Lessons Learned from Assessments of Fire Protection at U.S. Department of Energy Sites

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Office of Enterprise Assessments
U.S. Department of Energy

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Acronyms

BNA	Baseline Needs Assessment
CFR	Code of Federal Regulations
CRAD	Criteria and Review Approach Document
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FHA	Fire Hazard Analysis
FPE	Fire Protection Engineer
FPP	Fire Protection Program
FSS	Fire Suppression System
ITM	Inspection, Testing, and Maintenance
NFPA	National Fire Protection Association
NQA	Nuclear Quality Assurance
ORPS	Occurrence Reporting and Processing System
SSCs	Structures, Systems, and Components
TSR	Technical Safety Requirement

LESSONS LEARNED FROM ASSESSMENTS OF FIRE PROTECTION AT U.S. DEPARTMENT OF ENERGY SITES

Executive Summary

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), performed 15 fire protection assessments between August 2015 and July 2022. These assessments were performed at 16 nuclear facilities and 1 nonnuclear facility among 11 sites within the DOE complex. This lessons-learned report identifies common strengths and weaknesses, best practices, and recommendations with the goals of promoting organizational learning and improving performance throughout the DOE complex.

Ten of the 11 assessed sites demonstrated generally adequate fire protection programs (FPPs) that meet DOE objectives and requirements, and that incorporated widely accepted industry practices and consensus standards. EA identified several strengths in site FPPs, including 10 best practices (that were identified at the time the individual assessments were conducted):

- At the Hanford Site, the prime contractors and DOE established the Hanford Fire Protection Forum as a medium for routine, open discussions on fire protection topics. Additionally, The Hanford Site fire department established a self-contained breathing apparatus program that sponsors technicians to attend the manufacturer's continuing education program every two years. (Best Practices)
- At the Los Alamos National Laboratory, Triad National Security's system engineers developed and maintained system health reports, updated quarterly, using a "Path to Green" approach to drive system performance improvements, which supported operations and maintenance. (Best Practice)
- At the Nevada National Security Site under a former contractor, the fire department maintained a fully equipped shop and certified technicians to perform all maintenance, refurbishment, and hydrostatic testing on portable fire extinguishers. (Best Practice)
- At the Pacific Northwest National Laboratory, the Battelle Memorial Institute (Battelle) Building 325 Radiochemical Processing Laboratory facility operators used fire protection system drawings contained in inspection, testing, and maintenance (ITM) procedures to record inspection and test results, including valve positions and other attributes. Additionally, Battelle maintained a substantial inventory of fire protection spare parts that are dedicated and controlled in accordance with guidance established in American Society of Mechanical Engineers Nuclear Quality Assurance (NQA)-1. (Best Practices)
- At the Pantex Site, Consolidated Nuclear Security, LLC implemented an effective combustible control program for the nuclear facilities. Minimal combustibles were present, and the material present was logged and evaluated. (Best Practice)
- At the Savannah River Site, the Savannah River Nuclear Solutions, LLC fire department conducted monthly walkthroughs of a process building undergoing construction to maintain familiarity and to validate the status of the baseline needs assessment and pre-incident plans. Also, the Site Utilities Division used an interactive computer model of the underground piping infrastructure that identified facilities impacted by closure of sectional control valves. (Best Practices)
- At the Waste Isolation Pilot Plant, Nuclear Waste Partnership, LLC adopted a hazard analysis and checklist to evaluate the needs for fire suppression systems on mine vehicles. (Best Practice)
- DOE Federal oversight program performance was assessed at 10 sites; nine of the 10 sites had established effective programs and processes for assessing contractor FPPs.

EA also identified the following areas where improvements are needed:

- Forty-six contractor performance issues (17 findings and 29 deficiencies) identified by EA were related to safety basis and supporting engineering products (e.g., calculations, analyses, drawings, specifications), suggesting needed improvement in safety basis analysis and engineering associated with fire protection systems.
- Twenty-four contractor performance issues (5 findings and 19 deficiencies) identified by EA were associated with ITM (e.g., incomplete or missed ITM requirements; not meeting National Fire Protection Association requirements; and inadequate analysis of fire pump test data), suggesting a need for greater emphasis on producing and validating the engineering products that support the fire protection ITM program.
- The preponderance of 96 EA-identified contractor performance issues (29 findings and 67 deficiencies) challenges the rigor of contractor self-assessments and Federal oversight, suggesting a need for greater focus on identifying weaknesses that could have potential impact to safe mission performance.

In summary, the assessed DOE sites have implemented generally well-established contractor FPPs, processes, and procedures. However, EA identified several institutional and performance weaknesses that suggest areas for improvement. DOE organizations and site contractors should evaluate these results, best practices, and recommendations for applicability and possible implementation at their respective sites, supporting the continuous improvement of fire protection throughout the DOE complex.

Recommendations

This report provides the following recommendations to DOE field element managers and site contractors:

DOE Field Element Managers

To enhance DOE field/site office assurance of the quality of safety basis documents with respect to fire protection:

- Ensure that safety basis review teams are appropriately staffed with fire protection engineers (FPEs) who are familiar with implementing DOE-STD-1104, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, section 4.5, and thoroughly scrutinize fire protection-related analyses and technical safety requirements, and associated engineering bases.

To enhance DOE field/site office oversight of fire protection:

- Ensure that Facility Representative, safety system oversight, and FPE oversight planning processes include field assessments with priority on credited safety systems to include validating critical fire protection structures, systems, and components (SSCs) performance parameters through the safety basis and supporting engineering products during scheduled assessments.

Site Contractors

To improve nuclear facility safety bases, associated engineering products, and flow down to implementing surveillance and maintenance procedures (this recommendation can be conceptually applied to nonnuclear facility fire protection documents):

- Conduct periodic cross-functional reviews of selected safety class and safety significant fire protection SSCs addressed in the safety basis, associated engineering products, and flow down to implementing surveillance and maintenance procedures by a team composed of safety basis analysts, engineers, and FPEs (and/or other engineering/scientific disciplines, as appropriate). These cross-functional reviews could be structured as part of the contractor's self-assessment program.

To improve the development and update of future safety basis and fire protection documents, and associated engineering products:

- Ensure that safety basis/fire protection document development and update teams include fire protection staff who have the technical skills and sufficient time to provide complete and accurate designs/analyses and supporting documented engineering products.

To improve FPPs and implementation:

- Enhance FPP self-assessment plans by incorporating the applicable elements of the implementation verification review process described in DOE Guide 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements*, appendix C. Also, ensure that FPP self-assessment plans have input from safety basis analysts and engineers to include, for example, validation of design criteria and technical adequacy of calculations.

LESSONS LEARNED FROM ASSESSMENTS OF FIRE PROTECTION AT U.S. DEPARTMENT OF ENERGY SITES

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA) performed 15 fire protection assessments between August 2015 and July 2022. These assessments were performed at 16 nuclear facilities and 1 nonnuclear facility among 11 sites within the DOE complex. The 11 sites included those under the direction of the Office of Environmental Management, the National Nuclear Security Administration, and the Office of Science. The lessons learned presented in this report are based on a collective analysis of the assessment results and comparison with *Office of Enterprise Assessments Lessons Learned from Targeted Reviews of Fire Protection at Department of Energy Nuclear Facilities – August 2015* (subsequently referred to as the 2015 Lessons Learned Report).

2.0 METHODOLOGY

EA manages the Department's independent oversight program. This program is designed to enhance DOE safety and security programs by providing the Secretary and Deputy Secretary of Energy, Under Secretaries of Energy, DOE managers, senior contractor managers, Congress, and other stakeholders with an independent evaluation of the adequacy of DOE policy and requirements, as well as the effectiveness of DOE and contractor line management performance, risk management in safety and security, and other critical functions as directed by the Secretary. DOE Order 227.1A, *Independent Oversight Program*, describes and governs the DOE independent oversight program. EA implements the program through a comprehensive set of internal protocols and assessment guides.

Appendix A lists the contributors to this lessons-learned effort, the members of the Quality Review Board, and the EA management responsible for this evaluation. Appendix B addresses the scope of this review, applicable criteria and review approach documents, and the analysis methodology; appendix B also includes a table of the EA assessment reports used for this analysis.

3.0 RESULTS

This portion of the report summarizes fire protection strengths and weaknesses resulting from the collective analysis of the 15 fire protection assessments.

This lessons-learned review analyzed 10 best practices, 96 issues (29 findings, and 67 deficiencies) associated with contractor performance, and an additional 5 deficiencies associated with Federal oversight identified since August 2015. These assessment results were categorized into five major areas as shown in table 1 below. This table offers DOE facility managers a summary to prioritize improving their fire protection programs (FPPs). Further details are provided in the following sections of this report.

Table 1. EA-identified Fire Protection Best Practices, Findings, and Deficiencies

Major Areas	# Best Practices		# Findings	# Deficiencies	Total Issues
Safety basis [1] /fire protection documents and engineering products	1		17	29	46
Fire protection program [2]	5		5	15	20
Inspection, testing, and maintenance (ITM) [3]	3		5	19	24
Contractor self-assessment	1		2	4	6
Total contractor performance issues			29	67	96
DOE field/site office oversight			0	5	5

[1] The facility "safety basis" (defined in 10 CFR 830, Subpart B, *Safety Basis Requirements*) is the documented safety analysis (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.

[2] Includes the following categories: pre-incident plans, procurement, control of combustibles, aging/degradation, spare parts, issue analysis and trending, training, records, impairments, and equivalencies/exemptions.

[3] Fire protection related technical safety requirement (TSR) surveillances are included in ITM.

The assessed DOE site contractors have generally implemented well-established FPPs, processes, and procedures with some exceptions. Fire risks were generally well defined and analyzed in facility/site safety basis documents such as DSAs, fire hazard analyses (FHAs), and TSRs. However, EA identified 46 issues (17 findings and 29 deficiencies) with the safety basis and associated engineering products (e.g., calculations, analyses, drawings, specifications). Similarly, facility/site FPPs and fire suppression system (FSS) ITM are generally compliant with applicable DOE orders and fire protection codes and standards, although EA identified 44 issues (10 findings and 34 deficiencies) in these two areas. Contractor self-assessments were evident at all sites, although EA identified two findings and four deficiencies in this area at four assessed sites. Additionally, some similarities were identified between this report and the 2015 Lessons Learned Report, which is discussed in the sections below.

A set of 465 operational occurrences (Occurrence Reporting and Processing System, or ORPS, reports) related to fire protection was reviewed and analyzed. This analysis, addressed in section 3.6 of this report, was performed to gain insights and to identify any correlation of fire protection-related events with EA-identified issues. Fifty-three fire events were reported, none of which were considered significant by the reporting site.

3.1 Safety Basis/Fire Protection Documents and Engineering Products

This portion of the lessons-learned review addresses the strengths and weaknesses in the nuclear facilities' safety bases, the nonnuclear facility's fire protection documents, and associated engineering products.

Strengths

Fire hazards were generally well defined and analyzed in the assessed nuclear facilities' safety bases. With some exceptions, the safety bases adequately identified the functional requirements and performance criteria of the fire protection systems; demonstrated the ability of the fire protection systems

to meet the performance criteria; and appropriately credited required supporting systems. Design engineering processes were generally well defined to establish and maintain engineering products that support the safety basis, ensure configuration management, and control safety system modifications.

Weaknesses

EA identified 46 (17 findings and 29 deficiencies) contractor performance issues among all 11 sites associated with the nuclear facilities' safety bases, the nonnuclear facility's fire protection documents, and supporting engineering products. These issues are similar to findings addressed in the 2015 Lessons Learned Report. Such issues can adversely impact the reasonable assurance that fire protection safety systems will perform as expected to reduce risks by preventing or mitigating fires. The 17 findings included:

- Issues with technical analysis associated with system performance capabilities at five sites, such as:
  - Functional performance requirements of safety FSSs were not adequately specified and evaluated in the facility safety basis.
  - TSRs for FSSs lacked the specificity necessary to ensure operability.
  - Design basis hydraulic calculations were inadequate (e.g., missing calculations, incorrect methodology, calculational errors, and nonconservative assumptions).
  - FSS piping and components did not account for interaction with adjacent non-seismically qualified equipment.
- Noncompliance with Federal regulations or National Fire Protection Association (NFPA) standards at four sites, such as:
  - Inadequate analysis of emergency escapeway paths.
  - An evaluation that demonstrated a reliable and adequate water supply and distribution system for fire suppression was not provided.
  - Alarm signals and alarm signal pre-verification did not meet the requirements of NFPA 72, *National Fire Alarm and Signaling Code*.

An additional 29 deficiencies reflected inadequacies in other areas, such as hazards identification, inconsistencies between the DSA and FHA, configuration management, process documentation, and records management. These deficiencies were distributed over nine sites.

Analysis and engineering errors, such as the 46 issues noted above, represent weaknesses in safety basis development/updates, supporting engineering products, and design verification. (See section 5.0, Recommendations.) DOE relies on contractors to ensure the technical adequacy of nuclear facility safety basis and the appropriate flow down of this information into surveillance and maintenance procedures (further discussed in section 3.3 of this report). Many of these issues were not identified through self-assessments and Federal field/site office oversight.

3.2 Fire Protection Program

This portion of the lessons-learned review addresses the strengths and weaknesses in FPP description documents and associated implementing procedures.

Strengths

Seven of the 10 assessed sites with nuclear facilities were generally staffed with capable fire protection personnel and engaged facility managers. Interviews with numerous fire protection-related staff confirmed that they are knowledgeable and have an appropriate understanding of their facilities' fire protection systems. During walkdowns with EA, facility managers typically demonstrated a high level of knowledge regarding the inherent fire risks and how they managed the tracking and correction of identified deficiencies. Three sites involving multiple prime contractors closely coordinated efforts to achieve effective sitewide fire protection.

Most FPP description documents and associated procedures at the reviewed nuclear facilities were in accordance with DOE Order 420.1, *Facility Safety*. Reviewed nuclear facility/site FPP descriptions appropriately addressed policies, requirements, technical criteria, analyses, administrative procedures, systems and hardware, apparatus and equipment, plans, and personnel that ensure achievement of DOE fire safety objectives. Combustible material control programs were adequately addressed in facility/site FPPs at seven sites. Emergency response planning, including baseline needs assessments (BNAs) and pre-incident planning, was generally coordinated with fire response assets and consistent with NFPA 1620, *Standard for Pre-Incident Planning*.

Weaknesses

EA identified 20 contractor performance issues (5 findings and 15 deficiencies) among 8 sites associated with FPPs. Some of these issues are similar to those identified in the 2015 Lessons Learned Report.

EA identified five training program issues (two findings and three deficiencies) at four sites, which were associated with not meeting requirements specified in DOE orders. These issues involved the training of personnel in engineering, maintenance, operations, and fire protection. The FPP is a DSA safety management program and, in conjunction with engineered controls and TSRs, the program provides the essential measures (or commitments) to eliminate, limit, or mitigate hazards to workers, the public, or the environment as well as to mitigate maximum possible fire loss. With the current large departure of experienced workers due to retirement, the importance of effective training and qualification of the new workforce involved in operating and maintaining nuclear facility safety systems is amplified.

The remaining 15 issues were not training related and were associated with weaknesses in areas such as:

- Pre-incident planning
- Combustible loading and control programs
- Fire protection system impairments
- Equivalencies and exemptions
- Incomplete FSS configuration records
- Issue analysis and trending.

Missing requirements, incomplete records, and inadequate procedures collectively suggest the need for greater focus on program implementation documents and supervisory oversight because these issues could be the precursors to more significant FPP problems.

While these findings and deficiencies deserve appropriate corrective action among the affected sites, they do not suggest any major area of concern suitable for a complex-wide recommendation.

3.3 Inspection, Testing, and Maintenance of Fire Protection Safety Systems

This portion of the lessons-learned review addresses the strengths and weaknesses in ITM programs for fire protection systems.

Strengths

Ten of the 11 sites had generally well-established ITM procedures to confirm the functionality of fire protection-related safety structures, systems, and components (SSCs) and to ensure that the operating parameters and key safety features of these systems adhered to the requirements of the safety basis and applicable fire protection codes and standards.

Weaknesses

EA identified 24 contractor performance issues (5 findings and 19 deficiencies) among all 11 sites associated with FSS ITM. Fourteen findings analyzed in the 2015 Lessons Learned Report were also associated with these types of issues. In this lessons-learned report, five findings (at five of the assessed sites) were related to incomplete or missed ITM requirements; safety significant component qualification; analysis of fire pump test data; meeting NFPA requirements; and the coordination of organizations to ensure an adequate water supply to the FSS during a surveillance test. An additional 19 deficiencies were identified in the areas of FSS aging/degradation, spare parts, procedure content and workers' adherence to procedures.

These identified issues suggest a need for greater emphasis on producing and validating the engineering products that support the fire protection ITM program. Issues such as these significantly weaken the effectiveness of the FPP and lessen the reliability of fire protection systems, which depend heavily on an adequate technical basis and discipline of operations in the ITM of fire protection systems. (See section 5.0, Recommendations.)

3.4 Contractor Self-assessment

This portion of the lessons-learned review addresses the strengths and weaknesses associated with contractor self-assessments of FPPs.

Strengths

No common strengths were identified.

Weaknesses

EA identified two findings and four deficiencies associated with contractor self-assessment programs or performance among four sites. At two sites, the three-year self-assessment in accordance with site procedures was not performed or was missing key elements, such as fire system impairment and emergency response programs. EA noted that one site was performing annual facility FPP assessments in accordance with DOE Order 420.1 but had no documented process; this is contrary to DOE Order 414.1, *Quality Assurance*, which requires prescribed processes. Also, the assessments at this one site did not evaluate fire protection systems, a fundamental element of facility assessments.

Moreover, EA's identification of 96 contractor performance issues (about half of which are related to safety basis/fire protection documents) from a small sample of contractor documents and observed activities suggests that the rigor of contractor self-assessments could be improved. The effectiveness of

contractor self-assessments is dependent upon assessment planning and the assessors' inquisitiveness and questioning attitude. As emphasized in DOE Order 420.1, self-assessments are essential to ensure effective FPP implementation. Omission of required evaluations could allow noncompliant conditions to go undetected and uncorrected for long periods of time, posing increased fire-related risks. (See section 5.0, Recommendations.)

3.5 DOE Field/Site Office Oversight

This portion of the lessons-learned review addresses the strengths and weaknesses in Federal oversight programs and performance.

Strengths

Of the 10 DOE sites where EA assessed DOE field/site office oversight programs and performance, 9 sites had established effective programs and processes for assessing contractor FPPs. These sites had adequately documented and implemented roles, responsibilities, and processes to evaluate the contractors' FPPs using approved plans and schedules for assessments, including reviews of the contractors' self-assessments of fire protection processes and systems. Eight sites employed at least one appropriately trained and qualified FPE involved in the conduct of periodic assessments, resolution of issues, and review and approval of exemptions from (or equivalencies to) requirements and standards, as appropriate.

Weaknesses

EA identified five deficiencies associated with Federal field/site office oversight programs or performance at four of the assessed sites. One field office's oversight program did not meet the requirements of DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*. Oversight reports performed by one field office and one site office were lacking in scope. One field office was not following its established procedures for conducting contractor oversight.

Although most field/site offices established adequate oversight programs, EA's identification of 96 issues (29 findings and 67 deficiencies) in contractor performance challenges the rigor of DOE oversight. More specifically, in the areas of safety basis, FHAs, and supporting engineering products, EA identified 46 issues (17 findings and 29 deficiencies). These issues suggest a lack of thorough evaluation by DOE safety basis review teams of supporting fire protection engineering products. This thorough evaluation depends upon effective safety basis review planning, staffing, and strategy that includes enhanced inquisitiveness and questioning attitude by assessors. 10 CFR 830.207, *DOE approval of safety basis*, is achieved by DOE's implementation of DOE-STD-1104, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*. DOE-STD-1104, section 4.5 identifies key expectations to ensure the integrity of described safety SSCs (e.g., safety functions, boundaries, supporting SSCs, functional requirements, performance criteria, technical basis, and key assumptions). A more rigorous review of safety basis documentation by the safety basis review team may ensure fewer subsequent discoveries of latent safety SSC issues.

Additionally, EA identified 44 issues (10 findings and 34 deficiencies) related to contractor FPPs and ITM. These are also areas that would benefit from improved DOE oversight by Facility Representatives, safety system oversight personnel, and FPEs. (See section 5.0, Recommendations.)

3.6 Occurrence Reporting and Processing System Data Analysis

This portion of the lessons-learned review analyzes fire-related ORPS reports to gain insights and identify any correlation of fire protection-related events with EA-identified issues.

A set of 465 operational occurrences related to fire protection that were submitted between August 2015 and July 2022 for the 16 nuclear facilities and 1 nonnuclear facility at the 11 assessed sites was reviewed and analyzed. EA analyzed these data using the following categories:

- Fire protection system degradation
- Fire/heat/smoke events
- Fire protection system ITM
- Fire protection system impairments
- Other topics.

Of the 465 ORPS reports, 210 were due to problems with one site's aging fire detection and alarm systems. These ORPS reports describe extensive efforts with fire department investigative responses, attempted system resets, condition assessment walkdowns, impairment actions, fire watches, operations restrictions, and corrective maintenance associated with these systems. EA identified one deficiency with these systems at this site and recognizes that line management is addressing this problem.

Fifty-three of the remaining 255 ORPS reports were related to fires. Two fires were moderately significant (one ORPS report addressed a roof fire during a subcontractor reroofing activity, and the other ORPS report addressed a site transformer fire that affected underground hoists and evacuation capability at another site). The remaining fire events were considered small fires by the reporting sites; many were associated with experimental apparatus or laboratory bench-scale activities. Inadequate recognition or evaluation of the potential hazards (e.g., unrecognized chemical reactivity or pyrophoricity), or the lack of adequate hazard controls contributed to several of the small laboratory fires. The number of reportable fires per year ranged from 4 to 10, with an average of 7.

The remaining 202 ORPS reports were associated with FPP elements, ITM documentation and implementation, and other various fire protection-related events. The FPP and ITM areas are addressed in sections 3.2 and 3.3 of this report, respectively.

Overall, these data do not suggest any major areas of concern suitable for a complex-wide recommendation.

4.0 BEST PRACTICES

A best practice is a safety-related practice, technique, process, or program attribute observed during an appraisal that may merit consideration by other DOE and contractor organizations for implementation because it has been demonstrated to substantially improve safety or security performance of a DOE operation, or it represents or contributes to superior performance (beyond compliance). Additionally, a best practice could be identified because it solves a problem or reduces the risk of a condition or practice that affects multiple DOE sites or programs, or it provides an innovative approach or method to improve effectiveness or efficiency. The following best practices were identified at the time that the individual assessments were conducted and may be valuable to other DOE sites:

- **Fire Protection Forum**. The Hanford Site established a Fire Protection Forum that serves as an opportunity for routine, open discussions among the Hanford Site's prime contractors and DOE on fire protection topics and issues. The Fire Protection Forum has wide participation, including contractors' FPEs, managers, the Hanford fire marshal, fire department staff, and the DOE FPE. The Forum assists the DOE field office in maintaining uniform and integrated fire protection programs across the site.
- **Continuing Education on Self-Contained Breathing Apparatus**. A former contractor at the Hanford Site fire department established a self-contained breathing apparatus program that sponsored technicians to attend the manufacturer's continuing education program every two years.
- **System Health Reports**. At the Los Alamos National Laboratory, Triad National Security, LLC's system engineers developed and maintained system health reports, updated quarterly, using a "Path to Green" approach to drive system performance improvements, which supported operations and maintenance.
- **Fire Extinguisher Maintenance Shop**. The fire department, under a former contractor at the Nevada National Security Site, maintained a fully equipped shop and certified technicians to perform all maintenance, refurbishment, and hydrostatic testing on portable fire extinguishers.
- **ITM Performance and Spare Parts Maintenance**. At the Pacific Northwest National Laboratory, Battelle Memorial Institute (Battelle) Building 325 Radiochemical Processing Laboratory facility operators used fire protection system drawings contained in ITM procedures to record inspection and test results, including valve positions and other attributes. Additionally, Battelle maintained a substantial inventory of fire protection spare parts that are dedicated and controlled in accordance with guidance established in American Society of Mechanical Engineers Nuclear Quality Assurance (NQA)-1.
- **Control and Management of Combustibles**. At the Pantex Site, Consolidated Nuclear Security, LLC conducted combustible loading dispositions for specific weapons programs and/or facilities that contain nuclear material (e.g., bays and cells, ramps and corridors, and storage facilities) to prevent an unacceptable exposure to thermally sensitive components. Minimal combustible material was observed in the facility, and the material present was logged and evaluated. Fire modeling evaluated fires from representative fuel packages to ensure appropriate minimum separation distances. A rigorous combustible control program limits the ability of an incipient fire to spread to an explosives package.
- **BNA Maintenance and ITM**. At the Savannah River Site, the Savannah River Nuclear Solutions, LLC fire department conducted monthly walkthroughs of a process building undergoing construction to maintain familiarity and to validate the status of the BNA and pre-incident plans. Also, the Site Utilities Division used an interactive computer model of the underground piping infrastructure that identified facilities impacted by closure of sectional control valves.
- **Evaluation of Fire Protection Needs on Mine Vehicles**. At the Waste Isolation Pilot Plant, Nuclear Waste Partnership, LLC adopted a hazard analysis and checklist to evaluate the needs for FSSs on mine vehicles. The process used a comprehensive five-phase analysis to determine the potential for fire, assess the consequences of fire, determine the need for fire protection, select from the available fire suppression options, and establish the appropriate FSS hardware.

5.0 RECOMMENDATIONS

The following recommendations are based on the analysis of assessments as summarized in section 3.0 of this report. While the underlying findings and deficiencies from the individual assessments did not apply

to every reviewed site, the recommended actions are intended to provide insights for potential improvements at all DOE nuclear sites. Consequently, DOE organizations and site contractors should evaluate the applicability of the following recommended actions to their respective facilities and/or organizations and consider their use as appropriate in accordance with Headquarters and/or site-specific program objectives.

DOE Field Element Managers

To enhance DOE field/site office assurance of the quality of safety basis documents with respect to fire protection:

- Ensure that safety basis review teams are appropriately staffed with FPEs who are familiar with implementing DOE-STD-1104, section 4.5, and thoroughly scrutinize fire protection-related analyses and TSRs, and associated engineering bases.

To enhance DOE field/site office oversight of fire protection:

- Ensure that field/site Facility Representative, safety system oversight, and FPE oversight planning processes include field assessments with priority on credited safety systems to include validating critical fire protection SSCs performance parameters through the safety basis and supporting engineering products during scheduled assessments.

Site Contractors

To improve nuclear facility safety bases, associated engineering products, and flow down to implementing surveillance and maintenance procedures (this recommendation can be conceptually applied to nonnuclear facility fire protection documents):

- Conduct periodic cross-functional reviews of selected safety class and safety significant fire protection SSCs addressed in the safety basis, associated engineering products, and flow down to implementing surveillance and maintenance procedures by a team composed of safety basis analysts, engineers, and FPEs (and/or other engineering/scientific disciplines, as appropriate). These cross-functional reviews could be structured as part of the contractor's self-assessment program.

To improve the development and update of future safety basis and fire protection documents, and associated engineering products:

- Ensure that safety basis/fire protection document development and update teams include fire protection staff who have the technical skills and sufficient time to provide complete and accurate designs/analyses and supporting documented engineering products.

To improve FPPs and implementation:

- Enhance FPP self-assessment plans by incorporating the applicable elements of the implementation verification review process described in DOE Guide 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements*, appendix C. Also, ensure that FPP self-assessment plans have input from safety basis analysts and engineers to include, for example, validation of design criteria and technical adequacy of calculations.

Appendix A
Supplemental Information

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Appendix B
Scope, Requirements and Guidance, and Assessed Sites

This lessons-learned report identifies common strengths and weaknesses, best practices, and recommendations, with the goal of increasing organizational learning throughout the U.S. Department of Energy (DOE) complex. This lessons-learned report is based on an analysis of 15 Office of Enterprise Assessments (EA) reports as detailed in table B-1. These 15 reports document 13 full-scope assessments and 2 follow-up assessments that included evaluation of some fire protection program elements. These 15 assessments were performed at 16 nuclear facilities and 1 nonnuclear facility located at 11 DOE sites between August 2015 (when the previous EA fire protection lessons-learned report was issued) and July 2022. The objective of each assessment was to determine whether the fire protection program, as implemented, was adequate to protect workers, the public, and the environment from hazards arising from postulated fires and related events.

The assessments included elements from the following criteria and review approach documents (CRADs) to determine whether the policies, procedures, and operational performance met DOE objectives for effectiveness in the areas examined. These elements address the adequacy of programs and performance.

- CRAD 31-12, Revisions 0, 1, and 2, *Fire Protection Program*
- CRAD 31-15, Revision 1, *Safety Systems Management Review*
- CRAD 45-34, Revision 1, *Fire Protection Inspection Criteria, Approach, and Lines of Inquiry*
- CRAD 45-21, Revision 1, *Feedback and Continuous Improvement Inspection Criteria and Approach – DOE Field Element*
- CRAD 30-01, Revision 1, *Contractor Assurance System*
- CRAD EA-30-07, Revision 0, *Federal Line Management Oversight Processes*.

Best practices were identified in 7 of the 15 EA assessment reports and listed in section 4.0 of this report. Additionally, prior to spring 2016, EA reports identified only findings. Subsequently, in response to DOE's issuance of DOE Order 227.1A, *Independent Oversight Program*, on December 21, 2015, EA began to differentiate findings (deficiencies that warrant a high level of attention on the part of management) from deficiencies (inadequacy in the implementation of an applicable requirement or performance standard).

All findings and deficiencies identified during these assessments were included in a spreadsheet and categorized by a team of fire protection engineers and subject matter experts. This approach provided insight into five key areas for analysis:

- Safety Basis/Fire Protection Documents and Engineering Products
- Fire Protection Program
- Inspection, Testing, and Maintenance of Fire Protection Safety Systems
- Contractor self-assessment
- DOE field/site office oversight.

In addition, an analysis was conducted of occurrence reports submitted to the DOE Occurrence Reporting and Processing System database from August 2015 to July 2022 containing the word "fire." These data were examined to identify any causal relationships with the five key areas.

Table B-1. Assessed Sites and Associated Source Documents

Assessed Site	Date Published	Assessed Facilities	DOE Field/Site Office/ Program Office	Source Document
Argonne National Laboratory	August 20, 2015	Alpha Gamma Hot Cell Facility, and Waste Management Operations Facility	Argonne Site Office/SC	EA Report, *Office of Enterprise Assessments Review of the Argonne National Laboratory Fire Protection Program, August 2015*
Nevada National Security Site	October 29, 2015	Device Assembly Facility, and U1a Complex	Nevada Field Office/NNSA	EA Report, *Office of Enterprise Assessments Review of the Nevada National Security Site Fire Protection Program, October 2015*
Waste Isolation Pilot Plant (WIPP)	November 16, 2015	Sitewide Review (Engineering and Procurement Processes)	Carlsbad Field Office/EM	EA Report, *Office of Enterprise Assessments Review of Waste Isolation Pilot Plant Engineering and Procurement Processes, November 2015*
Savannah River Site (SRS), Follow-up	February 1, 2016	Salt Waste Processing Facility (SWPF)	Savannah River Operations Office, and Salt Waste Processing Facility Project Office(1)/EM	EA Report, *Office of Enterprise Assessments Salt Waste Processing Facility Construction Quality and Fire Protection Systems Follow-up Review at the Savannah River Site, January 2016*
West Valley Demonstration Project	March 31, 2016	Main Process Plant Building, and the Lag Storage Area facilities	West Valley Demonstration Project Field Office/EM	EA Report, *Office of Enterprise Assessments Review of the West Valley Demonstration Project Site Fire Protection Program, March 2016*
Hanford Site	April 28, 2016	Waste Treatment and Immobilization Plant	Office of River Protection/EM	EA Report, *Office of Enterprise Assessments Assessment of Construction Quality and the Fire Protection Program at the Hanford Site Waste Treatment and Immobilization Plant, April 2016*
WIPP	July 8, 2016	Waste Handling Building, and Underground Facility	Carlsbad Field Office/EM	EA Report, *Office of Enterprise Assessments Assessment of the Waste Isolation Pilot Plant Fire Protection Program, July 2016*
SRS	June 14, 2017	H-Canyon and K-Area	Savannah River Operations Office/EM	EA Report, *Office of Enterprise Assessments Assessment of the Savannah River Site Fire Protection Program as Implemented at the H-Canyon and K-Area, June 2017*

Assessed Site	Date Published	Assessed Facilities	DOE Field/Site Office/ Program Office	Source Document
Sandia National Laboratories – New Mexico	July 23, 2018	Microsystems and Engineering Sciences Applications MicroFab 858EF Building	Sandia Field Office/NNSA	EA Report, *Office of Enterprise Assessments Assessment of the Sandia National Laboratories/New Mexico Fire Protection Program Implementation, July 2018*
Hanford Site	May 3, 2019	Central Waste Complex and T-Plant	Richland Operations Office/EM	EA Report, *Fire Protection Program Implementation Assessment at the Hanford Site Central Waste Complex and T Plant, May 2019*
SRS, assessment performed to prepare for the SWPF operational readiness review	August 29, 2019	SWPF	Savannah River Operations Office, and Salt Waste Processing Facility Project Office/EM	EA Report, *Fire Protection Program Implementation Assessment at the Savannah River Site Salt Waste Processing Facility, August 2019*
Lawrence Livermore National Laboratory, Follow-up	September 30, 2021	Plutonium Facility (Building 332)	Livermore Field Office[(1)]/NNSA	EA Report, *Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory, September 2021*
Pantex	April 8, 2022	Building 12-096, Building 12-084, and Building 12-104	National Nuclear Security Administration Production Office/NNSA	EA Report, *Independent Assessment of Fire Protection Program Implementation at the Pantex Plant, April 2022*
Pacific Northwest National Laboratory	July 7, 2022	Building 325 Radiochemical Processing Laboratory	Pacific Northwest Site Office/SC	EA Report, *Independent Assessment of the Fire Protection Program at the Pacific Northwest National Laboratory Radiochemical Processing Laboratory, July 2022*
Los Alamos National Laboratory	July 21, 2022	TA-55	Los Alamos Field Office/NNSA	EA Report, *Independent Assessment of TA-55 Fire Water Pump Safety System Management at the Los Alamos National Laboratory, July 2022*

[(1)] The field office was not included in the assessment scope.