



**Independent Assessment of the  
Fire Protection Program  
at the  
Pacific Northwest National Laboratory  
Radiochemical Processing Laboratory**

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## Acronyms

325RPL	Building 325 Radiochemical Processing Laboratory
AHJ	Authority Having Jurisdiction
Battelle	Battelle Memorial Institute
BNA	Baseline Needs Assessment
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FHA	Fire Hazards Analysis
FHE	Fire Hazards Evaluation
FPE	Fire Protection Engineer
FPP	Fire Protection Program
FSS	Fire Suppression System
FW	Facility Worker
HDI	How Do I
HFD	Hanford Fire Department
ITM	Inspection, Testing, and Maintenance
NFPA	National Fire Protection Association
OFI	Opportunity for Improvement
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
psig	pounds per square inch gauge
SDD	System Design Description
SLP	Safeguards Limits Project
SR	Surveillance Requirement
SS	Safety Significant
SSCs	Structures, Systems, and Components
TSR	Technical Safety Requirement

# **INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE PACIFIC NORTHWEST NATIONAL LABORATORY RADIOCHEMICAL PROCESSING LABORATORY**

## **Executive Summary**

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted an independent assessment of the effectiveness of fire protection program implementation at the Pacific Northwest National Laboratory (PNNL) Building 325 Radiochemical Processing Laboratory from November 2021 to January 2022. The Radiochemical Processing Laboratory is a hazard category 2 nuclear facility with a safety significant fire suppression system. This assessment evaluated the effectiveness of the operating contractor, Battelle Memorial Institute (Battelle), and DOE Pacific Northwest Site Office in managing and maintaining fire protection program performance.

EA identified the following strengths, including two best practices:

- Facility operators use fire protection system drawings in addition to procedures to record inspection and test results, including valve positions and other attributes. (Best Practice)
- Battelle maintains a substantial inventory of fire suppression sprinkler spare parts, which have been dedicated and controlled in accordance with quality assurance requirements. This approach will significantly reduce procurement lead times when repairs are required. (Best Practice)
- Fire protection engineers annually review new National Fire Protection Association code editions for impacts on operations and design requirements.

EA also identified the following fire protection weaknesses:

- Structures, systems, and components required for the safety significant fire suppression system to perform its safety function are not adequately identified. As a result, monitoring and controls are inadequate to ensure that the fire suppression system remains operable.
- The documented safety analysis does not identify safety significant controls for a fire-induced explosive reaction in a glovebox or hot cell and does not provide a technical justification for the omission of such controls. Such an accident could expose facility workers to serious injury or fatality.
- Sprinklers in two rooms were obstructed by protective caps, but Battelle had not entered into the fire system impairment process or evaluated the condition for operability. Failure to enter into the impairment and operability evaluation processes could result in the facility not appropriately addressing issues that affect the functionality of fire suppression systems.

In summary, the PNNL fire protection program is adequate in most respects and minimizes the likelihood and consequence of a fire-related event affecting the public, workers, environment, property, and missions. However, until the concerns relating to the fire protection program are addressed or effective mitigations are put in place, the level of risk will remain elevated.

# INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE PACIFIC NORTHWEST NATIONAL LABORATORY RADIOCHEMICAL PROCESSING LABORATORY

## 1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the effectiveness of fire protection program (FPP) implementation at the Pacific Northwest National Laboratory (PNNL) Building 325 Radiochemical Processing Laboratory (325RPL). PNNL is managed and operated by Battelle Memorial Institute (Battelle) under contract to the DOE Office of Science. Onsite portions of this assessment were performed at PNNL on December 13-17, 2021.

The 325RPL is a hazard category 2 nuclear facility with a safety significant (SS) fire suppression system (FSS). Battelle is pursuing the 325RPL Safeguards Limits Project (SLP), which modifies the 325RPL to facilitate storage of accountable nuclear materials. These modifications affect fire protection aspects of the 325RPL safety basis and include already-installed modifications to the existing SS FSS and the startup of a new SS hydrogen displacement system.

This assessment evaluated the effectiveness of Battelle and the DOE Pacific Northwest Site Office (PNSO) in managing and maintaining FPP performance. This assessment was conducted in accordance with the *Plan for the Independent Assessment of the Fire Protection Program at the Pacific Northwest National Laboratory Radiochemical Processing Laboratory, November 2021*.

## 2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which is implemented through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. This report uses the terms “best practices, deficiencies, findings, and opportunities for improvement (OFIs)” as defined in DOE Order 227.1A.

As identified in the assessment plan, this assessment considered requirements related to FPPs at DOE nuclear facilities. EA used sections 4.1, 4.2, 4.4, and 4.6 of EA Criteria and Review Approach Document (CRAD) 31-12, Rev. 2, *Fire Protection Program*.

EA examined key documents, such as system descriptions, work packages, procedures, manuals, analyses, policies, and training and qualification records. EA also interviewed key personnel responsible for developing and executing the associated programs; observed surveillance activities; and walked down the 325RPL, focusing on the design and condition of the SS FSS, potential fire hazards and controls, including management of transient combustibles, and other observable FPP elements. The members of the assessment team, the Quality Review Board, and management responsible for this assessment are listed in appendix A.

There were no previous findings for follow-up addressed during this assessment.

## **3.0 RESULTS**

### **3.1 Fire Protection Program**

The objective of this portion of the assessment was to verify that Battelle has established and implements an effective FPP for the 325RPL through policy/program description documents, implementing procedures, the fire hazards analysis (FHA), facility fire protection assessments, the baseline needs assessment (BNA), pre-incident plans, and the wildland fire management plan.

#### **FPP Administration**

Battelle has established and implements a DOE-approved FPP as documented in WSH-PD-026, *Program Description – Fire Protection*. The FPP is appropriately based on contract requirements; DOE Order 420.1C, *Facility Safety*; DOE-STD-1066-2016, *Fire Protection*; National Fire Protection Association (NFPA) codes and standards; and the International Building Code. WSH-PD-026 defines an FPP organization consisting of staffing, roles and responsibilities, resources, and training appropriate for effective FPP implementation. The roles and responsibilities of the FPP authority having jurisdiction (AHJ), as assigned by PNSO to Battelle in accordance with DOE Order 420.1C, are adequately documented in WSH-PD-026 and FP-304, *Fire Protection Codes and Standards Authority Having Jurisdiction and Exemptions/Equivalencies*.

The last programmatic self-assessment was completed by Battelle in October 2019 (*Worker Safety & Health Assessment Report – 2019 Fire Protection Program Assessment*). The self-assessment comprehensively evaluated key FPP elements and satisfies the three-year self-assessment frequency requirement in DOE Order 420.1C. The issues resulting from the self-assessment were entered into the contractor issues management system for tracking to completion. Annual FPP AHJ and fire protection engineer (FPE) reviews of new NFPA code editions (e.g., OTS-05864-001, *Worker Safety & Health Assessment Report – 2020 Fire Code Operational Provisions Change Assessment*) are proactively performed to determine any impacts on operations and design requirements.

#### **FPP Implementing Procedures**

Battelle generally implements appropriate procedures for performing design activities, modifications, and operations and for managing impairments, but EA identified several exceptions, as described below.

PNNL appropriately manages the 325RPL facility fire protection and life safety structures, systems, and components (SSCs) as defined within procedures ADM-058, *OSD Facility and SSC Configuration Management*, and ADM-057-PG-01, *Engineering Design Standards*. PNNL developed adequate engineering designs to modify the existing 325RPL SS FSS for the SLP, consistent with appropriate applicable DOE directives, DOE-STD-1066-2016, PNNL engineering standards, and NFPA 13, *Standard for the Installation of Sprinkler Systems* (2016 edition). The design package (design, plans, specifications, and test and inspection plans) for the modifications to the 325RPL SS FSS properly retained the existing safety basis system-design assumptions (i.e., NFPA 13 ordinary hazard pipe schedule configuration), pipe supports, and lateral restraints, and incorporated an adequate design margin. In addition, the fire protection modification package for the project appropriately included new quick-response sprinklers and smoke detectors in the protected room, implementing applicable NFPA and asset/property protection criteria. Finally, the design package was properly verified by independent qualified FPEs and 325RPL systems engineering reviewers to ensure that the requirements of the documented safety analysis (DSA)/technical safety requirement (TSR) addendum and facility FHA were met.

Modifications to the 325RPL SS FSS for the SLP were appropriately and comprehensively documented in a service request package (PNNL Service Request S707900N) and are consistent with the submitted proposed DSA/TSR addendum. S707900N adequately integrated the design package and specifications. Equipment modifications have largely been completed in support of the SLP. EA determined that the modifications made to the FSS in support of this project have not adversely affected the existing safety basis. The revised safety basis to support the full implementation of the SLP remains under PNSO review and is therefore outside the scope of this assessment.

The Battelle operations procedures for the PNNL 325RPL adequately address hot work control, ignition source control, control of combustibles, and SSC impairment management, but several concerns were identified, as described below. Battelle uses a comprehensive set of electronic “How Do I?” (HDI) procedures and instructions. HDI Work Control, *Hot Work*, incorporates the use of a “hot work permit” with appropriate site condition reviews, role assignments (e.g., welder, fire watch), and work release approvals as delineated in NFPA 51B, *Standard for Fire Prevention During Welding, Cutting and Other Hot Work* (2019 edition). HDI Work Control, *Basic Laboratory and Operations Practices*, and HDI Work Control, *Basic Staff Practices*, adequately address other ignition sources, such as space heaters, temporary electrical equipment, laboratory furnaces, ovens, and other appliances posing a fire hazard within the 325RPL. However, contrary to HDI Work Control, *Hot Work*, EA observed combustible materials within the 35-foot exclusion area established by the approved hot work permit (RPL-206-HWDAP-11734 R6) for the designated hot work area within the Room 206 Maintenance Shop. The designated hot work area was surrounded by a welding curtain, but the hot work permit did not cite the curtain as an approved control to allow reduction of the combustible exclusion distance. Furthermore, the hot work permit included two different exclusion distances for combustible material but did not describe when each applied (see **OFI-Battelle-1**). No hot work was in progress at the time of the observation; however, any combustible materials within the exclusion area would provide fuel sources for a potential fire to start from sparks or flame produced by hot work activities.

The Battelle HDI procedures for controlling and minimizing combustible materials within the 325RPL provide only qualitative expectations, resulting in subjective determination of the acceptability of combustible loading throughout the facility (see **OFI-Battelle-2**). The PNSO, *2020 Fire Protection (FP) and Safety System Oversight (SSO) Assessment Report*, includes observation OBS-A-21-PNSO-FPP-001-001, which cites the need for improved implementation of the combustible control program. Similarly, EA observed significant quantities of combustible materials in several facility areas. The presence of these materials in these areas is not consistent with Battelle’s procedures and instructions for minimizing and proactively managing combustibles:

- Room 901S (second floor mechanical space) contained staged equipment and parts in cardboard boxes on wood pallets and dunnage (may or may not be fire-retardant).
- Room 904 (second floor electrical breaker room) contained staged electrical breakers in cardboard boxes on wood pallets and other miscellaneous combustibles.
- Basement Room 45 had new laboratory equipment staged in plywood (not fire-retardant) and cardboard boxes, wood pallets, and miscellaneous cardboard boxes in several locations.
- The basement mezzanine office area corridor contained construction and painting supplies staged adjacent to a means of egress.

Generally, Battelle effectively controls and manages impaired fire protection SSCs through ADM-120, *Impairment of Fire Protection Systems and Fire Protection Features*, which is augmented within 325RPL by SOP-325-FSS-02, *325RPL Fire Suppression System Outage Procedure*. The Battelle procedures and instructions for managing and controlling impairments and outages of fire protection SSCs (e.g., fire

alarms, fire suppression and extinguishing systems, portable fire extinguishers, and fire barriers) are appropriately based on NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials* (2020 edition); DOE Order 420.1C; and DOE-STD-1066-2016. However, contrary to NFPA 801, section 4.6, and NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Fire Suppression Systems* (2020 edition), section 15.5, and despite the piping being in-service (connected to the FSS piping network), the sprinklers in Rooms 52 and 504 had protective caps in place due to construction activities but had not been declared as impaired as per ADM-120 and/or SOP-325-FSS-02 (see **Deficiency D-Battelle-1**). These protective caps prevent the sprinklers from operating as designed during a fire. Because the impairment process had not been implemented, the impact of these caps had not been evaluated and compensatory actions had not been identified or implemented.

This deficiency was identified during EA's walkdown of the 325RPL basement on December 13, 2021. The ongoing construction activities for Room 52, including modification of the sprinklers, were noted by Battelle as temporary modifications during the annual floor-level visual inspection of the FSS in August 2021. Battelle had also documented the as-found condition of the capped sprinklers in monthly system health reports prepared by the 325RPL FSS system engineer for September and October 2021. However, in neither case did Battelle declare an impairment as per ADM-120. Upon EA's notification of this deficiency, 325RPL management evaluated the situation and on December 13, 2021, determined, in accordance with ADM-120, that the FSS in Room 52 was impaired. An extent-of-condition review by 325RPL management on December 14, 2021, determined that Room 504 within the facility had a similar impairment. With sprinklers remaining capped in Rooms 52 and 504 pending further construction, 325RPL management entered the impairment process and implemented compensatory measures, including additional operational and fire hazard controls, a roving fire watch and reliance on active remotely monitored automatic smoke detection, and notified the Hanford Fire Department (HFD) of the impairments.

### **Fire Hazards Analysis**

The 325RPL FHA, documented in PNNL-FHA-325, *Radiochemical Processing Laboratory*, identifies most unique fire safety risks, but EA identified several weaknesses. The FHA is within the three-year review and update cycle required by DOE Order 420.1C and consistent with PNNL FP-306, *Fire Hazards Analysis and Fire Hazards Evaluation*. PNNL FP-306 also appropriately implements the requirement for developing fire hazards evaluations (FHEs) for gloveboxes and hot cells consistent with AGS-G010, *Standard of Practice for Glovebox Fire Protection* (2011 edition), as referenced by DOE-STD-1066-2016. The issues identified by Battelle in the FHA were appropriately entered into the Battelle issues management program for corrective action. However, EA identified the following two weaknesses, which are contrary to requirements in DOE Order 420.1C and NFPA 801 and guidance in DOE-STD-1066-2016 (see **Deficiency D-Battelle-2**):

- The FHA does not analyze the hazards or potential damage of fire and/or explosions for propane-fueled industrial trucks (forklifts) and heaters that are operated within or near the facility. Incomplete evaluation of such hazards may preclude identification of all appropriate controls for these hazards.
- The FHA or individual FHEs do not establish the basis for selecting the installed manual Class ABC dry chemical extinguishing agent with glovebox and hot cell enclosure contents. Selection of an agent must consider compatibility with the fire hazards present (NFPA 17, *Standard for Dry Chemical Extinguishing Systems* [2021 edition], section 5.1.2) and the effectiveness of the agent at suppressing fire (DOE-HDBK-1081-2014, *Primer on Spontaneous Heating and Pyrophoricity*). Incompatibility of the selected manual fire extinguishing agent with enclosure contents could exacerbate a developing fire within the enclosure upon deployment (e.g., violent chemical reaction), significantly increasing the consequences and post-fire recovery.



EA also identified the following two observations regarding the 325RPL FHA:

- The updated fire protection water supply analysis, *300 Area Hydrant Flow Analysis* (Technical Memorandum No. 717.04.03.303), for calendar year 2021 is not integrated with the FHA as required by NFPA 801, paragraph 4.3.2.2.
- The FHA does not clearly explain that the entire 325RPL building is currently designated as a single Class C Laboratory Unit as per NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals* (2019 edition), and a single International Building Code control area for the management of flammable and combustible liquids, flammable and compressed gases, and other hazardous materials. PNSO stated that Battelle intends to update the FHA later in 2022 to describe that the 325RPL is now a single control area for hazardous material management.

### **Facility Fire Protection Assessments**

Battelle has performed facility fire protection assessments to periodically evaluate FPP implementation at the 325RPL. The Battelle facility fire protection assessment program is described in WSH-PD-026; implemented by PNNL FP-303, *Building Fire Assessments*; and appropriately based on DOE Order 420.1C requirements and DOE-STD-1066-2016 guidance. Facility fire protection assessments of the 325RPL are performed annually by or under the supervision of a qualified FPE, as required by DOE Order 420.1C. The most recent 325RPL fire protection assessment, completed in August 2021 (PNNL AST-02229-00001, *Worker Safety & Health Fire Protection Assessment Report – 325RPL Building Fire Assessment*), addressed the status of the facility, including in-progress modifications, and the implementation of FPP procedures. The assessment also evaluated facility conditions; fire protection and life safety SSC inspection, testing, and maintenance (ITM); emergency response readiness; and the status of facility documentation (e.g., FHA and FHEs). The issues resulting from PNNL AST-02229-00001 were entered into the Battelle issues management program for corrective action. However, PNNL AST-02229-00001 did not identify or address any of the weaknesses described in this EA assessment report.

### **Baseline Needs Assessment**

Battelle has developed and implements an adequate BNA to ensure an effectively planned emergency response at the 325RPL. The PNNL BNA, documented in *PNNL Richland Campus and 300 Area Baseline Needs Assessment*, is appropriately based on DOE Order 420.1C, DOE-STD-1066-2016, and applicable requirements of NFPA codes and has been updated and approved by DOE within the required three-year cycle. The PNNL BNA appropriately discusses available fire response resources from the HFD and the Richland Fire Department as an alternative to establishing minimum fire department and emergency response requirements relating to staffing, apparatus (firefighting vehicles), and equipment based on fire response scenarios. The PNNL BNA defines and affirms emergency response mutual aid agreements in support of the Hanford Emergency Management Plan, which includes the 300 Area facilities operated by Battelle. In support of the HFD, the Richland Fire Department is an appropriately identified mutual aid service provider to the 325RPL. The gaps and improvement actions identified in PNSO's August 15, 2019, approval letter were entered into the Battelle issues management program for corrective action. The conclusions from the PNNL BNA are appropriately incorporated into the 325RPL FHA.

### **Pre-Incident Plans**

The HFD has developed and implements adequate pre-incident planning that enhances the effectiveness and safety of 325RPL emergency response activities, with two identified weaknesses. WSH-PD-026 appropriately ensures that HFD pre-incident plans are subject to input from and review by Battelle FPEs,

facility subject matter experts, and criticality safety staff for moderator-controlled areas. The HFD pre-incident plans adequately convey key information needed for effective emergency response and are appropriately based on DOE-STD-1066-2016 and NFPA 1620, *Standard for Pre-Incident Planning* (2020 edition). Physical access and appropriate apparatus and equipment for manual firefighting are consistent with the descriptions in the PNNL BNA and HFD 325RPL pre-incident plans, as verified by EA during facility walkdowns. However, individual 325RPL rooms and laboratories containing hazardous materials are not posted in a way that informs emergency response personnel of their contents (see **OFI-Battelle-3**). Additionally, the HFD pre-incident plans do not include the location of or information on the three dry standpipe systems or the manual dry chemical fire extinguisher piping systems that are installed for manual firefighting in some hot cells. The manual dry chemical fire extinguisher piping systems require the use of hot cell manipulators for effective delivery of the agent in the hot cell, which may preclude effective use by HFD personnel who are not trained on the use of the manipulators.

### **Wildland Fire Management**

Battelle has developed an adequate wildland fire management plan and submitted it for PNSO review and approval in accordance with DOE Order 420.1C. The proposed PNNL wildland fire management plan, WSH-PL-001, *WSH Plan – Pacific Northwest National Laboratory Wildland Fire Management*, is appropriately based on applicable requirements.

### **Fire Protection Program Conclusions**

Battelle implements a generally effective FPP for the 325RPL, approved by DOE and verified through periodic self-assessments. Design activities, modifications, and operations are adequately performed using established implementing procedures. The 325RPL FHA appropriately identifies most unique fire safety risks. Facility fire protection assessments adequately evaluate the status of FPP implementation. BNAs and pre-incident plans ensure effective emergency response planning. An adequate wildland fire management plan has been submitted for PNSO review and approval. However, EA identified two deficiencies regarding FSS impairments and FHA analyses and three additional weaknesses regarding hot work control, control of combustible material, and posting of hazardous material.

### **3.2 Fire Hazards Analysis and Documented Safety Analysis Integration**

The objective of this portion of the assessment was to verify that the 325RPL FHA is integrated into the design basis documentation and to evaluate the adequacy of fire safety controls, performance criteria, and safety support systems for the implementation of the facility safety basis.

In general, Battelle has integrated the FHA into the DSA (PNNL-DSA-325, *325 Building Radiological Processing Laboratory Documented Safety Analysis*); however, EA identified three deficiencies, which are described below. The FHA adequately evaluates most potential fire scenarios for the facility, including interior and laboratory spaces, hot cells, gloveboxes, and fuel truck and external fires, but EA identified several weaknesses as described in section 3.1 of this report. The evaluated fire scenarios and consequences in the FHA are appropriately included in the DSA hazard evaluation and accident analysis sections.

### **Identification of Safety Controls**

In general, the fire safety controls are appropriately based on fire hazard identification and analysis to ensure adequate protection of workers, the public, and the environment in accordance with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented*

*Safety Analyses.* However, the control allocation described in CRL-TECH-ESH-010, *Control Allocation for the 325 Building Extended Mission Documented Safety Analysis*, is insufficient to demonstrate the effectiveness of the hazard controls for protecting the facility worker (FW) from the consequences of the events identified in the DSA appendix 3A hazard analysis worksheets. SS controls to protect the FW from the following events, using the safety classification criteria specified in DSA Table 3.7, which are derived from worker safety controls described in DOE-STD-3009-94, section 3.3.2.3.3, were not considered (see **Deficiency-D-Battelle-3**). As a result, the controls to prevent or mitigate these hazards may be inadequate.

- The DSA identifies high-energy accidents capable of compromising glovebox and High-Level Radiochemistry Facility hot cell containment boundaries. DSA events E.3 and E.4 are evaluated as explosions in a closed space (e.g., glovebox, hot cell) due to the accumulation of flammable gas in the presence of an ignition source. The DSA appendix 3A hazard analysis worksheets state that the unmitigated consequences of either of these events would challenge the evaluation criteria for the FW by causing significant exposure to a hazardous material. Several safety management programs, including conduct of operations (work control) and fire protection (hot work permit), are identified as controls for preventing the accumulation and subsequent ignition of flammable gas and are designated as TSR administrative controls. Although the use of safety management programs may be evaluated and subsequently determined to be appropriate hazard controls for protecting the FW, the DSA does not consider the use of SS engineered controls as specified in Table 3.7.
- DSA event F.2 is described in the FHA as an internal fire involving a vehicle in the truck lock (Rooms 610/610E). The truck lock is currently used as workspace, for material shipping and receipt, and for storage. PNSO stated that because the truck lock is not currently used for vehicles, specific controls are not necessary. However, the truck lock is designed for vehicle loading and offloading. No controls are in place to restrict its use for this purpose, despite a determination in the FHA that a fire involving a vehicle in the truck lock could result in a flashover condition and extensive fire spread into the adjacent high-level radiochemistry facility, causing structural collapse of the unprotected steel columns and plugging of the high-efficiency particulate air (HEPA) filters, which could lead to an unconfined release pathway to the building exterior. The hazards analysis and selected preventive controls that are identified in CRL-TECH-ESH-010, *Control Allocation for the 325 Building Extended Mission Documented Safety Analysis*, include the FSS and Inspection Before Use, with a frequency of “anticipated” for the unmitigated consequence. However, the FHA concludes that the FSS would not be effective for this fire scenario due to the limitations of the ordinary hazard sprinkler design for hydrocarbon fires. Additional controls are not provided.

### **FSS and Safety Support SSCs**

The DSA defines and evaluates most credited systems in order to support implementation of the facility safety basis. However, contrary to DOE-STD-3009-94, section 4.4.X.2, which is required as part of the methodology chosen by Battelle to comply with 10 CFR 830.204, DSA chapter 4 does not adequately define the SS FSS boundary or include all support SSCs whose failure would result in an SS SSC losing the ability to perform its required safety function. Excluding portions of the FSS or required support SSCs necessary to accomplish its safety function results in TSR surveillance requirements (SRs) that are inadequate to fully verify the operability of the SS FSS.

- FSS TSR SR 4.3.1.3 ensures the adequacy of fire water supply by verifying that the minimum FSS pressure and main drain residual pressure are maintained. The gridded water supply path to the 300 Area delivers a supply pressure ranging from 50 psig to 60 psig. The hydraulically calculated demand (ref. CALC-RPL-2008-004-ARS) for the bounding FSS within 325RPL is riser 1 and requires a minimum pressure of 69 psig. In order to maintain required pressure, the fire water supply pumps to

start and run on demand. However, the SR does not include verification of the ability of the fire water pumps to perform this function. FSS TSR 4.3.1.1 requires a monthly visual inspection of the FSS control valves to verify that the valves are open and that the system is properly aligned to provide flow on demand. However, the SR does not include surveillance of the valves controlling the underground piping located upstream from the post indicator valve and downstream from the fire water supply pumps. The position of these valves would not necessarily be identified by TSR SRs. Without ensuring the ability of the fire water pumps to start and run, and the position of the water supply control valves located between the discharge of the fire water pumps and the post indicator valves, availability of the fire water supply cannot be assured. (See **Deficiency D-Battelle-4.**)

- The FSS is dependent on the fire water supply pumps to start and run on demand in order to maintain required pressure. Neither the pumps supplying the normal 300 Area water supply nor the fire water supply pumps are designated as part of the SS FSS or as required support SSCs. FSS backflow preventers are credited as SS as part of the FSS pressure boundary and flow path for FSS risers 1 and 2. Temperature switches monitor the temperature of the heated enclosures containing FSS riser equipment where freezing temperatures could occur. These switches are designed to send a supervisory “freeze” signal to the fire alarm control panel when the ambient temperature falls below the detector set point of approximately 40°F. Neither the enclosure heaters nor the supervisory temperature monitoring switches within the heated enclosures are designated as safety support systems even though a heater failure could allow the fire protection piping to freeze, precluding the FSS from being able to perform its intended function. The failure of the monitoring switches would prevent personnel from receiving alerts that the heaters had failed and taking actions to restore FSS operability. (See **Deficiency D-Battelle-5.**)

### **Fire Hazards Analysis and Documented Safety Analysis Integration Conclusions**

Battelle has generally integrated the FHA into the DSA, with two notable exceptions. The 325RPL DSA hazards analysis adequately evaluates and analyzes the FSS for most accident events in order to support the implementation of the facility safety basis. However, the hazards analysis does not adequately evaluate the effectiveness of the FW consequence hazard controls from a fire-induced explosive reaction in a glovebox or hot cell or for fire involving a vehicle in the truck lock. Additionally, it does not adequately define the FSS boundary or include the SSCs whose failure would result in the SS FSS losing the ability to perform its required safety function.

### **3.3 Inspection, Testing, and Maintenance**

The objective of this portion of the assessment was to verify that Battelle performs effective fire protection SSC ITM for the 325RPL through defined ITM requirements, conducting visual inspections, managing spare parts, and maintaining the water supply system in order to ensure that fire protection and life safety systems will operate and perform as designed.

#### **ITM Requirements**

WSH-PD-026 adequately identifies the requirements for the ITM of fire protection and life safety SSCs based on NFPA codes and standards, DOE Order 420.1C, and DOE-STD-1066-2016. Based on documents reviewed by EA, the HFD adequately performs NFPA-prescribed testing of the 325RPL fire alarm and FSS in accordance with facility-provided procedures, with oversight by the FSS system engineer. The ITM of the facility fire detection and alarm system SSCs, facility portable fire extinguishers and manual dry chemical fire extinguishing systems for the material examination and process development hot cells, and FHA-designated fire barriers and associated opening protectives (doors, dampers, and penetrations seals) within 325RPL is consistent with NFPA requirements.

The ITM program for 325RPL water-based fire protection SSCs (automatic sprinklers, standpipe systems, and the supporting water supply system) is appropriately based on NFPA 25 and generally well documented. Special Teflon-coated (corrosion-resistant) sprinklers in certain fume hoods within Rooms 520, 524, 528, and 611B are not subject to ten-year testing or replacement as typically required by NFPA 25, section 5.3.1.1.3, for harsh environments. 325RPL facility personnel stated that the current uses of these fume hoods are not considered to be harsh environments. However, no description of or rationale for the installation of these corrosion-resistant sprinklers in these locations is provided in the FHA or RPL-FSS-SDD, *325RPL Building Fire Suppression System Design Description (SDD)* (see **OFI-Battelle-4**).

### **FSS Visual Inspections**

Simulated visual inspections of the 325RPL SS FSS in support of TSR SRs 4.3.1.1, 4.3.1.2, and 4.3.1.3 were adequately performed by 325RPL operators in accordance with facility-issued procedures and instructions, with oversight by the FSS system engineer. During these surveillances, 325RPL operators use fire protection system drawings in addition to valve line-up data sheets to verify that acceptance criteria are met for FSS valve position and other attributes, e.g., location, number, pressure, and temperature. This approach provides more effective configuration management of installed SSCs than using valve line-up sheets alone and is cited as a **Best Practice**. The training records for 325RPL operators and related interviews demonstrate that the operators are qualified and receive adequate training to conduct visual inspections in accordance with facility procedures.

### **Spare Parts**

325RPL maintenance personnel maintain a well-stocked and organized FSS spare parts inventory. FSS parts (e.g., sprinkler heads, common fittings, valve components) for most common repairs are maintained in stock, reducing outage time for these repairs compared to relying on commercial vendors for needed parts, which may not be immediately available. The spare parts staff implements practices that are more rigorous than required by American Society of Mechanical Engineers Nuclear Quality Assurance (NQA)-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* (to which Battelle is contractually committed), including software quality assurance controls for the inventory spreadsheet used to track spare parts. This rigorous approach is cited as a **Best Practice**.

### **Fire Protection Water Supply Network**

The PNNL 300 Area fire protection water supply and underground distribution network, including supply to the 325RPL SS FSSs and fire hydrants, are generally subject to ITM and evaluation as required by NFPA 25, though weaknesses were identified. Reviewed records show that HFD adequately performs NFPA 25-prescribed flush and fire flow testing of the 300 Area fire hydrants, including those around the perimeter of the 325RPL, in accordance with approved procedures and instructions, with oversight by the 300 Area water system building engineer. NFPA 25-prescribed analyses of the fire hydrant flow rates around the perimeter of the 325RPL are current. However, observed ITM activities and interviews with Battelle personnel showed that contrary to NFPA 25, section 13.3, the 300 Area water supply system underground sectional and hydrant control valves (also known as curb-box or road-box valves) are not subject to routine inspection and testing or valve alignment verification, e.g., counting and recording the number of turns opened and closed (see **Deficiency D-Battelle-6**). Closed, partially closed, or inoperable valves can disable or hamper water flow to the FSS and/or fire hydrants.

The fire pumps associated with the fire protection water supply system are subject to ITM in accordance with the applicable requirements of NFPA 25, but weaknesses were noted in both the weekly diesel fire

pump tests and the most recent annual fire pump tests. Observed weekly ITM of the diesel fire pump was adequately performed by Battelle 300 Area water supply system operators and assigned craft personnel (journeyman electricians, fitters, millwrights) in accordance with approved procedures and instructions (Preventive Maintenance activity 1669), with adequate oversight by the 300 Area FPE. However, the weekly diesel fire pump test at churn (no flow) pressure was performed with the fire pump main relief valve discharging water to the remote retention pond (“swale”) at a discharge rate greater than the allowable “weep” specified in NFPA 25, section 8.3.2.1. Although this approach deviated from the NFPA standard, the test demonstrated adequate fire pump performance.

In addition, contrary to NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection* (2010 edition), and NFPA 25, test records indicated that the annual pump capacity tests performed on November 20, 2021, (Preventive Maintenance activities 2786 and 2787) were inadequate to verify the design capacity of the fire pumps specified by the pump manufacturer (i.e., pump performance less than 95% of the acceptance test or manufacturer’s certified test curves as required by NFPA 20, section 14.5.1.4, and NFPA 25, sections 8.3.3.1 and 8.3.7.2.3). This issue was self-identified by Battelle. However, test records also showed that several pieces of maintenance and test equipment used for recording test data were overdue for calibration, inconsistent with NFPA 20, section 14.2.6.1.1, and NFPA 25, section 8.3.3.5. Specifically, documentation of the completed tests indicated that three test gauges for observing pump suction and discharge pressure had calibration due dates of December 3, 2020, and an in-line flow meter had a calibration due date of November 4, 2021.

### **Inspection, Testing, and Maintenance Conclusions**

Battelle performs generally effective ITM for the 325RPL fire protection and life safety SSCs, appropriately based on NFPA codes and standards and DOE requirements. Simulated visual inspections adhered to ITM procedures. Use of fire protection system drawings during these inspections, and 325RPL’s well-managed FSS spare parts inventory, are cited as best practices. However, EA identified several issues associated with the testing of sprinklers subject to harsh environments; routine inspection, testing, and alignment of control valves; and annual pump capacity tests.

### **3.4 TSR Surveillance**

The objective of this portion of the assessment was to verify that the 325RPL TSRs for the SS FSS ensure that the system can accomplish its safety function and continue to meet applicable system requirements and performance criteria in accordance with DOE Order 420.1C, attachment 2, chapter II; NFPA 25; and 10 CFR 830.

EA reviewed completed surveillance and test procedures and confirmed that key operating fire protection system parameters are maintained within acceptance criteria, ensuring conformance with safety basis requirements. For example, Battelle personnel involved in simulating the required surveillance (325RPL TSR Monthly FSS Control Valve Alignment Inspection) demonstrated knowledge of the system and valve inspection criteria and relied on the fire water piping drawing to confirm FSS valve attributes, e.g., position, location, and number (see the FSS Visual Inspections best practice). However, contrary to section 4.4.X.2 of DOE-STD-3009-94, DSA chapter 4 does not adequately define the FSS boundary or the SSCs whose failure would result in an SS SSC losing the ability to perform its required safety function (see additional discussion of the identification of safety controls and associated **Deficiency D-Battelle-4** in section 3.2). The FSS boundary is incomplete, so TSR SR 4.3.1.1 cannot validate an operable FSS by ensuring flow on demand due to the indeterminate position of some control valves, and TSR SR 4.3.1.3 cannot validate an operable FSS by ensuring that the minimum required pressure is met in the absence of the fire water supply pumps.

## **TSR Surveillance Conclusions**

In most cases, FSS operability was sufficiently demonstrated through completed facility TSR surveillance test procedures. Most TSRs were adequate and ensure that the FSS is being inspected, tested, and maintained in accordance with applicable requirements. However, because the FSS boundary is incomplete, two SRs cannot validate the operability of the FSS or ensure that the safety function for the system is being met.

### **3.5 DOE Field Element Oversight**

The objective of this portion of the assessment was to determine whether an effective DOE oversight program is in place to evaluate the adequacy of Battelle's PNNL FPP through operational awareness activities; assessments of facilities, operations, and programs; and assessments of the contractor assurance system.

#### **DOE Field Element Oversight Processes and Programs**

Procedure PNSO-PCDR-02, *PNSO Oversight Program Procedure*, provides suitable directions for implementing the DOE oversight and quality assurance requirements of DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*, and DOE Order 414.1D, *Quality Assurance*, at PNNL. PNSO-PCDR-02 specifies an appropriate series of oversight processes for evaluating Battelle's operations, activities, programs, and management systems. Oversight of Battelle fire protection activities is performed by an FPE qualified in accordance with DOE-STD-1137-2014, *Fire Protection Engineering Functional Area Qualification Standard*. Additional activities and observations are conducted by Facility Representatives. Periodic oversight of fire protection systems and activities, including programmatic reviews, are performed by the responsible FPE within PNSO.

Oversight of the implementation of the fire protection requirements of DOE Order 420.1C and DOE-STD-1066-2016 at PNNL is implemented through DOE Office of Science procedure FSA13, *Oversight of Facility Safety*. This procedure incorporates an appropriate set of baseline expectations for a comprehensive FPP and is used by PNSO for conducting oversight of Battelle's FPP throughout the site.

#### **Authority Having Jurisdiction**

As defined in procedure FSA13, the Site Office Manager, or the individual who is delegated the authority, fulfills the roles and responsibilities of the AHJ for matters involving fire protection as per NFPA requirements. The Battelle fire protection code authority (identified as the PNNL FPP AHJ) follows the provisions of FP-304, *Fire Protection Codes and Standard Authority Having Jurisdiction and Exemptions/Equivalencies*. The PNNL fire protection AHJ is assigned AHJ authorities by PNSO as per letter 21-PNSO-0201, *Contract No. DE-AC05-76RL01830 – Delegations, Assignments, and Designations of Responsibility and Authority at PNNL* (as amended). This letter also contains additional exclusions and expectations for the PNNL fire protection AHJ. These delegations do not limit or reduce PNSO's responsibility and authority as the AHJ for all fire protection requirements for DOE facilities managed by Battelle. PNSO reserves the right to review and amend all determinations made under letter 21-PNSO-0201. As part of PNSO oversight responsibilities, the Site Office Manager annually reviews all activities performed under the delegated AHJ authority to ensure that these authorities are being appropriately implemented.

## **DOE Assessments Related to Fire Protection**

PNSO establishes the annual assessment plan for PNNL in accordance with PNSO-PCDR-02. Annual oversight assessments are scheduled on a three-year cycle, such that different elements of Battelle's PNNL FPP are evaluated each year, and in combination, ensure that every three years the complete PNNL FPP is effectively implemented in accordance with DOE directives. The completion of these oversight cycles serves as PNSO's triennial assessment of the FPP. The assessments performed in 2019 and 2020 concluded that the PNNL FPP was effectively implemented. The conclusions contained in PNSO assessments, along with corrective action plans for any findings, serve as the basis for continued PNSO approval of Battelle's PNNL FPP.

The assessments generally demonstrated that an appropriate level of rigor and depth is applied in conducting oversight of the PNNL FPP. The assessments are appropriately planned, conducted, and documented. The results are entered into the PNSO Performance Assurance Reporting Tool and tracked until closure, and corrective actions are reviewed for effectiveness. However, EA identified issues that were not identified by PNSO oversight activities.

## **Issues Management System**

Based on the reviewed PNSO assessments, results are appropriately entered into the PNSO Performance Assurance Reporting Tool, and each issue is assigned a unique number for development and tracking of corrective actions until closure. The PNSO assessments pertinent to FPPs or systems are conducted by qualified FPEs, who verify appropriate closure of any identified issues. Regarding the reviewed fire protection issues, PNSO FPEs evaluated the completed corrective actions for adequacy prior to closure as specified in PNSO-PCDR-02.

## **Fire Protection Engineers and Other Technical Staff Performing Oversight**

The roles and responsibilities for oversight are described in several documents, along with the requirements for training and qualification. EA reviewed the qualifications of the two PNSO FPEs assigned to provide oversight of PNNL. The FPEs have degrees in fire protection engineering and, for the most part, had completed the technical qualification program under DOE-STD-1137, *Fire Protection Engineering Functional Area Qualification Standard* and DOE-STD-1146-2017, *General Technical Base Qualification Standard*. However, despite having the technical qualification program documented as complete, one PNSO FPE had not completed all of the qualification requirements of DOE-STD-1146-2017 as required by DOE Order 426.1B, *Department of Energy Federal Technical Capability* (see **Deficiency D-PNSO-1**). The FPE with incomplete qualifications did not have full responsibility for any oversight activity performed or documented by or on behalf of PNSO.

## **DOE Field Element Oversight Conclusions**

PNSO has an adequately documented and established fire protection oversight program. In general, PNSO adequately conducts oversight of the PNNL fire detection and protection systems with direct involvement from FPEs. PNSO generally provides adequate oversight of the Battelle FPP as implemented at PNNL. However, areas of weakness in the PNNL FPP identified during this independent assessment were not all identified by PNSO oversight activities.



## 4.0 BEST PRACTICES

Best practices are safety-related practices, techniques, processes, or program attributes observed during an assessment that may merit consideration by other DOE and contractor organizations for implementation. The following best practices were identified as part of this assessment:

- Facility operators use fire protection system drawings along with ITM procedures to record inspection and test results, including FSS valve positions and other attributes, e.g., location, number, position, pressure, and temperature.
- Battelle maintains a substantial inventory of FSS spare parts, which are dedicated and controlled in accordance with the guidance established by American Society of Mechanical Engineers NQA-1-2000.

## 5.0 FINDINGS

No findings were identified during this assessment.

## 6.0 DEFICIENCIES

Deficiencies are inadequacies in the implementation of an applicable requirement or standard. Deficiencies that did not meet the criteria for findings are listed below, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

### Battelle Memorial Institute

**Deficiency D-Battelle-1:** The protective construction caps remaining on sprinklers in Rooms 52 and 504 after the associated FSS piping was placed into service (connected to the FSS piping network) were not evaluated or declared to be a fire impairment as per ADM-120 and/or SOP-325-FSS-02. (NFPA 13, sections 4.1.1, 9.1.1(1), 9.1.1(3), and 10.7.2.3; NFPA 25, section 15.5; NFPA 801, section 4.6)

**Deficiency D-Battelle-2:** The 325RPL FHA does not address all present fire/explosion hazards or address potential extinguishing agent incompatibility with gloveboxes and hot cell contents. (DOE Order 420.1C, chapter II, sections 3.c(2)(4) and 3.f(1); NFPA 801, sections 4.3.2, 6.7.3(1), 6.7.3(5), and A.4.3.2.1; NFPA 17, section 5.1.2; DOE-STD-1066-2016, sections 4.4.2.3, 4.2.7.8, 4.2.7.8.3, 7.1, and appendix B (B.1.6.1); DOE-HDBK-1081-2014; AGS-G010-2011)

**Deficiency D-Battelle-3:** The control allocation (ref. CRL-TECH-ESH-010) for glovebox explosion and truck lock fire events is insufficient to demonstrate the effectiveness of the FW consequence hazard controls identified in DSA appendix 3A, *Hazard Analysis Work Sheets*. (10 CFR 830.204(b)(4); DSA Table 3.7, *Safety Classification Criteria*; DOE-STD-3009-94 §3.3.2.3.3)

**Deficiency D-Battelle-4:** The surveillance requirements developed for the FSS, TSR SR 4.3.1.x, are not sufficient to demonstrate operability. (10 CFR 830.205)

**Deficiency D-Battelle-5:** The DSA does not include the SSCs whose failure would result in an SS SSC losing the ability to perform its required safety function. (10 CFR 830.204 (4); DOE-STD-3009-94 §4.4.X.2)

**Deficiency D-Battelle-6:** The 300 Area fire protection water supply system underground sectional and hydrant control valves (also known as curb-box or road-box valves) are not subject to routine inspection, testing, or valve alignment verification. (NFPA 25, section 13.3)

#### **Pacific Northwest Site Office**

**Deficiency D-PNSO-1:** A PNSO FPE providing oversight of the contractor on behalf of PNSO did not complete Part B of DOE-STD-1146-2017. (DOE Order 426.1B, section 4.d(1))

## **7.0 OPPORTUNITIES FOR IMPROVEMENT**

The assessment team identified four OFIs to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in assessment reports, they may also address other conditions observed during the assessment process. These OFIs are offered only as recommendations for line management consideration; they do not require formal resolution by management through a corrective action process and are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to issues identified during the assessment.

#### **Battelle Memorial Institute**

**OFI-Battelle-1:** Consider revising the hot work permit for the designated hot work area within the Room 206 Maintenance Shop to more clearly describe the combustible controls required for hot work and provide floor markings or signage to designate the combustible material exclusion area for the designated hot work area.

**OFI-Battelle-2:** Consider developing quantitative or other objective review and acceptance criteria for the management of combustible materials.

**OFI-Battelle-3:** Consider updating the postings on individual room doors to clearly communicate to first responders the hazards present in each room.

**OFI-Battelle-4:** Consider documenting in the FHA, the SDD, or other suitable document, the basis for the installation of corrosion-resistant sprinklers within fume hoods in Rooms 520, 524, 528, and 611B, including an explanation of environmental conditions, the rationale for ITM requirements, and the ITM change control mechanism should operational conditions change.

## **Appendix A Supplemental Information**

### **Dates of Assessment**

Onsite Assessment: December 13-17, 2021

### **Office of Enterprise Assessments (EA) Management**

John E. Dupuy, Director, Office of Enterprise Assessments  
William F. West, Deputy Director, Office of Enterprise Assessments  
Kevin G. Kilp, Director, Office of Environment, Safety and Health Assessments  
David A. Young, Deputy Director, Office of Environment, Safety and Health Assessments  
Kevin M. Witt, Director, Office of Nuclear Safety and Environmental Assessments  
Charles C. Kreager, Director, Office of Worker Safety and Health Assessments  
Jack E. Winston, Director, Office of Emergency Management Assessments  
Joseph J. Waring, Director, Office of Nuclear Engineering and Safety Basis Assessments

### **Quality Review Board**

William F. West, Advisor  
David A. Young, Chair  
Laura H. Micewski  
Christopher M. Rozycki  
William A. Eckroade

### **EA Site Lead for Hanford Site**

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