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NOT MEASUREMENT SENSITIVE

DOE-STD-1066-2016
December 2016

Superseding
DOE-STD-1066-2012

DOE STANDARD

FIRE PROTECTION

U.S. Department of Energy
Washington, DC 20585

FOREWORD

This Department of Energy (DOE) Standard (STD) supersedes DOE-STD-1066-2012, *Fire Protection*, and is approved for use by DOE and its contractors. This revision reflects the following major changes:

- Lessons learned and good practices since the last revision was issued;
- Guidance on Wildland Fire Management Programs;
- Guidance and criteria for Fire Protection of Subterranean Facilities; and,
- Clarification of guidance on use of industry codes and standards, maximum possible fire loss, leased facilities, baseline needs assessments, high efficiency particulate air filters, and gloveboxes.

This Standard now serves as the primary source document for criteria and guidance for fire protection programs (FPPs) supporting implementation of DOE Order (O) 420.1C, *Facility Safety*. Other information supporting DOE's FPPs (such as past guidance, models, sample reports, and reference documents) is available through the DOE Fire Protection Program website: http://energy.gov/ehss/fire-protection-program.

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 composed 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 e-mailed to nuclearsafety@hq.doe.gov or sent to:

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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: (a) a contract or (b) an implementation plan or program plan of a DOE requirements document.

Throughout this Standard, the word "shall" is used to denote a requirement of this Standard; the word "should" is used to denote a recommendation of this Standard; and, the word "may" is used to denote permission, but not a requirement or a recommendation of this Standard. 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. "Should" statements represent DOE technical expectations. Alternative approaches to "should" statements are permitted and do not require approval by DOE.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 PURPOSE

The purpose of this Standard is to facilitate implementation of 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 (FPPs). This Standard addresses 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 all departmental elements within the scope of DOE O 420.1C and to all contractors required to meet the Order's Contractor Requirements Document (Attachment 1 to the Order).

Other Departmental documents contain requirements and guidance pertaining to the protection of personnel and facilities from fire hazards. These include:

- 10 Code of Federal Regulations (CFR) 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*.

This Standard may not apply to certain facilities identified in Section 3.c of DOE O 420.1C.[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. Alternate approaches that demonstrate an equivalent level of safety are acceptable if approved by the DOE field element.

1.3 OVERVIEW OF STANDARD

This Standard follows the order of topics in DOE O 420.1C, Attachment 2, Chapter II:

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 G 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 safety significant (SS) and safety class (SC) applications.

1.4 REFERENCED DOCUMENTS

The following documents are referenced to assist in implementing this Standard.

a. Federal Laws and Regulations

(1) Public Law 107-217, Title 40, *Public Buildings, Property, and Workers*
(2) 10 CFR Part 820, *Procedural Rules for DOE Nuclear Activities*
(3) 10 CFR Part 830, *Nuclear Safety Management*
(4) 10 CFR Part 851, *Worker Safety and Health Program*

(Note that the use of the following regulations is directed by either 10 CFR Part 851 or by DOE)

(5) 29 CFR Part 1910, *Occupational Safety and Health Standards*
(6) 29 CFR Part 1926, *Safety and Health Regulations for Construction*
(7) 30 CFR Part 57, *Mine Safety and Health Administration (MSHA), Safety and Health Standards – Underground Metal and Nonmetal Mines*

b. DOE Requirements and Guidelines

(1) DOE O 151.1C, *Comprehensive Emergency Management System*
(2) DOE O 231.1B Admin Chg. 1, *Environment, Safety, and Health Reporting*
(3) DOE O 251.1C, *Departmental Directives Program*
(4) DOE O 410.1, *Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements*
(5) DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*
(6) DOE O 420.1C Admin Chg. 1, *Facility Safety*
(7) DOE O 426.1, *Federal Technical Capability*
(8) DOE O 440.1B Admin Chg. 2, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*
(9) DOE O 471.6, *Information Security*
(10) DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Guide for Use with DOE O 420.1C, Facility Safety*
(11) DOE G 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements*
(12) DOE Administrative Records Schedule 18, *Security, Emergency Planning, and Safety Records, September 2010, Revision 2*

c. Department of Energy Technical Standards and Handbooks

(1) DOE-HDBK-1081-2014, *Primer on Spontaneous Heating and Pyrophoricity*
(2) DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook*
(3) DOE-STD-1020-2016, *Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities*
(4) DOE-STD-1066-99, *Fire Protection Design Criteria*
(5) DOE-STD-1083-2009, *Processing Exemptions to Nuclear Safety Rules and Approval of Alternative Methods for Documented Safety Analyses*
(6) DOE-STD-1137-2014, *Fire Protection Engineering Functional Area Qualification Standard*
(7) DOE-STD-1189-2016, *Integration of Safety into the Design Process*
(8) DOE-STD-3006-2010, *Planning and Conducting Readiness Reviews*
(9) DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*
(10) DOE-STD-3024-2011, *Content of System Design Descriptions*

d. Other Standards and Criteria[2]

American Glovebox Society (AGS)

(1) AGS-G006, *Standard of Practice for the Design and Fabrication of Nuclear Application Gloveboxes*
(2) AGS-G010, *Standard of Practice for Glovebox Fire Protection*

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

(1) ASHRAE 52.2 (2012), *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*

American Society of Mechanical Engineers (ASME)

(1) ASME AG-1, *Code on Nuclear Air and Gas Treatment*
(2) ASME, *Boiler and Pressure Vessel Code*
(3) ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*

ASTM International

(1) ASTM E 84-15b, *Standard Test Method for Surface Burning Characteristics of Building Materials*
(2) ASTM E 108-11, *Standard Test Methods for Fire Tests of Roof Coverings*
(3) ASTM E 136-16, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*
(4) ASTM E 2032-09, *Standard Guide for Extension of Data from Fire Endurance Tests*
(5) ASTM E 2174-14b, *Standard Practice for On-Site Inspection of Installed Fire Stops*
(6) ASTM E 2393-10a, *Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers*
(7) ASTM E 2750-13e1, *Standard Guide for Extension of Data from Penetration Firestop System Tests Conducted in Accordance with ASTM*

Department of Defense (DoD)

(1) DoD 6055.06-M, *DoD Fire and Emergency Services Certification Programs*

FM Global Group

(1) FM 4991, *Approval Standard for Firestop Contractors*

FM Global Property Loss Prevention Data Sheets

(1) 1-0, *Safeguards During Construction*
(2) 1-6, *Cooling Towers*
(3) 1-20, *Protection Against Exterior Fire Exposure*
(4) 1-28R, *Roof Systems*
(5) 1-31, *Metal Roof Systems*
(6) 3-2, *Water Tanks for Fire Protection*
(7) 3-7, *Fire Protection Pumps*
(8) 3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances*

(9) 5-4, *Transformers*
(10) 7-40, *Heavy Duty Mobile Equipment*
(11) 7-98, *Hydraulic Fluids*

International Code Council (ICC)

(1) *International Building Code (IBC)*
(2) *International Fire Code*

National Fire Protection Association (NFPA)

(1) NFPA 1, *Fire Code*
(2) NFPA 2, *Hydrogen Technologies Code*
(3) NFPA 10, *Standard for Portable Fire Extinguishers*
(4) NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*
(5) NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*
(6) NFPA 13, *Standard for the Installation of Sprinkler Systems*
(7) NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*
(8) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*
(9) NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*
(10) NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
(11) NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*
(12) NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*
(13) NFPA 22, *Standard for Water Tanks for Private Fire Protection*
(14) NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*
(15) NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*
(16) NFPA 30, *Flammable and Combustible Liquids Code*
(17) NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*
(18) NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*
(19) NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*
(20) NFPA 51B, *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*
(21) NFPA 55, *Compressed Gases and Cryogenic Fluids Code*
(22) NFPA 58, *Liquefied Petroleum Gas Code*
(23) NFPA 68, *Standard on Explosion Protection by Deflagration Venting*
(24) NFPA 69, *Standard on Explosion Prevention Systems*
(25) NFPA 70, *National Electrical Code®*
(26) NFPA 72, *National Fire Alarm and Signaling Code*
(27) NFPA 75, *Standard for the Fire Protection of Information Technology Equipment*
(28) NFPA 80, *Standard for Fire Doors and Other Opening Protectives*
(29) NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*
(30) NFPA 85, *Boiler and Combustion Systems Hazards Code*
(31) NFPA 86, *Standard for Ovens and Furnaces*
(32) NFPA 88A, *Standard for Parking Structures*
(33) NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilation Systems*
(34) NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*
(35) NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Particulate Solids*
(36) NFPA 101, *Life Safety Code®*

(37) NFPA 101A, *Guide on Alternative Approaches to Life Safety*
(38) NFPA 110, *Standard for Emergency and Standby Power Systems*
(39) NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*
(40) NFPA 122, *Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities*
(41) NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*
(42) NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*
(43) NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*
(44) NFPA 400, *Hazardous Materials Code*
(45) NFPA 484, *Standard for Combustible Metals*
(46) NFPA 501, *Standard on Manufactured Housing*
(47) NFPA 520, *Standard on Subterranean Spaces*
(48) NFPA 600, *Standard on Facility Fire Brigades*
(49) NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*
(50) NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*
(51) NFPA 720, *Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment*
(52) NFPA 750, *Standard on Water Mist Fire Protection Systems*
(53) NFPA 780, *Standard for the Installation of Lightning Protection Systems*
(54) NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*
(55) NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*
(56) NFPA 901, *Standard Classifications for Incident Reporting and Fire Protection Data*
(57) NFPA 1001, *Standard for Fire Fighter Professional Qualifications*
(58) NFPA 1143, *Standard for Wildland Fire Management*
(59) NFPA 1144, *Standard for Reducing Structural Ignition Hazards from Wildland Fire*
(60) NFPA 1221, *Installation, Maintenance, and Use of Emergency Services Communications Systems*
(61) NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*
(62) NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety*
(63) NFPA 1620, *Standard for Pre-Incident Planning*
(64) 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*
(65) NFPA 1901, *Standard for Automotive Fire Apparatus*
(66) NFPA 1906, *Wildland Fire Apparatus*
(67) NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus*
(68) NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*
(69) NFPA 2010, *Standard for Fixed Aerosol Fire Extinguishing Systems*
(70) NFPA 5000, *Building Construction and Safety Code®*

National Interagency Fire Center

(1) *Federal Wildland Fire Management Policy*, 2009
(2) NFES 2092, *National Interagency Mobilization Guide*

National Wildfire Coordinating Group (NWCG)

(1) NWCG, PMS 210, *Wildland Fire Incident Management Field Guide*
(2) NWCG, PMS 310-1, *Wildland and Prescribed Fire Qualification System Guide*

Society of Fire Protection Engineers (SFPE)

(1) *SFPE Engineering Guide to Performance-Based Fire Protection, 2nd Edition*

Underwriters Laboratories (UL)

(1) UL-790, *Standard for Standard Test Methods for Fire Tests of Roof Coverings*
(2) ULC Subject C263E, *Criteria for Use in Extension of Data from Fire Endurance Tests*
(3) UL Building Materials Directory

U.S. Forest Service

(1) Forest Service Handbook 5109.18, *Wildfire Prevention Handbook*

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: Any structure, having a roof and walls, used or intended for supporting or sheltering any occupancy. It excludes structures not designed for occupancy (e.g., waste tanks, sand filters, saltstone vaults) or that do not have at least partial enclosure by construction materials (e.g., exhaust stack, burial ground, open pads, bridges/roads, etc.).

Building Code Official (or Building Official): The officer or other designated authority charged with the administration and enforcement of the building code, or a duly authorized representative. The DOE head of field element or designee is the Building Code Official, unless otherwise directed by the Cognizant Secretarial Officer.

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.[3]

Code of Record (COR): A set of technical and operational requirements, including Federal and state laws, as defined in contracts and Standards or Requirements Identification Documents (or their equivalent), that are in effect at the time a facility or item of equipment was designed or modified, and accepted by DOE.

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 E 136-16, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

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

Documented Safety Analysis (DSA): 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 alternate means of providing an equal or greater degree of fire safety than that afforded by strict conformance to prescribed codes and standards, or an applicable DOE directive requirement.

Exemption: The release from one or more requirements in a DOE 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.[4]

Facility: Any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include accelerators, storage areas, fusion research devices, nuclear reactors, production, or processing plants, coal conversion plants, magneto-hydrodynamics experiments, windmills, radioactive waste disposal systems and burial grounds, environmental restoration activities, testing laboratories, research laboratories, transportation activities and accommodations for analytical examinations of irradiated, and non-irradiated components. For the purpose of this Standard, the definition most often refers to buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein to delineate a facility.

Facility Assessment: A formal documented review of the facility/building programmatic and physical fire protection features that is conducted annually, by or under the supervision of a fire protection engineer, for facilities with a replacement value in excess of $111 million (2016 dollars), facilities considered a high hazard, or those in which vital programs are involved and at least every three years for remaining low and ordinary hazard facilities.

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 events unless they cause a fire or occur as a consequence of the event: lightning or electrical discharge;

rupture of a pressure vessel not caused by internal combustion; detonation of munitions; overheat (without damage to initiating material); or failure of electric motors and other electrical equipment through overheating or shorting where any visible sparks or flames self-extinguish after power is removed from the device.

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

Fire Barrier: A fire separation system component that limits for a specified period of time (the fire resistance rating) 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 hazardous materials stored on the other side of the barrier.

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 Hazard Analysis (FHA): A comprehensive assessment of the hazards of and potential damage from fire in a building or group of buildings, which takes one of the following forms: (a) Building/Facility FHA that establishes the fire safety of the facility at the time it is issued; (b) Preliminary/Project FHA which establishes the fire protection requirements for a new building or a modification to an existing building; or, (c) Transitional FHA which evaluates the minimum fire protection needs during a major transition from an operating status to some other status.

Fire Loss: The dollar cost of restoring damaged property from an actual fire event to its pre-fire condition.[5]

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 (FPDA): An engineering analysis for non-nuclear facilities during or preceding the preliminary design to establish fire protection design criteria, including applicable national codes and consensus standards. Updated during the design process, the FPDA provides a comprehensive design review that ensures the fire protection requirements are incorporated into the design.

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 individual 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-1137-2014, *Fire Protection Engineering Functional Area Qualification Standard*, or its predecessors.

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 Resistant Construction: A building element, component, or assembly, designed and tested to maintain its ability to continue to perform a given structural function, as determined by the fire tests or the methods based on the fire tests, for the associated fire resistance rating.

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 and structural stability, that separates buildings or subdivides a building into fire areas.

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 are defined in Table 1, Appendix A to Subpart B of 10 CFR Part 830, as follows: (1) a Hazard Category 1 facility has the potential to cause significant off-site consequences; (2) a Hazard Category 2 facility has the potential to cause significant on-site consequences beyond localized consequences; and (3) a Hazard Category 3 facility has the potential to cause only locally significant consequences.

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, other gaseous agents, dry chemical, water, or hybrid systems (e.g., a Vortex system).

Listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the AHJ 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 (OSHA).

Major Modification: As defined by 10 CFR Part 830, major modifications are those that "substantially change the existing safety basis for the facility." See DOE-STD-1189-2016, *Integration of Safety into the Design Process*, for further guidance on determining major modifications.

Maximum Possible Fire Loss (MPFL): The dollar cost of restoring damaged property in a single, well-defined fire area, from a hypothetical fire event, assuming the failure of both automatic fire

suppression systems and manual fire-fighting efforts.[6]

Minimum Efficiency Reporting Value (MERV): Measurement created by ASHRAE to rate effectiveness of air filters.

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.

Program Self-Assessment: A documented comprehensive evaluation of the fire protection program that is performed at least every three years, by or under the supervision of an FPE, to review the adequacy of the site-wide and/or facility fire protection program.

Pyrophoric Material: A chemical with an auto ignition temperature in air at or below 130°F.[7] [DOE-HDBK-1081-2014]

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 AHJ for categorization.

Safety Basis: The DSA and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public, and the environment. [10 CFR § 830.3]

Safety Class Structures, Systems, and Components (SC SSCs): Structures, systems, or components, including portions of process systems, whose preventive or mitigative function is necessary to limit radioactive hazardous material exposure to the public, as determined from safety analyses. [10 CFR § 830.3]

Safety Significant Structures, Systems, and Components (SS SSCs): Structures, systems, and components which are not designated as safety class SSCs, but whose preventive or mitigative function is a major contributor to defense-in-depth and/or worker safety as determined from safety analyses. [10 CFR § 830.3]

Significant Modification: An addition, alteration, renovation, or repair to an existing facility that involves a change in floor area, number of stories, size of rooms, use of the area or occupancy of the structure. A significant modification does not include replacement with a like structure or equipment.[8]

Subterranean Facility: Spaces that cannot meet NFPA 101, *Life Safety Code*®, NFPA 520, *Standard on Subterranean Spaces,* or the International Building Code (IBC) egress requirements due to the orientation or configuration of parts of the structure below ground level, which may include open and cut excavations. Requirements in this Standard divide these facilities into one or more the following areas:

- Undeveloped Space: An area of the subterranean facility that has been excavated, including subterranean and ground support structures and systems, but has not been altered for the performance of mission-oriented process operations or experiments. Undeveloped space may include roadways, railways, and entrances.

- Developed Space: An area of the subterranean facility that has been altered for the performance of mission-oriented process operations or experiments. Including Process Operation/Experiment Areas, an area of the subterranean facility in which materials that are likely to burn with extreme rapidity or from which explosions are likely, are staged or used that is separated from the underground infrastructure or undeveloped space by fire-resistive construction. This excludes basements of surface structures and buildings as defined by NFPA 101, NFPA 520, and the applicable building code.

Variance: An exception to compliance with some part of 10 CFR Part 851. The process for requesting and approving variances from the provisions of 10 CFR Part 851 is delineated in Subpart D of Part 851 and in supplemental guidance promulgated by DOE.

1.6 ACRONYMS

AHJ	Authority Having Jurisdiction
BNA	Baseline Needs Assessment
CFR	Code of Federal Regulations
COR	Code of Record
CTA	Central Technical Authority
DOE	Department of Energy
DSA	Documented Safety Analysis
FACP	Fire Alarm Control Panel
FHA	Fire Hazard Analysis
FPDA	Fire Protection Design Analysis
FPE	Fire Protection Engineer
FPP	Fire Protection Program
G	Guide
HDBK	Handbook
HPR	Highly Protected Risk
IBC	International Building Code
ITM	Inspection, Testing, and Maintenance
L/RMP	Land/Resource Management Plan
LCO	Limiting Conditions for Operation
MERV	Minimum Efficiency Reporting Value
MPFL	Maximum Possible Fire Loss
NFPA	National Fire Protection Association
O	Order
QA	Quality Assurance
SC	Safety Class
SLC	Signaling Line Circuits
SS	Safety Significant
SSC	Structure, System, and Component
STD	Standard
TSR	Technical Safety Requirement
WFMP	Wildland Fire Management Plan

2 GENERAL FIRE PROTECTION REQUIREMENTS

2.1 FIRE PROTECTION POLICY STATEMENT

DOE O 420.1C (Attachment 2, Chapter II, Section 3.a(1)) requires that a policy be established affirming the contractor's commitment to provide a comprehensive fire protection and emergency response program.[9]

A fire protection policy statement[10] should:

- Provide an organizational commitment to satisfy Highly Protected Risk levels for fire protection;
- Document the duties and responsibilities of contractor management;
- Detail strategies to maintain fire prevention features; and
- For emergency response organizations, describe the level of capability the contractor intends to provide.

A fire protection policy statement is required to be consistent with DOE requirements and contractual obligations.

2.2 USE OF NATIONAL CODES AND STANDARDS

2.2.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.a(2)) requires that fire protection and emergency response programs meet the applicable building code and National Fire Protection Association (NFPA) codes and standards. Throughout this Standard, where possible, specific NFPA codes and standards are identified as "applicable" for identified fire protection features; these should be evaluated for site-specific and facility-specific applicability where such features are called for. Such statements are not intended to imply that the identified code or standard is the only acceptable approach.

2.2.2 DOE O 420.1C (Attachment 1, Section 1.c) requires contractors to identify the applicable industry codes and standards, including the IBC and applicable DOE requirements and technical standards for design and construction activities. The acquisition and construction of new facilities and major modifications of existing facilities shall meet the applicable parts of the IBC, NFPA standards, and other nationally recognized consensus standards for electrical, fire, and life safety.[11] [12]

2.2.2.1 If an alternative to the IBC is selected for use in accordance with DOE O 420.1C (Attachment 1, Section 1.c), it is acceptable to adjust the IBC references in this Standard to appropriate references in the selected alternative building code for that particular site.

2.2.2.2 Performance of administrative functions of the building code should be documented by the contractor as required by DOE Orders and not by the administration chapter of the IBC.

2.2.3 National Electrical Code. NFPA 70, *National Electrical Code*®, is the applicable NFPA standard for electrical design requirements.

2.2.4 State and Local Codes. Applicable state, regional, and local building codes should be incorporated into the Code of Record (COR), as necessary and as directed by the Authority Having Jurisdiction (AHJ).

2.2.5 Performance-based design alternatives to any code requirement should be based on the methodology described in the SFPE Engineering Guide to Performance-Based Fire Protection, 2nd Edition. Other methodologies, including Chapter 5 of NFPA 101, *Life Safety Code*®, may also be used. Performance-based design alternatives shall be prepared under the direction of an FPE and 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 minimize the conflict while assuring that an equivalent level of fire protection is maintained. For such conflicts, consultation among appropriate designated safety and security officials and the fire protection subject matter expert should be pursued. Appropriate approvals of relief from requirements are necessary.

2.2.7 DOE O 420.1C (Attachment 2, Chapter II, Section 3.a.(2)(c)2) requires that conflicts between NFPA requirements and the applicable building code requirements be resolved by the Head of the Field Element following consultation with designated building code and fire protection subject matter experts.

2.2.8 DOE O 420.1C (Attachment 2, Chapter II, Section 3.a.(2)(b)) requires that technical provisions of subsequent editions of codes or standards (promulgated after the original design COR) are mandatory only to the extent that they are explicitly stated to be applicable to existing facilities.

2.2.9 Operational provisions of the most recent codes and standards (promulgated after the original design COR) should be evaluated and implemented to the extent practicable. Such operational provisions include inspection, testing, and maintenance necessary to ensure that design functions are preserved during the operational lifetime.

2.3 HIGHLY PROTECTED 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.”[13]

3 FIRE PROTECTION PROGRAM ADMINISTRATION

3.1 DOCUMENTATION

3.1.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.b(1)) requires a documented FPP that addresses the elements and requirements identified in Attachment 2, Chapter II of the Order. The FPP is required to address design, operations, emergency response, Fire Hazard Analysis (FHA) and facility assessments, wildland fire, and specific FPP criteria developed, implemented, and maintained by the contractor.

3.1.2 The site-wide FPP should: (a) document the overall program or management systems established to assign responsibilities and authorities, define policies and requirements; and (b) provide for the performance and assessment of fire protection and emergency response program 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 shall identify any alternative methods approved to the required methods described in this Standard, and identify where the bases for these alternative methods may be found. As such, the FPP would also identify applicable variances, equivalencies, exemptions, and performance-based designs.

3.1.6 DOE O 420.1C (Attachment 2, Chapter II, Section 3.b(1)) requires that the FPP be submitted to the DOE Field Element for review and approval when developed and revised. The detailed policies and procedures that make up the fire protection and emergency response program should be included for information only in the submittal.

3.2 PROGRAM SELF-ASSESSMENTS

DOE O 420.1C (Attachment 2, Chapter II, Section 3.b(2)) requires that a documented comprehensive self-assessment of the FPP be performed at least every three years, or at a frequency with appropriate technical basis approved by the AHJ.[14] The principal objectives of self-assessments are to verify the adequacy of the site-wide and/or facility FPP and identify strengths and weaknesses in FPPs.

3.2.1 Programmatic self-assessments shall be performed by, or under the direction of an FPE.

3.2.2 Self-assessments should, as a minimum, encompass the following FPP elements:[15]

- 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 (ITM) of installed fire protection systems and features;
- Fire protection engineering staff (number, qualifications, training);
- Emergency response, including the Baseline Needs Assessment (BNA), pre-incident planning, staffing, training, and equipment;
- Management support;
- Documented exemptions and equivalencies;
- Fire protection system impairment process;
- Hot work process;
- Wildland fire management planning and preparation; and,
- Documentation and recordkeeping.

4 FIRE PROTECTION DESIGN

This section applies to new construction and significant facility modifications, including major modifications to nuclear facilities. Appendix A of this Standard describes an acceptable approach for implementing the design and operational requirements specified in DOE O 420.1C for new SS and SC fire protection systems, specifically, wet pipe automatic sprinklers, water supplies, and fire barrier systems.

4.1 DESIGN PROCESS

4.1.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.c.(1)) requires that a process be established to ensure that FPP requirements are documented and incorporated into plans and specifications for the design of new facilities and major modifications to existing nuclear facilities. For new facilities, major modifications to nuclear facilities, and other significant modifications to existing facilities, fire protection design criteria shall be developed by, or under the direction of, an FPE as early in the conceptual design phase as practicable and updated throughout the design process to ensure the fire protection requirements are documented and incorporated into plans and specifications. The technical baseline for fire protection systems shall be maintained throughout the life of the building.

4.1.2 DOE O 420.1C (Attachment 2, Chapter I, Section 3.a.(1)) 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-1189-2016, *Integration of Safety into the Design Process*. This requirement applies to the design of fire protection systems and components.

4.1.3 For new building construction, significant building modifications, and major modifications to nuclear facilities, the design documents shall include fire protection criteria based on either a Fire Protection Design Analysis (FPDA) or a Preliminary/Project FHA, [16] depending upon whether or not a building FHA is normally required (See Section 7 and Appendix B of this Standard for guidance).

4.1.4 New Hazard Category 1, 2, and 3 nuclear facilities should be classified as High Hazard (typically Group H-4) occupancies, as defined in IBC, unless a different classification is approved by the Building Official.

4.1.5 The special industrial occupancy exception in the IBC for height and area limits shall not be applied to new Hazard Category 1, 2, and 3 nuclear facilities.

4.2 GENERAL DESIGN CRITERIA

DOE O 420.1C (Attachment 2, Chapter II, Section 3.a(2)(a)) requires that the design and construction of new facilities and major modifications to existing facilities meet codes and standards in effect when the design criteria are approved (i.e., the COR). The applicable codes and standards for design include the provisions of the applicable requirements of Federal regulations, DOE directives, the IBC, NFPA codes, and other national codes and consensus standards in effect when the COR is established during the conceptual design phase. 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 subsection 5.3 of this

Standard for additional fire protection guidance for leased facilities).

4.2.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.a.(2)(a)) also requires facility modifications other than those classified as a major modification (in accordance with DOE-STD-1189-2016) to meet the most recent applicable codes and standards to the extent determined by the AHJ. In such cases, the current editions of the codes and standards should apply to the modification unless compelling technical basis exists to do otherwise. [17] For these cases, the COR should be updated to reflect the codes and standards used for the modification.

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."[18] FM Global Loss Prevention Data Sheets may be used as guidance for design activities.

4.2.3 DOE O 420.1C (Attachment 2, Chapter II, Section 3.c.(2)(d)) requires that multiple fire protection approaches be provided for property protection in areas where the Maximum Possible Fire Loss (MPFL) exceeds $167 million (in 2016 dollars). This requirement may be met using any two of the following approaches:[19]

- Automatic suppression systems, such as fire sprinklers, foam, gaseous, explosion suppression, or other specialized extinguishing systems plus appropriate alarms.
- 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.
- Fire walls, high-challenge fire walls, or fire barriers.
- For outdoor locations, sufficiently rated fire barriers; adequate physical separation; or, a combination of the two.

4.2.4 Facility Layout and Construction

4.2.4.1 Fire Area Determination. Buildings should be subdivided into separate fire areas as determined by the FHA, FPDA, or other appropriate design documentation. Fire areas can be separated from each other by fire walls, protection from external fire exposure, or other approved means.[20]

4.2.4.2 Fire Barriers. NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls and Fire Barrier Walls*, is the applicable NFPA standard for design and installation of fire barriers. Other design standards such as FM data sheets for fire wall construction and the IBC may provide acceptable alternatives (see Section 2.2.1).

4.2.4.3 Fire barriers relied on 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. [21]

4.2.4.3.1 Fire Barrier Firestop Systems. The installation of new and or repair/replacement of existing firestop (penetration and joint) systems for fire barriers should be performed by qualified installers (e.g., FM 4991, *Approval Standard for Firestop Contractors*, approved, firestop

material manufacturer certified, or UL Qualified) that are directed by a "Designated Responsible Individual." This should be enforced through procurement and construction specifications and work orders. Proper installation should be verified by visual inspection of penetration seal during installation.

4.2.4.3.2 Criteria for Firestops. Assemblies for fire barrier firestop systems should be installed per their listing instructions. Where an alternate installation is used, systems should be installed in accordance with ASTM E 2032-09, *Standard Guide for Extension of Data from Fire Endurance Tests*; ULC Subject C263E, *Criteria for Use in Extension of Data from Fire Endurance Tests;* or ASTM E 2750-13e1, *Standard Guide for Extension of Data from Penetration Firestop System Tests Conducted in Accordance with ASTM.*

4.2.4.3.3 Alternative Firestop Systems. Refer to IBC and/or NFPA 221 (Section 4.9.2.2.1) for alternative fire barrier firestop methods.

4.2.4.3.4 Fire Barrier Identification and Inspection. Fire barriers necessary for life safety, nuclear safety, hazard protection, or property protection should be (1) identified with appropriate signs or facility maps to help prevent improper breaches, and (2) periodically inspected to detect deterioration of the barrier, firestop/joint systems, and opening protective systems.

4.2.4.4 Structural Materials. DOE O 420.1C (Attachment 2, Chapter II, Section 3.c.(2)(a)) requires that new (non-relocatable) buildings 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 non-combustible.[22]

4.2.4.5 Roof Covering. Roof coverings shall be Class A as defined in ASTM E 108-11, *Standard Test Methods for Fire Tests of Roof Coverings,* or UL-790, *Standard for 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 Loss Prevention Data Sheets 1-28R, *Roof Systems*, and 1-31, *Metal Roof Systems*.

4.2.4.6 Interior Finishes. Unless determined otherwise by the FHA, interior finishes in Hazard Category 1, 2, and 3 nuclear facilities and radiological facilities, shall be a minimum of Class A as defined in NFPA 101 (Section 10.2.3.4.1) and should have a flame spread index of 25 or less and a smoke development index of 450 or less, when tested in accordance with ASTM E 84-15b, *Standard Test Method for Surface Burning Characteristics of Building Materials*. (See also NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials,* Section 5.8.)

4.2.5 Building Services

4.2.5.1 Ventilation Systems. NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilation Systems,* or NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* are the applicable NFPA standards for design and installation of ventilation systems. NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, is the applicable NFPA standard for exhaust conveyance systems. Once-through ventilation systems do not require shutdown upon activation of duct smoke detectors unless the FHA establishes that shutdown is needed 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 containing no combustible dielectric fluids. Outside transformers shall be located and protected in accordance with FM Global 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 systems when required. (See also DOE-STD-1020-2016, *Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities*, for additional information on lightning protection).

4.2.5.4 Drainage. When high-value property, safety SSCs, or mission-critical 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 means of floor drains, sumps and sump pumps, equipment pedestals, or combinations thereof. Other methods may be used based on a documented analysis.

4.2.5.5 Cooling Towers. NFPA 214, *Standard on Water-Cooling Towers*, is the applicable NFPA standard for cooling towers. FM Data Sheet 1-6, *Cooling Towers*, also provides useful methods and guidance.

4.2.6 Life Safety

4.2.6.1 10 CFR Part 851 provides requirements for worker safety including protection of workers from fire hazards. NFPA 101 is the applicable NFPA code for life safety from fire as stated in Appendix A, Section 2 of 10 CFR Part 851. Additional means of egress requirements may be provided within the applicable building code according to Appendix A, Section 2 of 10 CFR Part 851; if any conflicts exist, Section 2.2.7 of this Standard addresses resolution. Performance based designs, in accordance with NFPA 101, may be applied to support equivalencies to NFPA 101 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 equivalencies to NFPA 101 in which strict compliance with NFPA 101 is not practical.

4.2.6.3 Refer to Appendix D of this Standard for subterranean facility life safety requirements.

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 (Attachment 2, Chapter II, Section 3.c.(3)(e)) requires that a reliable and adequate water supply and distribution system be provided for fire suppression, as documented through appropriate analysis.[23]

4.2.7.1.1 Redundant Water Supply. Redundant water supplies (including storage tanks and pumping systems) shall be provided when a fire protection water supply system is classified as SC (see

Appendix A of this Standard), and should be provided when the MPFL exceeds $390 million (in 2016 dollars) in any site facility.

4.2.7.1.2 Adequacy. The water supply should be designed to meet the following combined demands for a period of not less than two hours: (a) hydraulically most demanding sprinkler system; (b) 500 gallons per minute (gpm) for fire hose streams (Ordinary Hazard Group II and higher);[24] and (c) uninterruptable domestic and process demands.

4.2.7.1.3 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, St*andard for Water Tanks for Private Fire Protection*, is the applicable NFPA standard for design and installation of fire water tanks.[25]

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.[26]

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 sources. Fire protection risers and valves should be located as close as practical to the building's exterior walls. When the system could be affected by radioactive contamination in the facility, consideration should be given to locating the riser adjacent to the building in a separately-protected enclosure.

4.2.7.3.2 Fire Hydrants. Hydrants should be installed no closer than 40 feet from the facility's external walls. Hose runs from hydrants should not exceed 300 feet to all exterior portions of the facility. A minimum of two hydrants per building should be provided. Branch piping between the water main and a hydrant should not exceed 300 feet.

4.2.7.3.3 Control Valves. Listed and/or approved control valves should be installed at maximum intervals not exceeding 5,000 feet on supply lines and at maximum intervals not exceeding 1,200 feet on main distribution loops, feeders and all primary branches connected to the supply 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 mission importance 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 and controllers. Pumps should be sized to meet the system demand without exceeding 120 percent of rated capacity.[27] 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 objective 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.

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 where laying of hoselines is problematic 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. [28]

4.2.7.6.1 To account for possible occupancy fluctuations, occupancy classification for a sprinkler system should not be less than 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, 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, the design of sway bracing for seismic supports of sprinkler piping shall meet site-specific acceleration criteria. These requirements may exceed the minimum seismic bracing requirements of NFPA 13.

4.2.7.7 Water Spray Systems. NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, is the applicable NFPA standard for water spray systems.

4.2.7.8 Special Suppression Systems. When automatic sprinkler or water spray systems cannot be safely employed or need to be supplemented, an analysis of alternative approaches should be performed by, or under the direction of, an FPE. The analysis should consider, initial design and installation cost and the long-term cost of 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.[29]

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

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.

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.

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.

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.

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.

4.2.8 Fire Detection and Alarm Systems

4.2.8.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.c.(3)(f)) requires a means to notify responders and building occupants in case of fire.

4.2.8.1.1 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.

4.2.8.1.2 A fire alarm system shall be provided for DOE buildings to monitor fire suppression and detection systems, to notify occupants, to perform safety functions, and to notify emergency responders.

4.2.8.2 NFPA 72, *National Fire Alarm and Signaling Code*, is the applicable NFPA standard for design, installation, and maintenance of fire detection and alarm systems, including circuits and pathways, initiation devices, and audible and visual alarm devices.[30]

4.2.8.2.1 Circuits and Pathways. At a minimum, all pathways should be designed with Pathway Survivability Level 1, unless an FHA or other appropriate design documentation indicates that a higher survivability level is required.[31]

4.2.8.2.2 Signaling line circuits (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 an FHA or other appropriate design documentation. 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.

4.2.8.2.3 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), this system may be used as an acceptable portion of the fire alarm notification.[32]

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.[33]

4.3.2 Combustible Mists and Vapors. Processes that create or have the potential to create combustible mist and vapors shall be designed to (a) monitor accumulations of vapors and provide an alarm set at 25 percent of the lower flammable limit and (b) control the accumulation of combustible residues in adjacent areas and ductwork. (See NFPA 69, *Standard on Explosion Prevention Systems*; and NFPA 91.)

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 Loss Prevention Data Sheets and DOE-HDBK-1081-2014, *Primer on Spontaneous Heating and Pyrophoricity*, 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. New process furnaces shall 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, oven temperature, or detection of combustible gas in the vicinity of the furnace.

4.3.7 Carbon Monoxide Gas. NFPA 720, *Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment*, is the applicable NFPA standard for the design and installation of carbon monoxide detection systems where required by the use of permanently installed natural gas or propane fired equipment within a structure.

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, construction, and use of Hazard Category 2 and 3 nuclear facilities.[34] NFPA standards (801, 803-806) 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 shall not be used.

4.4.1.3 If the facility's interior surfaces are contaminated, or if a 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' flow expected from sprinkler and hose systems during an anticipated fire event.[35]

4.4.1.4 Additional fire protection features may be determined based on the FHA in concert with the Documented Safety Analysis (DSA) 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. [36]

4.4.1.6 Storage racks for special nuclear materials shall be constructed of non-combustible materials and designed to (a) securely hold storage containers in place, and (b) maintain structural integrity under fire conditions.

4.4.1.7 Where required as a confinement barrier, the confinement structure and supporting members shall be able to withstand anticipated fire conditions along with failure of any fire suppression system. The fire resistance rating of the confinement structure shall exceed the maximum fire exposure and duration anticipated, and in any event shall not be less than 2 hours. This rating shall be achieved by use of structural features (concrete slabs, walls, beams, and columns) and not by use of a composite assembly (membrane fireproofing).[37]

4.4.2 Gloveboxes, Hot Cells, and Canyons

4.4.2.1 Hot cells and canyons shall be constructed of non-combustible or fire-resistive material.

4.4.2.2 If oil filled windows are used for radiation shielding, they shall be protected with an automatic fire suppression system designed for the hazard, fire shutters, or other physical protection means, as required by the FHA.

4.4.2.3 AGS-G010, *Standard of Practice for Glovebox Fire Protection*, provides requirements and guidance for the protection of gloveboxes from fire.[38]

4.4.2.4 When inerting is used for fire prevention, 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[39] or safety basis documentation. A safety factor should be 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.[40] Oxygen levels should be monitored and high oxygen alarms be annunciated at a constantly attended location to facilitate timely restoration of the inert atmosphere or the establishment of adequate compensatory measures until the inert atmosphere is re-established.

4.4.2.5 Requirements for deflagration mitigation and prevention are identified in NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, and NFPA 69.

4.4.2.6 When a non-listed fire suppression system is employed, the system should satisfy the intent of the applicable code. Where no code is available that addresses a particular system, efficacy should be demonstrated through calculation, fire modeling, or fire testing, and approved by the AHJ.

4.4.3 Fume Hoods

4.4.3.1 Hoods and hood installations shall meet the requirements of NFPA 801 and NFPA 45.

4.4.3.2 Hoods should be made of non-combustible materials and capable of maintaining a negative pressure environment relative to the room whenever toxic, flammable, or other hazardous chemicals are located within the hood.

4.4.3.3 A hood shall be provided with a fire suppression system where required by NFPA 45, unless otherwise determined, as allowed, in an FHA or appropriate analysis.[41]

4.4.4 Nuclear Confinement Ventilation System Fire Protection[42]

4.4.4.1 Fire protection in or around nuclear confinement ventilation systems shall be designed to accomplish the following objectives: (a) prevent fires from affecting the operation of the ventilation system; (b) protect the filtration function; and, (c) prevent the release of material that has accumulated on filters.[43]

4.4.4.1.1 Alternate confinement ventilation system protection strategies to the prescriptive requirements established in paragraphs 4.4.4.2 through 4.4.4.18.3 are permitted. The technical adequacy of the alternate protective strategy shall be demonstrated by an analysis that establishes the quantitative fire demand that could potentially be created in the rooms and compartments served by the ventilation system. Such analysis shall be approved by DOE and summarized in the FHA.

4.4.4.1.2 The alternate protection strategy should demonstrate that the fire demand estimates do not exceed the filter performance capabilities. In addition, the potential for fires starting inside the filter ducts or plenums, or room fires that expose ventilation system components necessary to maintain the confinement function, shall be evaluated and control strategies established to minimize the potential for significant unfiltered radioactive releases. Emergency response procedures to actively manage a fire event with filter damage should be one of the control strategies addressed in the analysis.

4.4.4.2 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 HEPA filters and other components used in nuclear ventilation exhaust systems.[44]

4.4.4.2.1 When nuclear HEPA filters serve as the final means of cleaning, DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook*, calls for a minimum of two stages of HEPA filters arranged in series in the final filter plenum for the primary confinement zone. The two stages of

HEPA filtration are typically arranged in series in the final filter plenum for secondary confinement zones. This is appropriate for both primary and secondary confinement zones.

4.4.4.3 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.

4.4.4.3.1 In addition to the two-hour fire-rated separation recommended above, filter assemblies and associated fans located on the roof of buildings should be protected against exposure fires either by fire barriers or spatial separation.

4.4.4.3.2 Separate buildings which house filter plenums should be a minimum of: (a) two-hour fire-rated construction when located less than five feet from an adjacent building; (b) one-hour fire-rated construction when located more than five feet, but not more than 20 feet from an adjacent building; (c) unprotected, non-combustible construction, when greater than 20 feet, provided that no unprotected openings occur in the adjacent building; and, (d) if unprotected openings exist in an adjacent structure, the minimum exposure distance determined by analysis to be acceptable. 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.

4.4.4.3.3 Filter plenums located near combustible or flammable liquid storage buildings or tanks (including cryogenic liquified gas 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. If such tanks or storage buildings exist on the premises, the minimum exposure distance for a non-combustible filter plenum enclosure should be determined by analysis.

4.4.4.3.4 NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, NFPA 90A, and the IBC provide guidance on the protection of openings in fire-rated construction.

4.4.4.3.5 Fire dampers are not required when ducting penetrates one-hour or less fire-rated construction. For such arrangements, the duct should pass through the wall and extend into both adjoining areas, which shall be completely protected by an automatic fire suppression system. Transfer grills and other similar openings without ducting should be provided with an approved damper.

4.4.4.3.6 Fire dampers should not be used in ducting that is part of a nuclear air filtration system required to function continuously as part of the confinement system. Such ducting should be protected from exposure fires up to the rating of the barrier being penetrated, or alternatively, the ducting itself can be shown capable of withstanding a two-hour exposure fire. The means of guaranteeing duct integrity should be addressed in the FHA and be based as needed on fire testing and engineering analysis.[45]

4.4.4.3.7 Small filter plenums that serve as a final filter and have a total leading surface area of 12 square feet or less may be located in buildings protected throughout with an automatic fire

sprinkler system that is designed and installed in accordance with NFPA 13. In such cases, additional fire separation is not necessary.

4.4.4.4 Walk-in Filter Plenums. Filter plenum enclosures shall be used only for ventilation control equipment. Transient combustible materials, and spare filters shall not be stored in such enclosures.

4.4.4.5 Electrical Equipment. NFPA 70 is the applicable NFPA standard for design and installation of all electrical equipment located in a filter plenum enclosure. All electrical wiring located in a filter plenum enclosure shall be installed inside metal conduit.[46]

4.4.4.6 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. The following subsections provide additional guidance.

4.4.4.6.1 Gloveboxes, hot cells, and fume hoods connected to containment ventilation systems should be provided with duct entrance filters. The prefilters should meet ASME AG-1, Section FJ, "Low Efficiency Filters" or Section FB "Medium Efficiency Filters" requirements with a minimum rating of MERV 5 based on ASHRAE 52.2, (2012), *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*.

4.4.4.6.2 High efficiency prefilters[47] should be provided in the ventilation system to protect the final HEPA filters from: (a) particles with diameters larger than 1 or 2 microns; (b) lint; and (c) dust concentrations greater than 10 grains per 1,000 cubic feet. Such prefilters should meet ASME AG-1 Section FB "Medium Efficiency Filters" requirements with a minimum rating on MERV 9 based on ASHRAE 52.2 (2012), *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*.

4.4.4.6.3 Prefilters located in final filter plenums enclosure should meet ASME AG-1, Section FB requirements. These prefilters should be located at least 36 inches upstream from the final HEPA filters.

4.4.4.7 When airborne materials are known to be combustible (such as metal powders), replaceable prefilters should be located as near to the source as practical, but without posing an unacceptable radioactive hazard to personnel when changing the prefilters.

4.4.4.8 Fire screens should be located upstream from prefilters and final filter plenums.[48] Duct entrance filters may not require fire screens unless a significant amount of combustible materials is expected to be present in the exhaust stream exiting the duct.

4.4.4.9 Pyrophoric Metals. When operations or processes involve pyrophoric materials that may cause deposition of pyrophoric particulates on a final filter, a method to remove such particles (such as a prefilter or duct entrance filter) should be installed between the source of the material and the final filter.

4.4.4.10 Fire Detection. NFPA 72 is the applicable NFPA standard for design, installation, and testing of fire detection systems. Rate-compensated type heat detectors or line type heat detection cable approved for the specified use should be provided in the enclosure for the final filter.

Such detectors should be of the 190° F temperature range, unless operations require higher temperature air flows. These detectors can also operate the automatic deluge sprinklers without the need for a second set of detectors dedicated for that purpose.

4.4.4.10.1 Airflow should be considered when determining detector location. Detectors should be arranged to detect a fire in the first stage HEPA filters, which may necessitate locating detectors on both sides (upstream and downstream) of the first stage HEPA filters.[49] Control units and signaling alarm systems connected to the heat detectors should be listed for their intended purpose.

4.4.4.10.2 If an automatic deluge system actuated by pilot sprinklers has been installed in the final filter enclosure, heat detectors are not required in the ducting or the filter enclosure, unless otherwise directed by the AHJ.

4.4.4.10.3 Heat detection systems should be designed and installed to allow for regular testing. Remote testing should be provided for detectors that are made inaccessible by unacceptable hazards. Remote testing of detectors may be accomplished by use of 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.

4.4.4.10.4 When high contamination levels are not expected in the final filter enclosure, detectors may be installed to allow removal for testing.

4.4.4.11 Temperature Control from Fire Exposure. In fire events filters should be protected from overheating and potential ignition. Filter cooling should be accomplished by dilution air, or a water-based automatic suppression system, or both.[50] Such cooling equipment shall be treated as a required support system when the ventilation equipment is relied on for nuclear safety purposes (e.g., classified as SC or SS).

4.4.4.11.1 Automatic deluge spray systems provided upstream of the HEPAs should be designed according to the applicable provisions of NFPA 13 and NFPA 15, with the following additional guidance:[51] (a) density - water spray density should be 0.25 gpm per sq. ft. over the entire filter area or 1 gpm per 500 cubic feet per minute (cfm) air flow, whichever is greater; (b) sprinkler type - spray sprinklers with fusible elements and caps removed, or open spray nozzles approved for fire protection applications; (c) location from prefilters or demisters: the spray pattern of the deluge sprinklers/nozzles should be in the form of a downward vertical water curtain approximately 6 inches in front of the prefilter or demister, with spacing such that each sprinkler/nozzle does not exceed 4 lineal feet of curtain coverage; and (d) activation by detection: a deluge system should operate upon activation of fire alarm system heat detectors or pilot sprinklers, located in either the final ducting or filter plenum housing. The automatic system should be equipped with a locked bypass valve that can be manually opened if the detection system for the deluge valve fails to operate.

4.4.4.12 Filter Plugging. HEPA filters serving as final filters should be protected from excessive pressure drops across the filter media caused by plugging by soot or smoke particles from a fire. Plugging may be prevented or mitigated by suppressing the fire and by providing filters upstream of the final HEPA filters.[52]

4.4.4.13 Suppression of Fires in Final HEPA Filters. When HEPA filters serve as the final means of preventing a release of radioactive or toxic materials, the filters should be protected by either (a) a fire suppression system capable of preventing an unacceptable release of material accumulated on the filters, or (b) isolation dampers, based on an analysis in the FHA. If the FHA determines that isolation of the damper assembly is insufficient to prevent release of unfiltered air, a water-based suppression system should be provided.[53]

4.4.4.14 Isolation Dampers. If airtight 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 remote-operated from a safe location. Such dampers and associated equipment shall be treated as a required support system when the ventilation equipment is relied on for nuclear safety purposes (e.g., classified as SC or SS). Isolation dampers should not be used for primary confinement unless a redundant filter bank is provided and equipped with such dampers to maintain active confinement ventilation.

4.4.4.14.1 Manual water spray systems provided in the HEPA enclosure should be designed according to NFPA 15 with the following additional guidance (a) location from filters: open 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 (b) activation by manual operation: activation should be by manually activating a deluge valve or opening a normally closed indicating gate valve. A similar design density to that of the automatic deluge system should be used.

4.4.4.14.2 Control devices to activate the deluge valve should be provided in the process operator's control room or other locations accessible to emergency responders. When a deluge valve is used, manual activation may be provided at the deluge valve as well.

4.4.4.15 Deluge Spray Suppression Systems. Automatic and manual deluge systems should be designed to allow for periodic testing without requiring conditions that could result in the spread of contamination.[54]

4.4.4.16 Demister Guidelines. (a) When automatic deluge or water spray systems are installed in filter housing enclosures, a means to protect HEPA filters from moisture should be provided. One option is to install a demister downstream of the sprinklers/nozzles 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. (b) Demisters should be located as far away as possible from the HEPA filters (no less than 36 inches) and at least 6 inches from the sprinklers/nozzles.

4.4.4.17 Water Supply Guidelines. (a) Water supply for a deluge system should be redundant. One of the two water supplies may be a fire department connection, if approved by the AHJ. (b) The water supply for the deluge system should be hydraulically analyzed and shown to be capable of supplying for a minimum of two hours a simultaneous flow of the automatic and manual water spray systems, if provided, together with the overhead automatic sprinkler system for the fire area providing air to the plenum. (c) A minimum two-hour water supply is not required for a "limited water supply system," discussed below, where justified to prevent accidental criticality events.

4.4.4.18 Special System Guidelines

4.4.4.18.1 Water Drains. Water drains with traps and a means to eliminate drain trap evaporation should be provided in plenum floor drains. Plenum floor 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 water from the fire suppression systems for the densities and durations required in the FHA. Criticality safety should be observed in all drainage and storage systems when the potential for affecting fissile materials is encountered.

4.4.4.18.2 Limited Water Supply Systems. Limited water supply systems for the fire suppression system(s) 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.

4.4.4.18.3 Lighting and Window Viewing Ports. Lighting should be provided inside the filter plenum in front of or between the filter banks in the area where automatic and manual sprinklers/nozzles are located. Such lighting may be provided with an on/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 sprinklers/nozzles are located and should be placed so that all sprinklers/nozzles are visible from outside the filter plenum.

4.4.5 Protection of Essential Electronic/Information Technology Equipment. Unless otherwise directed by the DOE Field Element Manager, high monetary value (over 10 million dollars) and mission essential electronic/information technology equipment shall be designed and installed according to NFPA 75, *Standard for the Fire Protection of Information Technology Equipment.* The need for supplemental fire protection (such as clean agent systems) shall be determined based on an analysis by, or under the direction of, an FPE with input and concurrence by major stakeholders. Examples of systems that should be considered for supplemental protection include advanced computing systems, mission-critical computing systems, control room computer systems, data storage libraries, and automatic information storage systems.

4.4.6 Subterranean Facilities. Fire protection for subterranean facilities shall meet the requirements in Appendix D of this Standard, “Fire Protection for Subterranean Facilities.”

5 OPERATIONS

5.1 CRITERIA AND PROCEDURES

DOE O 420.1C (Attachment 2, Chapter II, Section 3.d(1)) requires establishment of comprehensive, written fire protection criteria and procedures to implement the following FPP requirements:

- Site-specific requirements;
- Staff organization, resources, training, roles and responsibilities;
- ITM of fire protection systems;
- Use and storage of combustible, flammable, radioactive, and hazardous materials;
- A "hot-work" control program;
- Identification and tracking of fire protection system impairments;
- Fire prevention measures (e.g., combustible loading, hot-work, and ignition source controls);
- Facility and FHA assessment programs;
- Design and construction oversight; and,
- Equivalencies, exemptions, modifications, and variances processes.

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 NFPA standards are applicable to the 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. Other NFPA codes containing ITM requirements may be applicable in certain circumstances. Appendix A of this Standard provides additional ITM requirements for SC and SS fire protection systems.

5.1.3.2 Inspection of fire barrier firestop systems should be performed in accordance with the criteria established in ASTM E 2174-14b, *Standard Practice for On-Site Inspection of Installed Fire Stops*, and ASTM E 2393-10a, *Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers*. In accordance with ASTM E 2174 and ASTM E 2393 conflict-of-interest guidelines, inspections, including destructive testing, should not be performed by installers, manufacturers, or suppliers, or competitors of any of these entities, of the material being inspected.

5.1.3.3 Test results should be reviewed by or under the direction of 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.

5.1.3.4 Section 11.4 of DOE Administrative Records Schedule 18, "Security, Emergency Planning and Safety Records" provides the requirements for inspection and test records.[55] 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 and results of relevant ITM procedures, to facilitate trending, 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 Loss Prevention Section 7 Data Sheets, and the International Fire Code, as applicable.

5.1.4.3 A combustible control program shall be included in FPPs. Additional fire protection measures may be required for nuclear, radiological, high-hazard, explosive, and mission-critical facilities.[56]

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 when the system does not meet the operating requirements. Compensatory measures are determined by, or under the direction of, an FPE based on the significance of the impairment compared to performance objectives. Appendix A of this Standard provides additional requirements for SC and SS fire protection system impairments.

5.1.5.2 The ITM program includes a fire protection system impairment program. This portion of the ITM program should include the process for: (a) approving and initiating impairments; (b) tracking of impairments; and, (c) reporting to DOE when impairments exceed DOE field element-established criteria for reporting and recording.[57]

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 control of hot work such as welding, cutting, brazing, and grinding.

5.1.6.2 Fire watch personnel should additionally monitor workers performing hot work or nearby the hot work area, especially where visual observation might impair normal viewing of the work area.

5.1.6.3 Control of potential ignition sources, such as space heaters, furnaces, ovens, lighting fixtures, sparks from failing insulation on motors and pumps, static electricity, cooking and temporary electrical equipment, other hot surfaces, and smoking by employees, subcontractors, and visitors, shall be established by site-specific FPP.

5.2 IMPLEMENTATION

5.2.1 Staffing

5.2.1.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.d.(2)(a)) 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.[58]

5.2.1.2 Emergency response training and qualifications shall be based on established industry criteria, such as those promulgated by the NFPA, and the 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.[59]

5.2.1.3 A training and qualifications program commensurate with their duties shall be established for FPEs and fire protection technicians. This program shall cover DOE-specific FPP elements and application of relevant DOE orders and technical standards.

5.2.1.4 An FPE shall meet the minimum qualifications standards in Section 1.5 of this Standard. 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.

5.2.2 Design Reviews. The design process shall include appropriate documented reviews by, or under the direction of, an FPE of plans and specifications, design changes, inspections, acceptance testing, and commissioning of fire protection features. DOE-STD-1189-2016 provides design process requirements for nuclear facility design. The design review should be documented in either an FHA or an FPDA (for non-nuclear facilities only), depending upon the complexity of the project.

5.2.3 Relief from DOE Directives, Mandatory Codes and Standards, and the Building Code. Contractors are required by DOE O 420.1C (Chapter II, Section 3.d.(2)(c)) to establish a process for developing and requesting AHJ approval of fire protection equivalencies and exemptions to fire protection requirements. This process should address the development, review, approval, and periodic reevaluation of variances, exemptions, and equivalencies in accordance with applicable rules, directives, and standards.[60] Documented requests for relief should be developed by, or under the direction of, the responsible subject matter expert 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[1]
10 CFR Part 851	Variance[2,3]	Office of Environment, Health, Safety and Security (AU)	Under Secretary
DOE O 420.1C	Exemption[3,4]	Central Technical Authority (CTA) for nuclear facilities only	Program Secretarial Officer
DOE O 420.1C	Equivalency[3,4]	CTA for nuclear facilities only	Program Secretarial Officer
NFPA Codes and Standards	Equivalency[5]	Subject Matter Expert	Head of Field Element
Building Code	Alternative[5]	Subject Matter Expert	Head of Field Element
DOE-STD-1066-2016	Alternative[6]	Subject Matter Expert	As designated by Head of Field Element

Notes:

1. Approval Authority applies to nuclear and non-nuclear facilities.
2. See 10 CFR Part 851 for variances to the Worker Safety and Health Rule.
3. Variances to 10 CFR 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.
4. See DOE O 251.1C for exemptions and equivalencies for DOE O 420.1C.
5. An exemption from applicable NFPA codes and standards, or the Building Code, requires an exemption from DOE O 420.1C.
6. DOE O 420.1C requires that any alternate approach to DOE-STD-1066-2016 provides an equivalent level of safety. The DOE field element provides approval of the FPP. The site-wide FPP is used to catalogue where alternate approaches to DOE-STD-1066-2016, in whole or in part, are adopted.

5.2.4 Delegated Authority

5.2.4.1 DOE O 420.1C (Section 5.c.(6)) assigns the responsibilities for the AHJ to the DOE Heads of Field Elements under advisement of an FPE as the subject matter expert.

5.2.4.2 The DOE Head of Field Element may approve generic equivalencies to specific standard or code requirements. In such cases, the contractor would apply the generic equivalencies by identifying and documenting specific instances that meet the criteria established in the approved generic equivalencies.

5.2.4.3 The Heads of Field Elements may designate a contractor as the site's AHJ to act as DOE's representative for routine activities.[61] DOE retains the right to override decisions of the contractor, including the interpretation and application of DOE orders, guides, standards, and mandatory codes and standards.

5.2.4.4 A contractor AHJ shall maintain a current written record of all delegations made by DOE for fire protection activities.

5.2.4.5 DOE O 420.1C (Section 5.d.(7)) assigns the responsibilities for the Building Code Official to the DOE Head of Field Element for the purposes of enforcement. The DOE Head of Field Element may delegate, to the contractor, responsibility for routine code activities, but may not delegate approval authority for 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 tailored to the leased facility according to (a) facility hazard; (b) DOE liabilities for injuries and accidents; (c) mission importance; and (d) remaining facility lifetime. The graded approach should be determined by, or under the direction of, an FPE and approved by the AHJ. Prior to signing any lease agreement, the lessee or its designee 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. Facilities and operations that are determined to need additional safety features and/or supplemental fire protection should be provided with such protection or compensatory measures prior to leasing.

5.3.1.2 Communicate to the owner all fire protection deficiencies (measured against the applicable industry codes) within the facility/structure. Verify that closure of deficiencies affecting life safety, DOE-owned equipment, and mission objectives will be tracked to 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 Specify responsibilities in the lease agreement, and participate and partner with the local jurisdiction's fire department in developing their pre-incident plan for leased facilities situated outside DOE site boundaries (i.e., off-site facilities).

5.3.1.4 Specify in the lease agreement DOE and owner responsibilities for coordinating and participating in evacuation exercises for off-site facilities.

5.3.1.5 Reach agreement on the scope and frequency of DOE-conducted and owner-conducted fire protection assessments. In general, the owner would be responsible for assessing off-site leased facilities in accordance with local jurisdictions and the DOE contractor would be responsible for assessing leased facilities within the site's jurisdiction.

5.3.1.6 Specify in the lease agreement the DOE and 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 and ITM of supplemental fire protection installed for DOE-owned equipment and operations.

5.3.1.7 For leased facilities that are located off-site, 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 should be in accordance with Section 5.1.4 of this Standard.

5.3.1.8 Specify in the lease agreement the lessee and owner roles and responsibilities for control of hot work operations in the facility.

5.3.1.9 Specify in the lease agreement that all fire protection assessments, ITM records, and hot work operations will be available to the local AHJ, the facility owner, and the DOE contractor.

5.3.1.10 For off-site leased facilities, specify in the lease agreement the lessee and owner roles and responsibilities for addressing owner-initiated impairments and responding to and resolving out-of-service components in facility fire protection systems.

5.3.1.11 Leased facilities should not be used for Hazard Category 1, 2, or 3 nuclear facilities, radiological facilities, or explosive handling facilities unless approved for such use by the responsible DOE Head of Field Element with concurrence from the CTA (for Hazard Category 1, 2, or 3 facilities). Such leased facilities should meet all construction and operating requirements that a new DOE-owned facility would be required to meet, including the applicable requirements of this Standard.

5.3.1.12 Off-site leased facilities shall transmit building fire alarms to an Underwriters Laboratories listed central station, unless otherwise approved by the AHJ.

6 EMERGENCY RESPONSE

DOE O 420.1C (Attachment 2, Chapter II, Section 3.e) requires contractors to provide emergency response capabilities, as necessary, to meet site needs, as established by the BNA, safety basis documentation, and applicable regulations, and in codes and standards. A comprehensive, multi-faceted emergency response capability can be achieved in a number of ways. These approaches 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. Department of Defense (DoD) 6055.06-M, DoD *Fire and Emergency Services Certification Program*, may be used as a guide to assist in meeting the requirements of this section.

Regardless of the approach, DOE's overall objective is to maintain adequate emergency response capabilities to effectively and safely respond to and mitigate credible emergency incidents, including fire, emergency medical and applicable operations. Emergency response includes resources and command capabilities for the initial incident management of emergency events of Type 4 complexity as defined by the National Incident Management System (NIMS).

6.1 BASELINE NEEDS ASSESSMENT

6.1.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3e (1)) requires the BNA to address facility hazards, response capabilities, response time requirements, staffing levels and training, apparatus and equipment, mutual aid agreements, and procedures.[62]

6.1.1.1 DOE O 420.1C (Attachment 2, Chapter II, 3.e(1)(c)) requires the BNA to be submitted to the DOE Field Element for approval.

6.1.1.2 DOE O 420.1C (Attachment 2, Chapter II, 3.e(1)(d)) requires the BNA to be reviewed at least every three years or when a significant new hazard is introduced, and updated as necessary. The BNA should be submitted for approval triennially or on a schedule acceptable to the AHJ and when significant changes are made.

6.1.2 The BNA should be prepared by knowledgeable and experienced individuals and address compliance with the governing requirements, codes and standards, and site-specific conditions that are applicable to the emergency response organization.[63] In addition, the BNA should describe the organization's various programs that support its personnel. Such programs include training, physical fitness, and medical programs relating to emergency responders.

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.

6.1.4 If off-site emergency response organizations are relied on completely to satisfy the emergency response requirement, the BNA should define the DOE emergency response needs compared to the services available from the off-site organization and identify the gaps between the needs and the available services.[64]

6.1.5 If a combination of on-site and off-site emergency services response organizations is relied on, a comprehensive emergency response capability should be demonstrated based on a combination of the efforts described above.[65]

6.1.6 The BNA should also include a review of the emergency response organization's activities and permitted practices that may increase response time or result in reduced staffing for DOE site needs.[66]

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's 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.[67]

6.1.8 The BNA should be based on responding to a single significant emergency event, such as a fire or explosion that includes a casualty requiring medical assistance, and at the same time responding to a one-person medical emergency, such as a heart attack or fall with injuries.

6.1.9 The BNA should describe how the fire department will respond if a second incident occurred while the first was underway. The second response capability may be based on documented mutual aid agreements and use of some percentage of off-duty personnel overtime. To the extent that an insufficient response capability is determined to exist for this second incident emergency, the BNA should address any supplemental emergency response resources and response times that would be needed to respond to this event.

6.1.10 The BNA should describe how the fire department will respond if the initial emergency incident expanded in complexity (such as multiple operating periods and/or initial response resources beyond NIMS Type 4). This description includes the availability and use of additional alarm assignments and discussion on the command structure methodology used in supporting the site's emergency plan in addressing Operational Emergencies addressed in the DOE O 151.1C, *Comprehensive Emergency Management System*. This discussion should identify the limits of the Fire Department's response capabilities, situations that may call for defensive tactical strategies, and limit situations for the site's emergency management system and external emergency response assistance. The BNA shall be coordinated with, and incorporate the elements and requirements of site emergency response plans to provide a complete, seamless and effective response capability.

6.1.11 If the Fire Department also provides emergency services 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 an on-site response, including the potential for delayed response or a resource-limited response and resulting potential risks and vulnerabilities.

6.1.12 Where on-site staff (i.e., emergency response teams or ERTs) supplements professional Fire Department services as first responders or HAZMAT teams, the BNA should evaluate and address such resources based their availability, training, and qualifications.

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.[68] Fire stations providing initial response resources to defense nuclear and other significant missions should be designed to withstand natural phenomena events and ensure delivery of emergency response resources as appropriate.

6.2.1.2 New fire stations shall be constructed and maintained in accordance with the applicable Facility Safety Chapter in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

6.2.1.3 Fire stations should be located to meet time objectives established by 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*.[69]

6.2.2 Fire Department Apparatus

6.2.2.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.e) requires that emergency response capabilities meet site needs as established by the BNA, safety basis requirements, and applicable regulations, codes and standards. Meeting site needs includes procuring of fire department apparatus.[70]

6.2.2.2 NFPA 1901, *Standard for Automotive Fire Apparatus*, NFPA 1906, *Wildland Fire Apparatus*, and NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus* are the applicable NFPA standards for fire apparatus. Procedures shall be established and implemented to maintain and eventually replace outdated equipment.[71] Fire apparatus' not meeting applicable NFPA standards or exceeding 25 years in service shall be replaced.

6.2.2.3 Reserve apparatus, if used, shall be properly maintained and equipped to provide the intended backup response capability.

6.2.3 Fire Department Staffing

6.2.3.1 NFPA 1710 and NFPA 1500 are the applicable NFPA standards for determining the minimum number of trained fire-fighters necessary to begin interior structural fire-fighting. In addition, the following OSHA rules are applicable: 29 CFR Section 1910.156, *Fire Brigades*; and 29 CFR Section 1910.134(g)(4) (two-in-two-out rule).[72]

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 the OSHA two-in-two-out rule, NFPA guidelines, pre-incident fire planning, and the judgment of trained and experienced incident commanders.[73]

6.2.3.3 Management and support functions should also be considered when developing staffing needs for an emergency response organization.[74]

6.2.3.4 NFPA 600, *Standard on Facility Fire Brigades*, is the applicable NFPA standard for staffing and operation of fire brigades.

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 and Command Safety*, are the applicable NFPA standards for ensuring emergency radio communications are compatible with other organizations involved in emergency response.

6.2.4.3 New emergency communications systems shall be designed, installed and maintained consistent with the performance standards identified in NFPA 1221, *Installation, Maintenance, and Use of Emergency Services Communications Systems*.

6.2.5 Training Certification and Drills

6.2.5.1 NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, is the applicable standard for emergency responder training. All DOE fire departments shall have a training program and policy that ensure that members are trained and competency is maintained to execute all responsibilities consistent with the Department's organization and deployment.[75]

6.2.5.2 Drills and exercises should be structured to emphasize realistic scenarios and feature standard, and 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 shall be made available for training consistent with the training requirements identified above.[76]

6.2.5.4 Fire department staff should be certified under state programs when available. When a state program is not available, certification may be done by an organization approved by the DOE Head of Field Element (for example, a certification program from an adjoining state).[77]

6.2.5.5 To the extent possible, common base qualifications for company and command officers should be used to facilitate interoperability between Sites. The Emergency Management Issues Special Interest Group (EMI-SIG) Field and First Responders Subcommittee Recommended Practice, DOE/NNSA Company and Command Officer Baseline Qualifications should be used in site qualification programs to the extent relevant.

6.3 PRE-INCIDENT PLANNING

DOE O 420.1C (Attachment 2, Chapter II, 3.e.(2)) requires that pre-incident strategies, plans, and standard operating procedures be established to enhance the effectiveness of manual fire suppression activities, including areas within or adjacent to, moderator-controlled areas. The criticality safety staff is required to review pre-incident plans and procedures related to moderator-controlled areas.

6.3.1 NFPA 1620, *Standard for Pre-Incident Planning*, is the applicable NFPA standard for development of pre-incident plans. The provisions of this code are complemented by input from the site fire protection engineering staff, facility subject matter experts, and emergency responders.

6.3.2 Pre-incident fire plans should be developed in accordance with standard practices within the emergency services community and DOE expectations, as reflected in published guidelines. The format of such plans may be established by the organization providing the emergency response.

6.4 FIREFIGHTING ACTIVITIES INVOLVING SPECIAL CONSIDERATIONS

6.4.1 Procedures for firefighting activities involving special hazards shall be developed and maintained.[78] The FHAs and safety basis documentation should reflect firefighting strategies when rapid intervention may not be possible (for example, in areas covered by criticality control) and when fixed fire protection systems may no longer be available as in transitional facilities. (See Appendix F of this Standard for additional information.)[79]

6.4.2 Fire-fighting procedures should address delays related to security and nuclear safety concerns.

6.4.3 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 and to use the facility for training activities.

6.4.4 DOE O 471.6, Admin Chg. 2, *Information Security*, provides protection and notification requirements for access to classified information by non-cleared individuals during an emergency.

6.5 FIRE DEPARTMENT REPORTING

6.5.1 DOE O 231.1B, Admin Chg. 1, *Environment, Safety, and Health Reporting*, provides DOE reporting requirements for emergency responses. Emergency response records shall 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. The AHJ or designee should then incorporate this information into the DOE O 231.1B data collection system.

7 FACILITY FIRE PROTECTION EVALUATIONS

7.1 FIRE HAZARD ANALYSIS

The purpose of an FHA is to assess the hazards of and potential damage from fire and verify that fire safety objectives are met. 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-1189-2016, and for demonstrating compliance with DOE orders and standards, building codes requirements, and industry fire protection standards. An FHA may be required for facilities other than buildings if the value and hazard warrant. Additionally, the FHA may incorporate facilities, other than buildings, when they are exposed to or are integral to the building operations.

7.1.1 Building/Facility FHA

7.1.1.1 DOE O 420.1C (Attachment 2, Chapter II, Section 3.f (1)) requires FHAs to be prepared using a graded approach for (a) Hazard Category 1, 2, and 3 nuclear facilities and major modifications thereto; (b) facilities that represent unique fire safety risks; (c) new facilities, or modifications to existing facilities with value greater than $167 million (in 2016 dollars), and (d) when directed by the responsible DOE authority.

7.1.1.2 DOE O 420.1C (Attachment 2, Chapter II, Sections 3.f.(1)(b) and (c)) requires the FHA be updated, as needed, when changes occur to the facility structure or layout, processes, occupancy, safety basis documentation, or the BNA impacts the analysis in the FHA. The FHA shall be reviewed and updated, as necessary, at a minimum of every three years.

7.1.2 Documented Fire Protection Design Review and Analysis

7.1.2.1 An FPDA should be performed to ensure that FPP 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, new facilities that represent a unique fire safety risk, facilities valued over $167 million (in 2016 dollars), or when directed by the responsible DOE authority, the FPDA should be documented in a Preliminary/Project FHA that will be converted or incorporated into the facility FHA after project completion.

7.1.2.3 The FPDA and Preliminary/Project FHA should be of sufficient detail to identify applicable design criteria for meeting the fire safety objectives. The Preliminary/Project FHA should be used to justify design decisions, where required, when one or more solution is available, when multiple protection approaches are necessary, or where prescriptive requirements do not adequately address the situation encountered.

7.1.3 Transitional FHA

7.1.3.1 Transitional facilities have been shut down (i.e., are no longer operational) and may be in surveillance and maintenance mode or undergoing decontamination and decommissioning (D&D). The need for fire protection features in such facilities should be governed by the

consequences of a fire to the public, workers, and fire-fighters, and the potential for a release of hazardous and radiological materials.[80] See Appendix F of this Standard for guidance on transitional facilities.

7.1.3.2 For transitional facilities covered by DOE O 420.1C, and when directed by the DOE Field Element, a transitional FHA shall be developed.

7.1.4 Preparation, Review, and Approval of FHAs

7.1.4.1 FHAs and FPDAs are required by DOE O 420.1C (Attachment 2, Chapter II 3.f.(1)(a)) to be prepared by or under the direction of an FPE, and should be subjected to an adequate peer review, and approved through an established process.

7.1.4.2 A Building/Facility FHA is required by DOE O 420.1C (Attachment 2, Chapter II 3.f.(1)(b)) to be reviewed at least every three years with the review documented and the FHA revised as necessary.

7.1.4.3 An FPDA and Preliminary/Project FHA should be reviewed at major project milestones or following significant changes to the project scope.

7.1.4.4 A Transitional FHA should be reviewed at major milestones in the transition process, if any.

7.1.5 Detailed criteria and guidance for FHAs are provided in Appendix B of this Standard.

7.2 FACILITY ASSESSMENTS

The principal objective of a facility assessment is to strengthen the facility FPP. This objective 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 (Attachment 2, Chapter II, Section 3.f) provides requirements on the frequency of facility assessments.

7.2.2 Facility assessments shall be performed by, or under the direction of an 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 Facility assessments should evaluate the following programmatic and physical fire protection features:

- Applicable codes and standards;
- Fire and explosion hazards;
- Protection of SC and SS equipment;
- Life safety;
- Protection of mission-critical equipment or programs;
- Protection of high-value property;

- Suppression equipment;
- Detection and alarm systems and equipment;
- Fire system ITM;
- Water runoff;
- Facility fire prevention planning documents;
- Emergency response capability;
- Completeness of FHA, and, 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 and tracking of previous findings; and
- Equivalencies and exemptions.

7.3 COMPENSATORY MEASURES

7.3.1 When modifications are necessary to correct significant fire safety deficiencies, interim compensatory measures shall be provided until the modifications are complete.[81] Compensatory measures shall be initiated without delay, commensurate with the identified fire safety deficiencies and the Head of the Field Element should be notified.

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 support of an equivalency or exemption request, they shall remain in place and be reviewed annually until the request has been dispositioned.

8 WILDLAND FIRE MANAGEMENT

8.1 PURPOSE

This section provides guidance for wildland fire management at DOE sites.[82]

8.2 APPLICABLE DOE ORDER REQUIREMENTS

DOE Order 420.1C, provides the following requirements for wildland fire management:

- Section 4f: "DOE must … [E]stablish an integrated site-wide wildland fire management plan, consistent with the Federal Wildland Fire Management Policy."

- Attachment 2, Chapter II, Section 3b: "Documentation. A documented fire protection program that includes the elements and requirements identified in this chapter for design, operations, emergency response, fire analysis and assessments, wildland fire, and specific fire protection program criteria must be developed, implemented, and maintained by the contractor."

- Attachment 2, Chapter II, Section 3g: "Wildland Fire. An integrated site-wide wildland fire management plan, consistent with the *Federal Wildland Fire Management Policy*, must be developed, provided to DOE for approval, and implemented in accordance with the relevant portions of the NFPA 1143, *Standard for Wildland Fire Management*, 2014."

8.3 OVERVIEW OF APPROACH

The *Federal Wildland Fire Management Policy* (referred to hereafter as the "Federal Policy") and NFPA 1143 are different in structure and purpose. The former document is coordinative in nature, providing guidelines to promote "consistent implementation of federal wildland fire policy." The NFPA Code states its purpose as "specify[ing] management practices and policies necessary for a fire protection organization to develop a wildland fire management program." As a matter of government policy, DOE is expected to demonstrably conform to the Federal Policy as written, to the extent it applies to DOE's sites and operations.

Guidance on wildland fire management is organized into the following three subsections:

- Subsection 8.4 is devoted to explaining how DOE implements the Federal Policy.
- Subsection 8.5 offers guidance on the application of NFPA 1143 to DOE's site-wide wildland fire management plans.
- Subsection 8.6 provides additional guidance on several topics.

8.4 IMPLEMENTING FEDERAL GUIDANCE

8.4.1 Identification of DOE Policies

Table 1 of the *Federal Wildland Fire Management Policy* lists 17 topics and provides for each topic an additional statement of "Management Intent" and a set of "Implementation Actions" for federal agencies. In the tables below, the contents of the first and second column come directly from the *Federal Wildland Fire Management Policy*; the core policy is shown in italics in the first column, and statements of management intent are shown as lettered items in the first column.

8.4.2 Firefighter Safety

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Firefighter and public safety is the first priority. All Fire Management Plans and activities must reflect this commitment. (a) No natural or cultural resource, home, or item of property is worth a human life. (b) All strategies and tactics should seek to mitigate the risk to firefighters and the public.	(1) Agency administrators will develop and establish process, procedures and objectives that ensure firefighter and public safety. (2) Incident Commanders will develop and establish incident objectives, strategies and operational tactics that ensure firefighter and public safety.	DOE wildland fire activities should reflect a commitment to firefighter and public safety as the first priority. DOE site management contractors should: (a) Establish procedures for issuance, use, and accountability of personal protective clothing and equipment; (b) Ensure that training, use, appropriate employee medical surveillance programs, and maintenance and storage of the protective equipment comply with applicable standards; (c) Provide 4 hours of annual wildland fire safety refresher training to personnel directly involved with such activities; and, (d) Ensure that work supervisors are responsible for the safety of employees engaged in wildland fire management activities.

8.4.3 Fire Management and Ecosystem Sustainability

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
The full range of fire management activities will be used to help achieve ecosystem sustainability, including its inter-related ecological, economic, and social components. (a) "Full range of fire management activities" may include any vegetative management treatment tool. (b) Ecosystem sustainability provides a supply of goods, services, social values, and natural processes in perpetuity. (c) Economic intent is to provide for sustainable supplies of goods, services, and social values through implementation of appropriate fire management activities.	(1) Land/Resource Management Plans (L/RMP) will be developed consistent with both ecological conditions, and fire regime dynamics, and consider the short and long term effects of both action and no action alternatives for planned vegetation management activities as well as responses to wildfire. (2) Agencies will exploit the full range of fire management options to sustain healthy ecosystems within acceptable risk levels as identified in the L/RMP, or Fire Management Plan (FMP). (3) Fire management activities will be based on planning and decision analysis processes that address current and anticipated situational conditions.	See DOE O 436.1, *Departmental Sustainability*

8.4.4 Response to Wildland Fire

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Fire, as a critical natural process, will be integrated into land and resource management plans and activities on a landscape scale, and across agency boundaries. Response to wildland fires is based on ecological, social and legal consequences of the fire. The circumstances under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and, values to be protected, dictate the appropriate response to the fire. (a) The L/RMP will define and identify fire's role in the ecosystem. The response to an ignition is guided by the strategies and objectives outlined in the L/RMP and/or the Fire Management Plan. (b) Values to be protected from and/or enhanced by wildland fire are defined in the L/RMP and/or the Fire Management Plan. (c) The L/RMP and fire management planning is coordinated across jurisdictional boundaries.	FMPs assist in developing the management response to meet L/RMP objectives in designated Fire Management Units (FMU). (1) Fire management strategies will consider current landscape conditions and spatial and temporal components of the fire regime. (2) Responses to wildland fires will be coordinated across jurisdictional boundaries.	DOE site management contractors should: (a) Identify the applicable Fire Management Unit; and (b) Coordinate wildland fire response as agreed with other agencies adjacent to the DOE site.

8.4.5 Use of Wildland Fire

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Wildland fire will be used to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role. Use of fire will be based on L/RMP and associated Fire Management Plans and will follow specific prescriptions contained in operational plans. (a) Use planned and unplanned ignitions to achieve land and resource management goals. Fire management is one tool in the restoration process and should be integrated with other land management activities.	(1) Incident objectives will identify resource objectives for wildfires managed to achieve resource objectives. (2) Beneficial accomplishments will be measured through specific quantified objectives**.**	DOE sites should integrate fuel management and fire management programs in support of the following resource management objectives. (a) Use an interdisciplinary approach to integrate fuel management planning into all appropriate activities. (b) Identify, through economic analysis, the most cost-efficient fuel profile to meet resource management direction. Consider a full range of fuel management alternatives, including no treatment. Fuel management activities should be responsive to long-term site productivity,

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
(b) Preference will be given for natural ignitions to be managed in meeting the role of fire as an ecological process. (c) Decision support process encourages strategies to manage fire to restore and maintain the natural fire regime where safe and possible.		utilization opportunities, and air quality considerations. (c) Where a management activity, such as timber sales, thinning, or road construction, contributes to an unacceptable fuel profile, modify that activity to reduce its incremental contribution to the fuel profile. (d) On lands where repetitive management activities will occur, evaluate the projected fuel profile to determine the most cost-efficient time(s) of entry and the level of treatment(s). (e) Manage fuel in accordance with fire management direction in the site land-use planning and management process.

8.4.6 Rehabilitation and Restoration

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Rehabilitation and restoration efforts will be undertaken to protect and sustain ecosystems, public health and safety, and to help communities protect infrastructure. (a) Conduct emergency stabilization of burned areas such that no further harm is done. (b) Probability of success will be evaluated for rehabilitation and restoration efforts.	(1) Burned areas will be assessed to determine suitable and effective emergency stabilization and rehabilitation needs to meet current and anticipated environmental conditions. (2) Rehabilitation and restoration activities will be evaluated to assess effectiveness of treatments.	The following post-fire activities (for prescribed, operational and wild fires) should be accomplished at the earliest opportunity. (a) Sites should conduct an immediate assessment of watershed conditions following the fire. (b) Sites should determine if emergency watershed rehabilitation efforts are required to restore watershed functions and minimize damage to soil resources. (c) Sites should initiate post-fire rehabilitation treatments as necessary (e.g., sediment reduction, channel treatments, check dams) to stabilize biotic communities, address safety concerns, and to prevent degradation of critical known natural and cultural resources. (d) Sites should monitor the effectiveness of rehabilitation treatments to determine if additional treatments are required.

8.4.7 Protection Priorities

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
The protection of human life is the single, over-riding priority. Setting priorities among protecting human communities and community infrastructure, other property and improvements, and natural and cultural resources will be done based on the values to be protected, human health and safety, and the costs of protection. Once people have been committed to an incident, these human resources become the highest value to be protected. (a) Resources are allocated nationally, geographically, and locally based on protection priorities. (b) Protection of human life overrides all other priorities should response capability limits be reached. (c) Local protection priorities are established in the L/RMP and/or FMP.	NMAC [National Multi-Agency Coordinating Group] establishes national protection priorities considering maintenance of initial attack capability; protection of communities, infrastructure, property, cultural and natural resources; costs; local agency objectives; and national response framework and tasking. (1) Geographic and local area coordination groups will establish a process to set protection priorities. (2) The Agency Administrator will convey protection priorities, based on the L/RMP and FMP, to the geographic and national groups through an incident status report and ensure that protection priorities are known and carried out by the incident commander(s).	In general, DOE field elements are responsible for developing, implementing, and overseeing protection programs for individuals and assets under their cognizance. This includes protecting assets from internal structural fire damage and from the conflagration potential associated with the external wildland fire. A Wildland Fire Management Program comprises the full range of activities and functions necessary to plan, prepare, and respond to potential fires and rehabilitate undeveloped lands following a fire. DOE should observe the following fire management priorities on all fires: (a) Ensure firefighter, worker, and public safety. (b) Protect mission property and natural and cultural resources based on the relative values to be protected.

8.4.8 Wildland Urban Interface

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
The operational roles of federal agencies as partners in the Wildland Urban Interface are wildland firefighting, hazard fuels reduction, cooperative prevention and education, and technical assistance. Structural fire suppression is the responsibility of tribal, state, or local governments. Federal agencies may assist with exterior structural protection activities under formal Fire Protection Agreements that specify the mutual responsibilities of the partners, including funding. (Some federal agencies have	(1) Agreements will be developed to clarify jurisdictional inter-relationships and define roles and responsibilities among local, state, tribal, and federal fire protection entities, based on each organization's enabling protection authorities and assistance/mutual aid responsibilities. (2) Agencies will support the	The zone where structures and other human development meet or become intermingled with undeveloped wildland is referred to as the wildland/urban interface. The objectives of wildland/urban interface fire management are to facilitate fire prevention and protection and minimize fire loss and damage to structures, other human development, and wildland resources; to prevent a structure fire from spreading into wildland fuels; and to encourage property owners to take an active role in establishing and maintaining their own fire prevention and safety measures in the wildland/urban interface. The following recommendations are applicable to this category. (a) Document DOE wildland fire protection and suppression assistance in mutual-aid agreements

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
structural protection authority for their facilities on lands they administer and may also enter into formal agreements to assist state and local governments with structural protection). (a) Prevent the movement of wildfires from the wildlands into the Wetland-Urban Interface area, out of the Wetland-Urban Interface area into the wildlands, and improve efficiency of wildfire suppression in Wetland-Urban Interface situations. (b) The primary responsibility for protecting private property and rural communities lies with individual property owners and local governments. (c) Recognize that many states have wildland fire responsibility while rural fire districts have structural responsibility.	development and implementation of Community Wildfire Protection Plans (CWPP). (3) The Federal wildland agencies will collaborate with tribal, state and local fire management organizations to identify and reconcile gaps in protection responsibility.	with all emergency response organizations engaged in such activities; (b) Collaborate with outside emergency response organizations to (1) establish and update cooperative agreements that recognize the jurisdictional protection responsibilities and assistance capabilities of the respective cooperators; (c) Educate wildland firefighters about safe operational procedures in the wildland/urban interface and provide training in safe wildland firefighting operations for structural firefighters who respond to wildland/urban interface fires; (d) Provide education to adjoining property owners on fire risks and hazards and on fire prevention responsibilities and actions to minimize losses and damage to structures and lands in the wildland/urban interface; (e) Assess, analyze, and plan for fire prevention and protection in conjunction with other Federal, tribal, state, county, and local government entities and with community and citizen groups; (f) Integrate wildland/urban interface considerations in the DOE land-use planning and management process, as well as in program project and plans; (g) Implement fuel modification projects to mitigate fire hazards; (h) Adopt special building construction requirements in wildland/urban interface areas, such as the construction requirements of NFPA 1144; and (i) Implement other practices that reduce wildland fire risks.

8.4.9 Planning

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Every area with burnable vegetation must have an approved Fire Management Plan. Fire Management Plans are strategic plans that define a program to manage wildland fires based on the area's approved land management plan. Fire Management Plans must provide for firefighter and public safety; include fire management strategies, tactics, and alternatives; address values to be protected and public health issues; and be consistent with resource management objectives, activities of the area, and environmental laws and regulations. (a) Promote interagency and inter-governmental planning. (b) Encourage landscape scale planning across jurisdictional boundaries.	(1) The FMP should be interagency or intergovernmental in scope and developed on a landscape scale, where practical to take advantage of efficiency, reduce conflict and provide understanding and cooperation. (2) The L/RMP and/or FMPs will address the location and conditions under which resource benefits and protection objectives can be met.	Preparedness planning provides for timely recognition of approaching fire management situations and for setting priorities, deploying resources, and considering other actions to respond to those situations. Wildland fire preparedness planning should include the following: (a) The purpose of preparedness plans and reviews is to ensure the timely recognition of and appropriate response to fire management situations and to provide the basis for ensuring program accountability. Preparedness planning requires (1) an intelligence system, (2) an analysis and decision-making process, and (3) identified actions to be taken at increasing levels of fire severity and activity (preparedness level). Preparedness plans should be documented in a site mobilization guide or other appropriate document. (b) When developing preparedness plans, consider the following: 1) Actions for responding to fire preparedness levels (National Interagency Mobilization Guide, NFES 2092); 2) Preparedness levels and actions addressing the full range of anticipated fire danger and activities; 3) Documented processes to coordinate actions among cooperating agencies and to transmit decisions promptly to all affected organizations, including adjacent units and cooperators; 4) Preparation of a Fire Management Plan documenting the fire management program that most effectively achieves land-use planning and management process direction; 5) Preparation of a Site Fire Plan, to be reviewed and revised at least once every three years, for any activities that increase wildland fire risk or constitute a wildland fire hazard, such as land clearing, timber harvesting, mining, and power line or highway construction; and 6) Triennial review and update of all cooperative wildland fire agreements.

8.4.10 Science

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Fire Management Plans and programs will be based on a foundation of sound science. Research will support ongoing efforts to increase our scientific knowledge of biological, physical, and sociological factors. Information needed to support fire management will be developed through an integrated interagency fire science program. Scientific results must be made available to managers in a timely manner and must be used in the development of land management plans, Fire Management Plans, and implementation plans. (a) Increase the body of scientific knowledge and understanding about fire management programs through the development of management tools and transfer of knowledge to practitioners and decision makers. (b) Social sciences are a part of the research need.	(1) Agencies will integrate science in planning and monitoring processes. (2) Agencies will coordinate fire-related research to improve fire management program capability. (3) Agencies will emphasize applied science including fire and fuels, physics, social science, and operations research areas. (4) Agencies will seek to improve decision support tools through updated data sets and advances in technology.	No specific action recommended.

8.4.11 Preparedness

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Agencies will ensure their capability to provide safe, cost-effective fire management programs in support of land and resource management plans through appropriate planning, staffing, training, equipment, and management oversight. (a) Recognize that particular budget processes and external influences will affect capability and capacity. (b) Size the organization to meet realistic and sustainable management objectives by effective preparedness planning on an interagency basis. (c) Realize efficiencies by incorporating other federal, tribal, state, and local agencies and nongovernmental organizations to meet peak demands for resources. (d) Preseason agreements are an integral part of preparedness.	(1) Agencies will identify and realign organizational staffing and equipment mixes to implement a safe and cost effective fire management program that meets the fire management guidance identified in the L/RMP. (2) Agencies will develop a common process for determining budget needs and cost sharing for all aspects of fire management operations. (3) Implement training program to meet staffing levels (qualification requirements) with the emphasis on managing fires for both protection and resource management objectives. (4) Agencies will develop agreements to efficiently utilize other federal, state, local, and non-governmental resources.	DOE site management contractors should: (a) Establish and document the need for developing agreements with other federal, state, local, and non-governmental resources; (b) Relay the need for these agreements to the DOE Head of Field Element (or designee) so that DOE may pursue these agreements; (c) Assist DOE, as requested, in developing agreements with other federal, state, local, and non-governmental resources; and (d) Identify and address staffing, equipment, and training needs based on the wildland fire threat as determined by the BNA.

8.4.12 Suppression

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Wildland fires are suppressed at minimum cost, considering firefighter and public safety, benefits, and values to be protected, consistent with resource objectives. (a) Suppression considerations will be addressed in L/RMP and FMP's.	(1) Use a decision support process to assess conditions, analyze risk and document decisions. (2) Predictive services products will be used to support pre-positioning resources. (3) Agencies will coordinate staffing levels through common trend analysis of environmental indicators.	Wildland fire suppression is intended to safely suppress wildland fires at minimum cost, consistent with land and resource management objectives and fire management direction as stated in fire management plans. Expectations or actions to take in the event of a wildland fire include the following. (a) Ensure that suppression planning, operations, and personnel comply with the wildland fire suppression principles and practices that are set out in the DOE Wildland Fire Management Program and associated procedures. (b) Conduct fire suppression in a timely, effective, and efficient manner, giving the first priority to firefighter and public safety. (c) Decide how to organize and conduct suppression operations (suppression strategies). Line managers

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
(b) Notwithstanding protection of life, the cost of suppression, emergency stabilization and rehabilitation must be commensurate with values to be protected.		should minimize both suppression cost and resource loss consistent with the resource management objectives for the values to be protected. (d) Consider fire behavior, the availability of suppression resources, the value of natural resources and property at risk, direction in the site land-use planning and management process, and the potential cost of suppression. (e) Consider using a wildland fire situation analysis to document suppression strategy decisions (f) Conduct a cost-effective initial attack on any wildland fire not considered as an operational fire or a prescribed fire. (g) Respond to each reported wildland fire with planned forces and tactics as directed in the fire management plan.

8.4.13 Prevention

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Agencies will work together and with their partners and other affected groups and individuals to prevent unauthorized ignition of wildfires. (a) Prevention focuses on the activities needed to reduce human-caused ignitions. (b) Prevention includes mitigating risks and loss to ecosystems and communities.	Agencies will work with all partners to develop and implement risk assessment, prevention, and mitigation plans to reduce the frequency of wildfires due to human–caused ignitions.	The objective of wildland fire prevention is to avoid the costs and risks associated with wildland fire suppression activities. A DOE site's wildland fire prevention program should be: (a) Coordinated with local stakeholders to encourage planning and analysis of stakeholder lands in accordance with wildland fire prevention programs; and (b) Coordinated with other agencies where risks affect other jurisdictions.

8.4.14 Standardization

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Agencies will use compatible planning processes, funding mechanisms, training and qualification requirements, operational procedures, values-to-be-protected methodologies, and public education programs for all fire management activities. (a) All processes are compatible and transparent so that individuals from cooperating agencies (federal, tribal, state, and local) can more effectively work together. (b) Enhance public and cooperator understanding of wildland fire management processes.	(1) To the extent possible, agencies will use common standards in all aspects of fire management programs so that planning and budgeting methodologies applied in one situation will provide the same results in similar circumstances. (2) Agencies will develop and implement common operational field guidance and operational procedures to deal with all aspects of fire management operations. (3) Agencies will streamline interagency transfer of funds to reduce fiscal inconsistencies.	No specific action recommended. This Standard provides DOE's standard approach.

8.4.15 Interagency Cooperation and Coordination

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Fire management planning, preparedness, prevention, suppression, fire use, restoration and rehabilitation, monitoring, research, and education will be conducted on an interagency basis with the involvement of cooperators and partners. (a) Involve all participating agencies, federal, tribal, state, local, and non-governmental organizations in fire management activities. (b) Get everyone working in concert, rather than in opposition to each other.	(1) Ensure that fire management program actions are implemented in collaboration with cooperators and affected partners with due consideration of all management objectives. (2) Agencies will engage cooperators and affected partners at the strategic, and program planning levels, as well as the tactical, program implementation level.	Each site's Fire Management Plan should: (a) Contain or reference all cooperative agreements and interagency contacts. (b) Describe or reference the interagency coordination needed to implement the wildland fire management plan. (c) List or reference key interagency contacts by function. (d) Discuss local agreements that are in place. Include major cooperators, such as state and other Federal agencies, as well as local volunteer fire companies.

8.4.16 Communication and Education

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Agencies will enhance knowledge and understanding of wildland fire management policies and practices through internal and external communication and education programs. These programs will be continuously improved through the timely and effective exchange of information among all affected agencies and organizations. (a) Knowledge and understanding reach all personnel in the field, across agencies. (b) Develop and provide consistent communication, education and outreach with shared messages for the public and internal staff. [Communication and Education, cont.] (c) Have a public that understands the risk, benefits and complexity of wildland fire management.	(1) Develop a consistent and uniform message using common terminology on importance and role of wildland fire in natural resource management. (2) Develop understanding with the public on what we're trying accomplish with fire management. (3) Build understanding with the public on their role when living and recreating in fire prone ecosystems.	Each site's wildland fire management plan should address: (a) The overall wildland fire prevention and community education and assistance programs for the site, (b) A description of the typical human-caused wildland fire, and (c) The main activities of the site related to wildland fire prevention.

8.4.17 Agency Administrator and Employee Roles

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Agency administrators will ensure that their employees are trained, certified, and made available to participate in the wildland fire program locally, regionally, and nationally as the situation demands. Employees with operational, administrative, or other skills will support the wildland fire program as necessary. Agency administrators are responsible and will be held accountable for making employees available. (a) Employees participate in wildland fire operations to obtain understanding, expand capabilities, and increase organizational capacity. (b) Assure that we maximize use of the local workforce for efficiencies of knowledge, cost and involvement. (c) Maintain a competent and capable workforce to implement the wildland fire management program to include fuels, aviation, suppression, planning, monitoring, research, communication, finance, etc.	(1) Agency administrators will train, qualify, and certify available personnel for local fire needs and interagency fire management priorities. (2) Agencies will consider adjustment of annual performance expectations based on employee and program contribution to the fire effort.	Every DOE site where wildfire risk exists is expected to: (a) Provide training adequate to meet fire management needs, and (b) Ensure that cognizant DOE and contract employees meet standards for training, experience, and physical fitness before they are certified for wildland fire organization positions. Site management should adhere to the qualification standards established by the NWCG, NFPA and state or local laws or regulations.

8.4.18 Evaluation

Federal Policy	Federal Policy Implementation Actions	DOE Guidance
Agencies will develop and implement a systematic method of evaluation to determine effectiveness of projects through implementation of the 2001 Federal Fire Policy. The evaluation will assure accountability, facilitate resolution of areas of conflict, and identify resource shortages and agency priorities. (a) Use adaptive management process to evaluate and improve the fire management program at all levels. (b) Provide a formal review process to monitor and evaluate performance, suggest revisions, and make necessary adaptations to the implementation guidance at all organizational levels on a regular basis.	Conduct interagency, internal and periodic reviews of the fire management program (all agencies) to determine: (1) Consistency of policy implementation; (2) Effectiveness of interagency coordination; (3) Progress towards ecosystem sustainability; (4) Cost management; (5) Safety.	DOE site management contractor should provide periodic reviews of wildland fire management planning consistent with Section 3.2.2 of this Standard.

8.5 USE OF NFPA CODE 1143

8.5.1 Overview

As noted in Section 8.2 above, DOE Order 420.1C requires that each DOE site where wildfire risk exists create and implement an integrated, site-wide wildland fire management plan (WFMP) "in accordance with NFPA 1143, *Standard for Wildland Fire Management, 2014*." Section 5.1.3 of NFPA 1143, "Preparedness Planning," requires that the AHJ prepare a plan having the contents specified in subsection 5.1.3.2.[83]

Once developed, the WFMP shall be reviewed every three years or when conditions addressed by the plan change to an extent that a revision to the plan is necessary for accuracy and effectiveness.

The wildland fire management plans are prepared, approved and reviewed periodically to (a) formally document the site wildland fire program elements, objectives, strategies and resource considerations based on the land-use planning and management process; (b) provide the responsible manager with specific guidance to implement fire-related direction on the ground; and (c) interpret strategic Land Management Plan direction into specific wildland fire management direction for each fire management unit delineated in the wildland fire management plan. A WFMP does not document wildland fire management decisions; rather, it provides operational parameters whereby fire managers implement the goals and objectives in the site land-use planning and management process.

The comprehensive site plan should contan the following major sections:[84]

- Introduction;
- Relationship to Land Management Planning and Wildland Fire Policy;
- Wildland Fire Management Strategies;
- Wildland Fire Management Program Components;
- Organizational and Budgetary Parameters; and
- Monitoring and Evaluation.

Information on a site's wildland fire risk profile and prevention/suppression strategies will also be found in other DOE and contractor documents:

- The site's FPP is required by DOE O 420.1C to cover wildland fires;
- The site's BNA evaluates the site's resources and staffing available to suppress wildland fires;
- DSAs under 10 CFR Part 830, for nuclear facilities contain an evaluation of wildland fires as possible accident initiators; and
- FHAs for individual facilities on the site address wildland fire risks and methods for mitigation.

While much if not all of the information required in NFPA's plan could be located in the above-cited DOE documents, the requirement of DOE O 420.1C is for "an integrated, site-wide wildland fire management plan" using the NFPA code's approach. The following subsection explains how the Order's requirement for an integrated plan should be met.

8.5.2 Site-Wide Integrated Plan

The site management contractor at each DOE site where wildland fire hazards exist shall prepare and triennially review and update as necessary an integrated WFMP that addresses the following topics:

(a) Identification of specific wildland fire hazards, ignition risks, and potential hazard areas within the jurisdiction and other hazards that negatively affect wildland fire control efforts;

(b) Identification of fire protection features such as lakes, rivers, water points, natural firebreaks; potential escape routes, and other areas or features that are beneficial to wildland fire control efforts;

(c) A list of fire-fighting resources, including personnel, apparatus, and equipment;

(d) A list of all cooperating agencies and other mutual aid resources and the procedures for requesting assistance from those agencies and resources;

(e) A reference to any and all existing mutual aid agreements, contracts, and other protection agreements applicable to wildland fire control efforts;

(f) A list of specific objectives relating to training, safety, response times, and staffing levels; and,

(g) A list of other resources that provide analyses of fire cause, identification of special fire hazards, identification of ignition risks, assessment of wildland/urban interface and intermix fire protection problems, and proposed measures to reduce fire occurrence.

Other topics related to wildland fires may be included in the WFMP. Maximum use should be made of existing analysis and assessments such as DSAs prepared under DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, (or other approved safe harbor method) and BNAs prepared under this Standard. Incorporating such documents by reference in whole or in part is an acceptable approach.

When developing a WFMP, the following topics should be considered:

- Actions needed for responding to fire preparedness levels (see NFES 2092, *National Interagency Mobilization Guide*);
- Preparedness levels and actions covering the full range of anticipated fire danger and activities;
- Written procedures for coordinating actions among cooperating agencies;
- Methods to transmit decisions promptly to all affected organizations; and,
- Schedules and approaches for conducting preparedness reviews and exercises.

The WFMP shall be submitted to the DOE Head of Field Element or designee for review and approval.

8.6 ADDITIONAL GUIDANCE

8.6.1 Fire Reports

Timely reports of fire activities provide information essential for land and resource management and for both internal and external administrative purposes. DOE site/field offices should log a report for each wildland fire in accordance with standard site fire reporting methods. A prescribed fire that burns out of prescription and is declared a wildland fire should be reported as a wildland fire.

8.6.2 National Interagency Fire Center (NIFC) and National Wildfire Coordinating Group (NWCG)

Guides and reference publications offered by these two organizations should be reviewed and considered by DOE sites in addressing wildland fire hazards. For example, the following publications provide useful guidance: NWCG PMS 210, *Wildland Fire Incident Management Field Guide*, and NWCG PMS 310-1, *Wildland and Prescribed Fire Qualification System Guide*.

APPENDIX A
SAFETY SIGNIFICANT AND SAFETY CLASS FIRE PROTECTION SYSTEM SPECIFICATIONS

This appendix describes an acceptable approach for implementing the design and operational requirements specified in DOE O 420.1C, *Facility Safety*, for new safety significant (SS) and safety class (SC) fire protection systems, specifically, wet pipe automatic sprinklers, water supplies, and fire barrier systems. This appendix may also apply to situations where DOE decides to modify the safety basis for an existing nuclear Hazard Category 1, 2, or 3 nuclear facilities, such that an existing fire protection system is reclassified to perform a SC or SS function. This appendix does not apply to existing fire protection systems that have already been classified as SS or SC in Hazard Category 1, 2, and 3 nuclear facilities.[85]

- 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 used in SC and SS applications along with this Standard.[86]

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 used 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-3009-2014, *Preparation of 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-3009-2014 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 used 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-1189-2016, *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-1189-2016 (e.g., preliminary and final hazard assessments, preliminary and final DSA).[87]

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 an essential part of the SC or SS function, such actions shall be described in the appropriate section of the DSA. Documentation in the DSA shall include the conditions under which the sprinkler system is to remain operable to prevent or mitigate analyzed events such as earthquakes and disruptions of electrical power

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, number of sprinklers, flow and pressure demand at the base of the riser, and water supply sources);
- 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;
- Natural phenomena hazards requirements (e.g., 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 System[88]

A.2.2.1 The boundary of a SC or SS wet pipe sprinkler system shall be defined to clearly identify which components are 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 specify 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 should be evaluated for additional protection, such as an anti-freeze subsystem, the use of dry type sprinkler heads, heat tracing subsystems, 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 subsystem or water circulation systems. The freeze protection systems that form an integral part of the sprinkler system (e.g. anti-freeze subsystem, 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 is classified at the same level as the sprinkler system. Examples of appropriate freeze protection systems include heating the space, heat tracing, building insulation, anti-freeze, and water circulation. However, the freeze protection or building heating system should not 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. 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.[89] 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 from a constantly attended location should be provided.[90] 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 this Standard.

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 and/or socket type fittings (i.e., fittings attached to plain end pipe by a friction fit and gaskets); and,
- Cast iron pipe fittings.[91]

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, according to 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 should be no greater than 100 sq. ft.[92]

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 use 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) according to ASME NQA-1-2015, *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, Chg. 2, *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 SC sprinkler system shall be designed to preclude loss of safety function due to failure of any single active component of the system. Active components include the sprinklers themselves and any other component that can change state. 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.[93] [94]

A.2.4.2.2 Redundancy in the suppression system to provide operational flexibility for inspection, test, and maintenance activities should be provided in facilities that cannot be readily transitioned to a cold standby or shutdown mode and, when available, compensatory measures cannot effectively control a design basis fire.[95]

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; 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 (ITM) 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 this Standard)

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).[96] 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-1066-2016 may be used to supply a new safety-related sprinkler system. In such cases, the adequacy of the water supply systems shall consider 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 long-term availability and reliability of water supply systems required to support a safety-related suppression system for an enduring mission shall be assessed. For enduring missions, a new, appropriately-designed, safety-related water supply system shall be provided.

A.3.1.2 Critical Characteristics. The critical characteristics of the system should include the following, as appropriate:

- Hydraulic performance requirements (total demand/duration, supply volume, pressure, flow rate);
- System construction materials;
- Fire pump performance;
- Fire pump startup criteria and sequence of operations;
- Availability and reliability requirements;
- Component design lifetimes and any environmental condition limitations;
- Natural phenomena hazards requirements (e.g., 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 Design of the Water Supply System[97]

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 typically starts at the water source and includes 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 developed for each system should clearly delineate 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 are public/municipal water supplies, water storage systems, water treatment systems, freeze protection, and electric power systems that supply power to water pumps. The guidance for protecting freeze protection systems in Sections A.2.3.1.1 through A.2.3.1.5 should be applied to water supply systems for safety class and safety significant applications.

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, the piping and water source should be evaluated to determine if reliability is sufficient to meet project needs. The reliability evaluation should cover failure history, operational problems, long term availability of the water source, motive power for pressure maintenance of the system, water storage capacity, 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 continued operation after an earthquake, if required by the DSA.

A.3.2.5.2 Partial Control Over Safety-Related Water Supply. If DOE does not control all portions of the water supply from source to the safety-related suppression system, those portions that are under DOE control should be operated and maintained according to safety system criteria. Procedures and systems should be in place to promptly notify the management of the facility depending on the water supply that an off-normal event has occurred which may cut off water supply or diminish the flow and pressure.

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 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. Water supply piping, valves, hydrants, and large process demands located near the facility should 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 depends on the number and location of the sources.

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 program.

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.

A.3.2.5.2.4 Any required agreements between the facility management and the organization operating the water supply system should be incorporated into a binding contract or 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.

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

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 with DOE O 420.1C criteria.

A.3.3.2 Water Treatment Systems. Water treatment systems are seldom within the SC or SS boundary since 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 supply to SC fire pumps necessary to support a required safety function shall be designated SC and designed to preclude single point failure. 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.[98]

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 Appendix 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 (ANSI/AWWA Thickness Class 52 at a minimum), polyvinyl chloride piping with a dimension ratio of DR14, and high density polyethylene piping of dimension ratio (DR9). Additional limitations of material type may be imposed for seismic design.

A.3.4.1.2 When joint restraints are required, two separate means should be used (e.g., thrust blocks, mechanical, rodding).

A.3.4.1.3 Ductile iron piping should be provided with corrosion prevention such as polyethylene wrap or cathodic protection according to 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 (measured 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 Loss Prevention Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances*.

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 An in-ground pipe identification systems should be provided.

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 Potential adverse conditions should be specified for water supply systems and, if necessary, support systems should be provided to mitigate these conditions. Adverse conditions include:

- Natural phenomena hazards such as seismic events, tornadoes, high winds, flooding, lightning, low temperature and high humidity;
- Facility hazards, such as internal flooding, explosion, fire, missile impact, vehicle
- impact, and corrosive environments;
- Wildland fire;
- Physical damage from adjacent equipment and systems (such as tornado missiles); and
- Marginal water quality.

A.3.4.1.10 To support appropriate implementation of the site or project QA program for fire protection systems, the following topics should be addressed:

- 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), according to ASME NQA-1-2015;
- 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.3.4.2 Safety Class Design Criteria for Water Supply Systems. In addition to the criteria for general use and SS applications, the following additional design requirements and guidance are applicable to 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 water supplies. Both supplies should be able to meet the demand independently.[99]

A.3.5 Codes and Standards. The following codes and standards apply to the design, installation, operation, and testing of water supply systems:

- NFPA 20
- NFPA 22
- NFPA 24
- NFPA 25
- NFPA 70

Additional guidance is contained in the following FM Global 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 surveillance requirements should be defined using NFPA 25 ITM maintenance requirements, as a minimum, or other established requirements by equipment manufacturers and water purveyors. See DOE G 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements* for guidance on the preparation of TSRs.

A.4 FIRE SEPARATION

The following sections identify the functions, critical characteristics, requirements, criteria and guidance for new SC and SS fire separation installations.[100]

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). The DSA 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 for a specified period of time 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. 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 include the following as relevant:

- The fire barrier's fire-resistance rating;
- Performance characteristics of doors, dampers, windows, fire stop systems, fireproof coatings, 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,
- Technical basis for the design criteria (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 separation system shall clearly identify which components are within the system. A boundary for fire separation 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 features that may incorporate certain self-actuating active elements such as fire dampers. Support elements for the fire barriers are typically structural components such as; columns, beams, trusses, and roof framing. These support elements shall have a fire-resistance rating equal to, or greater than, that of the SC or SS fire barrier and shall be classified the same as the supported barrier when one or both of the following conditions apply: (a) the support elements provide structural support to credited SC or SS fire barriers; or (b) failure of the support elements could damage an adjacent SC or SS fire barriers.

A.4.4 Design Criteria for Fire Separation Systems. Requirements, criteria, and guidance for new SC and SS fire separation systems are stated in the following subsections.

A.4.4.1 Safety Significant Design Criteria for Fire Separation Systems. In addition to the criteria identified in this Standard, the following additional design requirements and guidance apply to installations used in SS applications.

A.4.4.1.1 Fire barrier installations should be designed to remain operable during events for which they are relied on in the DSA. Examples of such events include:

- Earthquakes;
- Other natural phenomena hazards, such as high winds, tornadoes, flooding, and lightning;
- Facility hazards, such as internal flooding, explosions, missile impacts, and corrosive environments;
- Wildland fires; and,
- Physical damage from adjacent equipment and systems; (such as tornado missiles).

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 such as barriers, doors, and 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 for fire barrier systems, the following topics should be addressed:

- 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) according to ASME NQA-1-2015;
- 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.4.4.2 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 A fire-rated glazing assembly or curtain-style fire damper (in a non-confinement ventilation duct) may be used as safety class fire barrier only when a thorough technical evaluation approved by DOE demonstrates its reliability in the proposed application.

A.4.4.2.2 Fire-resistive glazing materials may be used on a SC fir door only when glazed area does not exceed 100 square inches in one door leaf.

A.4.4.2.3 Fire doors in SC fire barriers should be normally closed. If a fire door needs to be held open for reasons other than convenience, it should be equipped with an electro-magnetic hold open device. The hold-open device 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, Section on 2-10.6, "Smoke Detectors 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 door hold-open should release on failure of primary electrical power. All components should be rated as SC. Fusible link devices, including those that are integral to the door closers, should not be used to hold doors open.

A.4.4.2.4 A fire damper used in a SC fire separation system should be designed to close under anticipated air flow velocities and pressures. If this design criterion cannot be met, an acceptable alternative approach is to provide automatic shutdown of air flow through the damper initiated by a redundant detection system.[101]

A.4.4.2.5 All opening protection devices that change position (such as doors and dampers) shall be designed so that a single active component failure will not defeat the separation function. Achieving this objective may require use of redundant doors or dampers and redundant closers, or the use of highly reliable components accompanied by increased frequency of inspection and testing.

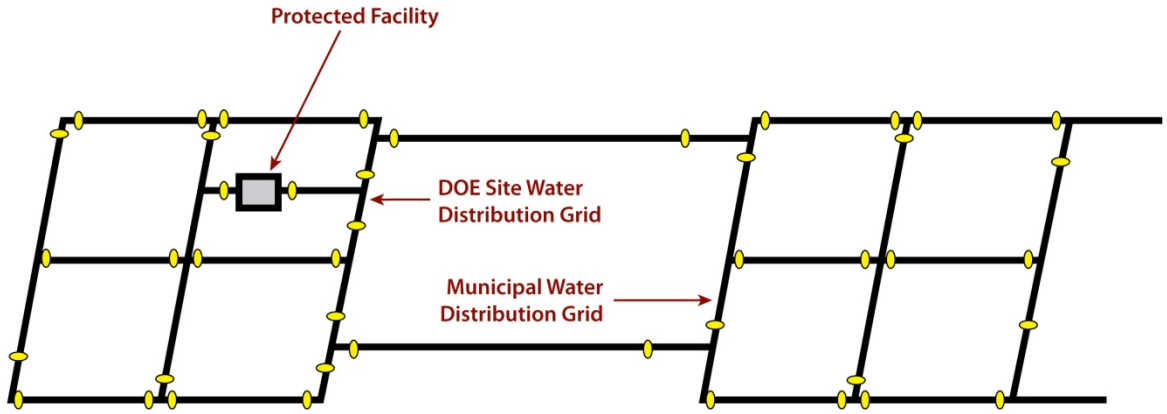
A.4.5 Operability Criteria for SS and SC Fire Barriers. ITM of active components should be performed in accordance with NFPA 80 to verify barrier system function. Passive features such as walls, floors and penetration seals should be inspected under a documented program which identifies the nature of the inspections, their frequency and acceptance criteria. See DOE G 423.1-1B, for guidance on the preparation of TSRs.

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.

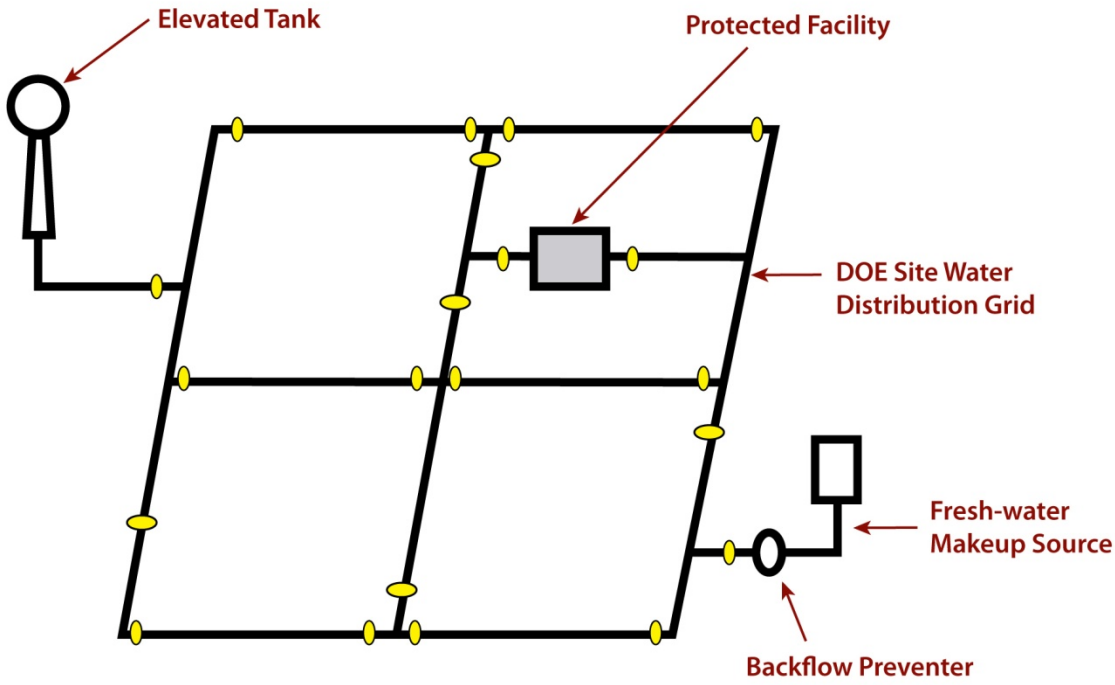
In this arrangement, water is obtained from a qualified municipal water purveyor.



This arrangement should not be used 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 use 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.

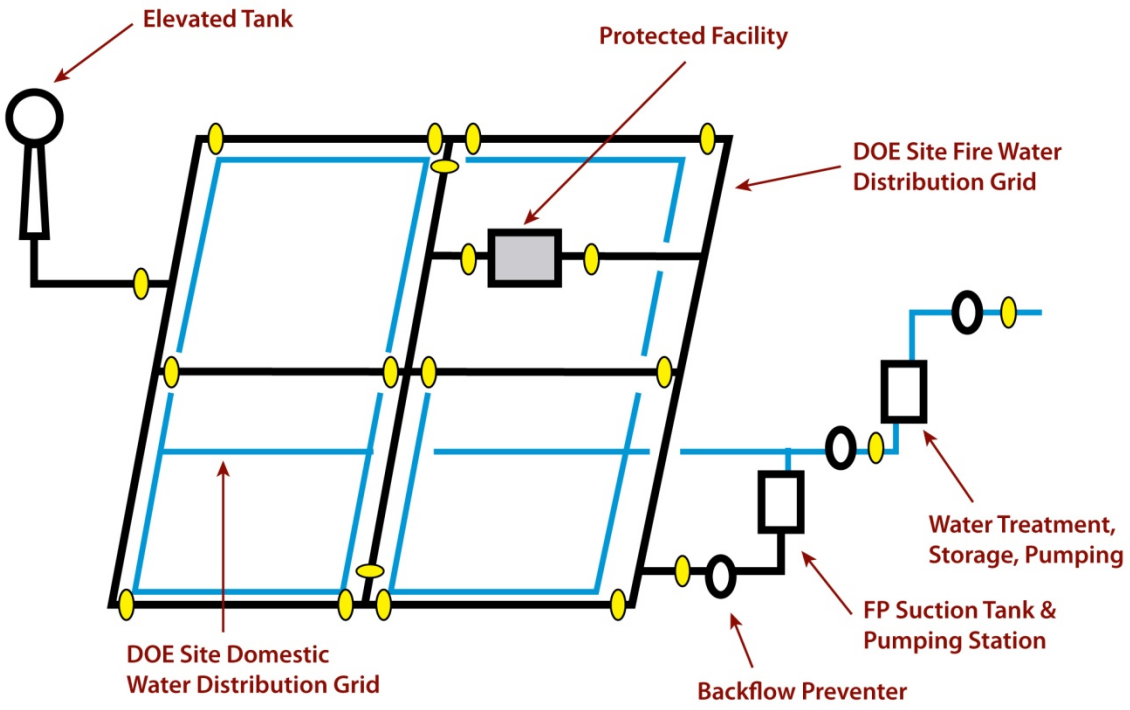
In this arrangement, water is obtained from a fresh-water source, such as a well or river, treated and then stored on site by both suction and elevated water storage tanks.



Similar to Arrangement 1, this arrangement should not be used 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.

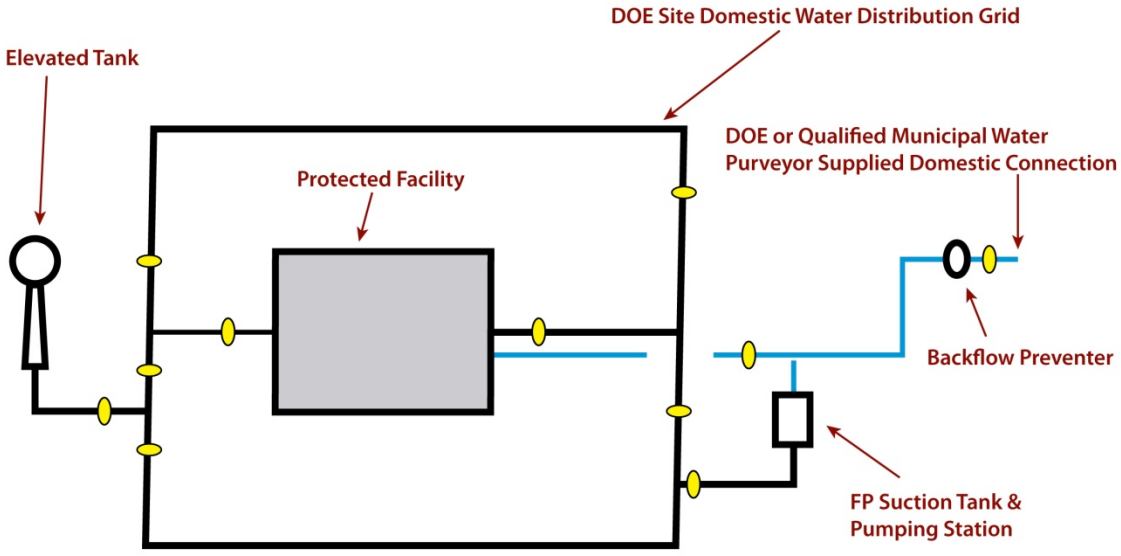
In this arrangement, water is obtained from a fresh-water source, such as a well or river, treated and then stored on site by both suction and elevated water storage tanks. The fire water and domestic water systems are separate. The only interface is the feeding of the fire water suction tank from the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



Similar to Arrangement 2, this arrangement should not be used 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.

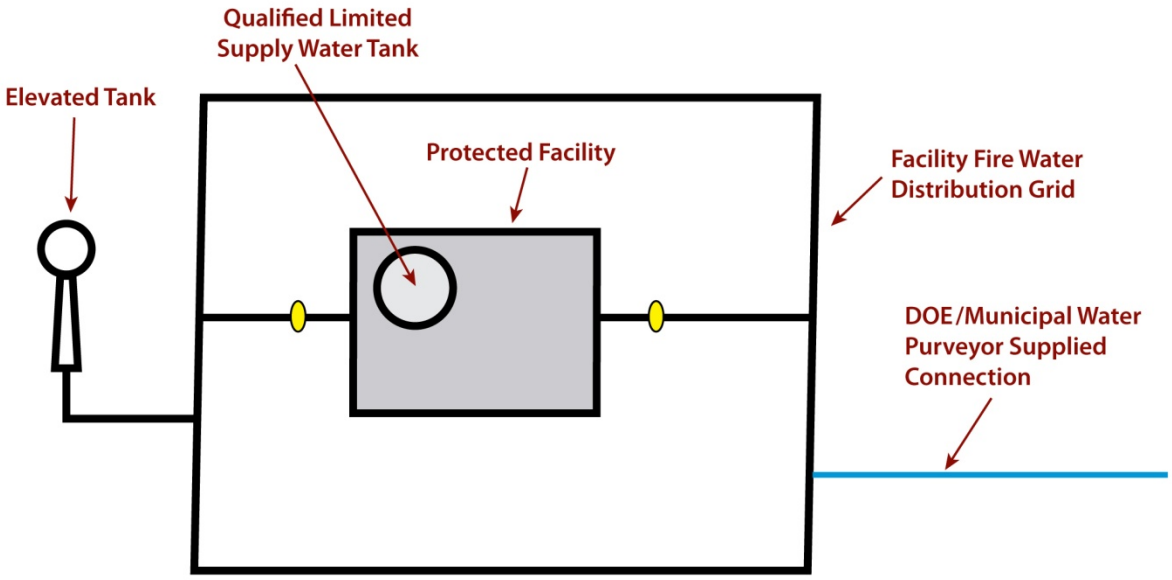


This arrangement could be used for SS applications, if conditions specified in A.3.2 and A.3.3 of Appendix A are met. If the supplied sprinkler system is required for mitigation of a seismically-induced fire, the supply system shall be categorized as SS.

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, *Fire Code*, NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, the International Building Code (IBC), NFPA 13, or other general industrial standards. These standards typically require from several hundred thousand to several million gallons of water. However, none of these standards specify the amount of water needed to adequately supply an SC or SS special hazard system. This amount shall be determined on a case-by-case basis and justified in the FHA or DSA, taking into account such hazards 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, according to the above codes and standards, shall be provided to meet other fire protection objectives, but that additional supply need not meet SC or SS criteria.



APPENDIX B
FIRE HAZARD ANALYSIS

B.1 INTRODUCTION AND OVERVIEW

This appendix provides guidance on the development and content of a Fire Hazard Analysis (FHA) for DOE facilities as required by DOE O 420.1C (Section 3.f(1) of Attachment 2, Chapter II), *Facility Safety*, and Fire Protection Design Analysis (FPDA) to ensure the design requirements of this Standard (Section 7.1) are accomplished.

B.1.1 The purpose of a FHA is to comprehensively assess the hazards of and potential damage from fire in a DOE building or group of buildings in relation to existing or proposed fire protection, so as to ascertain whether the objectives of DOE O 420.1C and this Standard have been satisfied.

B.1.2 The FHA should identify DOE directives, and fire safety codes and standards applicable to the facility.

B.1.3 If, during the analysis, it is determined that a departure from requirements is necessary, the FHA should capture the technical basis for requested relief in the form of variances, exemptions or equivalencies. Note: The process requirements to obtain approval for requested relief would still apply.

B.1.4 In accordance with the "graded approach" concept, the level of detail necessary for an acceptable FHA is based on the complexity of the facility, the potential risk to the public and facility operators, and, property loss potential. A FHA for a fully compliant facility can be relatively brief, but deviations from codes, standards or directives, on multiple or complex hazards require documentation that may substantially increase the level of detail.

B.1.5 FHAs and facility assessment reports may be combined, provided they address all essential elements.

B.1.6 Where required, an FHA may take one of several forms: (A) Building/Facility FHA; (B) Preliminary/Project FHA; or (C) Transitional FHA.

B.1.6.1 The Building (or Facility) FHA addresses all fire hazards and fire protection features and programs in a specific existing building/facility requiring one at the time the FHA is issued or revised.

B.1.6.2 The Preliminary (or Project) FHA documents fire protection design criteria established as the Code of Record (COR) for new facilities or significant modifications to an existing facility along with the design review to satisfy those requirements. For modifications to existing facilities, it also evaluates the impact of the changes to the prior hazards and level of protection. By necessity, this document is more detailed in design description and review and less detailed in programs and procedures than a Building/Facility FHA. As the project is completed, applicable portions of the FPDA are incorporated into established building FHAs or evolved into a stand-alone building FHA.

B.1.6.3 The Transitional FHA documents the changes to a facility undergoing a transition from one operating mode to another (e.g., operational to cold and dark). This document looks ahead to future milestones in the transition and evaluates the hazards that may be present and the fire protection features and programs/procedures that are needed to protect against those hazards. The Transitional FHA may be a replacement of or a supplement to the Building/Facility FHA and contain elements of the Preliminary/Project FHA or FPDA.

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 preliminary or project FHA should be updated whenever significant changes occur and should form the basis for a post-construction Building/Facility FHA, if required. The Preliminary/Project FHA should be revised, as necessary, to document the changes during the design. The analysis should also be integrated into the Preliminary Documented Safety Analysis (PDSA) or other nuclear safety documentation when required.

B.2.1.2 For new facilities and significant modifications (e.g., valued in excess of $167 million, in 2016 dollars), that are non-nuclear and not considered hazardous, the preliminary or project FHA serves to guide the construction process and provide historic documentation, but post-construction FHA revisions are not required.

B.2.2 The FHA shall be performed by, or under the direction of a fire protection engineer (FPE) and reviewed and approved through an established process. This process 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 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.

B.2.4 A FHA should cover the following as subject areas as they relate to fire safety:

- DOE orders, and industry codes and standards;
- Mission and associated hazards;
- Occupancy classification and building code construction requirements;
- Mission-critical 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;[102]
- 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, 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.

The contents of the FHA may vary based on the type of FHA, the complexity of the FHA, and the hazards involved. A graded approach may be used to change or omit some of these topics, but the FHA should describe the changes, and the basis for the changes. Other topics not appearing in the list above may be included as relevant.

B.2.5 The FHA should include consideration of conditions that may exist during normal operations and special situations such as decontamination, renovation, modification, repair, and maintenance.

B.2.6 The FHA should evaluate the consequences of a single, worst-case automatic fire protection system malfunction. Examples of such malfunction include failure of a detection system used to activate a pre-action type sprinkler system and the failure of a valve in the underground main resulting in loss of water supply.

B.2.7 The FHA should address assessment findings, and when appropriate, provide a path forward for resolving the finding. The FHA should contain a list of assessment findings in table format. In disposing of the findings, the FHA should draw a distinction between mandatory actions and actions taken as voluntary enhancements.

B.2.8 The FHA should where practicable, employ the method of fire area analysis. A fire area is a portion of a building that is separated from other areas by rated fire barriers capable of containing the hazard in the area. In many industrial and commercial settings two-hour rated fire barriers are used to define fire areas. But this cannot be assumed as adequate in all cases. For example, the applicable building code may require three- or four-hour rated free-standing boundaries, without openings, designed not to fail 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 (IBC) and the “lab unit” concept in the National Fire Protection Association’s NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals.*

B.2.9 The boundaries of exterior fire areas such as yard areas should be as established in the FHA and approved by AHJ. In a situation where a facility is not internally subdivided by fire-rated construction, the fire area is defined by the exterior walls and roof of the facility, that is, the

building is considered one fire area. 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.2.10 The FHA's estimate of fire severity and duration should consider both fixed combustibles and transient combustibles, with a conservative margin. This margin should be increased when the fire barriers are being relied on to prevent or limit the release of radioactive or toxic materials.

B.2.11 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.[103]

B.2.11.1 All credible fire-related failure modes of safety systems, active or passive, should be analyzed in the FHA.[104]

B.2.11.2 The analysis should determine whether a fire can prevent a SC or SS system from performing its credited safety function.

B.2.12 Fire propagation and the potential for fire-induced dispersal of radioactive material 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 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 Fire models such as those developed by the National Institute of Standards and Technology may be useful in developing an FHA. The models approved for DOE use are listed in DOE's Central Registry Toolbox code.[105]

B.3.2 When a fire model is used, all assumptions should be listed in the FHA. Limiting conditions of operation or specific administrative controls should be established to ensure that these assumptions remain valid during operations.[106]

B.3.3 The use of fire models in FHAs for nuclear and other high-hazard facilities should be limited to persons highly-qualified in the model's use. Results from the model should be reviewed and approved by an FPE who is knowledgeable in 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 ADDITIONAL 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, non-combustible 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 (a) the effects of smoke/hot gas stratification that may occur at some intermediate point below the roof or ceiling, and (b) 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 (such as a DSA) are developed for a facility, the developmental effort should be coordinated to the maximum extent possible to ensure technical consistency.[107]

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 (BNA).

B.5 FIRE PROTECTION DESIGN ANALYSIS

The FPDA should include the elements identified below in order to ensure the requirements of DOE O 420.1C are incorporated into design criteria. In accordance with the "graded approach" concept, the level of detail necessary for an acceptable FPDA is based on the complexity of the facility, the potential risk to the public and facility operators, and, property loss potential. This section does not apply to the design of nuclear facilities.

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 occupancy group determines the limitations on height, area and construction type. Any other unique features

(e.g., atrium, balcony, below grade, windowless) of the building addressed by sections of the building code should be identified.

B.5.2 Fire Separation. Fire areas and other fire separations should be identified as required by values according to 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 within the building should also be identified (e.g., NFPA 45, NFPA 88A, *Standard for 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.

B.6 TRANSITIONAL FIRE HAZARD ANALYSIS

B.6.1 For facilities required by DOE O 420.1C to conduct an FHA, a Transitional FHA should be developed if the facility is undergoing transition to another state. Additional guidance on transitional facilities is provided in Appendix F.

B.6.2 Prior to commencement of work activities in a facility, the Transitional FHA should be prepared, 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.

B.6.3 The fire risks associated with materials and processes used as part of the transition process should be evaluated by an FPE. Fire protection features should be adequate to limit these risks to an acceptable level. Combustible equipment and supplies 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.

B.6.4 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 firefighting strategies; and,
- Other pertinent information, as necessary.

B.6.5 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 FHA.

B.6.6 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 used, when applicable, to complete this evaluation if the transition is over a short term, but a Transitional FHA should be prepared if the transition is lengthy or complicated. Approved relief from normal DOE requirements should be listed in the Transitional FHA. Where original requirements for specific fire protection features and programs have been eliminated (e.g., through reduction in replacement value, elimination of a process or hazard, etc.), the Transitional FHA should document this change in requirements and DOE should be notified prior to elimination of a feature or program.

B.6.7 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 Transitional 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.

B.6.8 Fire safety features that have originally been required by DOE may be rendered inoperable or considered no longer needed if justified by the Transitional 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.

B.6.9 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 affect manual fire suppression.

B.6.10 Retained fire protection features in these facilities are not required to comply with all 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.

B.6.10.1 The Transitional FHA should define the retained fire protection features, and associated inspection, testing, and maintenance (ITM) requirements, to ensure that the features will function adequately during fire incidents.

B.6.10.2 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 Transitional 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.

B.6.11 To the extent that the Transitional 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.

APPENDIX C
RELOCATABLE STRUCTURES

C.1 APPLICATION

The provisions of this appendix apply to the purchase lease, design and construction, of all relocatable structures that (a) will remain in place for more than 180 days on-site; (b) contain significant fire hazards; or, (c) 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. This appendix does not apply to 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 CRITERIA

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 directives.

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 and 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 properly designed and installed to resist overturning and lateral movement.

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

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

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

C.2.4.2 If fire retardant, pressure-treated wood is used as interior finish, it should be the non-leachable type, if exposed to weather 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 flame spread index of 25 or less and a smoke development rating of 450 or less, as tested according to ASTM E 8, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 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 feature, 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 according to 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 CRITERIA

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. NFPA 80A should be used to establish their separation distance. The FM data sheet 1-20, *Protection Against Exterior Fire Exposure,* also provides useful guidance. [108] [109]

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. Combustibles or hazardous materials should not be stored between the relocatable structure and nearby buildings.

C.3.3 Location Restrictions

C.3.3.1 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.

C.3.3.2 Relocatable structures should not be located where they impede or otherwise hinder personnel egress or ingress to, or within, other facilities or structures.

C.3.3.3 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.

C.3.3.4 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.

C.3.3.5 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.

C.3.3.6 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*®.

C.3.3.7 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 used as determined by the cognizant FPE.

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

C.4.1 This section addresses the use of relocatable structures as Hazard Category 2 and 3 nuclear facilities and as radiological facilities. Such usage is generally associated with the temporary storage of materials or with 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.

C.4.2 The use of relocatable structures for Hazard Category 2 and 3 nuclear operations or storage should be approved by the AHJ.

C.4.3 When semi-trailers and cargo containers are used to store or handle radioactive materials, the following guidance should be observed.

C.4.3.1 The trailer or cargo container’s exterior and interior, including floors, should be of non-combustible construction.

C.4.3.2 In the case of a trailer:

- Tires should be removed;
- Trailer should be adequately supported for safe normal usage, as well as for off-normal conditions such as earthquakes, floods, and high winds; and,
- Truck tractors should not be connected to trailers while the trailers are being used for storage or operational purposes.

C.4.3.3 Trailers and cargo containers should be safeguarded against exposure fires that may result from adjacent facilities or wildland fire events.

C.4.3.4 Trailers or cargo containers should be sited and protected to accommodate Fire Department operations.

C.4.3.5 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.

C.4.3.6 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 would be required to meet the worker safety requirements of 10 CFR Part 851.

C.4.4 When frame-supported fabric structures are used to store or handle radioactive materials, the following guidance should be observed.

C.4.4.1 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.).

C.4.4.2 May be used for the storage of non-flammable/combustible liquid waste in metal drums when such use is supported by FHA and safety basis documentation.

C.4.4.3 Should not be used for the storage of waste stored in combustible containers.

C.4.4.4 Fabric structures should be constructed in accordance with the building code.

C.4.4.5 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.

C.4.4.6 Fabric structures should be located or protected against exposure fires that may result from adjacent facilities or wildland fire events.

C.4.4.7 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.

C.4.4.8 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, *Standard for the Fire Protection of Information Technology Equipment*.

C.5.2 Laboratories. Structures may be used to house laboratories provided they were designed for this purpose and comply with this Standard 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 this Standard, 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 CRITERIA

C.6.1 Automatic Fire Suppression. DOE O 420.1C (Attachment 2, Chapter II, 3) provides requirements for automatic fire suppression. In addition, an automatic fire suppression system designed according to the applicable NFPA standards should be provided for relocatable structures as follows:

- In structures where the maximum possible fire loss (MPFL) will affect a vital program for a period longer than that specified as acceptable by the AHJ;
- In 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 structures used for sleeping quarters, including day care centers. (For such structures, "quick-response" sprinklers should be used.)
- In structures where radioactive material can be released by a fire.[110]

    - 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, *Standard for 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 $5.6 million (in 2016 dollars).
- 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 FIRE PROTECTION FOR SUBTERRANEAN FACILITIES

D.1 INTRODUCTION

D.1.1 Background

In 2014, DOE recognized the need to develop specific guidance on fire protection for its underground facilities. At that time, the DOE Fire Safety Committee established a nine-member Subsurface Facility Working Group (SFWG), consisting of fire protection experts working with such facilities. The SFWG identified twelve DOE facilities (see table below) that would benefit from additional guidance.

Facility	Location
Waste Isolation Pilot Plant (WIPP)	Chihuahuan Desert, Carlsbad, N.M.
Yucca Mountain nuclear waste repository	Nye County, Nevada
SLAC Linac tunnel	Menlo Park, CA
SLAC Beam Switch Yard (BSY)	Menlo Park, CA
SLAC LCLS	Menlo Park, CA
Fermilab- NuMI	Batavia, Illinois, near Chicago
Fermilab- ILC	Batavia, Illinois, near Chicago
Fermilab - LBNE	Batavia, Illinois, near Chicago
University of Minnesota – Soudan Underground Laboratory	Ely, Minnesota
Sanford Underground Research Facility - SURF (Deep Underground Science and Engineering Laboratory, DUSEL)	Homestake, SD
Nevada National Security Site	Nye County, NV
Ultra Low Background Counting Laboratory, 3425 Building, PNNL	Richland, WA

In June of 2014, the SFWG issued a report pointing out problems with simply adding applicable NFPA, MSHA, and OSHA criteria to DOE's existing directives. To address this problem, the SFWG developed recommendations for adding guidance to the next revision of DOE-STD-1066. In November of 2015, DOE convened an "Underground Facility Criteria Development Meeting" to develop proposed text for DOE-STD-1066.

The guidance criteria in this appendix focus principally on personnel safety but also address property protection, potential loss, and mission interruption. The criteria should be used to develop a site-specific worker safety and health plan in accordance with 10 CFR Part 851. This plan is intended to ensure personnel safety in an underground environment by:

- Reducing the risk of a fire,
- Minimizing the consequences of a fire, and
- Providing personnel a means to evacuate to the surface or to a refuge station pending rescue.

D.1.2 Overview

This Appendix provides supplementary fire protection requirements and guidance for subterranean facilities. Subterranean facilities differ most significantly from other facilities in respect to automatic suppression and means of egress. Requirements and guidance contained in the main body of this Standard continue to apply to subterranean facilities unless specific relief is provided below. Worker safety for subterranean facilities is governed by 10 CFR Part 851, *Worker Safety and Health Program,* and is described in an associated Worker Safety and Health Program; this Appendix provides relevant fire protection guidance for establishing in this program. If DOE subterranean facilities are required to meet parts of 30 CFR 57, *Mine Safety and Health Administration (MSHA), Safety and Health Standards – Underground Metal and Nonmetal Mines*, the requirements and guidance in this Appendix supplement those requirements.

The requirements of this Appendix apply to the design and operation of new subterranean facilities, and major modifications (as defined by 10 CFR § 830.3, Part B, and further described in DOE-STD-1189-2016, *Integration of Safety into the Design Process*) specific to:

- Tunnels/Drifts. An elongated, narrow, essentially linear excavated underground opening with a length exceeding its width or height, and its orientation usually horizontal but may be driven at angles up to 30 degrees; and
- Shafts. An excavation with a depth greater than its horizontal cross-section.

When requirements of this Appendix apply to any existing nuclear facility (that are operating or in operational standby, not in deactivation or decommissioning), and the facility is not in conformance with these requirements, then a design upgrade analysis shall be performed to determine whether the benefits of achieving compliance are warranted considering the hazard mitigation, programmatic impacts, future use, and cost (see DOE-STD-1189-2016, Section 5 and Appendix G for further discussion). For non-nuclear facilities, the design upgrade analysis should be applied using a graded approach.

D.2 FIRE PROTECTION DESIGN: DETECTION, ALARM, AND SUPPRESSION SYSTEMS

D.2.1 Automatic Suppression. Developed spaces shall be provided with automatic fire suppression systems.

Undeveloped spaces exceeding 5000 sq. ft. do not require suppression if all the criteria below are shown to be met by an engineering analysis or FHA:

- Maximum Possible Fire Loss (MPFL) less than $5.6 million (in 2016 dollars).
- Mission interruption is acceptable to the mission owner.
- Automatic suppression is not needed to protect egress paths.
- Combustible loading is maintained at insignificant levels.
- Separated from developed spaces by two-hour fire barriers.

Powered mobile equipment (such as wheeled, skid-mounted, track- or rail-mounted equipment capable of moving or being moved) and mobile fossil-fueled equipment shall be protected by installation of an automatic fire suppression system. The inspection, testing, and maintenance (ITM) of these systems shall be in accordance with the manufacturer's recommendations and per the applicable NFPA standard. Mobile equipment operators shall be trained in the proper use/actuation of this on-board fire suppression system. Automatic fire suppression is not required for welders or golf cart type equipment. To minimize combustion loading, non-fossil-fueled vehicles should be used whenever possible.

Other equipment shall be protected by automatic or manual suppression, as determined in the FHA.

Fire-resistant hydraulic fluids shall be used in hydraulically actuated underground machinery and equipment unless such equipment (a) has less than 20 gallons of hydraulic fluid and is protected by multi-purpose fire extinguishers, or (b) is protected by fire extinguishers rated at sufficient capacity for the type and size of hydraulic equipment involved, and rated at least 4A:40B:C. Note: See FM Global Loss Prevention Data Sheet 7-40, *Heavy Duty Mobile Equipment*, for additional guidance on less hazardous hydraulic fluids. Where it is not possible to use an approved, non-ignitable hydraulic fluid, a hydraulic fluid with as high a flash point as possible should be used and additional safeguards provided. See FM Global Loss Prevention Data Sheet 7-98, *Hydraulic Fluids*, for guidance.

D.2.2 Fire Extinguishers. Portable fire extinguishers shall be provided (a) in developed spaces; (b) in other spaces where combustible materials are present, processed, or handled; and (c) on mobile equipment, in accordance with NFPA 122, *Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities* based on the FHA or the AHJ.

D.2.3 Fire Detection and Alarm. Automatic fire detection shall be provided in all developed spaces of subterranean facilities. Automatic fire suppression systems that alarm on actuation may be used to provide fire detection.

Fire alarm or mass occupant notification systems capable of promptly warning every person underground shall be provided and maintained in operating condition. If persons are assigned to work areas beyond the warning capabilities of the system, alternative notification methods shall be provided.[111]

Alarm notifications shall be transmitted to a constantly-attended location.[112]

D.2.4 Two-Way Communication System. A two-way communication system for emergency responder use shall be provided throughout the subterranean facility.

D.2.5 Barriers (Compartmentation Requirements)

D.2.5.1 Partitions. Noncombustible materials shall be used in the construction of all new walls, fixed partitions, insulation, ceilings, and floors.

Fire retardant coating on otherwise combustible materials shall not be permitted unless approved by the AHJ based upon appropriate fire tests.

D.2.5.2 Fire Rated Barriers. Storage rooms greater than 150 sq. ft. and secondary power system rooms shall be separated from the remainder of the underground spaces by walls with at least a two-hour fire resistance rating. Developed spaces shall be separated from undeveloped spaces by a fire barrier with a minimum fire-resistance rating of two hours. Refuge stations shall be separated from other spaces by a fire barrier with a minimum fire-resistance rating of two hours.

D.3 FIRE PROTECTION DESIGN: EGRESS AND REFUGE

D.3.1 Egress. Every subterranean facility shall have two or more separate, properly maintained egress paths to the surface from the lowest levels. These paths shall be positioned so that damage to one does not lessen the effectiveness of the others.

A hoist (i.e., a power driven windlass or drum used for raising rock or other material from the underground facility, and for lowering or raising persons and material) to the surface, with an adjacent refuge station, is considered an acceptable approach for an egress path.

The maximum number of occupants for exit width calculations shall be based on either 150 percent of the highest occupant load (as defined in the FHA or worker health and safety plan) or 2,000 sq. ft. per person net floor area, whichever is greater.

The travel distance to a portal, hoist, refuge station, or the entrance to an exit passageway system shall be not more than 2,000 feet.[113] Any portion of a designated egress path which is inclined more than 30 degrees from the horizontal and that is more than 300 feet in vertical extent shall be provided with an emergency hoisting facility. Note: These distances may be extended based on modelling both the smoke and travel away from the hazard incident (for example, smoke, inerting, or cryogenic atmospheres).

The egress path shall be at least 7 feet 6 inches high. Any projection from the ceiling shall not reach a point less than 6 feet 8 inches from the floor.

An egress path shall be at least 44 inches wide at all points.

Surface facilities or structures within 100 feet of subterranean facility openings used for intake/exhaust air, or within 100 feet of subterranean facility portals, shall be:

- Constructed of non-combustible materials;
- Constructed to meet a fire resistance rating of no less than one hour;
- Provided with an automatic fire suppression system; or
- Covered on all combustible interior and exterior structural surfaces with non-combustible material or limited combustible material, such as 5/8 inch, type “X” gypsum wallboard.

D.3.2 Refuge Stations. A refuge station is a safe haven for people in a subterranean facility when evacuation to the surface from the facility is not possible.

Refuge stations constructed in accordance with NFPA 520, *Standard on Subterranean Spaces,* (Section 5.8) shall be required adjacent to hoists to the surface. Additional refuge stations, stand-alone locations from the hoist location, may be necessary depending on the underground facility's configuration.

Each refuge station shall provide 10 ft^2 of floor area for each person assigned to it. The total area of the refuge station shall be based on 125 percent of the number of persons assigned to the refuge station.

In addition to the requirements of NFPA 520, the refuge station may, in lieu of a dedicated air supply (i.e., borehole), be provided with fresh air via the compressed air system provided that the air intake is separated from the ventilation exhaust and entrances to the underground facility, and there are redundant paths for the compressed air to reach each refuge station.

Refuge stations shall be provided with suitable hand tools and stopping materials and equipment required to prevent smoke and gases from entering the refuge station.

The functionality of refuge stations and associated features shall be tested annually.

Compressed, gaseous breathing air, supplied by the compressed air system, shall meet the applicable minimum grade requirements for Type I gaseous air set forth in the Compressed Gas Association Commodity Specification for Air, G-7.1, 2011 (Grade D or higher quality).

The breathing air compressor shall be constructed and situated in accordance with 29 CFR 1910.134(i)(5). This provision requires that these design criteria be met:

(a) Prevent entry of contaminated air into the air-supply system;

(b) Minimize moisture content so that the dew point at 1 atmosphere pressure is 10 degrees F below the ambient temperature;

(c) Have suitable in-line air-purifying sorbent beds and filters to further ensure breathing air quality. Sorbent beds and filters shall be maintained and replaced or refurbished periodically following the manufacturer's instructions; and,

(d) Have a tag containing the most recent change date and the signature of the person authorized by the employer to perform the change. The tag shall be maintained at the compressor.

Each site shall determine the maximum estimated occupancy duration of a refuge station based on the accidents identified and provide supplies necessary for this duration.

D.4 FIRE PROTECTION DESIGN: EMERGENCY LIGHTING, SIGNAGE, AND VENTILATION

D.4.1 Emergency Lighting. In accordance with NFPA 101, *Life Safety Code*®, requirements, emergency lighting shall be provided in developed areas and in critical operations areas where

personnel are required to operate valves, dampers, fans, and other controls in an emergency. Individual/personal lighting equipment may be used as egress lighting for undeveloped spaces.[114]

Each individual that enters a subterranean facility shall be required to carry an MSHA-approved cap lamp and/or flashlight to provide adequate illumination during loss of normal power situations.

The minimum luminance for cap lamps and flashlights shall be 1 foot-candle at a distance of 9.8 feet along the centerline of the escape-way and 0.1 foot-candle along a 3.3-foot band throughout the escape-way.

Emergency lighting systems/fixtures should be considered in undeveloped spaces.

D.4.2 Signage. Unused chutes, manways, or other openings shall be tightly covered, bulk-headed, or fenced off, and shall be posted with warning signs indicating "Keep Out" or similar language. Unused sections of the subterranean facility shall be barricaded.

Dead-end headings and unused headings that cannot be used as escape-ways shall be posted with warning signs indicating "No Exit" or "Not an Exit."

Each exit sign within developed spaces shall be illuminated in accordance with the requirements stated in NFPA 101, Section 7.10.

Undeveloped spaces shall be identified for general traffic direction and emergency purposes by signage in reflective lettering that is at least 4 inches high with 1/2-inch wide stroke, leading the way to a refuge station, hoist, or portal.

Every drift (i.e., an approximately horizontal passageway or portion of a tunnel) and alcove (i.e., an opening into the rib of a drift to allow the placement of equipment so that it does not interfere with personnel or vehicular traffic) shall be identified by name, letter, or number with a large direction arrow associated with the word EXIT in letters not less than 6 inches high with 3/4-inch wide stroke pointing in the direction of nearest refuge station, hoist, or portal from the subterranean facility.

All drifts, alcoves, and escape-ways shall be shown on evacuation maps that are available to all persons using the facility, posted in all areas underground (such as adjacent to each directional sign), and made available to security personnel, the Fire Department, and other agencies with emergency jurisdiction.

Evacuation maps shall be reviewed every 6 months and updated, as necessary, to reflect changes.

D.4.3 Secondary Power Systems

(a) The required duration for a secondary power supply to a refuge station should be based on the estimated maximum occupancy duration during an accident, as stated in the FHA and in accordance with the applicable requirements of NFPA 110, *Standard for Emergency and*

Standby Power Systems, and/or NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*.

(b) Systems and equipment relied upon in the FHA (or other safety documentation) for ensuring personnel safety pursuant to NFPA 101 and 10 CFR Part 851 shall be supported by an emergency power system as defined in NFPA 70, *National Electric Code*®.

(c) For nuclear facilities, systems and equipment relied upon in the DSA shall be supported by an emergency power system as defined in NFPA 70.

(d) Systems and equipment other than those covered by (b) and (c) may be supported by standby power as defined in NFPA 70.

D.4.4 Ventilation Plan. A plan of the subterranean facility ventilation system shall be set out by the operator in written form. Revisions of the system shall be noted and updated at least annually. The ventilation plan or revisions thereto shall be submitted to the AHJ for review and comments upon their written request. The plan shall, where applicable, contain the following:

- Smoke Control (reversibility)
- Process Ventilation (shop and experimental areas)
- Air Quality
- Personnel Ventilation
- Internal Combustion Engines
- Filtration (including radiological)
- Combustible Separation
- Control doors, bulkheads, barriers and dampers
- Emergency controls
- Main fan control
- Ducts and plenums
- Gaseous suppression
- Protection of ventilation infrastructure
- Ventilation and instrumentation diagrams

See 30 CFR § 57.8520 for additional guidance on ventilation plan contents.

D.5 FIRE PROTECTION DESIGN: DRAINAGE AND CONTAINMENT

Hazardous material control areas shall be provided with a drainage and containment system to direct the flow of liquids to an approved location/area designed to provide secondary containment for the hazardous materials and fire protection water if a water-based suppression system is used.

The capacity of the secondary containment shall be sufficient to hold the volume of the largest two tanks or containers within the hazardous material control area and 30 minutes of sprinkler discharge, if water-based suppression is provided.

D.6 OPERATIONS: FIRE PREVENTION

D.6.1 Combustible Control

D.6.1.1 For at least 200 feet inside the subterranean facility portal (i.e., an entrance from the ground surface to a tunnel) or collar, timber used for underground support in intake openings and in exhaust openings that are also designated as escape-ways shall be:

- Provided with a fire suppression system, other than fire extinguishers and water hoses, capable of controlling a fire in its early stages; or
- Covered with shotcrete, gunite, or other material with equivalent fire protection characteristics; or,
- Coated with fire-retardant paint or other material to reduce its flame spread rating to 25 or less.

D.6.1.2 Flammable liquids shall not be stored underground, except:

- Five liters or less stored in an approved flammable liquid cabinet away from any heat source; and,
- The liquids shall not be stored in glass containers.

D.6.1.3 Gasoline shall not be stored underground in any quantity.

D.6.1.4 Storage of combustible liquids shall comply with NFPA 30, *Flammable and Combustible Liquids Code*. Combustible liquids, including oil and grease, shall be stored in non-glass containers or storage tanks. The containers or storage tanks shall be:

- Located in an area free of combustible materials; and
- Separated from explosives or blasting agents, shaft stations, and ignition sources including electric equipment that could create sufficient heat or sparks to pose a fire hazard. Separation shall be sufficient to prevent the occurrence or minimize the spread of fire.

D.6.1.5 Transient combustibles shall be removed at the end of each shift.

D.6.2 Control of Ignition Sources. Underground belt conveyors shall be equipped with a detection system capable of automatically stopping the drive pulley if slippage could cause ignition of the belt.

Internal combustion powered equipment shall be so located that the exhausts are well away from combustible materials.

Portable battery powered lighting equipment, used in connection with the storage, handling, or use of flammable gases or liquids, shall be of the type approved for the hazardous locations.

Adequate clearance shall be maintained around lights and heating units to prevent ignition of combustible material.

Internal combustible engines shall be switched off before refueling if the fuel tanks are integral parts of the equipment. This requirement does not apply to diesel-powered equipment.

D.6.3 Self-Rescuers. All personnel entering a subterranean facility shall carry or have immediate access to a Self-Rescuer. The requirements for self-rescuers shall be in accordance with 30 CFR § 57.15030 and 30 CFR § 57.15031.

D.6.4 Self-Contained Self-Rescuers. Self-Contained Self-Rescuers (i.e., MSHA approved, self-contained closed-circuit breathing apparatuses to assist in evacuating an area containing smoke, toxic gases or oxygen deficient atmosphere, rated for 60 minutes) shall be staged at locations where personnel have access to them when needed to assist in reaching the surface or to reach a Refuge Station.

D.7 EMERGENCY RESPONSE

The BNA for a subterranean facility shall address emergency response and firefighting activities within the subterranean facility. Emergency response may include facilitating evacuation, isolating the facility, controlling ventilation, or applying suppression agents to control a fire. For shaft-access subterranean facilities, all equipment described by the BNA as needed for rescue and suppression activities should be located within the subterranean spaces. Equipment locations shall be shown on the pre-incident plan.

Procedures shall include direction for any workers responsible for performing rescue or medical duties, and clearly identify responsibilities.

When an alarm system that differentiates among specific hazards has been installed, facility personnel shall be trained to recognize the meaning of the distinctive signals.

Emergency response procedures or emergency plan implementing procedures shall be reviewed with each worker covered by those procedures under any one of the following conditions:

- When the emergency plan is developed.
- When workers are initially assigned a responsibility under the procedures.
- When the worker's responsibilities under the emergency plan change.
- When the emergency plan is revised.

Mine rescue teams shall meet the applicable requirements in MSHA regulations, 30 CFR Part 49, *Mine Rescue Teams*.

APPENDIX E
SAMPLE QUALIFICATION TEMPLATE FOR LEAD FIRE PROTECTION ENGINEERS

E.1 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 FPEs, 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.

E.2 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. An FPE who serves as a 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 (FHA); reviews safety basis documentation, such as design safety analysis; or provides other site-specific approvals that should require fire protection expertise.

E.3 SAMPLE QUALIFICATION TEMPLATE

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 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

APPENDIX F
TRANSITIONAL FACILITIES

F.1 PLANNING

Transitional facilities are those that have been placed in a safe-shutdown condition and abandoned, or are undergoing decontamination and decommissioning (D&D) work and ultimately demolition or abandonment. 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 provides a significant mission or value 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.

F.2 REQUIREMENTS

Fire safety and emergency response for transitional facilities are governed by the requirements contained in 10 CFR Part 851, *Worker Safety and Health Program*, (including 29 CFR 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 Loss Prevention Data Sheet 1-0, *Safeguards During Construction*, and Chapter 8 of NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.)

F.3 FIRE SAFETY PRINCIPLES

Decisions relating to fire safety of transitional facilities should be made on the basis of the following principles to be used in preparing and implementing the Fire Hazard Analysis (FHA).

F.3.1 Fire hazards within transitional facilities may change over time, for example, combustible loading or occupancy may increase or decrease. [115] Fire protection features and procedures should be adequate to deal with these changes.

F.3.2 Fire safety features rendered inoperable or no longer needed should be properly identified as being out of service.

F.3.3 The decision to deactivate automatic fire suppression systems in large facilities should be influenced by the possibility that fire department personnel may not be able to safely enter the facility to effect manual fire suppression. A defensive tactical approach exterior fire attack may be evaluated in the BNA and may be implemented with the approval of DOE. If such approval is given, pre-fire plans should be appropriately updated. Pre-fire plans should stress the importance of maintaining communication and cooperation between facility personnel and the emergency responders so that emergency responders are aware of changes in occupancy that might bear on the type of attack launched in the event of fire.

F.3.4 Retained fire protection features should be inspected, tested, and maintained to ensure that they will function adequately during fires.

F.3.5 Transitional facilities should be routinely inspected and reviewed by representatives of the fire department and fire protection engineering staffs against standard operating procedures and fire protection program (FPP) 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 be conducted at t at a frequency commensurate with the fire risks and complexity of the facility.

F.3.6 Prior to commencement of work activities, appropriate procedures should be developed, approved, and implemented to govern the control of potentially hazardous activities. Hazardous activities include cutting and welding, storage and handling of flammable or combustible liquids, and use of temporary wiring and heating equipment. Smoking areas should be allowed only if otherwise permitted by law and capable of being separated from sources of fire risk.

F.3.7 Combustible material 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 of and away from the structure.

F.3.8 To prevent or minimize release of residual hazardous materials, a work control plan should be prepared prior to deactivation of process piping and tanks. The work plan should consider the removal of hazardous materials (flammables, combustibles, and corrosives) within the facility.

F.3.9 Safeguards to ensure facility worker and emergency responder safety and health should conform to the requirements in 10 CFR 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 approved. 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 (no human occupancy) do not need to maintain emergency egress features.

F.3.10 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. 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.

F.3.11 Installed Fire Protection Systems. (a) All retained interior fire protection systems should be maintained operational to the extent possible while interior work activities are taking place. Verification of operable status should include appropriate inspection and testing, in accordance with established procedures. (b) 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. (c) 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. (d) In cold climates during winter months when limited heating may be provided in transitional facilities freezing of water may

occur in hidden suppression piping and piping low points that may not drain, or cannot be drained economically. (e) Deactivated systems deteriorate rapidly. For this reason, fire suppression systems should not be removed from service for a prolonged period with the intent to restoring service at a later time. When feasible, automatic sprinklers should be maintained at least to the extent that they can be supplied by the fire department using the sprinkler connection.

F.3.12 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 fire apparatus should be maintained and verified on a frequent basis.

F.3.13 If the Transitional FHA requires maintaining certain fire protection features during transitional activities, such features should be inspected, tested, and maintained, consistent with established procedures, sufficient to ensure that they will function effectively during a fire.

F.3.14 Temporary structures may be erected to support transitional activities. These facilities require design review by a fire protection engineer, considering the application of the Building Code and provisions of this Standard. This review should be documented in a design requirements document used to procure and construct the temporary building

APPENDIX G EXPLANATORY MATERIAL

SECTION 1: Introduction

[1] 1.2 Where DOE facilities are used for work done by others, documents such as Memoranda of Understanding should address the following topics:

- Facility protection to prevent fire-related hazards to nearby nuclear and non-nuclear DOE facilities;
- Approval for modifications to the facility structure that might affect fire protection;
- Identify DOE fire protection requirements that are applicable to facility modifications;
- Fire protection water supply and potential impact on required water supply for DOE facilities, including the need for separate fire water supplies;
- Inspection, testing, and maintenance of fire protection systems; and,
- Roles and responsibilities of the DOE Field Office and the operating contractor.

[2] 1.4 This is not a comprehensive list of all codes and standards required by DOE O 420.1C, Attachment 2, Chapter II, Section 3.a(2).

[3] 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*.

[4] 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 CFR Part 830, *Nuclear Safety Management*, are found in 10 CFR Part 820, *Procedural Rules for DOE Nuclear Activities*; related guidance is provided in DOE-STD-1083-2009, *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*.

[5] 1.5 When determining fire loss, the estimated damage to the facility and contents typically includes (1) replacement cost, less salvage value, unless the property is scheduled for demolition, (2) the cost of decontamination and cleanup, including restoration in other areas that received water or smoke damage, and (3) the indirect costs of fire extinguishment (such as damaged fire department equipment).

[6] 1.5 MPFL is typically summarized for each Fire Area.

[7] 1.5 DOE-HDBK-1081-2014, *Primer on Spontaneous Heating and Pyrophoricity*, provides an understanding of spontaneous heating and pyrophoricity hazards.

[8] 1.5 See endnote 20 for additional information.

SECTION 2: General Fire Protection Requirements

[9] 2.1 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.

[10] 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.

[11] 2.2.2 NFPA 5000 *Building Construction and Safety Code*®, Chapter 34, provides information on control areas and protection levels as related to NFPA 1, *Fire Code*, and NFPA 400, *Hazardous Materials Code*.

[12] 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).

[13] 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 useful in determining 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.

SECTION 3: Fire Protection Program Administration

[14] 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.

[15] 3.2.2 The elements of the fire protection self-assessment also provide guidance for the conduct of independent program assessments.

SECTION 4: Fire Protection Design

[16] 4.1.3 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.

[17] 4.2.1 NFPA 101, *Life Safety Code*®, Chapter 43 provides criteria relevant for defining significant modification from a life safety perspective. IBC Chapter 34 provides criteria relevant for defining significant modifications from a building code perspective. DOE-STD-1189-2016, *Integration of Safety into the Design Process*, and DOE-STD-3006-2010, *Planning and Conduct of Operational Readiness Reviews*, provide guidance for defining major modifications for nuclear facilities.

[18] 4.2.2 See DOE-STD-3009-2014 for further discussion of defense-in-depth.

[19] 4.2.3 Refer to DOE O 420.1C or Appendix A of this Standard for nuclear safety-related SSC redundancy requirements.

[20] 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.

[21] 4.2.4.3 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.

[22] 4.2.4.4 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.

[23] 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.

[24] 4.2.7.1.2 For non-nuclear facilities only, Ordinary Hazard Group I facilities may use 250 gpm outside hose.

[25] 4.2.7.2 See FM Global Loss Prevention Data Sheet 3-2, *Water Tanks for Fire Protection*, for additional design guidance.

[26] 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.

[27] 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.*

[28] 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;
- 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.

[29] 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.

[30] 4.2.8.2 The requirements for providing a fire alarm system appear in the IBC, NFPA 101, and 29 CFR

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, *National Fire Alarm and Signaling Code*, or NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.

[31] 4.2.8.2.1 NFPA 72 refers to Fire Alarm Control Units 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.

[32] 4.2.8.2.3 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.

[33] 4.3.1 ASME *Boiler and Pressure Vessel Code*, Section VIII, *Rules for the Construction of Unfired Pressure Vessels*, also provides applicable design guidance.

[34] 4.4.1.1 NFPA 801 provides guidance for radioactive materials that may be applicable to DOE Radiological Facilities. 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.

[35] 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

[36] 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.

[37] 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.

[38] 4.4.2.3 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.

[39] 4.4.2.4 AGS-G010 includes criteria for developing a Fire Hazard Evaluation for glovebox operations that should be included within the FHA.

[40] 4.4.2.4 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.).

[41] An acceptable fire size that may not require an automatic fire suppression system is a fire that is (a)

confined to the hood; (b) self-extinguishes without releasing combustion byproducts to the room, or plugging or impacting filtration beyond what is acceptable to the facility and/or DSA; and (c) does not spread to adjacent gloveboxes or hoods. High efficiency particulate air (HEPA) filtration and impacts to collocated gloveboxes/hoods should also be considered during an analysis.

[42] 4.4.4 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.

[43] 4.4.4.1 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 this Standard. 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 used 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.

[44] 4.4.4.2 This paragraph is not intended to prohibit the use of fire retardant treated wood filter frames for existing applications.

[45] 4.4.4.3.6 Refer to Appendix D of DOE-STD-1066-99 for a discussion of this type of analysis.

[46] 4.4.4.5 When “listing” is required by NFPA 70, *National Electrical Code*®. and 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.

[47] 4.4.4.6.2 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.

[48] 4.4.4.8 Tests by H.A. Lee of Atlantic Richfield in 1974 established the following design features for fire screens to prevent the passage of fire. (See Lee, H.A., *Guide to Fire Protection in Caves, Canyons, and Hot Cells*, ARH-3020, Atlantic Richfield Hanford Company, Richland, July 1974; Lee, H.A., *Final Report - Program for Fire Protection, Caves, Canyons, and Hot Cells*, ARH-ST-104, Atlantic Richfield

Hanford Company, Richland, August 1974.) 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 according to DOE-HDBK-1169, Section 10.6.2.2) 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.

[49] 4.4.4.10.1 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 effect of this modification should be analyzed and approved by the AHJ.

[50] 4.4.4.11 High operating temperatures in the final filter enclosure can be minimized by multiple methods. 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 250^0F. 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.

[51] 4.4.4.11.1 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.

[52] 4.4.4.12 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.

[53] 4.4.4.13 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/ft^2 of filter face area and that the system is manually operated. Designs applying less water or automatic operation should be justified in the FHA.

[54] 4.4.4.14 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.

SECTION 5: Operations

[55] 5.1.3.4 See http://energy.gov/sites/prod/files/ADM%2018_0.pdf

[56] 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.

[57] 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.

[58] 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.

[59] 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.

[60] 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 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.

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 change in use or occupancy.

[61] 5.2.4.3 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 routine activities that are specifically identified and delegated by the DOE Heads of Field Elements. Such potentially delegated activities may include (1) application of generic equivalencies approved by DOE, and (2) development and approval of equivalencies to DOE technical standards and industry codes and standards identified as requirements in the Fire Protection Program, unless specifically invoked by DOE O 420.1C).

SECTION 6: Emergency Response

[62] 6.1.1 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.

[63] 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.

[64] 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.

[65] 6.1.5 In developing the BNA, the basic assumption should be that there is only one emergency incident occurring on-site, with a one-person medical emergency. 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.

[66] 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.

The response time requirements of NFPA 1710 should 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.

[67] 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.

[68] 6.2.1.1 Living quarters are intended to 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 would typically be provided to prevent interference and to ensure the viability of individual areas in the event of a fire.

[69] 6.2.1.3 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.

[70] 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.

[71] 6.2.2.2 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.

[72] 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 the Commander's 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.

[73] 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.

[74] 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.

[75] 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 CFR Part 851 are required to adhere to 29 CFR Parts 1910 and 1926, if these regulations are applicable to the hazards at their covered workplace. See 10 CFR § 851.23 (a)(3) and (7).

[76] 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.

[77] 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.

[78] 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.

[79] 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.

SECTION 7: Facility Fire Protection Evaluations

[80] 7.1.3.1 Facilities that are no longer operational and are being transitioned to another state may use a graded approach to fire protection based on actual needs during the transition and at the end point(s)of the transition. Full code compliance is often not practical.

[81] 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:

- 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).

SECTION 8: Wildland Fire Management

[82] 8.1 Much of the guidance in this section was drawn from archived DOE G 450.1-4, *Wildland Fire Management Program for Use with DOE [Order] 450.1, Environmental Protection Program.*

[83] 8.5.1 Some contents of the Wildland Fire Management Plan may require coordination with an action by the DOE Field Element (for example, coordination and agreements with other government agencies).

[84] 8.5.1 See Appendix B of archived DOE G 450.1-4, *Wildland Fire Management Program for Use with DOE [Order] 450.1, Environmental Protection Program*, for further guidance.

Appendix A: Safety Significant and Safety Class Fire Protection System Specifications

[85] 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.*

[86] 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.

[87] 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.

[88] 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, it 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 even). 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.

[89] 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.

[90] A.2.3.3 The purpose of the water pressure monitoring system is to indicate the availability of the actual

system supply pressure. As such, the monitoring point locations should be selected to achieve this purpose.

[91] A.2.4.1.1 Fittings may be used when made from malleable iron for additional fitting strength (see American Society of Mechanical Engineers (ASME) B16.3, Malleable Iron Threaded Fittings, Classes 150 and 300). Cast iron trim fitting, provided as part of a manufactured assembly, may be used when supported by appropriate safety basis risk analysis.

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

[93] 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.

[94] A.2.4.2.1 As an example, if a fire in a small closet with a single sprinkler could impact safety systems (e.g. safety-class power cables), a second sprinkler would be required.

[95] A.2.4.2.2 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 measurers 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 measurers. 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.

[96] 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, *Standard for the Installation of Sprinkler Systems*, 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.

[97] 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.

[98] 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.

[99]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.

[100] 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.

[101] 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.

Appendix B: Fire Hazard Analysis

[102] B.2.4 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.

[103] B.2.11 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.

[104] B.2.11.1 Safety system components 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.

[105] B.3.1 Information on Central Registry Toolbox codes can be found at http://energy.gov/ehss/safety-software-quality-assurance-central-registry. 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/

[106] B.3.2 The assumptions used in a model should ensure 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. A sensitivity analysis of major model assumptions should be considered in most cases.

[107] B.4.5 FHAs and DSAs should be coordinated 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.

Appendix C: Relocatable Structures

[108] C.3.1 NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures* does not specifically provide a methodology for evaluating non-parallel structures. However, an analysis could be conducted considering non-parallel structures using the appropriate radiation view factors and

the thresholds established in NFPA 80A.

[109] C.3.1 A "light" exposure hazard per NFPA 80A guidance should not be used in determination of safe separation distances without specific discussion on the appropriateness of such a classification. In addition, the ability of the exposure wall to withstand fire penetration should not be assumed unless the exterior wall is specifically fire resistance-rated.

Appendix D: Fire Protection for Subterranean Facilities

[110] C.6.1 Suppression should be considered to protect radioactive material stored in containers (such as industrial-grade drums) that could be damaged by a portable structure fire. By contrast, radioactive material stored in qualified containers, such as containers meeting the criteria of DOE-STD-3013-2012, would not need such protection.

Appendix D: Fire Protection for Subterranean Facilities

[111] D.2.3 Alerting provisions may take a variety of forms including radio, telephone, pagers, or even sensory (smell) systems.

[112] D.2.3 Wireless signal transmission of vehicle suppression system alarms is a good practice to be considered.

[113] D.3.1 The nominal requirement for 2000 ft. is derived from NFPA 520, *Standard on Subterranean Spaces*.

[114] D.4.1 Lighting in accelerator environments creates a difficultly with survivability of the electronic ballast. Consideration should be given to using incandescent lighting or remotely locating electronic ballast and uninterruptible power supplies. Light fixtures should be radiation-hardened type or equivalent.

Appendix F: Transitional Facilities

[115] F.3.1 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.