 4, Fire Protection Design

Section 5, Operations

Section 6, Emergency Response

Section 7, Facility Fire Protection Evaluations

Section 8, Wildland Fire Management

Appendix F provides additional explanatory material, indicated as endnotes throughout the body of the Standard. The other appendices contain detailed criteria and guidance for specific conditions, including criteria and guidance for fire protection systems used in SS and SC applications.

1.4 Referenced Documents

The following documents are referenced in this Standard. This is not a comprehensive list of all codes and standards required by DOE O 420.1C, Attachment 2, Chapter II, *Fire Protection*.

Federal Documents

Public Law 107-217, Title 40, *Public Buildings, Property, and Workers*

10 C.F.R. Part 830, *Nuclear Safety Management*

10 C.F.R. Part 851, *Worker Safety and Health Program*

29 C.F.R. Part 1910, *Occupational Safety and Health Standards*

29 C.F.R. Part 1926, *Safety and Health Regulations for Construction*

DOE Requirements and Guidelines

DOE O 151.1C, *Comprehensive Emergency Management System*

DOE O 231.1B, *Environment, Safety, and Health Reporting*

DOE O 251.1C, *Departmental Directives Program*

DOE O 410.1, *Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements*

DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*

DOE O 420.1C, *Facility Safety*

DOE O 440.1B, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*

DOE O 471.6, *Information Security*

DOE M 251.1-1B, *Departmental Directives Program Manual*

DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Guide for Use with DOE O 420.1C, Facility Safety*

DOE G 423.1-1, *Implementation Guide for Use in Developing Technical Safety Requirements*

DOE Administrative Records Schedule 18, *Security, Emergency Planning, and Safety Records*, September 2010, Revision 2

Department of Energy Technical Standards and Handbooks

DOE-STD-1020-2012, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*

DOE-STD-1137-2007, *Fire Protection Engineering Functional Area Qualification Standard*

DOE-STD-1189-2008, *Integration of Safety into the Design Process*

DOE-STD-3006-2010, *Planning and Conduct of Operational Readiness Reviews*

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*

DOE-STD-3024-2011, *Content of System Design Descriptions*

DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook*

Department of Defense (DoD)

DoD 6055-06-M, *DoD Fire and Emergency Services Certification Programs*

Other Criteria

American Glovebox Society (AGS)

AGS-G006, *Standard of Practice for the Design and Fabrication of Nuclear Application Gloveboxes*

AGS-G010, *Standard of Practice for Glovebox Fire Protection*

American Society of Mechanical Engineers (ASME)

ASME AG-1, *Code on Nuclear Air and Gas Treatment*

ASME B16.3, *Malleable Iron Threaded Fittings: Classes 150 and 300*

ASME, *Boiler and Pressure Vessel Code*

ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*

ASTM International

ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*

ASTM D323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

FM Global Property Loss Prevention Data Sheets

1-22, *Maximum Foreseeable Loss*

1-28R, *Roof Systems*

1-31, *Metal Roof Systems*

3-2, *Water Tanks for Fire Protection*

3-7, *Fire Protection Pumps*

3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances*

5-4, *Transformers*

National Fire Protection Association (NFPA)

NFPA 1, *Fire Code*

NFPA 2, *Hydrogen Technologies Code*

NFPA 10, *Portable Fire Extinguishers*

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam Systems*

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 13, *Standard for the Installation of Sprinkler Systems*

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*

NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*

NFPA 22, *Standard for Water Tanks for Private Fire Protection*

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*

NFPA 51B, *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*

NFPA 58, *Liquefied Petroleum Gas Code*

NFPA 69, *Standard on Explosion Prevention System*

NFPA 70, *National Electric Code®*

NFPA 72, *National Fire Alarm and Signaling Code*

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*

NFPA 86, *Standard for Ovens and Furnaces*

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilation Systems*

NFPA 91, *Standard for Exhaust Systems Conveying Vapors, Gases, Mists and Noncombustible Particulate Solids*

NFPA 101, *Life Safety Code*®

NFPA 101A, *Guide on Alternative Approaches to Life Safety*

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*

NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*

NFPA 400, *Hazardous Materials Code*

NFPA 484, *Standard for Combustible Metals*

NFPA 600, *Standard on Industrial Fire Brigades*

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*

NFPA 750, *Standard on Water Mist Fire Protection Systems*

NFPA 780, *Standard for the Installation of Lightning Protection Systems*

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*

NFPA 901, *Standard Classifications for Incident Reporting and Fire Protection Data*

NFPA 1001, *Standard for Fire Fighter Professional Qualifications*

NFPA 1143, *Standard for Wildland Fire Management*

NFPA 1144, *Standard for Reducing Structural Ignition Hazards from Wildland Fire*

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*

NFPA 1561, *Standard on Emergency Services Incident Management System*

NFPA 1620, *Standard for Pre-Incident Planning*

NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*

NFPA 1901, *Standard for Automotive Fire Apparatus*

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*

NFPA 2010, *Standard for Fixed Aerosol Fire Extinguishing Systems*

Society of Fire Protection Engineers (SFPE)

SFPE Engineering Guide to Performance-Based Fire Protection, 2nd Edition

Underwriters Laboratories (UL)

UL-586, *High-Efficiency, Particulate, Air Filter Units*

UL-790, *Standard Test Methods for Fire Tests of Roof Coverings*

UL-900, *Test Performance of Air Filter Units*

International Code Council (ICC)

International Building Code

International Fire Code

1.5 Definitions

Acceptable – Considered by the authority having jurisdiction as adequate for satisfying the goals, performance objectives, and/or performance criteria.

Alternative – A system, condition, arrangement, material, or equipment submitted to the authority having jurisdiction as a substitute for a criterion in a standard.

Approved – Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction (AHJ) – An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. In DOE, the head of field element is the AHJ, but responsibility can be delegated to another federal official and routine activities can be delegated to a contractor.

Building Code Official – The decision-making authority in matters concerning the building code. The DOE head of field element or designee is the final building code official, unless otherwise directed by the Cognizant Secretarial Officer.

Combustible – Any material that, in the form in which it is used and under the conditions anticipated will ignite and burn, or will add appreciable heat to an ambient fire. See ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

Central Technical Authority (CTA) – Part of DOE line management, CTAs provide centralized technical expertise and operational awareness to ensure adequate and proper implementation and maintenance of nuclear safety policy, requirements, and guidance, and assist the field and headquarters elements in developing line management oversight programs, policies, and processes.²

Critical Process Equipment – Equipment, the condition of which can cause an adverse change in the continued operation of mission-critical equipment as defined by the authority having jurisdiction.

Criticality Incident – The release of energy as a result of an accidental, self-sustained nuclear fission chain reaction.

Documented Safety Analysis – A documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment, including a description of the conditions, safety boundaries, and hazard controls that provide the basis for ensuring safety.

Emergency Response Organization – The site fire department, brigade, or other organization that performs any or all of the following functions: fire suppression; hazardous material (HAZMAT) response; emergency medical services; technical rescue; confined space entry; training; off-site assistance to other emergency response organizations; inspection, testing and maintenance of fire protection equipment or apparatus; facility fire prevention; and, life safety inspections.

Equivalency – An alternative means of providing an equal or greater degree of fire safety than that afforded by strict conformance to prescribed codes and standards.

Exemption – The release from one or more requirements in a directive. Unless specified otherwise in the directive, exemptions are granted, in consultation with the Office of Primary Interest (OPI), by the Program Secretarial Officer, or their designee, or in the case of the National Nuclear Security Administration, by the Administrator or designee, and documented for the OPI in a memorandum. For those directives listed in Attachment 1 of DOE O 410.1, *Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements*, Central Technical Authority concurrences are required prior to the granting of exemptions.³

Fire – Unplanned destructive and uncontrolled burning, including detonation and deflagration, as manifested by any or all of the following: flame, heat, or smoke. Fire does not include the following unless they cause a fire or occur as a consequence of a fire: lightning or electrical discharge; rupture of a pressure vessel not caused by internal combustion; detonation of munitions; or overheating (without damage to initiating material).

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

Fire Brigade – A group of people organized and trained to engage in rescue, fire suppression, and related activities.

Fire Department – An emergency response organization providing rescue, fire suppression, and related activities, including any public, governmental, private, industrial, or military organization engaging in this type of activity.

Fire Loss – The dollar cost of restoring damaged property to its pre-fire condition.⁴

Fire Prevention – The process of managing and regulating potential fire hazards (fuels and heat energy sources) and the mechanisms that bring them together to either eliminate the hazard(s) or reduce the risk associated with the hazard(s).

Fire Protection Assessment – A formal documented review conducted by DOE or contractors, in accordance with DOE requirements, that examines the essential fire protection elements as they relate to a specific facility or an overall fire protection program.

Fire Protection Design Analysis – An engineering analysis during or preceding the preliminary design to establish fire protection design criteria, including applicable national codes and consensus standards.

Fire Protection Engineer (FPE) – A graduate of an accredited engineering curriculum who has completed not less than four years of engineering practice, three of which were in responsible charge of diverse fire protection engineering work. If not such a graduate, an engineer should either: demonstrate knowledge of the principles of fire protection engineering showing evidence by specific academic courses and written examination in the related curriculum of physical, mathematical, and engineering sciences, and have completed not less than six years engineering practice, three of which in responsible charge of diverse fire protection engineering projects, or be a registered professional engineer in fire protection. Federal FPEs under the Department's Federal Technical Capability Program (see DOE O 426.1, *Federal Technical Capability*) are qualified according to DOE STD-1137-2007, *Fire Protection Engineering Functional Area Qualification Standard*.

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 structure, building material, or component under consideration.

Fire Separation – A continuous vertical or horizontal construction assembly designed and constructed with a specified fire resistance rating to limit the spread of fire and restrict the movement of smoke.

Fire Wall – A fire barrier assembly with a fire resistance rating of three test hours or longer, built to permit complete burnout and collapse of the structure on one side without extension of fire through the fire wall or collapse of the fire wall.

Glovebox – A controlled environment work enclosure providing a primary barrier from the work area. The operation is performed through sealed, gloved openings to protect the worker, the ambient environment, and/or the product.

Hazard Category (1, 2, 3) Nuclear Facilities – Hazard category 1, 2, and 3 nuclear facilities as defined in 10 C.F.R. Part 830, *Nuclear Safety Management*, are as follows: hazard category 1 has the potential for significant off-site consequences; hazard category 2 has the potential for significant on-site consequences beyond localized consequences; and, hazard category 3 has the potential for only locally significant consequences.

High Value Equipment – Equipment (such as cranes, pumps, valves, control panels, etc) that has a value exceeding the level of loss established by the authority having jurisdiction, or a one-of-a-kind piece of equipment that cannot readily be replaced.

Limited Supply Suppression System – A system installed in accordance with the applicable National Fire Protection Association standards and having a limited quantity of a suppression agent. These systems typically include carbon dioxide, dry chemical, other gaseous agents, or water.

Listed – Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material or service meets appropriate designated standards or has been tested and found suitable for a specified purpose. This definition applies to products that are Underwriters Laboratories listed, FM Global approved, or certified by another nationally recognized testing laboratory as defined in the Occupational Safety and Health Administration.

Maximum Possible Fire Loss – The value of a building and its contents, excluding land value, within a fire area, unless a fire hazard analysis or a fire protection assessment demonstrates a lesser (or greater) loss potential. This assumes the failure of both automatic fire suppression systems and manual fire-fighting efforts.

Noncombustible – A material that, in the form in which it is used and under the conditions anticipated, will not ignite, support combustion, burn, or release flammable vapors when subjected to fire or heat.

Pre-Incident Plan – A document, owned and developed by a fire department, that provides information to responding personnel that will help them safely and effectively manage incidents with available resources at a specific facility or area.

Pyrophoric Material – A substance capable of self-ignition on short exposure to air under ordinary atmospheric conditions.

Redundant Fire Protection System – A fire protection system that is designed and installed to function in the event of the failure of a primary fire protection system.

Relocatable Structure – Facilities including manufactured structures, mobile homes, trailers, semi-trailers, modular type structures, factory assembled structures, cargo containers, hazardous materials or flammable liquid storage containers, air supported/inflated structures, tent/membrane, and cloth/rib structures. This term does not apply to trailers and cargo containers that are being used in the transportation mode for conveying materials while on-site, or to prefabricated buildings designed for a permanent location. Structures not specifically identified herein should be referred to the authority having jurisdiction for categorization.

Variance – A deviation from 10 C.F.R. Part 851, *Worker Safety and Health Program*. The process for requesting and approving variances from the provisions of 10 C.F.R. Part 851 is delineated in the Rule and in supplemental guidance promulgated by DOE.

2 GENERAL FIRE PROTECTION REQUIREMENTS

DOE O 420.1C requires that a policy be established that affirms the contractors' commitment to provide a comprehensive fire protection and emergency response program.⁵

2.1 Fire Protection Policy Statement

A fire protection policy statement should document the fire protection program's expectations of senior DOE and contractor management. These statements should detail strategies to maintain an awareness of the importance of fire prevention features, such as housekeeping, unobstructed means of egress, and the control of sources of heat. For site emergency response organizations, statements should include strategies to describe the level of service that DOE expects, as well as the level of capability that the contractors intend to provide.⁶ Such policy statements may not conflict with regulatory, DOE, or contractual obligations.

2.2 Use of National Codes and Standards

- 2.2.1 DOE O 420.1C requires that fire protection and emergency response programs meet or exceed the applicable building code and National Fire Protection Association (NFPA) codes and standards.
- 2.2.2 Building code. The acquisition and construction of new facilities and significant modifications of existing facilities shall meet the applicable parts of the latest edition of the *International Building Code* (IBC), NFPA standards, and other nationally recognized consensus standards for electrical, fire, and life safety.⁷ Construction criteria should identify these technical codes and standards that will form a part of the building's code of record and be supplemented by the following:⁸
 - 2.2.2.1 If a DOE O 420.1C allowed alternative to the IBC is selected for use, the AHJ shall coordinate the IBC references in this Standard for that particular site with the acceptable building code alternative.
 - 2.2.2.2 Performance of administrative functions of the building code should be documented by the contractor as required by other DOE orders and not by the administration chapter of the IBC.
 - 2.2.2.3 Hazard category 1, 2, and 3 nuclear facilities should be classified as Group H-4 (high hazard) occupancies unless modified by the AHJ. If sufficient levels of other hazardous materials exist, an alternate classification of Group H occupancy should be used.
 - 2.2.2.4 Buildings that comprise hazard category 1, 2, and 3 nuclear facilities shall be of Type I or Type II construction.
 - 2.2.2.5 The special industrial occupancy exception in the IBC for height and area limits is not appropriate for, and may not be applied to, hazard category 1, 2, and 3 nuclear facilities.⁹
- 2.2.3 National Electric Code. NFPA 70, *National Electric Code*[®], is the applicable NFPA standard for technical electrical requirements.
- 2.2.4 State and Local Codes. State, regional and local codes represent important regional interests and conditions. As such, applicable state, regional, and local building codes should be incorporated as directed by the AHJ.

- 2.2.5 All performance-based design alternatives to any code requirement should use the methodology described in the Society of Fire Protection Engineers (SFPE), *SFPE Engineering Guide to Performance-Based Fire Protection*, 2nd Edition, available through <http://www.sfpe.org/> or other methodologies approved by the AHJ.
- 2.2.6 Conflicts between national codes and standards and DOE-specific safety or security requirements should be resolved by alternate designs that remove the conflict while assuring that an equivalent level of fire protection is maintained.
- 2.2.7 Conflicts between NFPA requirements and the applicable building code requirements shall be resolved by the head of the field element following consultation with designated building code and fire protection subject matter experts.
- 2.2.8 Programmatic Codes and Standards. Technical provisions of subsequent editions of codes or standards (promulgated after the code of record) are mandatory only to the extent that they are explicitly stated to be applicable to existing facilities. Operational provisions of the most recent codes and standards (promulgated after the COR) should be evaluated and implemented to the extent practicable.

2.3 Improved Risk Criteria

This Standard defines the minimum requirements for DOE improved risk level of fire protection and is consistent with the best protected class of industrial risks, commonly referred to as “highly protected risk” or “improved risk”.¹⁰

3 FIRE PROTECTION PROGRAM ADMINISTRATION

3.1 Documentation

- 3.1.1 DOE O 420.1C requires a documented fire protection program (FPP) that includes the elements and requirements identified in Attachment 2, Chapter II of the Order, for design, operations, emergency response, fire analysis and assessments, wildland fire, and specific fire protection program criteria developed, implemented, and maintained by the contractor.
- 3.1.2 The site-wide FPP should document the overall program or management systems established to assign responsibilities and authorities, define policies and requirements, and provide for the performance and assessment of fire protection and emergency response activities.
- 3.1.3 All record retention requirements necessary to support the FPP should be identified and implemented.
- 3.1.4 Section 5.1 of this Standard provides operational criteria and procedures for use in developing the FPP.
- 3.1.5 The site-wide FPP should identify any equivalencies approved to the methods described in this Standard, and identify where the bases for these equivalencies may be found.

3.2 Program Self-Assessments

DOE O 420.1C requires that a documented comprehensive self-assessment of the FPP be performed at least every three years, or at a frequency approved by the AHJ.¹¹ The principal objectives of self-assessments are to verify the adequacy of the site-wide and/or facility fire protection program and identify strengths and weaknesses in fire protection programs.

- 3.2.1 Programmatic self-assessments shall be performed under the supervision of a fire protection engineer (FPE) who may be supported by personnel with an appropriate level of knowledge and experience in the application of fire safety codes and standards in diverse facilities.
- 3.2.2 Self-assessments should, as a minimum, encompass the following FPP elements:¹²
 - Compliance with fire protection-related statutory requirements, DOE orders, and mandatory national consensus codes and standards;
 - Procedures for engineering design and review;
 - Procedures for inspection, testing, and maintenance of installed fire protection systems and features;
 - Fire protection engineering staff (number, qualifications, training);
 - Emergency response organizations, including the Baseline Needs Assessment (BNA), staffing, training, and equipment;
 - Management support;
 - Documented exemptions and equivalencies;
 - Fire protection system impairment process;
 - Hot work process; and,
 - Documentation and record keeping.

4 FIRE PROTECTION DESIGN

This Section applies to new construction and significant facility modifications.

4.1 Design Process

- 4.1.1 As addressed in Section 4.2 of this Standard, for new construction and significant facility modifications, design documents shall include fire protection criteria based on either a fire protection design analysis or fire hazard analysis (FHA)¹³ (see Section 7 and Appendix B of this Standard for guidance on developing these fire protection design documents).
- 4.1.2 To ensure the fire protection requirements are documented and incorporated into plans and specifications, fire protection design criteria shall be developed under the direction of a FPE as early in the conceptual design phase as practicable and should be updated throughout the design process. The technical baseline for fire protection systems shall be maintained throughout the life of the facility.
- 4.1.3 DOE O 420.1C requires that safety be integrated into the design early and throughout the design process for hazard category 1, 2, or 3 nuclear facilities through use of DOE-STD-1189-2008, *Integration of Safety into the Design Process*. This also applies to the design of fire protection systems and components.

4.2 General Design Criteria

Design of new DOE facilities shall be based on the provisions of the applicable requirements of the C.F.R.s, DOE directives, IBC, NFPA and other national codes and consensus standards in effect at the time of commencement of design. Appendix C of this Standard provides guidance for the design of relocatable structures. Leased facilities that are located outside DOE site boundaries should be constructed according to the construction requirements established by the local municipality as augmented by additional DOE life safety and property protection requirements contained in DOE O 420.1C, (see Section 5.3 of this Standard for additional fire protection guidance for leased facilities).

- 4.2.1 When a significant modification to an existing facility occurs, as determined by the AHJ, the current editions of the codes and standards shall apply to the modification.¹⁴
- 4.2.2 The design and construction of DOE facilities should have a level of fire protection sufficient to fulfill the requirements of the best protected class of industrial risks (commonly referred to as "highly protected risk" or "improved risk") and should provide protection to achieve "defense-in-depth." Design requirements contained in FM Global Property Loss Prevention Data Sheets may be used as guidance for design activities and are available at <http://www.fmglobalsdatasheets.com>.
- 4.2.3 DOE O 420.1C requires that multiple fire protection approaches be provided for property protection in areas where the maximum possible fire loss (MPFL) exceeds \$150 million. When multiple fire protection approaches are required for other than nuclear safety (e.g. property protection, mission continuity, etc.), any two of the following are considered satisfactory:¹⁵
 - Automatic suppression systems, such as fire sprinklers, foam, gaseous, explosion suppression, or other specialized extinguishing systems plus appropriate alarms. An adequate extinguishing agent supply, storage, and distribution system is an essential element.

- Automatic fire detection, occupant warning, manual fire alarm, and fire alarm reporting systems (considered together) combined with a sufficiently-staffed, properly-equipped, and adequately-trained fire department or brigade that is able and committed to respond in a timely and effective manner.
- Fire barriers of sufficient ratings.
- For outdoor locations, sufficiently rated fire barriers, or a combination of physical separation and barriers.

4.2.4 Facility Layout and Construction

- 4.2.4.1 Fire Area Determination. Facilities shall be subdivided into separate fire areas as determined by the FHA or other appropriate design documentation. Fire areas can be separated from each other by fire walls, separation from exterior fire exposure, or other approved means.¹⁶
- 4.2.4.2 Fire Barriers. Fire barriers used to separate hazards shall have adequate fire resistance to achieve the intended fire separation including protection of openings and penetrations, and should have a minimum two-hour fire resistance rating (or as required by the IBC or NFPA) or be demonstrated as adequate by documented analysis.
- 4.2.4.3 Structural Materials. DOE O 420.1C requires that new facilities (non-relocatable) exceeding 5,000 sq ft of floor area be of Type I or Type II construction, as defined in the applicable building codes. For hazard category 1, 2, or 3 facilities, structural materials shall be noncombustible.¹⁷
- 4.2.4.4 Roof Covering. Roof coverings shall be Class A per ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, or Underwriters Laboratories (UL) 790, *Standard Test Methods for Fire Tests of Roof Coverings*. Metal deck roof systems shall meet the requirements of Class I construction as defined in FM Global Property Loss Prevention Data Sheets 1-28R, *Roof Systems*, and 1-31, *Metal Roof Systems*.
- 4.2.4.5 Interior Finishes. Interior finishes in hazard category 1, 2, and 3 nuclear facilities and radiological facilities, shall be Class A as defined in NFPA 101, *Life Safety Code*®, and as required by NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.

4.2.5 Building Services

- 4.2.5.1 Ventilation Systems. NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilation Systems*, is the applicable NFPA standard for design and installation of ventilation systems. Ventilation systems that do not recirculate air (e.g., once through systems) do not require shutdown from duct smoke detectors, unless determined by the FHA or other documented analysis, as necessary, to prevent the spread of fire or for emergency management.
- 4.2.5.2 Transformers. Transformers installed inside buildings shall be of a dry type, with no combustible dielectric fluids. Outside transformers shall be located and protected in accordance with FM Global Property Loss Prevention Data Sheet 5-4, *Transformers*.
- 4.2.5.3 Lightning Protection. NFPA 780, *Standard for the Installation of Lightning Protection Systems*, is the applicable NFPA standard for lightning protection. NFPA 780 describes how to determine the need for lightning protection and how to install

and maintain lightning protection when required (see also DOE-STD-1020-2012, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, for additional information on lightning protection).

- 4.2.5.4 Drainage. When high-value property, safety structures systems and components, or critical process equipment is subject to flooding from the discharge of automatic sprinkler systems and/or use of manual hose streams, protection against water damage shall be provided by one or more of the following methods:

- Floor drains;
- Pits, sumps and sump pumps;
- Equipment pedestals; or,
- Other acceptable alternatives.

4.2.6 Life Safety

- 4.2.6.1 10 C.F.R. Part 851 provides requirements for worker safety including life safety from fire. NFPA 101 is the applicable NFPA code for life safety from fire per Appendix A, Section 2 of 10 C.F.R. Part 851. Additional means of egress requirements may be provided within the applicable building code per Appendix A, Section 2 of 10 C.F.R. Part 851; if any conflicts exist, Section 2.2.6 of this Standard addresses resolution. Performance based designs, in accordance with NFPA 101, may be applied to support equivalency requests in which strict compliance is not practical.

- 4.2.6.2 For business occupancies, the methods outlined in NFPA 101A, *Guide on Alternative Approaches to Life Safety*, may be applied to support equivalency requests in which strict compliance with NFPA 101 is not practical.

4.2.7 Fire Protection Systems and Equipment (Note: Appendix A provides further information applicable to new SC and SS fire protection systems for hazard category 1, 2, and 3 nuclear facilities.)

- 4.2.7.1 Water Supply. DOE O 420.1C requires that a reliable and adequate water supply and distribution system be provided for fire suppression, as documented through appropriate analysis.¹⁸ Redundant water supplies (storage and pumping systems) are necessary when either a fire protection water supply system is classified as SC (see Appendix A of this Standard), or when the maximum possible fire loss exceeds \$350 million in any site facility.

- 4.2.7.1.1 Adequacy. The water supply should be designed to meet the following combined demands for a period of not less than two hours: 1) largest single fire suppression system; 2) 500 gallons per minute (gpm) for fire hose streams; and 3) uninterruptable domestic and process demands.

- 4.2.7.1.2 Reliability. The water supply and distribution system should be designed to prevent a single failure from causing the system to fail to meet its demand. Design features should include looped and gridded distribution piping with sectional valves and redundant supplies (pumps and tanks or elevated water sources).

- 4.2.7.2 Tanks. NFPA 22, *Standard for Water Tanks for Private Fire Protection*, is the applicable NFPA standard for design and installation of fire water tanks.¹⁹

- 4.2.7.3 Water Supply Mains. NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, is the applicable NFPA standard for design and installation of water supply mains.²⁰
- 4.2.7.3.1 Facility Fire Protection Water Service. Fire protection water service piping should be run and controlled separately from any domestic or process water piping that enters the facility from a combination of fire and domestic-process water supply source. Fire protection risers and valves should be located as close as practical to the facility's exterior walls. When the system could be affected by contamination in the facility, consideration should be given to locating the riser adjacent to the facility in a separately protected enclosure.
- 4.2.7.3.2 Fire Hydrants. Hydrants should be provided so that they are no closer than 40 feet to the facility and hose runs from hydrants are no more than 300 feet to all exterior portions of the facility. There should be a minimum of two hydrants per building and branch piping between the water main and a hydrant should not be greater than 300 feet.
- 4.2.7.3.3 Listed and/or approved control valves should be installed at maximum intervals of not more than 5,000 feet on long supply lines and at maximum intervals of not more than 1,200 feet on main distribution loops, feeders and all primary branches connected to these lines. Such control valves should also be installed at selected points throughout the distribution system to provide system control over each service area. At intersections of distribution mains, one less control valve than the total number of intersecting mains may be provided. As an aid in determining the minimum number of sectional control valves, the critical nature of the building/facility should be considered, as well as the number of fire and domestic systems affected in a potential line failure.
- 4.2.7.4 Fire Pumps. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, is the applicable NFPA standard for design and installation of fire pumps, including controllers. NFPA 20 requires that pumps be sized so they meet the system demand without exceeding 120 percent of rated capacity.²¹ The system of pumps and drivers should be designed such that loss of primary electrical power will not prevent the system from meeting the design demand. This may be accomplished for general service systems by providing a diesel generator as an auxiliary electrical power source or by providing a diesel-driven fire pump(s).
- 4.2.7.5 Standpipe and Hose Systems. NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, is the applicable NFPA standard for design and installation of standpipes. Standpipes should be installed in all structures having three levels or more above or below grade. Additional standpipes should be provided, as necessary, to protect areas that do not permit the ability to lay hose through simultaneous door openings for extended periods of time because of ventilation, security, or other reasons.
- 4.2.7.6 Automatic Sprinkler Systems. NFPA 13, *Standard for the Installation of Sprinkler Systems*, is the applicable NFPA standard for design and installation of automatic sprinkler systems.²²
- 4.2.7.6.1 Due to the potential for facility occupancy changes or room occupancy changes within the facility, occupancy classification for the sprinkler system should not be less than an Ordinary Hazard Group 1.

- 4.2.7.6.2 Hydraulically designed sprinkler systems shall be designed for a supply pressure of at least 10 percent, but not less than 10 pounds per square inch (psi), below the water supply curve to provide a pressure margin to accommodate minor system modifications or degradation of the water supply and sprinkler systems that may occur over time.
- 4.2.7.6.3 When the building is seismically designed, sway bracing for seismic supports of sprinkler piping shall be based on the site-specific acceleration criteria.
- 4.2.7.7 Water Spray Systems. NFPA 15, *Standard for Standard for Water Spray Fixed Systems for Fire Protection*, is the applicable NFPA standard for water spray systems where provided.
- 4.2.7.8 Special Suppression Systems. When automatic sprinkler or water spray protection systems cannot be safely employed or need to be supplemented, the decision to install another type of fire suppression system should be based on engineering analysis performed by, or under the direction of, a FPE. The analysis should consider, in addition to initial design and installation cost, the long-term cost of inspection, testing, and maintenance (ITM) of the system over its useful life, especially where access for the performance of increased ITM activities may be difficult due to security or radiological concerns.²³
 - 4.2.7.8.1 NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam Systems*, or NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, are the applicable NFPA standards for design and installation of foam systems when provided.
 - 4.2.7.8.2 NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, is the applicable NFPA standard for design and installation of carbon dioxide systems where provided.
 - 4.2.7.8.3 NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, is the applicable NFPA standard for design and installation of dry chemical extinguishing systems where provided. NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, is the applicable NFPA standard for design and installation of wet chemical extinguishing systems where provided.
 - 4.2.7.8.4 NFPA 750, *Standard on Water Mist Fire Protection Systems*, is the applicable NFPA standard for design and installation of water mist fire protection systems where provided.
 - 4.2.7.8.5 NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, is the applicable NFPA standard for design and installation of clean agent fire extinguishing systems where provided.
 - 4.2.7.8.6 NFPA 2010, *Standard for Fixed Aerosol Fire Extinguishing Systems*, is the applicable NFPA standard for design and installation of fixed aerosol fire extinguishing systems where provided.
- 4.2.8 Fire Detection and Alarm Systems

DOE O 420.1C requires a means to notify responders and building occupants in case of fire. As a minimum, a manual notification method, such as telephone, radio, or manual fire alarm boxes, shall be available for all facilities. When required, a fire alarm system shall be provided for DOE facilities to monitor fire suppression and detection systems, to notify occupants, to perform safety functions, and to notify emergency responders.

NFPA 72, *National Fire Alarm and Signaling Code*, is the applicable NFPA standard for design, installation, and maintenance of fire detection and alarm systems.²⁴

- 4.2.8.1 Circuits and Pathways. NFPA 72 is the applicable NFPA standard for design, installation, and performance characteristics of fire alarm system circuits and pathways. As a minimum, all pathways should be designed with Pathway Survivability Level 1, unless a FHA or other appropriate design documentation indicates that a higher survivability level is required.²⁵
 - 4.2.8.1.1 Signaling line circuits (SLCs) that provide communication between local fire alarm control panels (FACPs) and the main or master fire alarm control station or panel should be designed as Class A or Class X. SLCs that provide communication between networked FACPs should be designed as Class A or Class X between each node on the network. SLCs that provide communication between addressable appliances and control panels over which multiple input and output signals are transmitted shall be designed as Class A, B, or X as determined by a FHA or other appropriate design documentation.
 - 4.2.8.1.2 Initiating device circuits and SLCs connecting initiation devices, such as detectors, monitor modules and manual pull stations should be designed, as a minimum, to meet the requirements for Class B.
 - 4.2.8.1.3 Notification appliance circuits connecting notification appliances with the FACP shall be designed, as a minimum, to meet the requirements for Class B.
- 4.2.8.2 Initiation Devices. NFPA 72 is the applicable NFPA standard for the selection, location, and spacing of initiating devices.
- 4.2.8.3 Notification Appliances. NFPA 72 is the applicable NFPA standard for the design and installation of notification appliances. When a public address system or other voice notification is provided and that system is evaluated and approved by the AHJ to be as reliable as the fire alarm system (e.g., backup power supply, circuit and speaker supervision), required fire alarm notification appliances may be reduced or eliminated. NFPA 72 is the applicable NFPA standard for the design and installation of visual alarm devices for all areas accessible to the public and all high ambient noise areas.²⁶

4.3 Process Fire Safety

- 4.3.1 Gases. The following NFPA standards are applicable for the design and installation of storage and distribution systems and sub-systems for flammable and other hazardous compressed gases: NFPA 2, *Hydrogen Technologies Code*; NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*; NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*; NFPA 55, *Compressed Gases and Cryogenic Fluids Code*; NFPA 58, *Liquefied Petroleum Gas Code*; NFPA 400, *Hazardous Materials Code*; and NFPA 801.²⁷
- 4.3.2 Combustible Mists and Vapors. Processes that create or have the potential to create combustible mist and vapors as determined by the FHA shall be designed to monitor for accumulations of vapors and alarm at 25 percent of the lower flammable limit and shall be designed to control the accumulation of combustible residues in adjacent areas and ductwork. (See Section 4.4.3.5 below; NFPA 69, *Standard on Explosion Prevention Systems*; and, NFPA 91, *Standard for Exhaust Systems Conveying Vapors, Gases, Mists and Noncombustible Particulate Solids*).

- 4.3.3 Flammable and Combustible Liquids. NFPA 30, *Flammable and Combustible Liquids Code*, is the applicable NFPA standard for the design of storage and distribution of systems and sub-systems for flammable and combustible liquids.
- 4.3.4 Combustible Dusts. NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, is the applicable NFPA standard for design of facilities that use or create combustible dusts.
- 4.3.5 Combustible Metals. NFPA 484, *Standard for Combustible Metals*, is the applicable NFPA standard, complemented by the applicable FM Global Property Loss Prevention Data Sheets, for the design of facilities that store, use, or process combustible metals. Additional features may be required to address the added hazards associated with radioactive materials that are not addressed in consensus codes and standards.
- 4.3.6 Furnaces. NFPA 86, *Standard for Ovens and Furnaces* is the applicable NFPA standard for the design and installation of furnaces. Process furnaces should be provided with a system for automatically shutting off the gas and purging with inert gas in the event of power failure, loss of coolant water, loss of exhaust ventilation, over temperature, or detection of combustible gas in the vicinity of the furnace.

4.4 DOE-Specific Facilities and Systems

4.4.1 Facilities Containing Radioactive and other Hazardous Materials

- 4.4.1.1 NFPA 801 is the applicable NFPA standard for the design and construction of hazard category 2 and 3 nuclear facilities.²⁸ NFPA standards for nuclear reactors are the appropriate NFPA standards, as applicable, for design and construction of hazard category 1 nuclear facilities.
- 4.4.1.2 Light hazard automatic sprinkler density, according to NFPA 13 is not acceptable.
- 4.4.1.3 If the facility contains surface contamination, or if the fire could result in the release of radioactive material, the fire suppression water shall be contained, monitored, and treated as necessary. The containment system shall be capable of collecting fire suppression water for a minimum of 30 minutes.²⁹
- 4.4.1.4 Additional fire protection features may be determined based on the FHA in concert with the Documented Safety Analysis or other safety basis documentation. (Note: Appendix A provides further information applicable to new SC and SS fire protection systems for hazard category 1, 2, and 3 nuclear facilities.)
- 4.4.1.5 Process confinement systems shall be constructed of non-combustible materials.³⁰
- 4.4.1.6 Storage racks for special nuclear materials shall be of noncombustible construction and designed to securely hold storage containers in place while maintaining structural integrity under both fire and non-fire conditions.
- 4.4.1.7 When required by DOE O 420.1C, the confinement structure surrounding critical areas and their supporting members are to remain standing and continue to act as a confinement structure during anticipated fire conditions including failure of any fire suppression system. Fire resistance of this shell should be attained by an integral part of the structure (concrete slabs, walls, beams, and columns) and not by composite assembly (membrane fireproofing).³¹ Additionally, the structure's fire resistance rating shall be designed for the maximum fire exposure and duration anticipated, but not less than two hours.

4.4.2 Gloveboxes, Hot Cells and Canyons

- 4.4.2.1 Hot cells and canyons shall be constructed of noncombustible or fire-resistive material to prevent fires from spreading into or out of the hot cell or canyon. If oil filled windows are necessary for radiation shielding, they shall be protected with automatic sprinklers in accordance with NFPA 13 criteria for windows or other methods (e.g., fire shutters or other methods supported by fire test evaluation results).
- 4.4.2.2 American Glovebox Society (AGS) Standard AGS-G010, *Standard of Practice for Glovebox Fire Protection*, is the applicable industry standard for the protection of gloveboxes from fire.^{32 33}
- 4.4.2.3 When inerting is used as a substitute for required automatic fire suppression systems, the level of inerting shall be sufficient to prevent ignition of the material(s) present both during normal operations and under potential accident conditions identified in the FHA or safety basis documentation. A safety factor is typically included in establishing the inert gas design concentration to compensate for errors in instrumentation or other conditions that might lead to an increase in oxygen level.³⁴
- 4.4.2.4 NFPA 69 provides acceptable methods for deflagration prevention.

4.4.3 Nuclear Confinement Ventilation System Fire Protection³⁵

Fire protection in or around nuclear confinement ventilation systems in facilities shall be designed to accomplish the following objectives: 1) prevent fires from affecting the operation of the ventilation system; 2) protect the filtration function; and, 3) prevent the release of material that has accumulated on filters.³⁶

- 4.4.3.1 Filter Housing Construction. ASME AG-1, *Code on Nuclear Air and Gas Treatment*, provides requirements for the performance, design, construction, acceptance testing, and quality assurance of high efficiency particulate air (HEPA) filters and other components used in nuclear ventilation exhaust systems. Filter enclosure assemblies shall be of noncombustible construction.³⁷
 - 4.4.3.1.1 When nuclear HEPA filters serve as the final means of effluent cleaning, a minimum of two stages of HEPA filters should be arranged in series in the final filter plenum. In existing HEPA installations, one of the two stages of final HEPA filters may be located upstream from the final filter plenum.
- 4.4.3.2 Location of Final Filter Assembly Ventilation System Equipment. Final filter assemblies and associated duct work and fans should be protected against exposure fires capable of affecting the operation of the filtration system. Filter assemblies and associated fans located inside buildings should be separated from all other parts of the building by two-hour fire-rated construction. Buildings and the room/enclosure around the filter assembly and fans should be provided with appropriate fire protection systems.
 - 4.4.3.2.1 In addition to the two-hour fire separation described above, filter assemblies and associated fans, located on the roof of the buildings they ventilate, should be protected against exposure fires either by fire barriers or spatial separation.
 - 4.4.3.2.2 Separate buildings which house filter plenums should be a minimum of: two-hour fire-rated construction when located less than five feet from an adjacent building; one-hour fire-rated construction when located more than five feet, but not more than 20 feet from an adjacent building; and, unprotected,

noncombustible construction, when greater than 20 feet, provided that no unprotected openings occur in the adjacent building. Filter plenum housings need not be fire-rated or separated from an adjacent building if the adjacent building wall is of minimum two-hour fire-rated construction with no unprotected openings.

- 4.4.3.2.3 Filter plenums located near combustible or flammable liquid storage buildings or tanks should be located not less than 50 feet away from the buildings or tanks and should be housed in minimum two-hour fire-rated construction.
- 4.4.3.2.4 NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, NFPA 90A and the IBC provides guidance on the protection of openings in fire-rated construction.
- 4.4.3.2.5 Fire dampers are not required when ducting penetrates one-hour fire-rated construction. The duct should pass through the wall and extend into the area to be considered. The areas on either side of the wall should be completely protected by automatic sprinklers in order to eliminate the dampers. Transfer grills and other similar openings without ducting should be provided with an approved damper.
- 4.4.3.2.6 Fire dampers in duct work should not be utilized when penetrating the fire-rated construction where the ducting is an integral part of the nuclear air filter system equipment that is required to continuously function as part of the confinement system. Such duct material penetrating fire-rated construction without fire dampers should: be made part of that fire-rated construction by either wrapping, spraying, or enclosing the duct with an approved material, or by other means of separating the duct material from other parts of the building with equivalent required fire-rated construction; or be qualified by an engineering analysis for a two-hour fire-rated exposure to the duct at the penetration location.³⁸
- 4.4.3.3 Walk-in Filter Plenums. Filter plenum enclosures should be used only for ventilation control equipment. The storage and accumulation of combustible materials, as well as combustible and flammable liquids in any quantity, are not permitted. In addition, the storage of spare filters inside the filter plenum is not permitted.
- 4.4.3.4 Electrical Equipment. NFPA 70 is the applicable NFPA standard for design and installation of all electrical equipment located in the enclosure. All electrical wiring located in the enclosure shall be in metal conduit.³⁹
- 4.4.3.5 Combustible Gases or Vapors. When operations or processes involve flammable or combustible liquids that produce combustible gases or vapors, the concentration of the gases or vapors inside the final filter plenum should not exceed 25 percent of their lower flammable limit inside the filter enclosure (see NFPA 69, *Standard on Explosion Prevention Systems*).
- 4.4.3.6 Protection of the final filters plenum from dust and particulate loading should be accomplished by using duct entrance filters or prefilters or a combination of both as follows:
 - 4.4.3.6.1 Gloveboxes, hot cells, and fume hoods connected to containment ventilation systems should be provided with at least moderately efficient (30 to 45 percent atmospheric dust spot efficiency based on ASHRAE 52-76.2 with a minimum efficiency of MERV 8) duct entrance filters.

- 4.4.3.6.2 High efficiency (ASHRAE 52.2 with a minimum efficiency of MERV 12 at least 80 percent atmospheric dust spot efficiency based on ASHRAE 52-76 test method) prefilters should be provided in the ventilation system to protect the final HEPA filters from: 1) particles with diameters larger than 1 or 2 microns; 2) lint; and 3) dust concentrations greater than 10 grains per 1,000 cubic feet (30 cubic meters). High efficiency prefilters not only provide a degree of fire protection to the final HEPA filters but can also extend the operational life of the HEPA filters.
- 4.4.3.6.3 Prefilters that should be located in final filter plenums enclosures should be high efficiency prefilters (at least 80 percent ASHRAE atmospheric dust spot efficiency). These prefilters should be located at least 36 inches (91centimeters) upstream from the final HEPA filters.
- 4.4.3.7 When airborne materials are known to be combustible (such as metal powders), replaceable prefilters should be located as near to the source as possible. Prefilters should not be located where there is an unacceptable radioactive hazard to personnel changing the prefilters.
- 4.4.3.8 Fire screens should be located upstream from the prefilters and final filter plenums.⁴⁰ Duct entrance filters may not require fire screens unless a significant amount of combustible materials are present in the exhaust stream exiting the duct.
- 4.4.3.9 Pyrophoric Metals. When operations or processes involve pyrophoric materials that may subject the final filter enclosure to the pyrophoric particulates, a method to remove the dust particles before reaching the final filters enclosure, such as a prefilter or duct entrance filters should be installed between the source of the material and the final filters.
- 4.4.3.10 Fire Detection. Rate compensated type heat detectors approved for the specified use should be provided in the HEPA filter enclosure serving as the final filter. Such detectors should be of the 190° F (89°C) temperature range, unless operations require higher temperature air flows. Airflow should be considered when determining detector location. Detectors should be arranged to detect a fire in the first stage of HEPA filters. This could require detectors on both the upstream and downstream side of the first stage of HEPA filters.⁴¹ Control units and signaling alarm systems connected to the heat detectors should be listed for their intended purpose. If filter plenum automatic deluge spray systems are actuated by pilot sprinkler heads, heat detectors are not required in the ducting or the filter enclosure, unless specified by the AHJ.
- 4.4.3.10.1 Detection Testing Capability. Detector installations should be engineered and installed so that they can be tested during the life of the detector. Remote testing should be provided for detectors that are not accessible due to unacceptable hazards. One method of providing remote testing is to provide detectors with heating strips or coils that can be energized by a separate control unit. If a line-type heat detection system is used, a heat testing pad should be provided outside the plenum for operability testing of the system.
- 4.4.3.10.2 When high contamination levels do not exist, detectors may be installed so that the detector can be removed from the plenum enclosure and tested externally.
- 4.4.3.11 Temperature Control from Fire Exposure. Filters should be protected from overheating to prevent filter weakening and potential ignition in the event of a fire in the area or the equipment being ventilated. This cooling should be accomplished

by one or more of the following: 1) sufficient cooling with dilution air; or, 2) automatic sprinkler or water spray protection in the filter enclosure inlet duct.⁴² Such cooling equipment is to be treated as a required support system when the ventilation equipment is relied on for nuclear safety purposes (e.g., SC or SS).

- 4.4.3.12 Filter Plugging. HEPA filters serving as final filters should be protected from excessive pressure drops across the filter media from plugging by soot and smoke particles from a fire in the area or equipment. This plugging may be controlled by suppressing the fire and by providing filters upstream of the final HEPA filters.⁴³
- 4.4.3.13 Suppression of Fires in Final HEPA Filters (when HEPA filters serve as the final means of effluent treatment). The provisions of Sections 4.4.3.1 and 4.4.3.11, of this Standard, are intended to prevent HEPA filter media from being ignited. A capability to suppress a fire shall be provided in final HEPA filter plenums, with the primary objective to prevent an unacceptable release of radioactive materials on the filters. This suppression capability may be provided by a manual deluge system or bubble-tight isolation dampers, depending on analysis in the FHA. If the FHA determines that isolation of the assembly described in 4.4.3.14 is insufficient to prevent release (e.g., the filter fire is deemed severe enough to breach the filter assembly enclosure prior to suffocation from isolating any inlet air), sprinkler or water spray protection should be provided as described in the following sections.⁴⁴
- 4.4.3.14 Isolation Dampers. If air tight isolation dampers are provided in the inlet and outlet ducts to prevent the release of radioactive material accumulated on the final filters resulting from a filter fire, these dampers should be able to be operated remotely and from a safe location. Such dampers and associated equipment are to be treated as a required support system when the ventilation equipment is relied on for nuclear safety purposes (e.g., SC or SS). Use of isolation dampers for fire suppression should not be used in facility design unless a redundant filter bank is available to maintain active confinement ventilation.
- 4.4.3.15 Deluge Spray Suppression Systems Location. When required by this Standard, automatic and manual water deluge spray systems should be designed in accordance with the following requirements.⁴⁵
 - 4.4.3.15.1 Automatic deluge spray systems provided upstream of the HEPAs should be designed per the applicable provisions of NFPA 13 and NFPA 15, and as follows:⁴⁶ 1) density - water spray density should be 0.25 gallon per minute (gpm) per sq. ft. over the entire filter area or 1 gpm per 500 cubic feet per minute (cfm) air flow, whichever is greater; 2) sprinkler head type - spray sprinkler heads should be deluge type sprinkler heads; 3) location from prefilters or demisters - the spray pattern of the deluge sprinkler head should be in the form of a downward vertical water curtain approximately 6 inches in front of the prefilter or demister and deluge sprinkler heads should be spaced so that each sprinkler head does not exceed 4 lineal feet of curtain coverage; and 4) activation by detection - a deluge spray sprinkler system should operate upon activation of fire alarm system heat detectors or pilot sprinkler heads, located in either the final ducting or filter plenum housing. Manual activation should be provided as well.
 - 4.4.3.15.2 Manual deluge spray systems provided in the HEPA enclosure should be designed per NFPA 15 and modified as follows: 1) location from filters - spray nozzles should be horizontally directed at the face of the first stage of HEPA filters so that all areas of the first stage filters and framing support system are

wetted; and 2) activation by manual operation - activation should be by manually activating a deluge valve or opening a normally closed outside screw and yoke gate valve. Control devices to activate the spray nozzle deluge valve should be provided in the process operator's control room or other locations accessible to emergency responders. When a deluge valve is utilized, manual activation may be provided at the deluge valve as well.

- 4.4.3.16 **Demister Guidelines.** When automatic deluge spray systems are installed in filter housing enclosures, a means to protect HEPA filters from moisture should be provided, such as a demister installed downstream of the automatic deluge spray sprinkler heads and upstream of the first stage of HEPA filters. When used, demisters should meet the airflow and moisture removal performance requirements found in ASME AG-1, Article FA-4200. Demisters should have a nearly 100 weight percent efficiency for water drops 50 microns and larger. They should have an efficiency greater than 99 weight percent for 1 to 50 microns with air flow velocities of 500 to 600 feet per minute, or at operating air flow velocities with operating water flow deluge spray delivery rate. Demisters should be located as far away as possible from the HEPA filters (a minimum of 36 inches) and approximately 6 inches from the deluge spray sprinkler heads.
- 4.4.3.17 **Water Supply Guidelines.** Water for the deluge spray systems should be provided by two separate water supply connections for reliability (one may be a fire department connection, if acceptable to the AHJ.) Automatic and manual water spray system water supplies should be hydraulically calculated and capable of supplying a simultaneous flow of the automatic and manual water spray systems, as well as the overhead ceiling automatic fire sprinkler systems for the fire area providing air to the plenum for a minimum period of two hours. A minimum two-hour water supply is not required when a limited water supply system, discussed below, is justified and provided for criticality event reasons.
- 4.4.3.18 **Special System Guidelines**
- 4.4.3.18.1 **Water Drains.** Water drains with traps and a means to eliminate drain trap evaporation should be provided in plenum floors to provide liquid run off control. Plenum drains should be piped to either a process waste system or to collection tanks. Process waste systems and collections tanks should be of sufficient capacity to capture all liquid from the water deluge spray systems for the densities and durations required herein. Criticality safety should be observed in all drainage and storage systems when the potential for impacting fissile materials is encountered.
- 4.4.3.18.2 **Limited Water Supply Systems.** Limited water supply systems for the deluge water supply should be permitted when a documented criticality potential exists in the final filter plenum. A documented criticality potential should be provided showing criticality calculations and the total amount of water allowed in the plenum enclosure before a limited water supply system is permitted. Limited water supply can be accomplished by either limited capacity water tanks or system water flow control valves.
- 4.4.3.18.3 **Lighting and Window Viewing Ports.** Lighting should be provided inside the filter plenum in front or between the filter banks in the area where automatic and manual heads and nozzles are located. Such lighting may be provided with an on and off switch provided that the switch is located outside the plenum at an accessible location. Window viewing ports made up of wire glass,

laminated lead safety glass, or fire-rated glass should be provided for viewing inside the filter plenum. The window viewing ports should be provided at each location where fire protection spray system heads and nozzles are located and should be placed in such a way with enough windows so all heads and nozzles are visible from outside the filter plenum.

5 OPERATIONS

5.1 Criteria and Procedures

5.1.1 Site-specific Requirements

Site-specific requirements that form the basis for the FPP shall be documented. Such documentation should address: site size; operation complexity; the need for the protection of the public, workers, and the environment; property value and mission; geography and climate; and, external support facilities available (e.g., emergency response, service contractors).

5.1.2 Staff, Organization, Training, Roles and Responsibilities. Necessary staffing levels, organizational structure, training requirements, and roles and responsibilities necessary to implement the FPP shall be established and documented.

5.1.3 Inspection, Testing, and Maintenance

5.1.3.1 The following NPFA standards are applicable to the inspection, testing, and maintenance (ITM) program for fire protection features, apparatus and equipment: NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, NFPA 72 for fire detection and alarm systems; NFPA 80 for fire doors and dampers; and others containing ITM requirements. Appendix A of this Standard provides ITM requirements for SC and SS fire protection systems.

5.1.3.2 Test results should be reviewed by the FPE, the system engineer or other qualified persons and compared to previous data to determine any adverse trends to system performance or reliability. Adverse trending may indicate the need for equipment repair or replacement, more extensive or frequent testing, or a more detailed evaluation of results to anticipate future conditions.

5.1.3.3 Section 11.4 of DOE Administrative Records Schedule 18, "Security, Emergency Planning and Safety Records" provides the requirements for inspection and test records.⁴⁷ If not specifically addressed in Schedule 18, the records shall be maintained for a minimum of three review cycles, but not less than three years. In addition, responsible authorities should retain records of all ITM procedures for as long as such equipment remains in service.

5.1.4 Use and Storage of Combustible, Flammable, Radioactive and Hazardous Materials

5.1.4.1 The FPP shall identify the baseline standards applied to manage the fire safety risks associated with the use and storage of combustible, flammable, radioactive and other hazardous materials.

5.1.4.2 NFPA 1, *Fire Code*, and NFPA 400 are the applicable NFPA standards for hazardous materials management plans within the FPP. These plans should be supplemented with FM Global Property Loss Prevention Section 7 Data Sheets, as applicable.

5.1.4.3 A combustible control program is a required element for all fire protection programs. Additional features may be required for nuclear, radiological, high-hazard, explosive, and mission-critical facilities.⁴⁸

5.1.4.4 Procedures necessary to implement the established controls shall be developed and documented.

5.1.5 Fire Protection System Impairments

- 5.1.5.1 Procedures shall be developed for assessing the operability of fire protection-related structures, systems, and components and for implementing compensatory measures determined by a FPE, based on the significance of the impairment to the fire protection performance objectives. Appendix A of this Standard provides requirements for SC and SS fire protection system impairments.
- 5.1.5.2 The ITM program includes a fire protection system impairment program, which, at a minimum, should consist of: the process for approving and initiating impairments; tracking of impairments; and, reporting to DOE when impairments exceed DOE field element-established criteria for reporting and recording (e.g., date, location, nature of impairment, corrective action taken, closure date, etc.).⁴⁹

5.1.6 Ignition Source Control

- 5.1.6.1 NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, is the applicable NFPA standard for hot work (e.g., welding, cutting, brazing, grinding).
- 5.1.6.2 NFPA 51B requires control of hot work. Implementation of procedures and controls for hot work at each site shall be under the management and supervision of a qualified permit authorizing individual.
- 5.1.6.3 Controls of other potential ignition sources, such as space heaters, furnaces, ovens open flames, cooking and temporary electrical equipment, and other hot surfaces shall be established when required by site-specific conditions.

5.2 Implementation

5.2.1 Staffing

- 5.2.1.1 DOE O 420.1C requires the contractor to ensure that it has access to qualified, trained fire protection staff (including FPEs, technicians, and fire-fighting personnel) needed to implement the FPP.⁵⁰
- 5.2.1.2 Emergency response training and qualifications shall be based on established industry criteria, such as those promulgated by the NFPA Center for Public Safety Excellence, and as supplemented by DOE fire safety criteria. As an alternative to DOE directives or applicable NFPA standards, emergency services organization officers and personnel may meet the minimum requirements for training and certifications as established in the BNA and approved by the AHJ.⁵¹
- 5.2.1.3 Training and qualifications shall be established for FPEs and fire protection technicians commensurate with their duties. These training qualifications shall include DOE specific fire protection program elements and application of DOE orders that are commensurate with their engineering responsibilities. As a minimum, a FPE shall meet the minimum standards as defined in Section 1.5 of this Standard and fire protection technicians should meet the standards of National Institute for Certification in Engineering Technologies. Appendix E of this Standard provides a sample qualification template for lead FPEs.
- 5.2.1.4 DOE FPEs should maintain qualification per DOE-STD-1137-2007, *Fire Protection Engineering Functional Area Qualification Standard*.

5.2.2 Design Reviews

The design process shall include appropriate reviews by a FPE of plans and specifications, design changes, inspections, acceptance testing, and commissioning of fire protection features. DOE-STD-1189-2008 provides design process requirements for nuclear facility design.

5.2.3 Relief from DOE Directives, Mandatory Codes and Standards, and the Building Code

Field elements and contractors should have a process for the development, review, and approval of variances, exemptions, and equivalencies in accordance with applicable rules, directives, and standards.⁵² Documented requests for relief should be developed by a FPE and submitted through the AHJ or building code official to the appropriate approval authority. Table 5.1 summarizes types of relief for various sources of requirements.

Table 5.1 Requirements Relief Summary

| Source of Requirement | Type of Relief | Concurrence | Approval Authority |
|-----------------------|----------------|-----------------------------------------------------------------|----------------------------------------|
| 10 C.F.R. Part 851 | Variance | HSS | Under Secretary |
| DOE O 420.1C | Exemption | Central Technical Authority (CTA) for nuclear applications only | Program Secretarial Officer |
| DOE O 420.1C | Equivalency | CTA for nuclear applications only | Program Secretarial Officer |
| National Fire Codes | Equivalency | Subject Matter Expert | Field Element Manager |
| Building Code | Alternative | Subject Matter Expert | Field Element Manager |
| DOE-STD-1066-2012 | Alternative | Subject Matter Expert | As designated by Field Element Manager |

Notes:

1. See 10 C.F.R. Part 851 for variances to the Worker Health and Safety Rule.
2. See DOE O 251.1C for exemptions and equivalencies of the requirements to DOE O 420.1C.
3. An exemption from the National Fire Codes or the Building Code requires an exemption from DOE O 420.1C.
4. Variances to 10 C.F.R. Part 851 and exemptions and equivalencies to DOE O 420.1C are typically submitted to the responsible Secretarial Office through the DOE field element, with the DOE field element providing a recommendation for action.
5. DOE O 420.1C requires that any alternate approach to DOE-STD-1066-2012 provides an equivalent level of safety. The DOE field element provides approval of the fire protection program. The site-wide FPP may be used to catalogue where alternate approaches to DOE-STD-1066-2012 are adopted.

5.2.4 Delegated Authority

- 5.2.4.1 DOE O 420.1C assigns the responsibilities for the AHJ to the DOE heads of field elements under advisement of a FPE as the subject matter expert.
- 5.2.4.2 The heads of field elements may designate a contractor as the site's AHJ to act as DOE's representative for routine activities.⁵³ This approval authority does not extend to DOE's approval of exemptions to applicable DOE orders, standards, and mandatory codes and standards such as those promulgated by the NFPA.
- 5.2.4.3 Site delegated AHJ activities shall be documented and available for DOE review.
- 5.2.4.4 DOE shall retain the right to override decisions of the contractor, including the interpretation and application of DOE orders, guides, standards, and mandatory codes and standards.

- 5.2.4.5 For the purposes of enforcing the adopted building code at sites, the head of the DOE field element shall be designated as the Building Code Official. The DOE head of the field element may delegate, to the contractor, responsibility for routine activities, but not the responsibility for approving alternatives to building code requirements.

5.3 Leased Facilities

- 5.3.1 A graded approach should be used in application of fire protection requirements to leased facilities, with emphasis on DOE criteria for personnel safety and protection of DOE programs and property. The graded approach should be applied to each leased facility on a case-by-case basis and may consider the following: 1) facility hazard; 2) DOE liability; 3) mission importance; and 4) remaining facility lifetime. Prior to signing any lease agreement, DOE heads of field elements should implement the actions set forth below.
- 5.3.1.1 Perform a fire protection assessment of the facility to verify the adequacy of life safety and fire protection features of the space, including limiting the loss of government-owned equipment to limits established by DOE and potential mission interruption.
 - 5.3.1.2 Communicate to the owner all fire protection deficiencies within the facility/structure. Closure of deficiencies that potentially impact life safety, and DOE-owned equipment and associated mission objectives shall be tracked until their resolution. Any pre-leasing agreements should describe the process in which fire protection deficiencies within the leased space will be corrected and funded before occupancy (such as installing special extinguishing systems), or after occupancy (such as general maintenance upgrades).
 - 5.3.1.3 As necessary, participate with the local jurisdiction's fire department to develop a pre-incident plan for leased facilities that are physically situated outside DOE site boundaries and are not under the jurisdiction of a site's FPP (i.e., off-site).
 - 5.3.1.4 Participate with the local jurisdiction or building owner on coordination of evacuation exercises for off-site facilities.
 - 5.3.1.5 Define the frequency of DOE/owner-conducted fire protection assessments. In general, the owner would be responsible for off-site lease assessments in accordance with local jurisdictions and the contractor responsible for leased facilities within the jurisdiction of a site's FPP.
 - 5.3.1.6 Specify in the lease agreement the DOE/owner responsibilities for ITM of facility fire protection systems in accordance with local jurisdiction building and fire code requirements. In general, the owner would be responsible for off-site assessments with local jurisdictions and the DOE contractor organization would be responsible for assessments of leased facilities within the jurisdiction of a site's FPP.
 - 5.3.1.7 For off-site facilities, verify that the leased building's hazardous materials control areas, as defined in the local jurisdiction's building code, have been documented. When applicable, the lease agreement should specify the way in which the maximum allowable quantities of hazardous materials will be apportioned to the DOE contractor and to any other tenants in the building. Hazardous materials control for leased facilities under the jurisdiction of a site-wide FPP shall be in accordance with Section 5.1.4 of this Standard.

- 5.3.1.8 Verify that all fire protection assessments and ITM records are accessible to the local AHJ, the facility owner, and DOE contractor.
- 5.3.1.9 Leased facilities should not be used for hazard category 1, 2, or 3 nuclear facilities unless specifically approved by the responsible field element with concurrence from the CTA, and shall meet all construction and operating requirements that a new DOE-owned facility would be required to meet, including the applicable requirements of this Standard.

5.4 Transitional Facilities

- 5.4.1 Transitional facilities are those facilities that have been placed in a safe-shutdown condition and may or may not be maintained, or are undergoing decontamination and decommissioning (D&D) work and ultimately demolition. The need for fire protection features in facilities and structures slated for transition should be governed by the consequences of a fire to the public, workers, and fire-fighters, as well as the potential release of hazardous and radiological materials while the facility is in the transition process. For facilities required by DOE O 420.1C to conduct a FHA, a transitional FHA shall be developed for facilities undergoing transition, including “cold & dark” (see Appendix D of this Standard).

The transitional FHA should address the following:

- Facility construction, including interior finish;
 - Fire protection features, their status, and plans for deactivation;
 - Potential need to restore system to service for D&D;
 - Facility hazards;
 - The removal of combustibles, including flammable or combustible liquids;
 - Periodic monitoring;
 - Appropriate signage showing the status of facility and fire protection systems;
 - Securing the facility from unauthorized entry;
 - Requirements for performance of transitional activities;
 - Maintaining worker safety;
 - Fire department notifications; and,
 - Other pertinent information as necessary.
- 5.4.2 Emergency response organizations responsible for firefighting activities should be informed of transitional planning and should revise pre-incident planning activities as necessary to accommodate the facility transition. When practicable, the emergency response organization should be given access to the facility to review firefighting strategies or to utilize the facility for training activities (see Section 6.4.1 of this Standard and associated endnotes for further information).

6 EMERGENCY RESPONSE

DOE O 420.1C requires contractors to provide emergency response capabilities, as necessary, to meet site needs, as established by the BNA, safety basis documentation, and applicable regulations, codes and standards. A comprehensive, multi-faceted emergency response capability can be achieved in a number of ways. These include: on-site emergency response organizations, such as the fire departments and fire brigades that currently exist at many DOE sites; off-site fire departments; or a combination of both, that can be relied on to meet emergency response objectives. Unless otherwise noted herein, the Department of Defense (DoD) instructions, DoD 6055.06M, *DoD Fire and Emergency Services Certification Programs*, on providing emergency response may be used as a guide to assist in meeting these requirements.

6.1 Baseline Needs Assessment

- 6.1.1 DOE O 420.1C requires the BNA to address facility hazards, response capabilities, response time requirements, staffing levels and training, apparatus and equipment, mutual aid agreements, and procedures.⁵⁴
- 6.1.2 The BNA should address compliance with the governing requirements, codes and standards, and site-specific conditions that are applicable to the emergency response organization.⁵⁵
- 6.1.3 If an on-site fire department or fire brigade will be relied on to provide complete emergency response, the BNA should delineate the full scope of its capabilities including: mission responsibilities; personnel; apparatus; equipment; facilities; programs; and, incident reporting. The BNA should be based on a single emergency event, such as a fire or explosion which includes a casualty requiring medical assistance, however, one additional medical response may be considered.
- 6.1.4 If off-site emergency response organizations (non-DOE) are relied on completely to satisfy the emergency response requirement, the BNA should define the DOE emergency response needs compared to the services available by the off-site organization.⁵⁶
- 6.1.5 If a combination of on-site and off-site emergency services response organizations are relied on, a comprehensive emergency response capability should be demonstrated based on a combination of the efforts described above.⁵⁷
- 6.1.6 The BNA should also include a review of the emergency response organization's activities and permitted practices that may negatively impact response time or result in reduced staffing to site emergency calls.⁵⁸
- 6.1.7 Information related to the site emergency response organization, such as the number of emergency responders, number and types of apparatus, and response time, should be incorporated into the site emergency plans, the FHAs, and the safety basis documentation. These plans establish a minimum level below which compensating safeguards and/or the restriction of hazardous operations should be applied.⁵⁹
- 6.1.8 DOE O 231.1B, *Environment, Safety, and Health Reporting*, provides DOE reporting requirements for emergency responses. Emergency response records should be based on standard fire incident reporting practices, such as the National Fire Incident Reporting System or NFPA 901, *Standard Classifications for Incident Reporting and Fire Protection Data*. Where off-site fire response is provided to a DOE owned or leased facility, such responding organizations should make available to the AHJ all logs or reports completed for the incident in the organization's standard reporting format. If available, the AHJ or

designee should then incorporate this information into the DOE O 231.1B data collection system.

- 6.1.9 The BNA should evaluate other fire and emergency service self-evaluation and improvement activities, such as accreditation through the Commission on Fire Accreditation International or equivalent programs that, at a minimum, contain an evaluation performed by external fire and emergency service personnel and address the categories of Governance and Administration, Assessments and Planning, Goals and Objectives, Programs, Physical Resources, Training, Equipment Resources, and Staffing.

6.2 DOE Fire Department Resources

6.2.1 Fire Stations

- 6.2.1.1 Where new DOE site fire stations are constructed or significantly modified, the provisions of Section 4 of this Standard apply.⁶⁰
- 6.2.1.2 Fire stations should be provided with automatic sprinkler protection, with quick response sprinklers in the sleeping quarters.
- 6.2.1.3 NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, provides applicable requirements for smoke detection and carbon monoxide detection.
- 6.2.1.4 Fire stations should be located so as to minimize response time.⁶¹

6.2.2 Fire Department Apparatus

- 6.2.2.1 DOE O 420.1C requires that emergency response capabilities meet site needs as established by the BNA. This includes determination, documentation, and procurement of fire department apparatus.⁶²
- 6.2.2.2 NFPA 1901, *Standard for Automotive Fire Apparatus*, is the applicable NFPA standard for fire apparatus, with procedures implemented to maintain and eventually replace outdated equipment.
- 6.2.2.3 Reserve apparatus, if utilized, shall be properly maintained and equipped to provide its intended response capabilities if first-line apparatus is out-of-service.⁶³

6.2.3 Fire Department Staffing

- 6.2.3.1 The following NFPA standards and Occupational Safety and Health Administration (OSHA) rules are applicable to determining the minimum number of trained fire-fighters necessary to begin interior structural fire-fighting: NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*; NFPA 1500; 10 C.F.R. Part 1910, Section 1910.156, *Fire Brigades*; and, OSHA two-in-two-out rule.⁶⁴
- 6.2.3.2 The minimum number of personnel required for fire-fighting, hazardous material incidents, specialized rescue, or other related events, shall be based on OSHA two-in-two-out rule, NFPA guidelines, pre-incident fire planning, and the judgment of trained and experienced incident commanders.⁶⁵
- 6.2.3.3 Management and support functions should also be considered when developing staffing needs for an emergency response organization.⁶⁶
- 6.2.3.4 NFPA 600, *Standard on Industrial Fire Brigades*, is the applicable NFPA standard for staffing and operation of fire brigades when provided.

6.2.4 Emergency Communications

- 6.2.4.1 NFPA 1710 requires the establishment of reliable communication systems.
- 6.2.4.2 NFPA 1710 and NFPA 1561, *Standard on Emergency Services Incident Management System*, are the applicable NFPA standards for ensuring emergency radio communications are compatible with other organizations involved with emergency response.

6.2.5 Training Certification and Drills

- 6.2.5.1 29 C.F.R. Part 1910, *Occupational Safety and Health Standards*, 29 C.F.R. Part 1926, *Safety and Health Regulations for Construction*, NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, and other NFPA qualification standards, as appropriate, provide training requirements for emergency responders. DOE O 151.1C, *Comprehensive Emergency Management System*, provides training requirements for site-specific training and familiarization for emergency responders.⁶⁷
- 6.2.5.2 Drills and exercises should be structured to emphasize realistic scenarios and feature standard, as well as special fire department tactical evolutions. Such drills should also be scheduled, as appropriate, during weekends and evening shifts, when normal activities are reduced.
- 6.2.5.3 Adequate facilities should be made available for training consistent with the training requirements identified above.⁶⁸
- 6.2.5.4 Fire-fighters and fire department officers shall be certified under state programs when available, or when such programs are not available through independent certification processes, when approved by the head of the DOE field element.⁶⁹

6.3 Pre-Incident Planning

- 6.3.1 Where DOE on-site emergency response is provided, NFPA 1620, *Standard for Pre-Incident Planning*, is the applicable NFPA standard for development of pre-incident plans, complemented by input from the site fire protection engineering staff, facility subject matter experts, and emergency responders.
- 6.3.2 Pre-incident fire plan documents or comparable electronic versions should be developed in accordance with standard practices within the emergency services community and DOE expectations, as reflected in published guidelines.

6.4 Firefighting Activities Involving Special Considerations

- 6.4.1 Procedures on firefighting activities involving special hazards shall be developed and maintained.⁷⁰ The FHAs and safety basis documentation should reflect firefighting strategies when rapid intervention may not be possible (e.g., moderation controlled areas) and when fixed fire protection systems may no longer be available as in transitional facilities (see Appendix D of this Standard for additional information).⁷¹
- 6.4.2 Fire-fighting procedures should address delays related to security and nuclear concerns.
- 6.4.3 DOE O 471.6, *Information Security*, provides protection and notification requirements for access to classified information by non-cleared individuals during an emergency.

7 FACILITY FIRE PROTECTION EVALUATIONS

7.1 Fire Hazard Analysis

The purpose of a Fire Hazard Analysis (FHA) is to conduct a comprehensive assessment of the risk from fire in a facility to verify that fire safety objectives are met. The FHA may also incorporate facilities, other than buildings, when they are exposed or are integral to the building operations. The FHA usually is broken down by building, but may be further broken down into fire areas. The FHA is also a vital tool for incorporating appropriate fire protection criteria into designs in accordance with DOE-STD-1189-2008, and for demonstrating compliance with DOE orders and standards, building codes requirements, and fire protection standards. A FHA may also be required for facilities other than buildings if the value and hazard warrant.

7.1.1 Building/Facility FHA

- 7.1.1.1 FHAs, using a graded approach, shall be conducted for all hazard category 1, 2, and 3 nuclear facilities, facilities that represent unique fire safety risks, and for new facilities or major modifications to existing facilities with value greater than \$150 million, or when directed by the responsible DOE authority.
- 7.1.1.2 All approved variances, equivalencies and exemptions, along with all supporting information, shall be provided or referenced in the FHA. Documentation of the basis for approved relief shall be reviewed during each FHA update to verify that conditions have not changed and the justifications are still valid.
- 7.1.1.3 The FHA shall be reviewed and updated, as necessary, in conjunction with the annual safety basis documentation updates, or during the Facility Fire Protection Assessment.

7.1.2 Fire Protection Design Analysis

- 7.1.2.1 A Fire Protection Design Analysis should be performed to ensure that fire protection program requirements are documented and incorporated into plans and specifications for new buildings and significant modifications to existing buildings (see Section 4.1.1 of this Standard).
- 7.1.2.2 For hazard category 1, 2, and 3 nuclear facilities, or facilities valued over \$150 million, the fire protection design review should be documented in a Preliminary or Project FHA (PFHA) that can be incorporated into the building FHA after project completion.
- 7.1.2.3 The Fire Protection Design Analysis or PFHA should be of sufficient detail to identify applicable design criteria for meeting the fire safety objectives.

7.1.3 Transitional Fire Hazard Analysis

- 7.1.3.1 A transitional fire hazard analysis shall be prepared when a hazard category 1, 2, or 3 nuclear or other significant facility will be changing from one major operational state to another (such as when transitioning from operational to cold standby or deactivated state, or from a shutdown to operational state) or when directed by the DOE field element.
- 7.1.3.2 A transitional fire hazard analysis should identify the existing fire protection features and programs along with conditions where the feature or program can safely be reduced or eliminated; or, when it should be returned to service.

7.1.4 Detailed criteria and guidance for FHAs is provided in Appendix B of this Standard.

7.2 Facility Fire Protection Assessments

The principal objective of a fire protection assessment is to aid in the improvement of the facility fire protection program. This is accomplished through the identification and correction of deficiencies and the effective communication of lessons learned from the assessment.

7.2.1 DOE O 420.1C provides requirements on the frequency of fire protection assessments.

7.2.2 Facility assessments shall be performed under the supervision of a FPE. Personnel conducting such assessments shall have an appropriate level of knowledge and experience in the application of fire safety codes and standards in diverse facilities.

7.2.3 The scope of assessments should include an evaluation of the following programmatic and physical features:

- Fire protection of SC and SS equipment;
- Life safety considerations;
- Fire protection of critical process equipment or programs;
- Fire protection of high-value property;
- Fire suppression equipment;
- Fire detection and alarm systems and equipment;
- Water runoff;
- Facility fire prevention planning documents (e.g., evacuation plan/fire wardens extinguisher training);
- Emergency response capability, including fire apparatus accessibility to a facility;
- Completeness of FHA, or other documented assessment of fire hazards;
- Fire barrier requirements and integrity;
- Completeness of fire loss potential determination;
- Fire safety training;
- Potential for toxic, biological and /or radiological incident due to fire;
- Status of previous findings and tracking until resolution;
- A review of the input, assumptions, and compensatory measures of equivalencies and exemptions to determine their validity;
- Fire and explosion hazards; and
- Applicable codes and standards.

7.3 Compensatory Measures

7.3.1 When modifications are necessary to correct significant fire safety deficiencies, interim compensatory measures (such as fire watches or fire patrols) shall be provided until the modifications are complete in accordance with the site's fire protection program.⁷² Compensatory measures shall be initiated without delay, commensurate with the finding.

7.3.2 When fire protection features are impaired, compensatory measure shall be put into place to offset the loss or reduction in protection, in accordance with an established impairment program.

- 7.3.3 When compensatory measures are used as administrative controls in an equivalency or exemption request, they shall remain in place and be reviewed annually until the request has been withdrawn or revised.

8 WILDLAND FIRE MANAGEMENT

8.1 Wildland Fire Management Program

DOE O 420.1C requires an integrated site-wide wildland fire management plan, consistent with the Federal Wildland Fire Management Policy, be established and implemented. The following NFPA standards, supplemented by applicable regional codes and standards, are applicable to the development of wildland fire management programs, which include the full range of activities and functions necessary to plan, prepare, and respond to potential fires: NFPA 1143, *Standard for Wildland Fire Management*, and NFPA 1144, *Standard for Reducing Structural Ignition Hazards from Wildfire*.

8.2 Land Management Program

The development and implementation of the Wildland Fire Management Program should be coordinated with site land management planning.

APPENDIX A

SAFETY SIGNIFICANT AND SAFETY CLASS FIRE PROTECTION SYSTEM SPECIFICATIONS

Appendix A of this Standard describes an acceptable approach for implementing the design and operational requirements specified in Department of Energy (DOE) Order (O) 420.1C for new safety significant (SS) and safety class (SC) fire protection systems, specifically, wet pipe automatic sprinklers, water supplies and fire barrier systems. Appendix A may also apply to situations where DOE decides to modify the safety basis for an existing nuclear hazard category 1, 2, or 3 nuclear facility such that an existing fire protection system is reclassified to perform a SC or SS function. Appendix A is not required for existing fire protection systems that have already been classified as SS or SC in hazard category 1, 2, and 3 nuclear facilities.⁷³

- Section A.1 provides general design criteria for any type of fire protection system that is used in SC and SS applications. This information is derived from and essentially repeats requirements and guidance contained in DOE O 420.1C and DOE Guide (G) 420.1-1A, *Nonreactor Nuclear Safety Design Guide for Use with DOE O 420.1C, Facility Safety*.
- Section A.2 describes design and operation criteria for SC and SS wet pipe sprinkler systems.
- Section A.3 describes design and operation criteria for SC and SS water supply systems.
- Section A.4 describes design and operation criteria for SC and SS fire barriers.

This Appendix also includes Attachment A which provides details on typical water supply arrangements.

A.1 General

General design criteria for SC and SS systems specified in DOE O 420.1C, Attachment 2, Chapter I, are applicable to fire protection systems utilized in SC and SS applications along with DOE Standard (STD) 1066-2012, *Fire Protection*.⁷⁴

Designation of a sprinkler system, water supply, fire barrier or other fire protection system as safety-related means this system is essential to protect the public and/or the worker from a fire in a nuclear facility. Designation of a system as SC or SS necessitates a more reliable performance than a general service system provided to meet property or building occupant life safety requirements. To achieve high reliability, DOE O 420.1C requires that applicable National Fire Protection Association (NFPA) standards, building code, as well as highly-protected risk criteria, are to be utilized for all fire protection systems. Design, operation, and testing of safety-related systems should normally exceed these requirements.

A.1.1 System Function and Critical Characteristics

The SC and SS function of the fire protection system is defined in the Documented Safety Analysis (DSA) or other safety basis documentation of the facility (typically in Chapter 4 of the DSA). DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, specifies that Chapter 4 of the DSA documents “the reason for designating the structures, systems and components (SSC) as a SC SSC, followed by specific identification of its preventive or mitigative safety function(s) as determined in the hazard and accident analysis. Safety functions are top-level statements that express the objective of the SSC in a given accident scenario.” DOE-STD-3009-94 also discusses the inclusion of “pertinent

aspects” of the SC and SS system and states that “pertinent aspects are considered to be those that directly relate to the safety function (e.g., diesel generator load capacity, time to load if critical).”

A.1.1.1 In addition to having the “pertinent aspects” of the system in the DSA, it is a good practice to document more detailed information on design or operational criteria critical to proper operation of the safety system. The combination of the pertinent aspects and this additional detailed information are “critical characteristics” of the system.

A.1.1.2 The critical characteristics shall be documented in a configuration-controlled system design document. This information can be included in a system design description document developed in accordance with DOE-STD-3024-2011, *Content of System Design Descriptions*.

A.1.2 Support Systems

Supporting systems shall be identified and included in a configuration-controlled system design document. This can be referenced in a system design description developed in accordance with DOE-STD-3024-2011. (See DOE G 420.1-1A for further information regarding supporting systems.)

A.1.3 Design Criteria

General design criteria for SC and SS systems specified in DOE O 420.1C, Attachment 2, Chapter I, are applicable to fire protection systems utilized in SC and SS applications.

Additionally, DOE O 420.1C, Attachment 2, Chapter II, requires that fire protection for DOE facilities, sites, activities, design, and construction meet, or exceed, applicable building codes and NFPA codes and standards.

DOE-STD-1189-2008, *Integration of Safety into the Design Process*, provides criteria for identifying SC and SS systems and criteria for the seismic design of SSCs, including fire protection systems.

A.1.4 Approach and Process for Preparing Fire System Safety-Related Design

DOE O 420.1C provides applicable requirements for design of SC and SS fire protection systems. DOE G 420.1-1A provides additional implementing guidance. Examples of documents that support the fire protection system design include the Fire Hazard Analysis (FHA), DSA, other safety basis documentation, and design documents identified in DOE-STD-1189-2008 (e.g., preliminary and final hazard assessments, preliminary and final documented safety assessment).⁷⁵

A.2 Wet Pipe Automatic Sprinklers

A.2.1 Safety Function and Critical Characteristics of the Wet Pipe Sprinkler System

A.2.1.1 Safety Function

The SC and SS function of the wet pipe sprinkler system is defined in the DSA of the facility (typically in Chapter 4 of the DSA). This may include information regarding the number, size, and type of fires that the system is designed for, along with any specific considerations that may be required for the system to perform its intended function. For example, automatic water-based fire suppression systems are generally intended to limit fire spread, but not necessarily extinguish it.

If the safety analysis determines that emergency responder actions to complete extinguishment are a part of the SC or SS function, this shall be identified as it could impact the critical characteristics by adding alarm/notification components.

Additionally, documentation shall include conditions under which the sprinkler system is to remain operable to prevent or mitigate analyzed events (e.g., seismic and loss of power events). The NFPA and DOE-STD-1066-2012-related design requirements should also be identified in the system design description.

A.2.1.2 Critical Characteristics

The critical characteristics of the system should include the following, as appropriate:

- Hydraulic performance requirements (e.g., sprinkler density, pressure, flow rate);
- Designs to accommodate the potential for multiple fires when required by the DSA;
- System Construction Materials;
- Components;
- Monitoring features;
- Component design lifetimes and any environmental condition limitations (e.g., corrosive atmosphere, temperature extremes);
- Potential for inadvertent actuation;
- Seismic requirements; and,
- Type and characteristics of sprinklers.

This information may also be included in the system design description.

A.2.2 System Boundary for the Wet Pipe Sprinkler System⁷⁶

- A.2.2.1 The boundary of the SC or SS wet pipe sprinkler system shall be defined in a way that makes clear which components are to be classified within the system. A boundary for sprinklers is typically determined at the system control valve or at the underground lead-in post indicator valve.
- A.2.2.2 All piping should be designed for the maximum expected pressure and design basis accident conditions.
- A.2.2.3 The designer should demonstrate that failure of the piping or components not credited to be SC or SS will not reduce functionality of the credited system.

A.2.3 Support Systems for the Wet Pipe Sprinkler System

Examples of support systems (beyond the water supply system) may include the freeze protection system, alarm devices and associated trim, and pressure monitoring systems. The general criteria in DOE G 420.1-1A specifies that support systems are to be designed, fabricated, erected, and tested to standards and quality requirements commensurate with their importance to safety. The support systems shall be classified as equal or superior to the classified wet pipe sprinkler system, if they are essential to the sprinkler system performing its safety function.

Details supporting implementation of DOE O 420.1C and DOE G 420.1-1A for the freeze protection system, alarm devices and associated trim, and water pressure monitoring system gauges are provided below.

A.2.3.1 Freeze Protection Systems

As a general rule, a sprinkler system will be protected from freezing by the facility's heating system. Isolated areas where sprinklers are subject to freezing during normal operations may require additional protection or methods, such as an anti-freeze loop, additional heating, or monitoring, to prevent freezing or to warn of freezing temperatures. Examples and features are described in Sections A.2.3.1.1 through A.2.3.1.5.

- A.2.3.1.1 When reliance is placed on building heat to prevent sprinkler freezing, the design should address monitoring the building and/or individual areas of the building for the loss of building heat during freezing weather. The monitoring system should be classified at the same level as the sprinkler system.
- A.2.3.1.2 Small or individual areas where sprinklers are subject to freezing during normal operations may rely on one or more of the following freeze protection methods:
- The use of anti-freeze loops or water circulation systems. The freeze protection systems that form an integral part of the sprinkler system (e.g. anti-freeze loop, water recirculation) should be designed, fabricated, erected, and tested to the standards consistent with that provided for the sprinkler system, unless the provisions of A.2.3.1.3 are met; and,
 - Freeze protection using additional heating of the space, additional building insulation, or heat tracing. The additional/alternate freeze protection system should be classified at the same level as the safety sprinkler system, unless the provisions of A.2.3.1.3 are met.
- A.2.3.1.3 In most cases, the freeze protection system will be classified at the same level as the sprinkler system. Examples of appropriate freeze protection systems may include heating the space, heat tracing, building insulation, anti-freeze, and water circulation. However, the freeze protection or building heating system does not need to be classified at the same level as the sprinkler system, provided:
- The loss of the freeze protection or building heating system can be promptly detected by a monitoring system classified at the same level as the sprinkler system; and,
 - An analysis is performed to determine the elapsed time between the loss of freeze protection or building heating system and the potential for sprinkler freezing. Information from the analysis should be used in the development of limiting conditions for operation (LCO) in technical safety requirements (TSRs) that address responses to loss of building or area/room heat during freezing weather.
- A.2.3.1.4 The freeze protection system does not need to be designed to preclude system failure given a single active component failure (even at the SC level) if the facility owner can justify that existing design features and/or controls are adequate to ensure that failure of the freeze protection would provide indication of its inoperability and would not immediately impact operability of the sprinkler

system. For instance, because of system failure alarms and compensatory measures, malfunctions are detected and corrected before the piping freezes. The operability of the freeze protection system should be included as an LCO in the TSRs.

- A.2.3.1.5 Compensatory actions should be specified in the LCO to ensure the operability of the sprinkler system on loss of the freeze protection system during freezing weather.

A.2.3.2 Alarm Devices

Water flow indicating devices and associated trim support the wet pipe sprinkler system by indicating that the system has operated.⁷⁷ A flow alarm is commonly achieved by a water pressure alarm switch that is pressurized when the alarm check valve is unseated long enough to register an alarm. In general, the alarm will alert locally, as well as remotely, to summon emergency responders.

- A.2.3.2.1 These devices do not normally perform a safety function in that this equipment is not required for the sprinkler system to perform its safety function (deliver water to the fire). However, the sprinkler system should be designed to be able to deliver water to the fire at the full volume and pressure required, with failure of these devices in any orientation (i.e., fail open/closed, pipe rupture).

A.2.3.3 Water Pressure Monitoring System

A means to monitor the system water pressure at a constantly attended location should be provided. A water pressure monitoring system (sensors and associated local and/or remote indicating system) may support a wet pipe sprinkler system by providing notification when system water pressure is below minimal allowable levels. This equipment should be classified at the same level as the sprinkler system it supports and should be designed, fabricated, erected, and tested to standard industrial practices supplemented by additional quality assurance (QA) provisions consistent with that provided for the sprinkler system.

A.2.4 Design Criteria for the Wet Pipe Sprinkler System

The following provides a summary of the requirements, criteria, and guidance for new SC and SS wet pipe automatic sprinkler installations. These are in addition to the criteria for sprinkler systems identified in DOE O 420.1C and Section 4 of DOE-STD-1066-2012.

A.2.4.1 Safety Significant Design Criteria for Wet Pipe Sprinkler Systems

In addition to the criteria for general use, the following additional design requirements/guidance is applicable for wet pipe sprinkler systems used in SS applications.

- A.2.4.1.1 The following sprinkler components should not be used:

- On/off sprinklers;
- Mechanical slip fittings; and,
- Cast iron fittings (fittings should be a minimum of malleable iron per American Society of Mechanical Engineers (ASME) B16.3, *Malleable Iron Threaded Fittings: Classes 150 and 300*, when additional fitting strength is required).

- A.2.4.1.2 Strainers should be used for all systems connected to water supplies prone to sediment or debris.
- A.2.4.1.3 Sprinkler piping should be a minimum of schedule 40 steel for pipe six inches or less in diameter and schedule 30 steel for pipe greater than six inches in diameter.
- A.2.4.1.4 Areas should be designed to no less than Ordinary Group 1 requirements, per NFPA 13, *Standard for the Installation of Sprinkler Systems*, and should not exceed 130 square feet (sq. ft.) per sprinkler. For Ordinary Hazard Group 2 and extra hazard occupancies, sprinkler coverage should not exceed 100 sq. ft. per sprinkler. In areas that have multiple small obstructed areas (larger than about 3 ft by 6 ft) and no sprinklers are provided under the obstructions, the sprinkler spacing shall be no greater than 100 sq. ft.⁷⁸
- A.2.4.1.5 The system should be designed to the greater hydraulic demand of either the NFPA 13 design area, or the worst case scenario as identified in the DSA.
- A.2.4.1.6 For Seismic Design Category 3 and higher, a qualified structural engineer should utilize the loads provided by the site seismic design authority in conjunction with NFPA 13 criteria, to design piping and evaluate locations where hangers and earthquake sway bracing are to be installed. The design should be capable of meeting the performance expectations established in the safety basis documentation, (i.e., performing during and after the design basis earthquake when required).
- A.2.4.1.7 Environmental conditions should be defined and documented for sprinkler systems and the system should be designed to remain operable for those events during which they are relied on, as specified in the DSA. Examples include:
- Seismic;
 - Other natural phenomena hazards such as high wind potential, tornadoes, flooding, lightning, low temperature, and humidity;
 - Facility hazards, such as internal flooding, explosions, fire outside the system boundary, missile and vehicle impacts, and corrosive environments;
 - Wildland fire;
 - Physical damage from adjacent equipment and systems (e.g., during a seismic event); and,
 - Water quality.
- A.2.4.1.8 The system should be designed by a professional engineer or a National Institute for Certification in Engineering Technologies Level III or IV technician.
- A.2.4.1.9 Critical components should be identified and spare parts maintained.

A.2.4.1.10 To support appropriate implementation of the site or project QA program relative to fire protection systems, the following topics should be addressed (beyond what is specifically identified in DOE O 420.1C and referenced NFPA codes and standards):

- Document control (documents are stored properly to avoid damage, the responsibility for completeness, maintenance, and distribution is identified, etc.);
- Records of qualification of fire protection staff and control of qualification records;
- Procurement documentation and control of purchased items or services;
- Receipt inspections and verification of quality;
- Identification and control of components (e.g., sprinkler heads) per Requirement 8 of ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*;
- Handling, shipping and storage requirements for components;
- Control of nonconforming items to prevent inadvertent installation or use;
- Commercial grade dedication of components, based on third party testing and production monitoring;
- Records of qualification for installation personnel and control of qualification records;
- Records of qualification for tools and equipment used in preparation of installation hardware (e.g. appropriate gauges and cutters for grooved pipe, welding) and control of qualification records;
- Records of proper use of manufacturer installation instructions (e.g. use of proper sprinkler installation wrenches, proper bolt torque for grooved fittings, valve trim, acceptance testing) and control of qualification records;
- Configuration and design control; and,
- Results of commissioning testing.

A.2.4.1.11 The QA program for wet pipe automatic sprinklers should be audited in different phases (design, construction, and operations) using DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

A.2.4.2 Safety Class Design Criteria for Wet Pipe Sprinkler Systems

In addition to the criteria for general use and SS applications, the following additional design requirements/guidance is applicable for wet pipe sprinkler systems used in SC applications:

A.2.4.2.1 Active features of a sprinkler system shall be designed to preclude a single point failure for SC sprinkler systems, if the component failure results in the system's inability to perform its safety function. Active features of a sprinkler system include the sprinklers themselves, as well as any other installed

component that would exhibit a change in state. The impact of the loss of a single sprinkler head shall be evaluated to ensure that it will not prevent the sprinkler system from performing its safety class function.⁷⁹

- A.2.4.2.2 A minimum of two sprinklers shall be installed in each area being protected if the failure of a single sprinkler head prevents the system from performing its safety objective.
- A.2.4.2.3 Redundancy in the suppression system to provide operational flexibility for inspection, test, and maintenance activities is important for facilities that cannot be readily transitioned to a shutdown mode and, when available, compensatory measures cannot effectively control a design basis fire.⁸⁰

A.2.5 Codes and Standards

The following codes and standards are applicable to the design, installation, operation, and testing of wet pipe sprinkler systems:

- NFPA 13, *Standard for the Installation of Sprinkler Systems*; and,
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

A.2.6 Operability Criteria for Safety Significant and Safety Class Wet Pipe Sprinkler Systems

TSRs and LCOs should be defined (including appropriate action statements that outline compensatory actions to address situations when the system is inoperable). TSR surveillance requirements should be defined using NFPA 25 inspection, testing, and maintenance requirements as a minimum. See DOE G 423.1-1, *Implementation Guide for use in Developing Technical Safety Requirements*, for guidance on the preparation of TSRs.

A.3 Water Supply (See also Section 4.2.7.1 of DOE-STD-1066-2012)

A.3.1 System Function and Critical Characteristics

A.3.1.1 System Function

The SC and SS function of the water supply system is defined in the DSA of the facility (typically in Chapter 4 of the DSA).⁸¹ This may include information regarding the water supply needs (flows and pressures) for the system being supported. Additionally, conditions under which the water supply system is to remain operable to prevent or mitigate analyzed events (e.g., seismic and loss of power events) are documented in the DSA or supporting design documents.

- A.3.1.1.1 Existing safety-related water supply systems meeting the criteria of DOE-STD-1066-2012 may be used to supply a new safety-related sprinkler system, provided the supply system still complies with DOE-STD-1066-2012. This includes considering any additional demands, including the potential for simultaneous demand resulting from common initiating events such as seismic-induced fires.
- A.3.1.1.2 The designer shall assess long term availability and reliability of water supply systems required to support a safety-related suppression system for an enduring mission. Providing a new, appropriately-designed, safety-related water supply system will be expected.

A.3.1.2 Critical Characteristics

The critical characteristics of the system should include the following, as appropriate:

- Hydraulic performance requirements (total demand, supply volume, pressure, flow rate);
- System construction materials;
- Fire pump performance;
- Standby and fire pump startup criteria;
- Availability and reliability requirements;
- Component design lifetimes and any environmental condition limitations;
- Seismic requirements;
- Level of DOE control of the supply system;
- Design for future planned expansion;
- Design to accommodate the potential for multiple fires; and,
- Water supply system arrangement and water source.

This information may also be included in the system design description.

A.3.2 System Boundary for the Water Supply System⁸²

- A.3.2.1 The boundary of the SC and SS water supply system shall be defined such that it is clear which components are SC, SS, and general industry use. The boundary of the SC and SS water supply may start at the water source and include all components necessary to deliver water up to the boundary of the facility safety-related system.
- A.3.2.2 Boundaries between safety and non-safety systems water supply components should be identified, including identification of the means of isolation between the two. System boundaries should be described in a configuration controlled design document. Piping and instrumentation drawings should be developed for each system that clearly delineates system interfaces and points of isolation.
- A.3.2.3 All piping should either be designed for the maximum pressure and DSA conditions, or the design should show that failure of the piping or component not credited to be SC or SS, will not negatively impact the credited portions of the system.
- A.3.2.4 Support systems for the water supply systems shall be identified. Examples of support systems may be public/municipal water supplies, water storage systems, water treatment systems, and electric power systems that supply power to water pumps. Details supporting implementation of DOE O 420.1C (consistent with guidance in DOE G 420.1-1A) for a public water supply, water storage system, water treatment system, and electric power system are provided below.
- A.3.2.5 Water Supply for a Limited Life Facility
- Given the short term nature of some DOE missions (five years or less), some flexibility may be allowed in relying on a non-safety-related water supply system and in establishing system boundaries, provided that the DOE controls and operates the system (although not necessarily by the protected facility management). The

reliability of the existing supply shall be evaluated to ensure it will remain viable over the life of that project. The following topics may be addressed in any evaluation with the results incorporated into safety basis documentation.

- A.3.2.5.1 Reliability. When existing supplies are to be used, they should be evaluated to determine if the piping and water source has sufficient reliability to meet the project needs. Topics to be considered are the failure history, problems identified in operating the system, long term availability of the water source (e.g., pumps, tanks, wells), motive power for pressure maintenance of the system (e.g., electric pumps, diesel pumps, gravity tanks), volume capacity of the storage, delivery capacity of the piping, availability of the supply at the point of use, redundancy of supplies, and redundancy of supply piping. The system should also be capable of fulfilling all of the critical characteristics defined for the system, including multiple demands and the continued operation after a seismic event, if required by the DSA.
- A.3.2.5.2 Operations. Although expecting the existing system to be fully upgraded to a safety-related system may not be reasonable, portions of the system should be operated and maintained to ensure the availability of water on demand to the safety-related system. This would include the portion of the existing supply near the safety-related system and the water source(s) for the supply. Since this equipment may not be under the control of the facility with the safety-related suppression system, procedures and engineered controls should be in place such that management of the facility with the safety-related system will be immediately notified of any planned or accidental off-normal event (e.g., a working fire using water, pipe break, loss of a well, or source) or operation of components within the identified area, the procedures and controls would allow appropriate TSRs or LCOs to be implemented as required by the facility safety basis documents.
 - A.3.2.5.2.1 To determine the extent of the controlled boundary, the water supply should be analyzed to identify the portion of the existing system when any single normal or off-normal event (e.g., closed valve, hydrant flow, periodic high flow process demand, water source not available, pump not available) can reduce the available pressure and flow to the safety system to below minimum requirements. Those portions and components of the existing system should be identified as part of the required boundary for the facility safety-related system. In general, the water supply piping, valves, hydrants, and large process demands located near the facility will need to be controlled. In a gridded supply network, this would typically be the components on the piping adjacent to the facility, as well as many of those on the neighboring loops. The need to control water supply sources will depend on the number and location of the source relative to the facility.
 - A.3.2.5.2.2 Those portions of the water supply system within the identified control boundary should be managed with a combination of procedures and engineered controls to achieve the safety function. Controlled components should be clearly identified by some readily recognizable method (such as locks, tags, seals, color, etc.) alerting operators that, prior to operating the component, the facility with the safety system needs to be notified so appropriate actions can be implemented. Those portions

of the system should also be brought under a configuration management system.

- A.3.2.5.2.3 Those portions of the water supply system within the identified control boundary should be included in enhanced maintenance and testing activities, consistent with requirements for any other safety-related system and clearly documented.
- A.3.2.5.2.4 Any required agreements between the facility management and the organization operating the water supply system to implement the water supply for a limited life facility should be incorporated into contract documents or memorialized in a memorandum of understanding.
- A.3.2.5.2.5 All activities associated with the water supply system should be addressed by the facility safety basis, LCOs, and TSRs, as if the portion of the water supply system within the boundary were part of the facility system.
- A.3.2.5.3 Redundancy. An existing water supply meeting all of the requirements of this Section may be used as one of the redundant supplies for a safety class system, provided the primary supply system is safety class, completely independent and not subject to any common mode failure.

A.3.3 Public Water Supplies

Refer to Attachment A for further discussion on use of various water supply arrangements. Attachment A provides some examples of possible water supply arrangements that are intended to illustrate general requirements of this Appendix. These examples do not necessarily provide all details, and may not describe all possible acceptable arrangements. Information in Attachment A is NOT to be construed as complete in all respects and the requirements of this Appendix, referenced codes, and standards, as well as “highly protected risk” expectations take precedence over any information presented in Attachment A.

- A.3.3.1 If a municipal system is the only source of water supply, an analysis should be made to ensure the water system will perform reliably in accordance with the DSA functional and reliability requirements and DOE O 420.1C, in a manner that is equivalent to, or exceeds, that provided by a separate, stand-alone, DOE-controlled system.

A.3.3.2 Water Treatment Systems

Water treatment systems are seldom within the SC or SS boundary since the treated water in storage normally meets SC or SS water capacity needs. However, treatment systems may be required to meet SC or SS criteria if water storage capacity is inadequate and the raw water source is not suitable for fire protection purposes.

A.3.3.3 Electric Power to Pumps

- A.3.3.3.1 The electric power to SC fire pumps that are necessary to support the safety function shall be classified at the same functional classification level. For SS fire pumps, when there is no diesel back-up, the electric power to the fire pumps should be fed from two separate utility connections or from a generator and a utility connection. The more usual arrangement is to install a diesel driver and pump that serves to back up an electric pump with a single source of power.⁸³

- A.3.3.3.2 For SC applications, in addition to the above, per DOE O 420.1C, the electrical power supplies shall be designed to preclude single point failure.

A.3.4 Design Criteria for the Water Supply System

The following provides a summary of the requirements, criteria and guidance for SC and SS water supply systems supporting wet pipe automatic sprinkler installations.

Attachment A of this Standard provides examples of arrangements of fire protection systems that are acceptable.

A.3.4.1 Safety Significant Design Criteria for Water Supply Systems

- A.3.4.1.1 Underground piping should be limited to cement lined ductile iron (Class 52 minimum), polyvinyl chloride piping with a dimension ratio (DR) of DR14, and high density polyethylene (HDPE) piping (DR9). Additional limitations of material type may be imposed for seismic design.
- A.3.4.1.2 When restraints are required, two separate means of joint restraint should be used (e.g., thrust blocks, mechanical, rodding).
- A.3.4.1.3 Ductile iron piping should be provided with corrosion protection such as polyethylene wrap or cathodic protection per American Water Works Association standards.
- A.3.4.1.4 A stable pipe bed such as backfilling around piping to a height of 18 inches of sand bedding (from outside of piping) should be provided in accordance with NFPA 24, *Standard for the Installation of Private Service Mains and Their Appurtenances*, and FM Global Property Loss Prevention Data Sheet 3-10.
- A.3.4.1.5 Sectional and sprinkler/standpipe control valves should be limited to factory assembled post indicator valve assemblies.
- A.3.4.1.6 In-ground pipe identification systems should be provided (ribbon, trace wire, red mud, etc.).
- A.3.4.1.7 All underground piping should be flushed as part of acceptance testing in accordance with the NFPA 24 requirements for underground pipe. The flow rate selected should be the maximum flow rate available to the system under fire conditions.
- A.3.4.1.8 If the water supply system feeding multiple suppression systems is considered by the DSA to be susceptible to multiple, independent fires, the water supply is required to meet its DSA credited safety functions with adequate flow and pressure during such an event.
- A.3.4.1.9 Environmental conditions should be specified for water supply systems and, if necessary, support systems should be provided to mitigate the condition. Examples include:
 - Natural hazards such as seismic events, tornadoes, high winds, flooding, lightning, temperature (e.g., below freezing), and humidity;
 - Facility hazards, such as internal flooding, explosions, fire, missile impacts, vehicle impacts, and corrosive environments;
 - Wildland fire;
 - Physical damage from adjacent equipment and systems (e.g., during a seismic event); and

- Water quality.

A.3.4.1.10 To support appropriate implementation of the site or project QA program relative to fire protection systems, the following topics should be addressed (beyond what is specifically identified in DOE O 420.1C and referenced NFPA codes and standards):

- Document control, including the assurance that documents are stored properly to avoid damage and that responsibilities for completeness, maintenance and distribution are identified;
- Records of qualification of fire protection staff and control of qualification records;
- Procurement documentation and control of purchased items or services, receipt inspections, and verification of quality;
- Identification and control of components (e.g., sprinklers, valves, water supply pumps), per Requirement 8 of ASME NQA-1-2008;
- Requirements for handling, shipping and storage of components;
- Control of nonconforming items to prevent inadvertent installation or use;
- Commercial grade dedication of components, based on third party testing and production monitoring;
- Records of qualification for installation personnel and control of qualification records;
- Records of qualification for tools and equipment used in preparation of installation hardware (e.g., appropriate welders and cutters for HDPE pipe, cathodic protection) and control of qualification records;
- Records of proper use of component manufacturer installation instructions (e.g., proper bolt torque for fittings, proper bedding of pipe, proper mounting of fire pumps) and control of qualification records;
- Configuration and design control; and,
- Results of commissioning testing (including resolution of deficient conditions found during testing).

A.3.4.1.11 The QA program should be audited in different phases (design, construction and operations) using DOE O 413.3B.

A.3.4.2 Safety Class Design Criteria for Water Supply Systems

In addition to the criteria for general use and SS applications, the following additional design requirements/guidance are applicable for water supply systems used in SC applications.

A.3.4.2.1 Active features of a water supply system should be designed to preclude a single point failure, if the component failure results in the system's inability to perform its safety function.

A.3.4.2.2 SC water supplies shall consist of two SC supplies. Both supplies should be able to meet the demand independently.⁸⁴

A.3.5 Codes and Standards

The following codes and standards are applicable to the design, installation, operation, and testing of water supply systems.

- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*
- NFPA 22, *Water Tanks*
- NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*
- NFPA 70, *National Electric Code*®

Additional guidance is contained in the following FM Global Property Loss Prevention Data Sheets.

- 3-2, *Water Tanks for Fire Protection*
- 3-7, *Fire Protection Pumps*
- 3-10, *Installation and Maintenance of Private Fire Service Mains and their Appurtenances*

A.3.6 Operability Criteria for Safety Significant and Safety Class Water Supply Systems

- TSR's LCOs should be defined (including appropriate action statements to address situations when the system is inoperable) in accordance with DOE G 423.1-1.
- TSR surveillance requirements should be defined using NFPA 25 inspection, testing, and maintenance requirements, as a minimum, or other established requirements by equipment manufacturers and water purveyors. See DOE G 423.1-1, for guidance on the preparation of TSRs.

A.4 Fire Separation

The following provides a summary of the functions, critical characteristics, requirements, criteria and guidance for new SC, and SS fire separation installations.⁸⁵

A.4.1 System Function and Critical Characteristics

A.4.1.1 System Function

The SC and SS function of the fire separation system is defined in the DSA of the facility (typically in Chapter 4). This may include information regarding the size and type of fires for which the system is designed, along with any specific considerations that may be required for the system to perform its intended function. For example, the function of the fire barrier is generally to limit the transfer of thermal energy from one side of the barrier to the other, thereby preventing a fire on one side of the barrier from starting a fire or affecting nuclear materials stored on the other side of the barrier for a specified period of time. If the barrier also has a load carrying function, it should also perform that function during and after the fire.

A.4.1.2 Critical Characteristics

The critical characteristics of the fire separation system should include the following as appropriate:

- The fire barrier's hourly fire-resistance rating;
- Performance characteristics of doors, dampers, seals and other components (e.g., load bearing, pressure rating, dynamic/static flow rating, leakage rate, temperature transmission);
- Materials used in the barrier that form the basic composition of the barrier (e.g., gypsum wall board on steel stud with specific screw size and pattern plus joint protection, or reinforced concrete masonry units of sufficient size and thickness);
- Protection of openings (including dimensions and materials of doors, door frames, dampers, and penetration seal fire stops);
- Mechanisms for, and timing of, any components that are required to reposition to perform their SC or SS safety function (e.g., fire damper, fire door closure); and,
- Design criteria basis (e.g., Underwriters Laboratory (UL) Listing Design Number, building code reference, test reports).

This information may also be included in the system design description.

A.4.2 System Boundary for the Fire Separation System

The boundary of the SC or SS fire barrier system shall be defined such that it is clear which components are to be classified within the system. A boundary for fire barriers may include all walls and devices designed to protect openings in the wall between different fire zones.

A.4.3 Support Systems for the Fire Separation System

Fire barriers are primarily passive with active elements using self-actuating devices that do not require motive force outside of the barrier component (e.g., self-actuating dampers). Support systems are typically structural components, such as: structural bearing or non-bearing fire barriers; floor/ceiling, column/beam assemblies; and, trusses/roof framing. The latter are the most important support elements and shall be classified as having a fire-resistance rating at least equal to, or greater than, that of the SC or SS barrier and classified as equal, or superior, to SC or SS fire barrier system when: 1) these elements provide structural support to credited SC or SS fire barriers; or 2) failure of the support system component could damage an adjacent SC or SS fire barrier.

A.4.4 Design Criteria for Fire Separation Systems

The following provides a summary of the requirements, criteria and guidance for new SC and SS fire separation systems.

A.4.4.1 Safety Significant Design Criteria for Fire Separation Systems

In addition to the criteria identified in Section 4.2 of DOE-STD-1066-2012, the following additional design requirements/guidance are applicable for installations used in SS applications:

- A.4.4.1.1 Fire barrier installations should be designed to remain operable for those environmental events for which they are relied on, as specified in the DSA. Examples include:
- Seismic events;

- Other natural phenomena hazards, such as high wind potential, tornadoes, flooding, lightning, low temperature, and humidity;
 - Facility hazards, such as internal flooding, explosions, fire outside the system boundary, missile and vehicle impacts, corrosive environments;
 - Wildland fire; and,
 - Physical damage from adjacent equipment and systems; (e.g., during a seismic event).
- A.4.4.1.2 Fire-rated doors, windows, dampers and penetration seals used to protect openings should maintain the fire resistance rating of the fire barrier assembly.
- A.4.4.1.3 Fire separation system components (e.g., barriers, doors, dampers) should be readily accessible for inspection and testing, as well as marked and identifiable in the field, as required by a national recognized testing laboratory.
- A.4.4.1.4 To support appropriate implementation of the site or project QA program relative to fire protection systems, the following topics should be addressed (beyond what is specifically identified in DOE O 420.1C and referenced NFPA codes and standards):
- Document control, including the assurance that documents are stored properly to avoid damage and that responsibilities for the completeness, maintenance and distribution are identified;
 - Records of qualification of fire protection staff and control of qualification records;
 - Procurement documentation and control of purchased items or services, receipt inspections, and verification of quality;
 - Identification and control of components (e.g., fire dampers, doors, seals) per Requirement 8 of ASME NQA-1;
 - Requirements for handling, shipping and storage of components;
 - Control of nonconforming items to prevent inadvertent installation or use;
 - Commercial grade dedication of components, based on third-party testing and production monitoring on the contractor's quality assurance program;
 - Records of qualification for installation personnel and control of qualification records;
 - Verification of approval or listing;
 - Records of qualification for tools and equipment used in preparation of installation hardware and control of qualification records;
 - Records of proper use of component manufacturer installation instructions (e.g., bolt torque for components, attachment to structure/wall, mounting of frames) and control of qualification records;
 - Configuration and design control; and,

- Results of commissioning testing (including resolution of deficient conditions found during testing).

A.4.4.1.5 The QA program should be audited in different phases (design, construction, and operations), using DOE O 413.3B.

A.4.4.2 Safety Class Design Criteria for Fire Barriers

In addition to the criteria for SS applications, the following additional design requirements/guidance are applicable for fire barrier installations used in SC applications:

A.4.4.2.1 The following components shall not be used unless their potential impact is evaluated and their reliability has been demonstrated:

- Fire-rated glazing assemblies; and,
- Curtain-style fire dampers in non-confinement ventilation ducts for SC fire barriers (since their reliability to sufficiently close and latch under dynamic flow has been documented as a concern by the Nuclear Regulatory Commission).

A.4.4.2.2 For SC fire doors, fire-resistive glazing materials shall not be used over an area of more than 100 square inches in one door leaf for the entire fire barrier.

A.4.4.2.3 Fire doors in SC fire barriers should be normally closed or equipped with electro-magnetic hold open devices when doors are held open for reasons other than convenience. These should be designed to close on activation of any one of four smoke detectors (two detectors on each side of the fire door, located as shown in the NFPA 72, *National Fire Alarm and Signaling Code*, section on smoke detection for door release service). The detectors should be integral with the magnetic hold open device (unless the fire detection and alarm system is also safety class). The doors should release on failure of primary electrical power. All components should be SC. Fusible link devices, including those that are integral to the door closers, should not be permitted to hold doors open.

A.4.4.2.4 When dampers are required in a SC fire separation system, they should be designed to close under anticipated air flow velocities and anticipated pressures, or air flow shall be shut down by redundant detection⁸⁶ so as not to compromise their effectiveness.

A.4.4.2.5 All opening protection devices that change position (e.g., doors, dampers) shall be designed to preclude a single active component failure from preventing achievement of the separation function. This may require redundant doors or dampers and/or redundant closers, or the use of reliable components accompanied with increased inspection and testing frequencies.

A.4.5 Operability Criteria for Safety Significant and Safety Class Fire Barriers

- The TSR's LCOs should be defined (including appropriate action statements to address situations when the system is inoperable) in accordance with DOE G 423.1-1.
- Inspection, testing and maintenance of active components should be performed in accordance with NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, to verify barrier system function. Passive features such as walls,

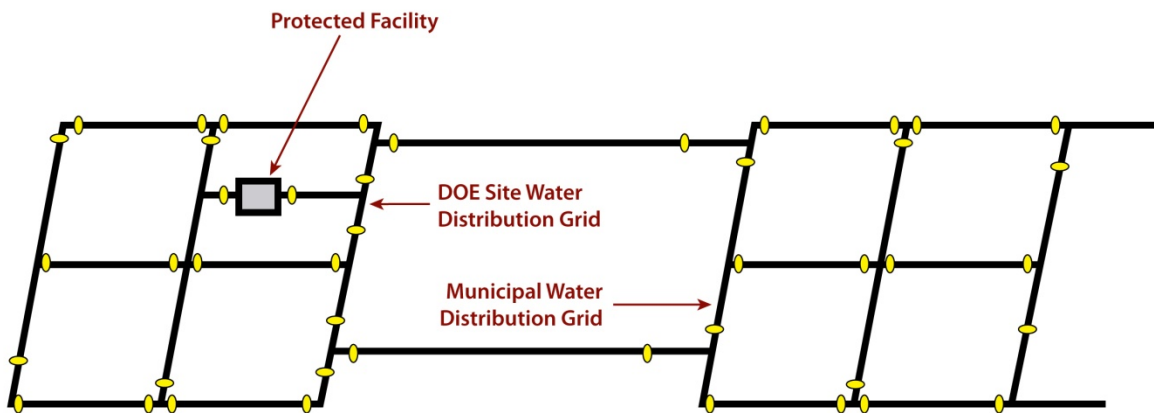
floors and penetration seals should be inspected under a documented program which identifies the nature of the inspections, their frequency and acceptance criteria.

Attachment A Typical Water Supply Arrangements

This attachment provides some examples of possible water supply arrangements that are intended to explain general requirements of Appendix A. These examples do not necessarily provide all details, and may not describe all possible acceptable arrangements. Information in this attachment is NOT to be construed as complete in all respects and the requirements of Appendix A, referenced codes and standards, as well as “highly protected risk” expectations take precedence over any information presented here.

Water Supply Arrangement No. 1: Multipurpose (domestic/industrial/fire) water supply system tied to a municipal water provider outside of Department of Energy (DOE) control.

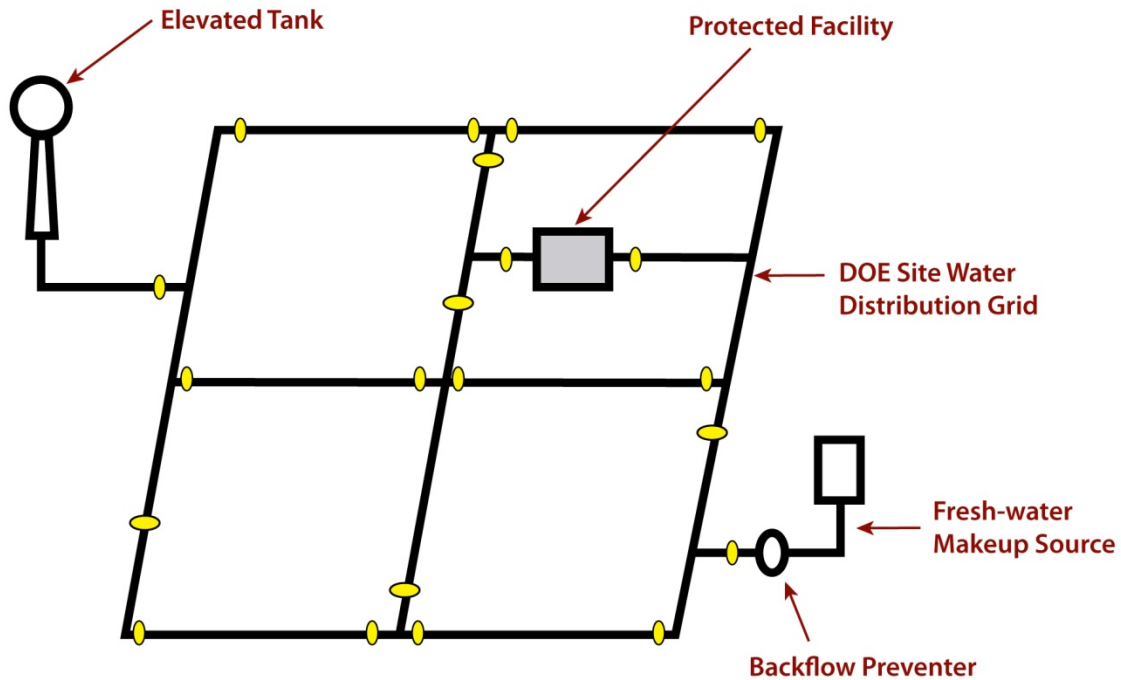
In this arrangement, water is obtained from a qualified municipal water purveyor.



This arrangement should not be utilized for safety class (SC) applications, but is used for general purpose fire protection. In addition, this arrangement may be used for safety significant (SS) applications if requirements for reliability, quality assurance (QA), and safe operation are met. The reason the system is not to be used in SC applications is that the lack of DOE control over the supply makes it prudent to have an additional system (e.g., backup) under DOE control, to supply the facility. The use of this system for either SC or SS applications raises concerns related to whether the municipality would be subject to DOE enforcement requirements that would need to be addressed. Finally, this arrangement also raises issues regarding where the SC or SS boundary would be drawn. Notwithstanding all these potential drawbacks, arguments have been made that municipal water supplies are extremely reliable, even more so than dedicated systems, and should be allowed. If this is the case for a given site and facility, providing a justification to utilize a municipal system may be possible if all of the nuclear safety criteria can be met and the issues discussed above are addressed.

Water Supply Arrangement No. 2: Multipurpose (domestic/industrial/fire) water supply system under DOE control.

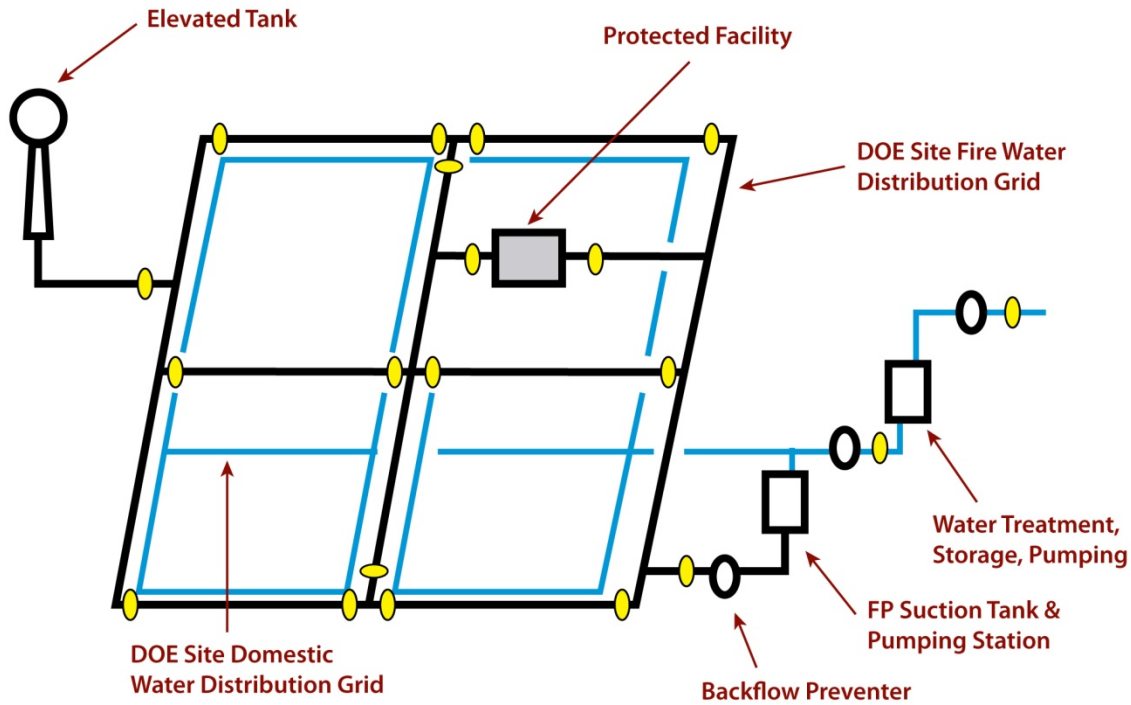
In this arrangement, water is obtained from a fresh-water source, such as a well or river, treated and then stored on site by both suction and elevated water storage tanks.



Similar to Arrangement 1, this arrangement should not be utilized for SC applications, but is used for general purpose fire protection. In addition, this arrangement may be used in SS applications, if requirements for reliability, QA, and safe operation are met. The reason the system is not to be used in SC applications is that, even though the system is essentially passive and under DOE control, it is not under the facility's control. Thus, having an additional backup system that is under the facility's control is prudent. Furthermore, this arrangement raises issues regarding where the SC or SS boundary would be drawn.

Water Supply Arrangement No. 3: DOE-site supplied by a separate site-maintained fire water distribution network.

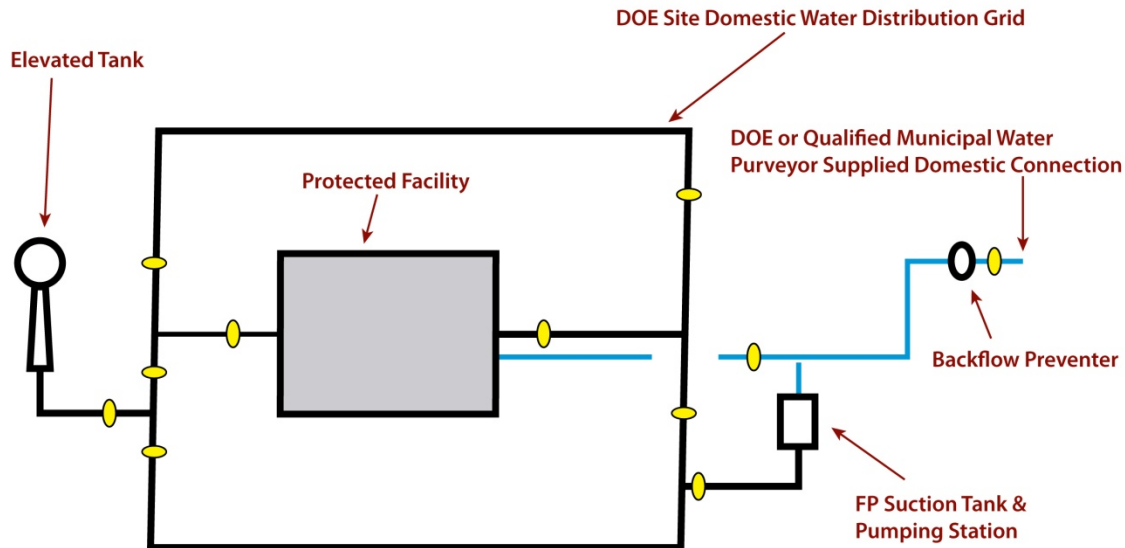
In this arrangement, water is obtained from a fresh-water source, such as a well or river, treated and then stored on site by both suction and elevated water storage tanks. The fire water and domestic water systems are separate. The only interface is the feeding of the fire water suction tank from the domestic water system.



Similar to Arrangement 2, this arrangement should not be utilized for SC applications, but is used for general purpose fire protection and may be used for SS applications, if requirements for reliability, QA, and safe operation are met. The reason the system is not to be used in SC applications is that, even though the system is under DOE control, it is not under the facility's control. Thus having an additional backup system that is under the facility's control is prudent.

Water Supply Arrangement No. 4: DOE-protected facility supplied by a dedicated fire water distribution network.

In this arrangement, water is obtained from a fresh-water source, such as a well or river, treated and then stored on site by both suction and elevated water storage tanks. The fire protection suction tank is sized to provide adequate water supply without reliance of the fill for the design basis fire.

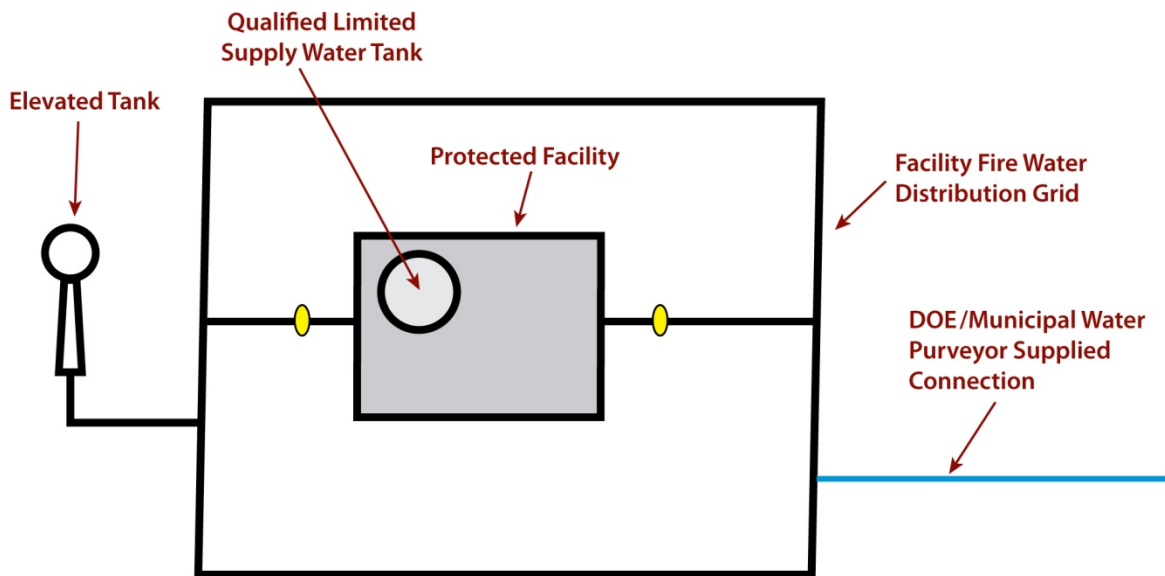


This arrangement could be utilized for SS applications, if conditions specified in A.3.2 and A.3.3 of Appendix A are met. If the supplied system (e.g., wet pipe sprinkler) needs to operate in a seismic event (e.g., to mitigate a seismically-induced fire), the supply system shall be qualified to the same level as the supplied system.

This arrangement may be appropriate for use in SC applications with assurance that no active single failure could disable the system.

Water Supply Arrangement No. 5: Hazard-specific limited supply water system.

Water system flow and capacity for property protection, program preservation, life safety, etc., are specified by NFPA 1, *Safety Code*, NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, the *International Building Code*, NFPA 13, *Standard for the Installation of Sprinkler Systems*, or other general industrial standards. These standards typically require from several hundred thousand to several million gallons of water. None of these specify the amount of water needed to adequately protect an SC or SS special hazard. This shall be determined on a case-by-case basis and justified in the FHA or DSA, taking into account issues, such as criticality and spread of contamination. Nuclear safety objectives often can be achieved with much lower quantities of water, provided the system is independent of the general building system. For example, 500 gallons may be sufficient to meet the SC objective to protect a special hazard (e.g., a glovebox) in a given facility. Such a limited supply could be provided by a single, passive, self-contained pressure tank within the facility, qualified to seismic and other SC criteria (such as redundancy of active components), thus significantly limiting the SC boundary. An additional water supply, per the above codes and standards, would be required to meet other fire protection objectives, but that additional supply is not required to meet SC or SS criteria.



APPENDIX B FIRE HAZARD ANALYSIS

This Appendix provides guidance on the development and content of a fire hazard analysis (FHA) for Department of Energy (DOE) facilities as required by DOE Order (O) 420.1C, *Facility Safety*, and fire protection design analysis to ensure the design requirements of Section 4, of DOE Standard (STD) 1066-2012, *Fire Protection*, are accomplished.

B.1 General

- B.1.1 The FHA should include an assessment of the risk from fire and related hazards (wildland fire exposure, direct flame impingement, hot gases, smoke migration, fire-fighting water damage, etc.) 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.
- B.1.2 The FHA should address/define DOE orders, or mandatory codes and standards that are applicable to the facility. If, during the analysis, it is determined that a departure from requirements is necessary, the technical basis for requested relief in the form of variances, exemptions or equivalencies should be documented in the FHA.
- B.1.3 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; the potential risk to the public and facility operators; and, property loss potential, in accordance with established DOE limitations. A FHA for a fully compliant facility can be relatively brief, but deviations from codes, standards or directives require documentation that may substantially increase the level of detail.
- B.1.4 The FHAs and facility assessment reports may be combined, provided they address all essential elements. To facilitate the development of graded FHAs, the DOE Fire Protection website contains copies of “models” of separate and combined FHAs and assessment reports.

B.2 FHA Development

- B.2.1 An analysis of planned facilities requiring a FHA should begin early in the development phase to ensure that an acceptable level of protection is being incorporated in the evolving design, including: building placement, height, area per floor, emergency access, construction materials, fire areas, and other fire-related details.
 - B.2.1.1 The project or preliminary FHA (typically called a PFHA) should be updated whenever significant changes occur and should form the basis for post-construction FHA. A post-design FHA is often useful to document the changes during the design. The analysis should also be integrated into the preliminary Documented Safety Analysis (DSA) or other nuclear safety documentation when required.
 - B.2.1.2 For new facilities and significant modifications (e.g., valued in excess of \$150 million), that are non-nuclear and not considered hazardous, the PFHA serves to guide the construction process and provide historic documentation, but post-construction FHA revisions are not required.
- B.2.2 The FHA should be performed under the direction of a fire protection engineer (FPE). This should include the directing of all of the technical aspects of a FHA’s development, including support from emergency services, systems, electrical, and mechanical engineers, as well as authorization basis and operations staff, as needed.

B.2.3 A FHA should contain, but not be limited to, a conservative assessment of the following as they relate to fire safety:

- DOE orders, and industry codes and standards;
- Mission and associated hazards;
- Occupancy classification and building code construction requirements;
- Critical process equipment;
- High-value property;
- Fire hazards;
- Operations;
- Potential for a toxic, biological and/or radiological incident due to a fire;
- Natural hazards (earthquake, flood, wind, lightning, and wildland fire) that may impact on fire safety;
- Damage potential: include the Maximum Possible Fire Loss (MPFL), including the basis for the conclusions;
- DSA design basis fire scenario;⁸⁷
- Fire protection features, including special fire protection features, and fire protection features classified as Safety Class (SC) or Safety Significant (SS);
- Protection of vital safety systems that have a safety function during or following a fire, such as confinement ventilation systems;
- Life safety analysis;
- Emergency planning;
- Fire Department/Brigade response (may be discussed and evaluated in a stand-alone site-wide document);
- Security and Safeguards considerations related to fire protection;
- Electrical systems (e.g., transformers, switchgears, multi-tier cable trays);
- Exposure fire potential and the potential for fire spread between two fire areas;
- Effect of significant fire safety deficiencies on fire risk; and,
- Environmental impacts from a fire, including suppression system run-off considerations.

A graded approach may omit some of these topics, but it should be clear that the omission was intentional.

B.2.4 The FHA should include consideration of conditions that may exist during normal operations and special situations (e.g., during periods of decontamination, renovation, modification, repair, and maintenance).

B.2.5 The FHA should evaluate the consequences of a single, worst-case automatic fire protection system malfunction, such as: the failure of a detection system used to activate a pre-action type sprinkler system and transmit an alarm to the site emergency response force; or, the failure of a valve in the underground main that could impair

multiple systems, either in the same building or in adjacent buildings evaluated as an exposure.

- B.2.6 The FHA should address findings, and when appropriate, provide a path forward for resolving the finding. It is recommended that the FHA, in addition to discussions of findings and recommendations found within the body of the report, provide a listing of findings in table format. This is to avoid the potential for findings to become lost. A distinction should be made between mandatory recommendations, including those listed as general industry practice and those proposed as a matter of preference.
- B.2.7 The focus of the FHA should be the individual fire areas that comprise the facility. A fire area is an area that is physically separated from other areas by space, barriers, walls, or other means, in order to contain fire within that area. Traditionally, fire-resistance ratings of a minimum of two hours have been used to define fire areas. It cannot be assumed that a two hour rated boundary is sufficient to contain a worst-case fire. Compliance with the building code may require three- or four-hour rated free-standing boundaries, without openings, designed to prevent failure in the event the structure on either side collapses. Additional focus should include fire-rated compartmentalizing providing for the separation and management of hazardous materials (chemical) inventories, such as the “control area” concept in the *International Building Code* and the “lab unit” concept in the National Fire Protection Association’s NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*.
- B.2.8 The boundaries of exterior fire areas (yard areas) should be as determined by the authority having jurisdiction (AHJ) or delegated authority. In a situation where a facility is not subdivided by fire-rated construction, the fire area should be defined by the exterior walls and roof of the facility. In production facilities, conveyor and trolley systems may pass through credited fire walls or barriers. In some instances, the design and operation of the equipment may preclude the use of fire dampers and similar devices. Such installations in new construction may require fire testing and taking credit for all features (non-rated fire dampers, metal construction, the use of fire-rated glass, in addition to confinement control glass, etc.) of the conveyor/trolley design that will impede fire spread from one fire area to an adjacent fire area.
- B.2.9 In determining the adequacy of fire-rated construction, especially when the facility structure or confinement system is being credited with preventing or limiting a radiological release, it is important to fully estimate the fire severity and duration within the facility, including transient, process equipment and facility construction materials that are combustible. For example, a large process piping system constructed of plastic piping could result in a large fire load, one which might challenge 1- or 2- hour fire-rated construction.
- B.2.10 An important element of an acceptable FHA for nuclear facilities is an inventory assessment of all SC and SS systems within the fire area that are susceptible to fire damage.⁸⁸
 - B.2.10.1 All credible fire-related failure modes of safety systems should be considered. It should be noted that such systems may be active or passive. In the case of certain passive SC or SS systems, the need for fire protection may not be required. This can arise in the case of concrete vehicle barrier systems or drainage systems. Such systems would generally be immune from fire damage by the nature of their construction, and, thus would not require protection by an active fire-suppression system.

- B.2.10.2 The analysis should determine whether a fire can have a credible impact on the SC or SS system such that the system's credited safety function is compromised.
- B.2.11 Fire propagation and the potential for fire-induced radiological dispersal through the facility should be considered. These effects should be considered for the normal operating mode of the air distribution system, as well as alternate modes, such as shutdown, that may result from a fire. In nuclear and radiological facilities, ventilation (air flow) is from the least contaminated to the most contaminated areas. In large facilities, this could represent a challenge for emergency responders, should the fire originate in a lower contaminated area. Consideration should be given as to whether such an event could compromise fire-fighter response, or if the facility's layout would permit alternate avenues to gain access to the fire area.

B.3 Fire Modeling

- B.3.1 While not usually needed, a tool that may be used in the development of a FHA is a fire model, such as those developed by the National Institute of Standards and Technology, as applied by FPEs, and approved for DOE use as a Central Registry Toolbox code.⁸⁹
- B.3.2 All assumptions used in a model should be listed in the FHA and limiting conditions of operation or specific administrative controls established to ensure that these assumptions produce reasonably conservative results. In addition, small variations in an assumption can have a major impact on the outcome. For example, assuming a door is closed might reduce fire intensity by half, but there is no assurance that the door will remain closed throughout the life of the facility. Because of their limitations and potential for errors, the use of fire models to estimate the potential effects of fire in nuclear, radiological, high-hazard and other facilities with potential resulting off-site and worker consequences, should be limited to persons highly-qualified in the model's use. Results or outputs from the model should be approved by a FPE who is knowledgeable on the use of the model. In all cases, the output of the model should be compared with expected fire dynamics. When the model's output does not match normally-expected fire dynamics, the model's output should be suspect.

B.4 Special Considerations

- B.4.1 As a general rule, nuclear, high-hazard, explosive, and certain other facilities may require a higher standard of fire protection than that normally accepted for general industry, and, in some cases, above that considered acceptable for "highly protected risk" facilities, including the use of SC and SS fire protection systems.
- B.4.2 The analysis may rely on actual fire testing or historical data on fire events both inside and outside the DOE complex, provided that adequate documentation of such information is available for the AHJ's review.
- B.4.3 The quantity and associated hazards of flammable liquids and gases, as well as combustible liquids and other materials that may be found within the fire area should be factored into the analyses. Consideration should also be given to the presence of transient combustibles associated with storage and maintenance activities.
 - B.4.3.1 When conditions prevent employment of normal fire protection features, such as automatic sprinklers, noncombustible construction, and fire-resistant boundaries, the FHA should quantify fixed-combustibles and their locations and determine limits and locations of transient combustibles. These limits are usually enforced through formal combustible loading programs with permits for each combustible material brought into the area.

- B.4.3.2 Averaging combustible loading throughout a space as a means to characterize the fire severity is not considered an acceptable technique since localized severity, vulnerability, and combustible loading may vary significantly from the average. If combustible loading calculations are provided under limited applications, it should be under the direction of the AHJ.
- B.4.4 FHAs for high-bay locations should consider the effects of smoke/hot gas stratification that may occur at some intermediate point below the roof or ceiling, as well as the potential for delayed sprinkler response. Similarly, the effect of smoke movement through doors and dampers held open by fusible links should be addressed.
- B.4.5 When both a FHA and a safety basis document (DSA, Safety Analysis Document, or Basis for Interim Operation) are developed for a facility, the developmental effort should be coordinated to the maximum extent possible to avoid duplication of effort. It is recognized, however, that because a FHA is based on the premise that a fire will occur and considers a variety of fire issues (property loss and program interruption potential) that are not normally considered in the DSA, the conclusions of the FHA may be more conservative for the facility as a whole, while the DSA may be more conservative for a specific process. For example, the FHA may assume that building sprinklers are sufficient for fixed and transient combustibles, but the DSA may rely on combustible controls to limit fire exposure in a specific area. Nevertheless, the FHA and its conclusions should be addressed in the facility DSA in such a manner as to reflect all relevant fire safety objectives, as defined in DOE O 420.1C. As a general rule, the FHA should be developed so as to provide input into the DSA. Thus, some portions of the FHA may be developed early in the safety basis development process, and, in some cases concurrently with the safety basis development process. In no case should the FHA be back-fitted so that results of the FHA correspond to results of the safety basis documentation. However, the FHA is required, as described in Section B.2.4 of this Appendix, to address DSA design basis fire scenarios and the protection of SC and SS features.
- B.4.6 Information related to emergency response (number of emergency responders, number and types of apparatus, response time, etc.) should be incorporated into the safety basis documentation as a means of clearly establishing a “floor”, below which this level of capability should not be reduced. This information may be discussed in the Baseline Needs Assessment.

B.5 Fire Protection Design Analysis

The Fire Protection Design Analysis should include the elements identified below in order to ensure the requirements of DOE O 420.1C are incorporated into design criteria. This analysis is not applicable for nuclear facilities (See Section B.2 of this Appendix for FHA development).

- B.5.1 Building Code Requirements. The occupancy group for the building should be identified based on the building’s intended use and preliminary hazards evaluation. This should be used to determine the limitations on height, area and construction type. Any other unique features of the building, which are addressed by sections of the building code should be identified (e.g., atrium, balcony, below grade, windowless).
- B.5.2 Fire Separation. Fire areas and other fire separations should be identified as required by values per DOE O 420.1C, such as occupancy groups, control areas, hazards separation and separation of safety systems. Fire wall and fire barrier fire resistance rating requirements should be identified.

- B.5.3 Life Safety. Life safety requirements for the occupancy group, such as occupant load, exit capacity, travel distance and fire protection features (e.g., fire detection and alarm, fire suppression, smoke control) should be identified in accordance with NFPA 101, *Life Safety Code*[®].
- B.5.4 Applicable Fire Protection Standards. The NFPA codes and standards relating to specific processes to be part of the project should be identified (e.g., NFPA 34, *Standard for Dipping Coating and Processes Using Flammable or Combustible Liquids*, NFPA 85, *Boiler and Combustion Systems Hazard Code*, NFPA 86, *Standard for Ovens and Furnaces*). NFPA codes and standards relating to specific occupancies that are to be part of the building should be identified (e.g., NFPA 45 *Fire Protection for Laboratories Using Chemicals*, NFPA 88A, *Parking Structures*, NFPA 820 *Fire Protection in Wastewater Treatment and Collection Facilities*). As the design matures, specific fire protection design requirements should be identified.
- B.5.5 Code Compliance. Design criteria documents should ensure compliance with the applicable codes and standards identified. Any changes in the design or construction should be monitored for compliance with the established criteria.

APPENDIX C RELOCATABLE STRUCTURES

C.1 Application

The provisions of this Appendix apply to the purchase and lease, and to the design and construction, of all relocatable structures that:

- will remain in place for more than 180 days on-site;
- contain significant fire hazards; or,
- have programmatic importance or significant value as determined by the cognizant fire protection engineer (FPE).

This Appendix also applies to all cargo containers, tents and membrane structures regardless of the 180 day minimum period described above. The applicability of this Appendix excludes mobile laboratories and other relocatable structures that contain an engine and drive train.

Modifications made to existing relocatable structures should be performed in accordance with this Appendix. Site-specific interpretations of the provisions of this Appendix should be the responsibility of the DOE authority having jurisdiction (AHJ).

C.2 Structural Requirements

C.2.1 Construction. Except for temporary, short term parking of cargo containers and semi-trailers, relocatable structures should be constructed to conform to applicable National Fire Protection Association (NFPA) standards and the *International Building Code* (IBC) and DOE Orders (O).

C.2.2 Compartmentation. Relocatable structures should be separated such that the largest fire area does not exceed the limits imposed by the building code. No fire area in a relocatable structure should have a Maximum Possible Fire Loss (MPFL) exceeding limits imposed by DOE O 420.1C, *Facility Safety*.

C.2.3 Anchors and Supports. Except for cargo containers and semi-trailers, each relocatable structure should have support and anchoring systems that have been properly designed and installed to resist overturning and lateral movement of the structure.

C.2.4 Interior Finish. The interior finish of all relocatable structures should comply with NFPA 101, *Life Safety Code*, as amended below.

C.2.4.1 Relocatable structures used for any of the following occupancies should have a Class A interior finish:

- Dedicated to housing electronic data processing equipment or other computer equipment;
- Structures used for sleeping quarters;
- Structures used for storing, processing, or involving radiological materials; and,
- Structures used for storing or operating lasers and related equipment.

C.2.4.2 If fire retardant, pressure-impregnated wood is used as interior finish, it should be the non-leachable type that meets Underwriters Laboratories (UL), Standard Rain Test, and should be installed with corrosion-resistant fasteners that will withstand

the chemicals impregnated in the wood. It should be rated as FR-S material, as currently listed in the UL Building Materials Directory, or equivalent.

- C.2.4.3 Tents or other membrane-type structures should have both a Class A surface burning characteristic and pass Test Method 2 of NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Film*.
- C.2.5 Exposed Flooring. Relocatable structures with open under-floor areas should be provided with a means, such as skirting, to prevent the accumulation of combustibles and debris beneath the structures.
- C.2.6 Identification. All relocatable structures should be marked with a number, symbol, or name for identification purposes. The marking system used should be permanent and consistent with the system currently used at the site.
- C.2.7 Heating Ventilating and Air Conditioning (HVAC). HVAC equipment should be listed or approved by a nationally-recognized, independent fire testing authority and installed in accordance with its approved design and applicable industry standards. Such HVAC equipment should be inspected and maintained per the manufacturer's recommendations. Portable heating appliances should not be permitted as a permanent source of building heat.
- C.2.8 Surveillance. Exterior structural features of relocatable structures should be inspected in conjunction with the site fire protection assessment program to monitor potential physical deterioration due to atmospheric conditions. If such deterioration has resulted in a significant increase in fire risk, structural repairs or other appropriate mitigating measures should be implemented.

C.3 Placement Requirements

- C.3.1 Separation Distances. Relocatable structures should comply with NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.
 - In all cases, the required separation distance should be based on the “worst-case” between the structures, such as when structures are positioned on an angle. Required distances to separate permanent buildings or facilities from relocatable structures should be determined in a similar manner. Due to the many factors that should be considered for permanent buildings, NFPA 80A should be used to establish their separation distance.
- C.3.2 Exposures. Exposures presented by exterior canopies, connecting walkways, and intervening combustibles should also be considered when determining separation distances and protection features.
 - There should be no storage of combustible or hazardous materials between the relocatable structure and the exposed building(s).
- C.3.3 Location Restrictions
 - Relocatable structures should be placed in a manner such that emergency vehicles can operate within 100 feet of the structure. The space between the structure and the road should be free of natural obstructions that would prevent, or severely restrict, access by emergency responders. Security barriers should be designed in a manner that permits emergency access. Landscaping and similar non-essential obstructions should not restrict emergency access.

- Relocatable structures should not be located where they impede or otherwise hinder personnel egress or ingress to, or within, other facilities or structures.
- Relocatable structures should not be located where they impede, or otherwise hinder, the access of emergency response vehicles to other facilities or structures or fire protection appurtenances, such as: post indicator valves; fire department connections; main drain and test connections; and, main control valves.
- Relocatable structures should not be placed inside permanent facilities that do not have sprinklers, unless a fire hazard analysis (FHA) demonstrates that there is no significant increase in fire risk to the facility. Structures that are placed inside permanent facilities should be protected with the same level of fire protection as provided for the permanent facility.
- Relocatable structures should not be placed over control valves, access ways to underground utilities, utility corridors, gas mains, or water mains. Relocatable structures may be placed above utility lines that service the structure itself.
- Relocatable structures should not be placed beneath vital power lines or lines over 600 volts such that a fire in the structure could damage the lines. Such structures also should not be placed under other vital utilities, such as communication cables and inerting gas lines, unless the relocatable structure is protected by an automatic fire suppression system. Service conductor clearances and disconnects should be in accordance with NFPA 70, *National Electric Code*[®].
- Site location(s) for relocatable structures should be evaluated for wildland fire exposures. When a significant fire risk exists, appropriate fire-resistive building materials and/or other methods of protection should be utilized as determined by the cognizant FPE.
- Relocatable structures should not be placed where they obstruct access to fire hydrants (see Section C.6.3 of this Appendix).

C.3.4 Cargo Containers. Cargo containers should be limited to stacks two-high, unless otherwise approved by the cognizant FPE. The arrangement of cargo containers should reflect the fire hazard of contents, the risk to personnel, value, and access for emergency responders.

C.4 Nuclear and Radiological Operations

Hazard Category 2 and 3 Nuclear and Radiological Facilities. This section addresses the use of relocatable structures for hazard category 2 and 3 nuclear and radiological operations and storage for both short-term as well as longer term usage. Such usage is generally associated with the temporary storage of materials, or waste management operations. The use of such structures for nuclear operations or storage is discouraged and should only be employed for very limited time periods, or when activities, such as waste remediation operations that are of a limited life. Such structures should not be employed for ongoing long-term operations. All other applicable requirements for nuclear facility operations (e.g., 10 C.F.R. Part 830, *Nuclear Safety Management*, documented safety analysis, FHA requirements, glovebox protection requirements) apply to these facilities.

C.4.1 The use of relocatable structures for hazard category 2 and 3 nuclear operations or storage should be approved by the AHJ.

C.4.2 Semi-trailers and cargo containers used for hazard category 2 and 3 nuclear materials, and radiological hazards.

- May be used for the temporary storage or handling of hazard category 2 and 3 quantities of nuclear materials and radiological materials, when such use is supported by the safety basis documentation.
- The trailer or cargo container's exterior and interior, including floors, should be of non-combustible construction.
- In the case of trailers:
 - tires should be removed;
 - the trailer should be adequately supported for safe normal usage, as well as for off-normal conditions such as natural phenomena hazards (e.g., seismic, wind, tornado, flooding); and,
 - truck tractors should not be connected to trailers while the trailers are being used for storage or operational purposes.
- Trailers and cargo containers should be safeguarded against exposure fires that may result from adjacent facilities or wildland fire events.
- Trailers or cargo containers should be sited and protected to accommodate fire department operations.
- When multiple trailers and or cargo containers are used to reduce material-at-risk (MAR), storage facilities containing MAR should either be: 1) provided with safety class or safety significant fire wall assemblies between structures which are designed to survive a design basis event; or, 2) or physically separated by the minimum distance as defined in NFPA 80A, unless the FHA or safety basis documentation determines that greater separation distance is required.
- When the trailer or cargo container is elevated, and access to the structure is required on a routine basis, a suitable means should be made for accessing and exiting the trailer. Steps and platforms when provided should meet OSHA requirements.

C.4.3 Fabric structures which are frame supported have the following limitations and requirements for hazard category 2 and 3 nuclear materials, and radiological hazards:

- May be used for buried waste retrieval operations where the FHA and safety documentation do not identify the potential for fires to impact the structure in an unacceptable manner (unacceptable radiological release, threat to workers or public, fire damage, impact to mission, etc.).
- May be used for the storage of non-flammable/combustible liquid waste in metal drums when such use is supported by fire hazard analysis and safety basis documentation.
- Should not be used for the storage of waste stored in combustible (wood, plastic, etc.) containers.
- Fabric structures should be constructed in accordance with the building code.

- Fabric structures should be constructed of non-combustible materials. Fabric should be fire retardant and not support continued combustion without the presence of a flame or heat source.
- Fabric structures should be located or protected against exposure fires that may result from adjacent facilities or wildland fire events.
- Multiple fabric structures should be fire separated from each other by physical distance or otherwise protected in accordance with NFPA 80A, unless the FHA or safety basis documentation requires additional separation.
- Structures located within fabric/tent structures and which are used for waste sorting or handling operations, combustible storage, equipment maintenance, or other similar operations should be provided with automatic fire suppression.

C.5 Occupancy Considerations

Unless a graded FHA demonstrates that a particular occupancy represents an unacceptable fire risk to the health and safety of the public, site personnel, or to program continuity, no restrictions are placed on the occupancy of portable structures except as described by NFPA, the IBC and DOE guidance listed below.

Relocatable structures should be governed by site or facility-specific procedures for the use and storage of combustible, flammable, radioactive, and hazardous materials so as to minimize the risk from fire. Such procedures should also exist for activities, such as smoking limitations, isolation of hot work, and other fire prevention measures that contribute to a reduction in fire risk.

- C.5.1 Computer Automated Information Systems Equipment. Relocatable structures used to house automated information systems or other computer equipment should comply with NFPA 75.
- C.5.2 Laboratories. Structures may be used to house laboratories provided they were designed for this purpose and comply with DOE-STD-1066-2012 and the applicable NFPA standards.
- C.5.3 Hazardous Material Storage. Relocatable structures may be used for the storage of hazardous materials if the structures comply with DOE-STD-1066-2012, the applicable NFPA standards, and all applicable hazardous waste storage requirements.
- C.5.4 Sleeping Facilities. Sleeping areas should not be permitted in relocatable structures unless they comply with NFPA 501, *Standard on Manufactured Housing*. Additionally, these should conform with the applicable provisions of NFPA 101, including the requirements for two remote means of egress, an automatic sprinkler system and a smoke detection system that alarms in the facility and is interconnected with the site fire alarm/signaling system.
- C.5.5 Remote Facilities. When the fire protection criteria of this Appendix cannot be feasibly met because the relocatable structure is in a remote location, alternate fire protection features may be provided as determined by the AHJ.
- C.5.6 Portable Heat Producing Devices. Coffee pots, hot plates, ovens, and similar items producing heat or capable of overheating should be listed by a nationally recognized, independent testing agency. All such devices or the receptacles into which they are plugged should feature a light or other equivalent means to indicate when the appliance is energized. Devices should be de-energized at the end of each workday.

C.6 Fire Protection Requirements

C.6.1 Automatic Fire Suppression. A complete automatic fire suppression system designed per the applicable NFPA standards when required should be provided for relocatable structures as follows:

- In all structures over 5,000 square feet;
- In all structures having an MPFL in excess of \$5 million;
- In all structures where the MPFL will affect a vital program for a period longer than that specified as acceptable by the AHJ;
- In all structures where quantities of hazardous materials are used or stored in excess of the limits delineated in NFPA 400, *Hazardous Materials Code*, or alternate model fire code as determined by the AHJ; and,
- In all structures used for sleeping quarters, including day care centers. (For such structures, “quick-response” sprinklers should be utilized).

Exception 1: Limited supply suppression systems may be used when a reliable water supply is not available, or when the application of water would increase the overall hazard in the event of a fire.

Exception 2: Automatic sprinkler systems are not required in fabric or membrane-type structures when alternate means of fire protection will provide an acceptable level of protection. Such means include, but are not limited to, fire detection systems combined with foam fire extinguishing systems and other special total flooding fire suppression systems.

C.6.2 Portable Fire Extinguishers. Portable fire extinguishers, listed by a nationally recognized independent testing agency, should be provided for relocatable structures in accordance with NFPA 10, *Portable Fire Extinguishers*.

C.6.3 Fire Hydrants. All relocatable structures should be placed between 50 feet and 300 feet to a fire hydrant.

Exception 1: This requirement does not apply to those structures that are required to be mobile and are moved on a regular basis to support an operation, such as field monitoring and sampling trailers.

Exception 2: This requirement does not apply to structures under 5,000 square feet in floor area, or when the MPFL is less than \$5 million.

Exception 3: This requirement does not apply to remote structures, as determined by the DOE AHJ.

C.6.4 Emergency Notification and Egress. All relocatable structures that are occupied by people should have access to a means to summon emergency assistance. In situations where a fire alarm or signaling system is not otherwise provided or required, this may take the form of a telephone, radio, or equivalent means.

- Relocatable structures should be provided with fire alarm and notification systems as required by NFPA 101 for the specific occupancy.
- Relocatable structures equipped with an automatic fire suppression or detection system should also be equipped with local alarm(s) that transmit separate and distinct signals for fire, trouble, and supervisory to either: 1) the site fire

department/emergency response center; or 2) to a continuously occupied station for the purpose of initiating emergency response.

- Provisions for emergency egress, including exits, emergency lighting, and exit signage should be in accordance with NFPA 101.

APPENDIX D TRANSITIONAL FACILITIES

- D.1 Transitional facility planning should consider the impact that such a transition has on fire protection features and activities. Such factors are additionally important if the facility possesses a definable value and/or mission as determined by the Department of Energy (DOE) program office, or if a fire would significantly increase the cost of the transition process. Examples of the latter, include the destruction of vital equipment required for transitional activities, a delay in transition commitments, the undermining of public confidence, and an increase in the cost of clean-up.
- D.1.1 It should be noted that considerable cost savings (e.g., electric, heating, inspection, testing, and maintenance) may be realized when combustibles within transitional facilities are reduced to near zero, which, in turn, permits deactivation of the building's fire suppression and alarm system, provided that fixed combustibles, such as construction materials, interior finish, electrical cables, and combustible roofing are not a fire threat.
- D.2 Fire safety and emergency response for transitional facilities are governed by the requirements contained in the Code of Federal Regulations (C.F.R.) 10 C.F.R. Part 851, *Worker Health and Safety Program*, (including 29 C.F.R. Part 1926, *Safety and Health Regulations for Construction*) and the provisions of the National Fire Protection Association (NFPA) Standard 241, *Safeguarding Construction, Alteration and Demolition Operations*. (See also FM Global Property Loss Prevention Data Sheet 1-0, *Safeguards During Construction*, and Chapter 8 of NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.)
- D.3 Decisions relating to fire safety of such facilities should be made on the basis of the following principles, with key aspects being captured in the transitional facility Fire Hazard Analysis (FHA).
- D.3.1 Fire risks imposed by the work in relation to the need for traditional fire safety features should be evaluated. The facility's FHA may be utilized, when applicable, to complete this evaluation. This can be accomplished through a graded FHA that has been reviewed and concurred with by the authority having jurisdiction (AHJ). All requests for relief should be processed in accordance with DOE procedures. Approved relief from normal DOE requirements should be listed on the signature page.
- D.3.2 Fire hazards within these facilities may change over time, such as an increase in combustible loading during abatement activities. Fire protection should be adequate to deal with these changes. The FHA, together with updated pre-incident plans, should account for these changes through a phasing schedule, or it should be revised, as appropriate, when significant changes in occupancy or hazard occur that affect fire safety.
- D.3.3 Fire safety features that have originally been required by DOE may be rendered inoperable or considered no longer needed if justified by the FHA, provided that the safety of facility workers and emergency responders will not be compromised and no additional threat to the environment is created. Such features may be abandoned in place (and properly identified as being out of service), until they are dismantled as part of planned demolition activities.
- D.3.4 The decision to deactivate automatic fire suppression systems in large facilities should consider the possibility that fire department personnel may not be able to safely enter the facility to effect manual fire suppression. If DOE concurs that such an

approach can be done safely without undermining public confidence, a defensive tactical approach (i.e., exterior fire attack and protection of exposures), should be a part of the baseline needs assessment described in Section 6 of DOE Standard (STD) 1066-2012, *Fire Protection*, and written into the emergency response organization's updated pre-incident plan. Such an approach necessitates additional emphasis on maintaining communication and cooperation between facility personnel and the emergency responders so that emergency responders are aware of changes in occupancy and fire protection system status.

- D.3.5 Retained fire protection features in these facilities are not required to comply with all of the design and installation criteria of the governing NFPA standard, if the AHJ concurs that the system will function adequately during a fire in its altered design mode. The AHJ concurrence should be documented in accordance with site procedures.
 - D.3.5.1 Retained fire protection features should be inspected, tested and maintained to ensure that the features will function adequately during fire incidents.
- D.3.6 Transitional facilities should be routinely inspected and reviewed by representatives of the fire department and fire protection engineering staffs consistent with established standard operating procedures and fire protection program criteria. Tours of facilities should also be conducted by the fire department to familiarize their personnel with existing conditions and to revalidate pre-incident plans. Drills and training exercises should also be conducted at these locations at an appropriate frequency commensurate with the fire risks and complexity of the facility.
- D.3.7 Prior to commencement of work activities in a facility, the transitional facility FHA should be updated, and appropriate procedures should be approved and implemented (including worker training) to govern the control of potentially hazardous operations including, but not limited to, cutting and welding, storage and handling of flammable or combustible liquids, transient combustibles, and sources of ignition, such as temporary wiring and heating equipment. Smoking areas, if allowed on the premises, should also be established.
- D.3.8 The fire risks associated with materials and processes used as part of the transition process should be evaluated by a fire protection engineer. Fire protection features should be adequate to limit these risks to an acceptable level. Combustible equipment required for transitional facilities should be limited to a one-day supply within the facility, unless automatic sprinkler protection is being maintained. Facilities for the storage of combustible materials should be located outside and away from the structure.
- D.3.9 The deactivation of process lines containing hazardous materials, as well as flammable or combustible liquids, should be preceded by an analysis or performed under a work plan that addresses the methods used to control related hazards during the deactivation process. Appropriate safeguards need to be in place to control and minimize the release of residual materials that may remain in piping and tanks.
- D.3.10 Safeguards to ensure facility worker and emergency responder safety and health should conform to the requirements in 10 C.F.R. Part 851 and the requirements for buildings under construction or demolition as provided in NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, unless relief has been granted by the AHJ. In buildings where regular tours and inspections are conducted, adequate exits and lighting should be provided as a minimum, as required

by NFPA 101, *Life Safety Code*. Compensatory measures should be established whenever routine surveillance is being performed in these facilities. These measures should be approved by the site fire authority. Locked and abandoned facilities where there is no human occupancy do not need to maintain emergency egress features.

- D.3.11 When no automatic system exists, an effective means for manually summoning the fire department and for communicating with personnel inside of a building is required. This can take the form of exterior fire alarm pull stations or call boxes, telephones (fixed or mobile), radios, or some combination of the above, based on the accessibility of the devices to all personnel and their reliability. However, in accordance with NFPA 101, all egress features should be reviewed once the facility is reopened for actual demolition activities. Stairwells should be inspected on a routine basis and maintained accessible, clear, and dry, in the event firefighting activities are required.
- D.3.12 All retained interior fire protection systems should be maintained operational to the extent possible while interior work activities are taking place. The sequence of removal of these systems should be clearly spelled out in contractor requirement documents and the FHA. Verification of operable status should include appropriate inspection and testing, in accordance with established procedures. Sprinkler systems should be retained until all fixed and transient combustible materials have been removed. When it is economically feasible, wet sprinkler systems may be converted to dry systems to minimize heating needs. Any temporary deactivation of fire protection features during transition operations should be treated as an impairment, with appropriate interim compensatory measures implemented until the feature is returned to full operational mode pending final demolition. It should be noted that, during winter months when limited heating is provided within facilities undergoing transition, it may be impossible to prevent sprinkler and standpipe system freezing, due to the potential for hidden piping and piping low points that may not drain, or that cannot be drained economically. Deactivated systems deteriorate rapidly. Fire suppression systems should not be removed from service for a prolonged period with the intent to restore protection for safety of workers when final disposition is funded. When feasible, automatic sprinklers should be maintained so that they can be supplied by the fire department utilizing the sprinkler connection.
- D.3.13 The site and facility fire water distribution system, including hydrants, fire department connections, and interior standpipe systems, should be maintained in an operable state. Access for mobile apparatus for emergency response should be maintained and verified on a frequent basis. (Refer to fire department pre-incident fire plans.)
- D.3.14 To the extent that the FHA validates the need to maintain fire protection features during transition activities, such features should be inspected, tested and maintained, consistent with established procedures, sufficient to ensure that they will function effectively during a fire, based on their intent during transition. Defects or design deficiencies that are not essential to ensure liability and effective performance, as determined by the AHJ, may remain as is.
- D.3.15 Temporary Building, Facilities or Shelter used to support transition activities. These type of buildings are ones that are used to support transition activities and may be built or used for supporting operations or ancillary functions. These facilities do not remain after facility transition is complete and are considered operational for no more than 18 months. These facilities require design review by a fire protection engineer, considering the application of the Building Code and DOE-STD-1066-2012 to ensure minimum fire and life safety is considered. Consideration should be given to the fact

that they will not be in service, except during the project life. Documentation may be in the form of the scope of work or design requirements document used to procure or construct the temporary building.

APPENDIX E

Sample Qualification Template for Lead Fire Protection Engineers

Introduction: Office/Facility-Specific Qualification Standards should (as applicable) supplement Functional Area Qualification Standards and establish unique operational competency requirements at the field element, site, or facility level.

Hazards (type, extent and degree) vary at individual sites and facilities and the qualification process should be tailored to meet specific needs. Not all fire protection engineers (FPEs) are expected to be qualified as lead fire protection engineers, but those responsible for key fire protection reviews and approvals should be qualified at this level. Further, individuals need not be qualified in all areas, but should be qualified for those areas when they are assigned final review or approval authority relative to fire protection.

Purpose: The purpose of this template is to establish suggested qualification requirements for Office/Facility-Specific Qualification Standards for FPEs that perform the following lead fire protection engineer activities.

Lead Fire Protection Engineer – A FPE who serves as program manager; provides final fire protection approval of new facility designs or significant modifications to existing facilities; approves, at the contractor's level, exemption, equivalency or alternative designs for fire protection; leads fire self-assessments; approves fire hazard analysis; reviews safety basis documentation, such as design safety analysis; or provides other site-specific approvals that should require fire protection expertise.

Organization and Content:

1. Applicability
2. Implementation
3. Background and Experience:
 - a. Minimum education, qualification, certification or registration level (graduate of fire protection engineer or engineering technology program, or registration as a fire protection engineer)
 - b. Minimum years of experience in fire protection engineering, including any required specific levels such as "responsibly-in-charge," and required minimum performance period
4. Level and degree of site specific knowledge required for:
 - a. Site fire protection organization
 - b. Fire protection program and associated procedures
 - c. How the fire protection organization interfaces with other site organizations such as safety basis, radiation protection, site utilities organizations, safety organization, and other organizations as may be appropriate.
 - d. Fire water supply system
 - e. Fire department services
 - f. Process for handling design changes
 - g. Process for management and readiness assessments
5. Previous experience that would be required and that is commensurate with the approval being granted, i.e., previous experience in design review, developing or reviewing relief requests from the Department of Energy (DOE) order or mandatory code and standard requirements, DOE directives interpretation and application.
6. Qualification sub-elements, including, but not limited to, the review and approval at the fire protection program level:
 - a. Design approvals
 - b. Design issue resolution

- c. Fire hazard analysis and fire protection assessment approvals
 - d. Safety basis documentation review and comment submittal approval
 - e. Fire protection engineering analysis approval
 - f. Approval of requests for relief from DOE directives and mandatory codes and standards
 - g. Approval of alternate approaches to design requirements
 - h. Nuclear fire safety
 - i. Performance base initiative submittals
 - j. Other site specific elements as may be applicable
7. Competency knowledge level. Approval authority should be at the expert level.
- a. Familiarity level
 - b. Working level
 - c. Expert level
 - d. Demonstrate the ability level
8. Evaluation requirement and method of qualification
- a. Satisfactory completion of a written examination
 - b. Satisfactory completion of an oral examination
 - c. Satisfactory accomplishment of an observed task or actively directly related to a competency
 - d. Documented evaluation of equivalencies (such as applicable experience in the field)

APPENDIX F EXPLANATORY MATERIAL

This Appendix provides additional explanatory material supporting the requirements in the body of Department of Energy (DOE) Standard (STD) DOE-STD-1066-2012, *Fire Protection*. These “endnotes” are identified by their corresponding section number.

¹ 1.2 Where DOE facilities are used for work done by others, applicable documents such as Memorandum of Understanding, should address the following concerns and responsibilities:

- Facility protection to prevent threats to nearby nuclear and non-nuclear DOE/NNSA facilities;
- Approval for modifications to the facility structure;
- Requiring that DOE/NNSA requirements be applicable to facility modifications;
- Fire protection water supply and potential impact on required water supply for DOE/NNSA facilities, including the need for separate fire water supplies;
- Inspection, testing and maintenance of fire protection systems; and,
- Which concerns and responsibilities should remain a Field Office responsibility, and which responsibilities may be transferred to the operating contractor.

² 1.5 The Central Technical Authority (CTAs) are designated by the Secretary of Energy, April 26, 2005, memorandum. CTA activities are described in DOE O 410.1, *Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements*.

³ 1.5 This definition is from DOE O 251.1C, *Departmental Directives Program*. In accordance with DOE O 410.1, *Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements*, exemptions may apply to Federal personnel and/or contractors. For Federal personnel, an exemption is formal and final relief from the need to comply with applicable requirements of DOE regulations and directives. For contractors, an exemption is a formal and final release from a provision in a DOE order, notice, or manual that has been included in their contract; or from one or more requirements in a Regulation. Processes for obtaining approval for exemptions to 10 C.F.R. Part 830, *Nuclear Safety Management*, are found in 10 C.F.R. Part 820, *Procedural Rules for DOE Nuclear Activities*; related guidance is provided in DOE-STD-1083, *Processing Exemptions to Nuclear Safety Rules and Approval of Alternative Methods for Documented Safety Analyses*. Processes for obtaining approval to exemptions to DOE orders, notices and manuals are either included in the Directive or are found in DOE M 251.1-1B, *Departmental Directives Program Manual*.

⁴ 1.5 Fire Loss. When determining fire loss, the estimated damage to the facility and contents typically includes replacement cost, less salvage value, and typically excludes property scheduled for demolition; and decommissioned property not carried on books as a value. Fire loss typically includes the cost of decontamination and cleanup; the loss of production; the indirect costs of fire extinguishment (such as damaged fire department equipment); and, the effects on related areas.

⁵ 2 DOE and contractor fire safety programs include all activities pertaining to fire hazards and related perils including: emergency services, operations and maintenance activities, such as hot work or combustible material handling or storage; activities related to fire safety; installation and testing of fire protection systems; water supply and distribution systems; fire safety training; assessments; facility and site walk downs; and other fire protection activities that are not explicitly identified here.

⁶ 2.1 For example: “DOE expects that the site fire department will maintain a capability to provide Advanced Life Support, as defined in the State of...” or “...will provide an emergency services capability that fully conforms with the requirements of the State of..., DOE directives, and National Fire Protection Association (NFPA) codes and standards, unless explicit relief has been granted by DOE.” Note that state requirements do not apply on DOE sites but may apply to responses off-site as part of mutual assistance agreements.

⁷ 2.2.2 Refer to NFPA 5000, *Building and Construction Code*, Chapter 34 for determination of control areas and protection levels as it relates to NFPA 1, *Fire Code*, and NFPA 400, *Hazardous Materials Code*.

⁸ 2.2.2 Public Law 107-217 Title 40, *Public Buildings, Property, and Works* requires Federal agencies to use national consensus standards. DOE regulations and directives require use of “applicable” fire standards. The National Fire Codes (NFC) comprise over 200 codes and standards. In addition, ASTM and other organizations promulgate national standards for fire protection. The applicable standards are generally a small subset of the total which may vary significantly from facility to facility, depending on how the facility is used and the hazards it contains. Applicability can usually be determined by an “applicability” statement at the beginning of each standard and as determined by the authority having jurisdiction (AHJ). Building construction related to egress and life safety should comply with the NFPA 101, *Life Safety Code*[®]. Conflicts between the *International Building Code* (IBC) and NFPA 101 related to fire resistance rating should conform to NFPA 101. Compliance with NFPA 101 should be considered to satisfy the exit requirements of 29 C.F.R. Part 1910, *Occupational Safety and Health Standards*. The *International Fire Code* (IFC) is a companion document to the IBC. However, for DOE operations, the IFC and other local codes, should only be applied when the required by local jurisdictional agreements. The NFPA 1, *Fire Code*, takes precedence over the IFC in all other situations. Other requirements of IFC are not considered criteria but may be used as a guide when established criteria do not address a specific situation.

⁹ 2.2.2.5 The definition of a special industrial occupancy can be found in the 2006 edition of the *International Building Code*, paragraph 503.1.1.

¹⁰ 2.3 Beginning with the Manhattan Project, facilities were also required to meet “Highly Protected Risk” (HPR) criteria. This requirement continues with latest revision of DOE O 420.1C. HPR is an insurance term used by the DOE to define a facility where both the frequency and the severity of a fire-related loss (risk) has been addressed by fire protection features, such as, but not limited to, noncombustible construction, the installation of fire suppression and detection systems, redundant water supplies, fire alarm systems, and specific measures and procedures to address special hazards. Compliance with national codes and standards, and building codes relative to property protection is required to be judged a HPR property. A graded approach and experience in the application of insurance industry standards is necessary to determine the appropriate HPR provisions for a given facility or process. When national codes and standards are lacking relative to a hazard at a DOE site, FM Global Datasheets and recognized experts are used to address the potential risk. Most importantly, management interest and commitment to loss prevention is essential to a HPR property and is demonstrated by timely completion of legacy non-compliances with these codes and standards. Additionally, impairments to fire protection systems are minimized and compensatory measures for impairments are invoked. Manual fire-fighting is provided to reduce the severity of fire loss. Additionally, mission impact from fire is appropriately addressed. HPR relates primarily to property protection and mission impact, rather than life safety or protection of the public from nuclear accident. However, HPR protection features can be effective in meeting life safety objectives.

¹¹ 3.2 DOE O 420.1C, *Facility Safety*, requires heads of field elements (AHJs) to establish and implement an appropriate self-assessment and oversight program for fire protection. Consistent with HPR principles, self-assessments of the site office fire protection program should be conducted triennially. In addition to elements identified in Section 3.2.2, of DOE-STD-1066, heads of field elements should assess: DOE organizational responsibilities; delegations and authorities for fire protection at the site office; the approval process for fire protection exemptions; equivalencies and variances; and, the effectiveness of the contractor’s performance.

Lines of Inquiry developed by the Commission on Fire Safety may serve as examples of questions that can be used in developing a comprehensive self-assessment. While some of the details in the questions will need to be updated to reflect changes in DOE policy and requirements, or may no longer apply, the

basic concepts and approach can be useful. The commission report can be found at: <http://www.hss.doe.gov/nuclearsafety/nfsp/fire/guidelines.html>. In addition lines of inquiry developed by other field offices or DOE/NNSA Headquarters subject matter experts may also be used.

¹² 3.2.2 The elements of the fire protection self-assessment also provide guidance for the conduct of independent program assessments.

¹³ 4.1.1 For large projects it may be beneficial to establish a fire protection working group comprised of DOE and contractor fire protection engineers, safety basis representatives, responsible design engineers, operations personnel and others as may be appropriate. Such working groups can be successful in resolving fire protection challenges, ensuring that issues do not become side-tracked, identifying as early as possible, the need for exemptions or equivalencies, and most importantly, avoiding costly delays in design or construction.

¹⁴ 4.2.1 NFPA 101, Chapter 43 provides criteria for defining significant modification from a life safety perspective. IBC Chapter 34 and IEBC provide criteria for defining significant modifications from a building code perspective. DOE-STD-3006-2010, *Planning and Conduct of Operational Readiness Reviews* and DOE-STD-1189-2008, *Integration of Safety into the Design Process*, provide guidance for defining major modifications for nuclear facilities.

¹⁵ 4.2.3 Refer to DOE O 420.1C or Appendix A of DOE-STD-1066-2012 for nuclear safety-related SSC redundancy requirements.

¹⁶ 4.2.4.1 In addition to the specific requirements in DOE O 420.1C, Attachment 2, Chapter II for redundant safety class systems and large loss potential, there may be other hazard occupancy or area separations required by codes and standards or facility specific fire safety objectives. The basis for establishing fire area should be documented.

¹⁷ 4.2.4.3 Special facilities should be designed and constructed using building components of fire-resistant and noncombustible material, particularly in locations vital to the functioning of confinement systems.

¹⁸ 4.2.7.1 Water supply demand consists of the following: 1) sprinkler or water spray demand; 2) the simultaneous demand of other water-based fire suppression systems, such as plenum cool down and water spray sprinklers or exposure protection sprinklers; 3) hose stream demand based on fire department operations criteria and safety basis assumptions, i.e., calculation for interior hose streams required in order to avoid opening confinement barrier doors; and, 4) other demands which cannot be curtailed such as domestic or industrial demands. Additionally, refer to NFPA 1, Section 18.4 for fire flow calculation requirements when determining water demand for new water supply installations.

¹⁹ 4.2.7.2 See FM Global Loss Prevention Data Sheet 3-2, *Water Tanks for Fire Protection*, for additional design guidance.

²⁰ 4.2.7.3 See FM Global Loss Prevention Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances*, for additional guidance.

²¹ 4.2.7.4 Fire pump redundancy can be provided by two 100% capacity pumps or, when demands vary greatly for multiple suppression system supplied by the pumps, redundancy can be provided by three 50% capacity pumps. For additional guidance on fire pumps, see FM Global Loss Prevention Data Sheet 3-7, *Fire Protection Pumps*.

²² 4.2.7.6 In some circumstances, the need for an automatic sprinkler system should be considered, despite the absence of explicit order requirements. Some examples of situations where automatic suppression may be warranted are:

- facilities that contain critical or long procurement time construction items;

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- a temporary-use trailer used as a control center for a vital one-time activity;
 - a facility with high public visibility or sensitivity (as defined by the AHJ);
 - electric power transformers with combustible contents that, if damaged, could result in an extended shut-down of the facilities they serve;
 - facilities in which a fire could result in the accidental release of significant quantities of toxic or hazardous materials or emissions (based on an engineering analysis);
 - facilities that can be protected by extending automatic fire suppression systems from an adjacent protected facility or area at a low incremental cost;
 - facilities in which a fire could damage more important adjacent facilities; and,
 - facilities used to store hard-to-replace or irreplaceable records.

The resulting protection should be designed to ensure that a fire would be successfully controlled until such time that emergency response forces arrive to extinguish it. The fire hazards analysis (FHA) and the safety basis documentation should specify any additional requirements beyond those for a standard wet pipe sprinkler system.

²³ 4.2.7.8 When the use of water sprinkler coverage is precluded because of nuclear criticality or other incompatibility reasons, nonaqueous extinguishing systems (e.g., inert gas, carbon dioxide, halon alternatives, etc.) that will be successful in extinguishing the anticipated fire, and which are not reactive to materials present, should be used. Additional precautions may be needed since these alternative systems are much less reliable than sprinklers and their limited supply of extinguishing agent may permit re-ignition.

²⁴ 4.2.8 The requirements for providing a fire alarm system appear in the IBC, NFPA 101, and 29 C.F.R. Part 1910, Section 1910.165. Additional requirements may be developed from the FHA. The facility's fire alarm control panel should be located near the main entrance or in a protected location, as determined by the AHJ. For facilities with multiple alarm zones, a zone alarm panel, or a graphic annunciator should be located at the main entrance unless other features are available to emergency responders.

Detector installations should be engineered and installed so that they can be tested during the life of the detector. Remote testing should be provided for detectors that are not accessible due to unacceptable hazards. One method of providing remote testing is to provide detectors with heating strips or coils that can be energized by a separate control unit (see Appendix E of DOE-STD-1066-99 for further information) If a line-type heat detection system is used, a heat testing pad should be provided outside the plenum for operability testing of the system. The remote testing arrangements may be unique to DOE facilities and not addressed in either NFPA 72 or NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.

²⁵ 4.2.8.1 NFPA 72 refers to Fire Alarm Control Units (FACU) to describe a variety of panels. The use of Fire Alarm Panel (FACP) is a fire alarm control unit that has inputs and outputs and communicates with other FACPs.

²⁶ 4.2.8.3. NFPA 72 allows fire alarm system speakers to be used for general paging and other non-emergency functions provided those functions do not interfere with the fire alarm or mass notification system function. Likewise, NFPA 72's sections on emergency communication systems establish the monitoring and reliability requirements for paging system to be used for emergency communication.

²⁷ 4.3.1 ASME *Boiler and Pressure Vessel Code*, Section VIII, *Rules for the Construction of Unfired Pressure Vessels*, also provides applicable design guidance.

²⁸ 4.4.1.1 NFPA 801 provides guidance for radioactive materials. Other hazardous materials are addressed by the *International Fire Code*, Chapter 27. Hazardous Materials are also addressed in Chapter 60 of NFPA 1 and various other NFPA Codes and Standards such as NFPA 400.

²⁹ 4.4.1.3 Both NFPA 801 and NFPA 400 require the secondary containment of hazardous materials to have sufficient capacity to contain the volume of the largest vessel and the water from fire suppression activities. NFPA 801 requires a “credible” quantity of fire suppression water, as determined by the FHA, and states that this is not intended to be a worst case. NFPA 400 requires the sprinkler discharge to be from the minimum design area, the room area, or the storage area, whichever is smaller. For a diked or curbed vessel, the additional volume for the sprinkler discharge need only consider the sprinkler discharge density over the diked area. The design objective of both of standards is to prevent the spread of hazardous materials via the fire suppression water. The design basis for the secondary containment should be documented and incorporated into the pre-fire plans to facilitate emergency activities to minimize the spread of contaminated water

³⁰ 4.4.1.5 Process confinement systems include the following: 1) ventilation systems; 2) gloveboxes; 3) material transfer systems that are enclosed; and, 4) piping systems with or without tanks. The confinement system is to be designed to provide its safety function during, and following, design basis accidents, including design basis fires. Hazard category 1, 2, and 3 nuclear facilities with uncontained radioactive material (as opposed to material determined by safety analysis to be adequately contained within drums, grout, or vitrified materials) should have the means to confine the uncontained radioactive materials to minimize their potential release in facility effluents during normal operations and during, and following, accidents (including firefighting water run-off or products of combustion from fire, such as smoke, particulates, etc.). The design to ensure continued confinement can only take credit for other safety systems, such as the fire suppression system, if they are designed to also survive the design basis accident and appropriately classified consistent with the confinement system.

To protect the integrity of the physical barriers associated with process confinement systems, fire protection features should include the following:

- A fire extinguishing system to rapidly remove heat produced by fire to prevent or minimize damage to the process system, or to prevent over pressurization of a process confinement system and to rapidly extinguish a fire to minimize the loading of ventilation system filters with combustion products;
- The introduction of the extinguishing agent in a way that does not result in over pressurization of the confinement barriers;
- When appropriate, vulnerable portions of the confinement system should be provided with a fire-resistive enclosure, or fire wrap of suitable fire rating; and,
- Administrative controls for the storage of combustible materials within, or close to, such systems.

³¹ 4.4.1.7 The discussion of how the fire resistance is attained refers to providing protection that is inherent in the element, such as a reinforced concrete member, or one where the protective membrane is applied directly to the exposed surfaces of the structural members such as sprayed on insulation or intumescent coatings. The “composite assembly (membrane fireproofing)” refers to providing insulation installed to form an enclosure around the structural member, in which case the fire-resistive barrier is placed between the potential fire source and the member. An example of membrane protection is a suspended ceiling positioned below open web steel joists, or a gypsum wall on steel studs surrounding a structural steel column. The concern for composite assemblies is that there is often electrical, plumbing and mechanical equipment above ceilings or behind walls and access may result in improper repair or replacement that may not be obvious in a visual inspection. The primary concern with membrane fire proofing systems is that once compromised, all structural components protected by the membrane will be subject to failure from fire exposure.

³² 4.4.2.2 AGS-G010, *Standard of Practice for Glovebox Fire Protection*, addresses performance criteria for glovebox design and operations, fire protection analysis, deflagration prevention, fire suppression, fire barrier penetrations, and other relevant topics for glovebox design and operations. See AGS-G006, *Standard of Practice for the Design and Fabrication of Nuclear Application Gloveboxes*, for additional information.

³³ 4.4.2.2 The design of material transfer systems that pass through a rated fire separation assembly and cannot be provided with a fire door or damper (due to operational concerns) should preclude fire and hot gases from entering or escaping from the transfer system or travelling along the length of the transfer system. The design should assume that the building's sprinkler system has failed or is not available, and consider the total amount of material at risk that might be put at risk by a single fire event. A test may be used to verify that the selected design for protection of the opening where the transfer assembly passes through the fire separation assembly will function as designed.

³⁴ 4.4.2.3 FM Global Data Sheet 5-79, *Inerting and Purging of Tanks Process Vessels and Equipment*, provides additional guidance on the assessment of hazards and the design of purging and inerting systems. Design of inerting systems should consider potential off-normal conditions and process upsets that could affect the inerting concentrations in addition to normal operating conditions. When an inerting system is credited as safety significant and the inerted process does not allow for the removal of the material-at-risk in the event of an impairment to the inerting system, the provision of a fire protection system, as a backup, should be considered. For combustible and pyrophoric metals, the oxygen concentration should not exceed 25 per cent of the level required for combustion. (Note that some combustible metals (e.g., aluminum powder) will burn in atmospheres other than air. Thus, it is important for the designer to select an appropriate inert gas and establish a design concentration based upon the hazard.).

³⁵ 4.4.3 Much of the information pertinent to fire protection for very high efficiency air cleaning filter plenums for nuclear applications is contained in technical papers, limited distribution reports, and job specifications that are often not readily available to DOE designers, facility managers, and fire protection engineers. This section provides personnel responsible for filter installations with practical fire protection guidelines for nuclear air cleaning final filter plenums. Although the guidelines in this section are specifically applicable when high efficiency particulate air (HEPA) type filters serve as the final means of effluent cleaning in a nuclear air cleaning ventilation system, they may also be applied with engineering discretion to other types of filtration and cleaning systems and their configurations.

³⁶ 4.4.3 DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook*, Chapter 10, expands on these objectives. These objectives are in addition to the Life Safety and property damage protection objectives discussed elsewhere in DOE-STD-1066-2012. Although the guidelines are specifically applicable when only HEPA type filters serve as the final means of effluent cleaning in a nuclear air cleaning ventilation system, the guidelines can be applied with engineering discretion to other types of filtration and cleaning systems and their configurations.

Design of confinement ventilation systems usually incorporates redundant trains of HEPA assemblies and fans to improve reliability and allow maintenance activities. The provision of these redundant trains is valuable from a fire protection standpoint since they allow isolation or even loss of one filter assembly without interrupting confinement ventilation filter function.

This section does not include specific definitive fire protection design requirements for High Efficiency Metal Fiber filter systems, Radioiodine Adsorber air cleaning systems, Deep Bed Fiberglass filter systems, or Deep Bed Sand filter systems. This section also does not include the protection of HEPA-type filters utilized in a clean room application. (Refer to NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*.) See also Appendix A of DOE-STD-1066-99 for information on other types of nuclear filtration and air cleaning systems.

³⁷ 4.4.3.1 This paragraph is not intended to prohibit the use of fire retardant treated wood filter frames for existing applications.

³⁸ 4.4.3.2.6 Refer to Appendix D of DOE-STD-1066-99 for a discussion of this type of analysis.

³⁹ 4.4.3.4 When there is no "listed" equipment or materials of the type planned for use, special one-of-a-kind equipment may be accepted, provided the AHJ can verify that all components meet high quality

control standards. Installation methods should be in accordance with the manufacturer's instructions, NFPA 70, and other applicable requirements.

⁴⁰ 4.4.3.8 Tests by Lee of Atlantic Richfield in 1974 established the following design features for fire screens to prevent the passage of fire. Fire screens should be located upstream from the prefilters and final filter plenums. Fire screens with meshes from 8 to 16 opening per inch should be located as close to fire sources as possible. If installed in the final HEPA plenums, they should be located at least 4 to 5 ft upstream of all filters that need to be protected, provided that sufficient distance (i.e. 20-30 ft per DOE Handbook 1169, 10-22) exists between the fire source and the final HEPA filter plenums. Metal demisters or metal prefilters may perform as fire screens when proven to be equivalent to the fire screens by testing or analyses. Duct entrance filters may not require fire screens unless a significant amount of combustible materials are present in the exhaust stream exiting the duct.

⁴¹ 4.4.3.10 If spot type heat detectors or pilot heads are used for fire detection in the HEPA filter housing, they should be installed in the airstream prior to the first stage and in the airstream after the first stage. If linear thermostatic cable is used for fire detection in the HEPA filter housing, it should be installed across the face of the first stage filters. It may also be desirable to install linear thermostatic cable either on the downstream side of the first stage filters or across the face of the second stage filters. If the heat detectors are modified for ease of maintenance or testing (e.g. in a thermal well), the affect of this modification should be analyzed and approved by the AHJ.

⁴² 4.4.3.11 If the cooling of the hot gases is to be accomplished with dilution air, engineering calculations should demonstrate that the inlet temperature to the HEPA assembly is no greater than 250°F. If the cooling of the hot gases is to be accomplished with water spray or sprinklers in the duct work, the flow rate of 1gpm for every 500cfm should be used, unless another flow rate can be justified. These in-duct systems should be automatic. Where automatic deluge spray systems are installed in filter plenum enclosures that do not contain prefilters, metal demisters can be installed downstream of the automatic deluge spray sprinkler heads and upstream of the first series HEPA filter.

⁴³ 4.4.3.12 Tests and calculation show that the pressure drop across prefilters is higher than the HEPA for the same mass loading because the HEPA filters have larger filter surface areas. Replacing the prefilters with either extended surface area media or HEPA type filters will greatly improve the performance of the ventilation system during a fire emergency. If it becomes necessary to maintain confinement ventilation, the redundant filter assembly should be engaged and the plugged filter train can be isolated.

⁴⁴ 4.4.3.13 Sprinkler or water spray should be designed to reach the face of the first stage of filters. This may require multiple nozzles if the filter assembly is subdivided. Previous DOE design guidance established a water density of 0.25 gpm/ft² of filter face area and that the system is manually operated. Designs applying less water or automatic operation should be justified in the FHA.

⁴⁵ 4.4.3.15 Direct impingement of water on filters can weaken and damage filter media. The automatic water deluge system is intended to protect the filters by cooling the airstream from a process-related fire. However, a high efficiency demister is installed downstream of the automatic deluge spray system to protect the filters from water damage when activated. The manual water spray system is directed at the final stage of filters and is only intended to be deployed when fire is verified on the final filters. Potential failure of the final filters can occur, if the manual system deployment is made without failure considerations. Failure mechanisms can be significantly mitigated by throttling back or terminating fan controls prior to system activation to prevent filter rupture, locking the manual spray system control valve in a normally closed position, and making the valve only accessible to personnel who are trained and knowledgeable in operating procedures of this system and failure mechanisms of the filters.

⁴⁶ 4.4.3.15.1 See also Appendix C of DOE-STD-1066-99 for information user guidance on use and testing of fire protection features for high efficiency air filtration systems.

⁴⁷ 5.1.3.3 See http://energy.gov/sites/prod/files/ADM%2018_0.pdf

⁴⁸ 5.1.4.3 Combustible control programs should address the quantity, type, and location limits on combustibles allowed in critical areas. These limits should be based on the minimum fire size capable of threatening structures, systems or components that are necessary to maintain an acceptable level of health and safety risk.

⁴⁹ 5.1.5.2 Impairment history should be reviewed on an annual basis and compared to previous data to determine any adverse trends to system performance or reliability. Adverse trending may require further evaluation of the causes of the impairments, further or more extensive testing, more frequent testing or more detailed evaluation of results to anticipate future conditions.

⁵⁰ 5.2.1.1 Staffing levels for the contractor's fire protection program should be based on a "work load analysis" or similar analysis that provides a technical basis for the fire safety staff. The qualifications of the staff members should be commensurate with the level of decision authority regarding fire protection that is delegate to them. Staffing for the fire department should be based upon conclusions reached in the Baseline Needs Assessment (BNA) required by DOE O 420.1C.

⁵¹ 5.2.1.2. Although state and local requirements do not apply on Federal reservations, it may be desirable to apply them selectively to facilitate mutual assistance agreements with nearby jurisdictions.

⁵² 5.2.3 The level of documentation necessary to support a request for relief will vary, depending on the issue. As a minimum, each request should:

- identify the specific site, facility location or condition at issue and the paragraph/section of the rule, directive, code or standard which addresses the issue;
- discuss why the requirements cannot or should not be met , including benefits that are to be gained by approval;
- provide identification and justification of the acceptance of the threat or threats that will be incurred if the request is granted;
- justify the conclusion that the alternate configuration is acceptable from a safety, environmental, property damage, or program continuity perspective to what is stipulated in the code or standard; and,
- discuss other pertinent data or information that supports the request for relief.

All functions should also be addressed. For example, an automatic sprinkler system provides detection, local alarms, fire department notification, and fire suppression. The description of alternatives in an equivalency should address each of these functions. In addition, relief from a requirement in one directive or standard does not constitute relief from a similar requirement in another directive or standard. Every source requirement for the system or feature should be identified and addressed, since the purpose of the system or feature may differ. For example, exemption from the DOE O 420.1C requirement for sprinklers in a radiological facility over 5000 square feet does not constitute relief from the requirement for sprinklers from NFPA 801. Both documents are to be identified and addressed in the exemption request.

A change in use or occupancy usually requires bringing a facility up to current codes and standards, voiding all exemptions, equivalencies and variances. Re-evaluation and re-submittal of requests for relief for the same deviations should clearly explain why the facility deviations could not be corrected during the conversion. A failure to follow request for relief commitments to which the operating contractor committed or a failure to comply with conditions of approval, may result in the relief being voided.

The temporary exemption process should be employed when corrective action is planned but may take several years to implement; the issue is of a short-term duration; the facility in question has a very short continued operational life of three years, or less, and similar circumstances.

⁵³ 5.2.4.2 Routine activities include: issuing of permits; reviewing and approving construction documents and shop drawings (new construction, modification, or renovation); accepting fire protection equipment,

materials, installation, and operational procedures (fire system inspection and testing), interpretation of building codes or standards; and other activities that require AHJ approval.

⁵⁴ 6.1.1 In addition, the BNA should describe the organization's various programs that support its personnel. This should include training, physical fitness, and medical programs relating to emergency responders. In developing the BNA, the intent is that this be a coordinated effort involving the AHJ and the representatives of the site emergency services organization. Additional expertise in unique emergency response or fire prevention issues, legal matters, labor-related issues, emergency medical protocols, etc., may be required to assist in the development of the BNA.

⁵⁵ 6.1.2 This does not mean that the BNA has to be written to confirm code conformance on the basis of line-by-line comparisons. A reasonable degree of documentation is expected. It should also address applicable contract provisions and aid agreements with other contractors on site, as well as off-site organizations. The goal is to capture, in one document, information that will identify needs and confirm that the emergency response requirements can be met.

⁵⁶ 6.1.4 This can be done via a BNA, or comparable document. This document should describe the site services required (fire suppression, emergency medical, rescue, etc.), the basis for the required service (facility construction and hazards, special hazards or other special needs, expected frequency of required need, remoteness of facility, availability of aid from other jurisdictions, code requirements, etc.). The analysis should determine whether the off-site emergency response organization is capable of providing the service and how such service will be provided, as well as the organization's ability to respond to both an on-site, as well as off-site, working fires or other simultaneous emergencies, including wildland fire threats. A staffing study should be provided that shows the organization's capability to provide a full first alarm response, in accordance with NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. When the off-site emergency responders exclude fire-fighting involving nuclear or other site hazards, the BNA should clearly describe: how such services are to be provided; how the safety of contractor provided emergency responders, such as a fire brigade, will be provided; and, the need for greater reliance on automatic fire suppression for fires involving nuclear or high hazard materials. The BNA should clearly describe how on-site and off-site emergency response efforts will be integrated during an emergency.

⁵⁷ 6.1.5 In developing the BNA, the basic assumption should be that there is only one emergency incident occurring on-site, with a casualty requiring emergency medical assistance. However, the document should also describe how the fire department would respond if a second incident occurred while the first was underway. The second response capability could be based on documented mutual aid agreements and utilization of some percentage of off-duty personnel overtime. To the extent that an insufficient response capability is determined to exist for this second emergency, the BNA should address the required supplemental emergency response resources that would be needed to respond to this event. When the fire department provides service to others, unless dedicated fire department services are reserved for protection of the site, the BNA should address the potential for off-site fire response concurrent with a required on-site response, including the potential for delayed response or a resource limited response.

⁵⁸ 6.1.6 A critical factor in any such analysis is the minimum response time necessary to begin active intervention (fire suppression, emergency medical, technical rescue, etc.) activities. The determination of a minimally acceptable response time should be based on risk, and should reflect categories, such as alarm, call processing, dispatch, response, and turnout times that have been established in NFPA 1710.

In addition, the BNA should address other emergency responder practices that may affect response times and efficiency, including, but not limited to: equipment/personnel being out-of-service for activities such as, training, inspections, pre-incident planning or other purposes; whether stations located at DOE sites are permitted to be vacant in order to maintain response capability within municipal or county areas; assistance to nearby state or local government jurisdictions; and, other standby situations, such as

confined entry that may impact response. The extent to which these practices may impact the delivery of emergency services will, in part, depend on whether the fire department is dedicated to a site; the fire department is in a contract arrangement with requirements that limit the impact of such actions on the delivery of site emergency services; or, if the arrangement is with a municipal or county fire department that may have competing responsibilities.

DOE expects that the response time requirements of NFPA 1710 be the starting point in the determination. Site specific conditions, such as the widespread installation of automatic fire suppression systems, could be used to extend response time to structural fires through the NFPA 1710-accepted equivalency process. Similarly, the provision of localized Automated External Defibrillators (AEDs) and first-aid supplies, along with appropriate employee training, could be used, in part, as a basis for extending Emergency Medical Service response times.

⁵⁹ 6.1.7 The level below which on-site fire department resources should not drop should consider whether mutual aid response would be timely, given the sites location, as well as whether off-site fire-fighters are prepared and willing to respond to fire events at the site, especially if fires might involve radioactive materials or other hazardous materials. This information can be inserted in summary fashion or the BNA can be incorporated directly into the referenced documents.

⁶⁰ 6.2.1.1 Living quarters should provide a comfortable, private and safe environment for personnel, consistent with state or local requirements. This includes adequate sleeping quarters, when necessary (when personnel are working more than a 12-hour shift), kitchen facilities, training rooms, physical fitness areas, and other ancillary needs. To the extent that related occupancies such as alarm rooms, maintenance rooms, and personnel areas are co-located within the same facility, appropriate fire-rated physical separation, ventilation and exhaust, and other fire protection features should be provided to prevent interference and to ensure the viability of individual areas in the event of a fire.

⁶¹ 6.2.1.4 Station location should also reflect prevailing traffic patterns, climatic conditions, railroad tracks and other sources of delay. When multiple stations are provided, they should be located near the site's high risk facilities or areas while providing an acceptable level of fire protection for other facilities located throughout the site. Station location and resource allocation should also consider: the hazard classification of the facilities; the actual fire threat to personnel, the facility, and its mission; the level of automatic fire suppression provided; the extent to which manual firefighting efforts may be required; and, traffic patterns, potential road bottle necks, and other factors, as may be appropriate.

⁶² 6.2.2.1 Examples include hazardous material response, heavy rescue, rough terrain rescue, chemical or large flammable liquid spills, and wildland fire response. The selection of apparatus should consider potential need and frequency, and whether special apparatus having limited need would be available through mutual aid or other means.

⁶³ 6.2.2.3 Periodic replacement programs for apparatus should be structured to avoid excessive "down time" and repair costs and should reflect the industry norm of useful life cycles (e.g., 20 years). The apparatus replacement program should be scheduled over time, so as to avoid peaks in apparatus replacement cost. Fire departments should be required to maintain apparatus response and mileage logs to assist in identifying inappropriate use of apparatus and in developing replacement schedules.

⁶⁴ 6.2.3.1 It is recognized that, when lives may be at risk, the Incident Commander has the authority and responsibility to initiate rescue with less than this minimum if, in his judgment, it is safe to do so for instance, in properties fully protected by automatic sprinkler systems. Additional emergency response personnel will be necessary when multiple hose lines are required to suppress a fire and to support other fire ground activities such as search and rescue.

⁶⁵ 6.2.3.2 Historical DOE guidance maintains that a minimum of five self-contained breathing apparatus-equipped emergency responders should be available at the fire ground prior to any interior firefighting or other operations are attempted.

⁶⁶ 6.2.3.3 When reliance is placed on off-site fire brigades or fire departments for fire suppression, efforts should be made to obtain suitable clearances for fire response personnel in order to avoid delays in fire department response, and associated consequences (e.g., loss of life, injury, and increased fire damage) that may result as a result of delayed response.

⁶⁷ 6.2.5.1 As part of this effort, regular facility tours should be conducted utilizing current pre-incident fire plans, as well as to verify that plans are accurate. Contractors subject to 10 C.F.R. Part 851 are required to adhere to 29 C.F.R. Parts 1910 and 1926, if these regulations are applicable to the hazards at their covered workplace. See 10 C.F.R. § 851.23 (a)(3) and (7).

⁶⁸ 6.2.5.3 This includes "live fire" training, confined space entry, vehicle extrication, hazardous material response, and other site-specific conditions. When on-site training facilities are unavailable, arrangements should be made for appropriate training for fire department personnel off-site at nearby city or county training facilities, or at regional or state training facilities.

⁶⁹ 6.2.5.4 The term 'fire-fighters' is intended to mean those whose sole responsibility is fire department activities, as opposed to fire brigades or emergency response team members, whose primary responsibilities are other than the fire department.

⁷⁰ 6.4.1 Special fire-fighting procedures should be developed and maintained in conjunction with efforts governing fire department procedures in general. DOE and contractor management should be kept routinely informed if fire department emergency operations for these special circumstances represent deviations from the norm. FHAs should reflect unique fire-fighting strategies when rapid intervention may not be possible (moderation controlled areas); demolition activities have made the facility unsafe for entry in the event of fire; and, when fixed fire protection systems may no longer be in-service, or of limited value. At a minimum the information should include:

- changes in activity level and scale;
- increases or decreases in the hazards;
- changes in both active and passive fire protection system status;
- identification of the point when the building is unsafe to enter.

⁷¹ 6.4.1 Fire-fighting procedures for transitional facilities should address conditions under which interior fire-fighting actions may be safely accomplished versus conditions under which interior firefighting efforts might be unsafe. As an example, interior fire-fighting might safely be accomplished, due to the facility being constructed of non-combustible or fire-resistive construction and the presence of only limited combustibles materials. However, combustible construction or the presence of quantities of combustible materials could make interior fire control a safety concern in the absence of fixed fire suppression equipment. Another factor to consider is whether automatic sprinkler protection and standpipe systems, that have been impaired, might still be supplemented via the fire department connection(s). This would assume that the sprinkler piping was drained and piping integrity was maintained. Other transitional facility factors to be considered include the need for exposure protection for nearby structures, and environmental concerns including the potential spread of contamination or contaminated fire-fighting water. As a facility enters and undergoes transition, the emergency response organization should be kept up-to-date as to the building's status, including the point at which demolition or other activities would make the structure unsafe for entry.

⁷² 7.3.1 Compensatory measures should be appropriate to the hazard present, considering the primary system is out of service. The user should consider the impact to the workers who may still be present, the facility, the public, the environment, as well as emergency responders. Compensatory measures generally cannot replace fixed automatic fire protection equipment.

Some additional compensatory measures that should be evaluated for applicability, particularly in nuclear facilities, include:

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- minimizing or eliminating combustibles;
 - limiting ignition sources (i.e., shut off electrical power);
 - curtailing or limiting activities in the area;
 - providing interim water sources (i.e., back-feeding a sprinkler through the fire department connection from a nearby hydrant);
 - increasing surveillances of hazardous operations;
 - positioning standby emergency response personnel with appropriate equipment;
 - providing a continuous fire watch; and,
 - removing and store nuclear materials in protected locations (i.e., vaults).

⁷³ Appendix A This Appendix incorporates new criteria and guidance related to the design and operation of fire protection systems used in safety class and safety significant applications that were developed as part of the Department's response to Defense Nuclear Facility Safety Board Recommendation 2008-1, *Safety Classification of Fire Protection Systems*.

⁷⁴ A.1 This appendix presents unique considerations and requirements applicable to safety-related fire protection systems and components. These are in addition to the general provisions for all systems. Any equivalencies, exemptions or alternative approaches to DOE-STD-1066 approved for a site or the non-safety-related portions of a facility should be evaluated in light of the potential safety-related implications when applied to safety-related systems. If still applicable, this should be documented in the equivalency, exemption or alternative approach and approved.

⁷⁵ A.1.4 Supporting information should include documentation of or reference to design issue resolution, alternative design approaches that may be employed, and documentation of any relief granted from DOE directives, standards, or other mandatory codes and standards, such as those developed by the NFPA.

⁷⁶ A.2.2 The safety classification of all system components, as well as the functional requirements for the safety function should be clearly identified, and the boundaries of the safety system delineated so appropriate design requirements for the components can be specified or the design developed to accommodate any differences in safety function.

For example, a pressure gauge for a safety class sprinkler system would typically be classified as safety class for the pressure boundary to maintain the integrity of the piping, even though the functionality of the gauge (the ability to be able to accurately read the system pressure) may not be a safety class function since failure of gauge to accurately depict the system pressure would not impact the ability of the sprinkler system to deliver water to the fire. However, if the pressure boundary of the gauge was not designated as safety class, the failure of the pressure boundary would need to be accounted for in the hydraulic calculations for the system to be sure sufficient water was available to supply the required pressure and duration, or a safety class means of isolating the non-safety gauge from the safety-related portion of the sprinkler system.

This may be trivial in the case of a gauge, but the concept would apply equally, for example, to a 2 inch drop from the safety class sprinkler system feeding a dry pipe sub-system for a dock outside the exterior wall of the facility. In this case, the dry-pipe system piping would need to be designed to the same design requirements of the safety-related system (including seismic design if the safety system is required post-seismic) even though a failure of the dock system to function may not impact the ability of the interior sprinkler system to perform its safety function. If the dock system were not designed to the same functional requirements as the interior system, the hydraulic calculation would need to show that the interior sprinkler system could still perform its safety function, even if the dock system catastrophically failed (i.e. the pipe broke during a seismic event). Another example would be a drop from the safety-related ceiling system protecting the interior of a glove box or hood that does not have a safety function.

⁷⁷ A.2.3.2 Safety basis documentation typically does not credit response for the fire department, and relies on the suppression system to control or extinguish the fire. If an emergency response is credited, alarm devices and supporting equipment would also need to be safety-related.

⁷⁸ A.2.4.1.4 A key reason for closer sprinkler spacing is to accommodate the potential for a failed sprinkler on demand.

⁷⁹ A.2.4.2.1 An alarm check valve acts like a simple check valve. This has been determined by the nuclear safety community to be a passive component.

⁸⁰ A.2.4.2.3 Additional redundancy, such as redundant risers and looped distribution mains within the building, in addition to the typical redundant water supplies should be considered when looking at operations that may be required to continue while portions of the system(s) are out for maintenance or repair. This may be critical when the risk to the workers and/or public cannot be mitigated by available compensatory measures since simple compensatory measures (i.e. fire watches) generally cannot replace fixed automatic fire protection equipment. Refer to section 7.3 of DOE-STD-1066 regarding compensatory measures. Other means of protecting the workers and/or the public from nuclear safety risks, such as removing and storing nuclear materials in protected locations (i.e., vaults) may not be practical or may take long periods of time (days to months, in some cases) to accomplish. Simply interrupting operations for extended periods to accommodate maintenance or testing may not be easily accommodated or may seriously impact the facility mission. The initial installation of the redundant components should be weighed against the long-term reduction in risk, potential mission impact and operational flexibility.

⁸¹ A.3.1.1 Note that the water supply system may be discussed as a support system to a SC or SS system (such as a wet pipe sprinkler system). In some cases, the nuclear safety function can be accomplished by providing a suppression system designed for a specific hazard, such as an interior glovebox protection. Such a system can be designed to meet only the SS or SC nuclear safety needs for its capacity and will not necessarily have to be designed to meet the capacity requirements of other requirements such as NFPA 1, NFPA 801, or NFPA 13, provided this system is independent of any other system in the facility. For example, if the nuclear safety objective can be met with a 500-gallon pressure tank within the facility, the NFPA criteria that may dictate larger water supply tanks for facility fire safety do not need to apply to the design of the independent portion of the system that is only serving the SS or SC function.

⁸² A.3.2 The safety classification of all system components, as well as the functional requirements for the safety function should be clearly identified, and the boundaries of the safety system delineated so appropriate design requirements for the components can be specified, or the design developed to accommodate any differences in safety function.

For example, when designing a safety-related fire pump house, the diesel fire pump is typically safety-related and the electric fire pump is defense-in-depth or general service for function. However, the casing of the electric fire pump would still need to be safety-related to maintain the safety-related pressure boundary of the water supply. The jockey pump for the system can be safety-related or not for both function and pressure boundary, depending on the design. If the jockey pump is safety-related, the electrical support system would need to be considered. If the jockey pump is not functionally safety-related, then either the casing of the jockey pump should be safety-related for pressure boundary, or the potential loss of water and all consequences of the loss of water (including water spraying in the pump house) would need to be accommodated in the design.

⁸³ A.3.3.3.1 Practical aspects of operation should be considered, beyond strictly safety-related needs, to provide good fire protection design. For example, while a jockey pump may not provide a safety-related function (although the pressure boundary is likely safety-related) as the system pressure can be maintained from a safety-related fire pump should the jockey pump not be available, Providing general

service emergency power to the jockey pump can provide a significant benefit, although it has no direct safety implication.

⁸⁴ A.3.4.2.2 If primary and secondary water storage tanks are located near each other, they should be arranged so either tank can supply either pump.

⁸⁵ A.4 Fire separations include all elements of the separation, including the primary construction, penetration seals and opening protectives (dampers and doors). Fire separations are provided for a variety of reasons based on the building code (i.e. occupancy and hazard separation, height and area limits, exiting and life safety) and DOE requirements (i.e., dollar loss limits, hazard separation, establishing fire areas). While separations required for other uses can also be used for nuclear safety considerations, these separations require additional considerations.

In general, safety significant separations need to meet the typical design requirements for fire-rated wall and floor assemblies, supplemented with the guidance in the section. Safety Class separations will generally need to be designed consistent with the requirements for High Challenge Fire Walls (as defined by NFPA) or a Maximum Foreseeable Loss Wall (see FM Global Data Sheet 1-22, *Maximum Foreseeable Loss*). Some key features of SC separations include avoiding or minimizing penetrations, redundant active components such as dampers, and redundant doors that accommodate exiting when required. Unique features, such as special nuclear materials trolleys or conveyors or other material transfer systems should have designs that have functionality equivalent to that for other opening protectives, and should be based on tested configurations, rather than simply engineering evaluations.

⁸⁶ A.4.4.2.4 Select the appropriate detection method according to the hazard being protected. While smoke detection is typically used, other detection may be appropriate, such as area detection or supplemented by other detection in the areas such as sprinkler waterflow.

⁸⁷ B.2.3 The FHA should contain at least one design basis fire scenario for each fire area that represents a reasonably conservative evaluation of potential consequences from the worst case fire. The scenario should be based on facility, process, and hazards descriptions, supported by the DSA, and be physically plausible. Consider unplanned hazards or activities that have a real potential of being introduced into the facility. Do not assume the presence of hazards not expected to be introduced into the facility simply to ensure a bounding analysis (e.g., excessive transient combustibles, flammable gases, explosives, etc). Consider items whose failure may increase damages beyond the established MPFL. The FHA evaluation of damage to radiological and chemical process confinement systems forms the basis for accident analysis supporting definition of SS and SC controls in the DSA.

⁸⁸ B.2.10 Impacts can be direct or indirect. For example, loss of the building ventilation system in a fire (due to damage of power cables) may result in an ambient air temperature rise, which may cause the failure of sensitive electrical components, such as relays. Such safety systems may include, but are not limited to, process monitoring instrumentation, instrument air, hydraulic systems, and emergency lighting systems.

In another case, it is insufficient to assume that fire will merely cause the loss of function of safety equipment when power cables to that equipment are within the fire area. It is also necessary to consider the potential for spurious signals that may cause the inadvertent operation of such equipment. Similarly, fire-induced electrical faults may trip upstream electrical disconnect devices in such a way as to render inoperable other safety systems that may not even be located within the fire area. In addition, the effects of combustion products, manual fire-fighting efforts, and the activation of automatic fire suppression systems should be assessed.

⁸⁹ B.3.1 Information on Central Registry Toolbox codes can be found at http://www.hss.doe.gov/nuclearsafety/qa/sqa/central_registry.htm. Fire modeling information from the National Institute of Standards and Technology can be found at <http://www.nist.gov/building-and-fire-research-portal.cfm>. Additionally, NUREG 1805, *Fire Dynamics* Tools can be found at the Nuclear Regulatory Commission website at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1805/>

CONCLUDING MATERIAL**Review Activity:**

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