Independent Assessment of the Fire Protection Program at the Lawrence Livermore National Laboratory Plutonium Facility – Building 332

March 2024

Office of Enterprise Assessments
U.S. Department of Energy

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Acronyms

ACFD	Alameda County Fire Department
AHJ	Authority Having Jurisdiction
ASME	American Society of Mechanical Engineers
AWWA	American Water Works Association
B332	Building 332
CFR	Code of Federal Regulations
CM	Configuration Management
CRAD	Criteria and Review Approach Document
CSE	Cognizant System Engineer
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
ES&H	Environment, Safety, and Health
FFPA	Facility Fire Protection Assessment
FHA	Fire Hazards Analysis
FHE	Fire Hazards Evaluation
FHFS	Final HEPA Filtration Stage
FPE	Fire Protection Engineer
FPMP	Fire Protection Management Plan
FPP	Fire Protection Program
FPPM	Fire Protection Program Manual
FR	Facility Representative
FSS	Fire Suppression System
GBES	Glovebox Exhaust System
HEPA	High-efficiency Particulate Air
ITM	Inspection, Testing, and Maintenance
LCO	Limiting Condition for Operation
LFO	Livermore Field Office
LFO P	LFO Process
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
NFPA	National Fire Protection Association
OFI	Opportunity for Improvement
RGL	Recovery Glovebox Line
RMA	Radioactive Materials Area
SAC	Specific Administrative Control
SC	Safety Class
SR	Surveillance Requirement
SS	Safety Significant
SSCs	Structures, Systems, and Components
SSO	Safety System Oversight
TQP	Technical Qualification Program
TSR	Technical Safety Requirement
UL	Underwriters Laboratory
VSS	Vital Safety System
WSPVS	Water System Piping and Valve Study

INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE LAWRENCE LIVERMORE NATIONAL LABORATORY PLUTONIUM FACILITY – BUILDING 332

Executive Summary

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted an independent assessment of the effectiveness of the fire protection program (FPP) at the Lawrence Livermore National Laboratory (LLNL) Plutonium Facility – Building 332 (B332) from October to December 2023. LLNL is managed and operated by Lawrence Livermore National Security, LLC (LLNS) for the National Nuclear Security Administration and is overseen by the Livermore Field Office (LFO). This assessment evaluated LLNS fire protection policies and procedures; fire hazards analysis (FHA) and documented safety analysis integration; design of fire protection structures, systems, and components; and surveillances and inspection, testing, and maintenance (ITM). Additionally, the assessment evaluated the status and resolution of fire protection issues documented in EA report *Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory, September 2021*. The assessment also included an evaluation of the LFO oversight activities related to fire protection.

EA identified the following strengths:

- LLNS technical staff supporting B332 were knowledgeable and competent, and demonstrated a high level of ownership and engagement for their assigned areas.
- LFO's procedures and work instructions provide clear and concise definitions of roles and responsibilities, and expectations related to the implementation of DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*.
- The LFO fire protection management plan provides clear integration of the requirements of DOE Order 226.1B and DOE Order 420.1C, *Facility Safety*, and the guidance of DOE-STD-1066-2016, *Fire Protection*.

EA also identified several weaknesses, as summarized below:

- LLNS procedures do not include requirements or instructions for developing fire hazards evaluations for glovebox operations.
- The FHA does not identify the hazards associated with the recovery glovebox line Vortex® fire suppression systems (FSSs) or reflect the proper safety classification of the FSS.
- The pre-fire planning facility layout plans do not designate the primary and secondary assembly points for evacuation of facility personnel or identify the location of the main electrical power disconnect(s).
- LLNS has not performed annual system condition assessments of the B332 facility fire alarm system.
- LLNS used non-listed components in the Vortex glovebox FSSs without the approval of the authority having jurisdiction and did not document the design basis for the Increment 1 room bypass damper.
- LLNS has not adequately planned for the replacement of the obsolete B332 fire alarm panel and emergency voice alarm system.
- LLNS does not perform adequate visual inspections of the FSS fusible plug for Increment 1 glovebox exhaust system spray plenum deluge valve to identify corrosion or degradation that could prevent operation.
- Some LLNS safety analyses (1) did not evaluate the adequacy of the high-efficiency particulate air (HEPA) filtration stages under postulated accident conditions and (2) allow the use of in-place HEPA

filter test aerosols that may contain particle size distributions exceeding those specified in applicable standards.

- LLNS was unable to provide a valve exercising frequency schedule for valves TB-2-332E and TB-2-332W or water utility ITM performance records.

In summary, LLNS has established a generally effective and comprehensive FPP. LFO's oversight program is well-established and generally tailored to provide the appropriate level of oversight. Furthermore, LFO is effectively performing Federal oversight of LLNS fire protection activities at B332 facilities. However, this assessment identified several weaknesses in the implementation of the LLNS FPP. Resolution of the weaknesses identified in this report will enhance the effectiveness of the LLNS FPP and further mitigate fire risks to B332 facilities.

INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE LAWRENCE LIVERMORE NATIONAL LABORATORY PLUTONIUM FACILITY – BUILDING 332

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 fire protection program (FPP) at the Lawrence Livermore National Laboratory (LLNL) Plutonium Facility – Building 332 (B332). Assessment activities were conducted from October to December 2023.

In accordance with the *Plan for the Independent Assessment of the Fire Protection Program at the Lawrence Livermore National Laboratory Plutonium Facility – Building 332, October - November 2023*, this assessment evaluated the effectiveness of the Lawrence Livermore National Security, LLC (LLNS) FPP, including fire protection program implementation; fire hazards analysis (FHA) and documented safety analysis (DSA) integration; design of fire protection structures, systems, and components (SSCs); and surveillances and inspection, testing, and maintenance (ITM). The assessment also included an evaluation of high-efficiency particulate air (HEPA) filter design and efficacy, the Livermore Field Office (LFO) oversight activities related to fire protection, and the status and resolution of fire protection issues documented in EA report *Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory, September 2021*.

LLNL is managed and operated by LLNS for the National Nuclear Security Administration (NNSA) and is overseen by LFO. B332 is located within the Superblock security area and is a hazard category 2 nuclear facility used to conduct research on the physical, metallurgical, and chemical properties of plutonium. These activities support NNSA's stockpile stewardship and fabrication, testing, and assembly of plutonium parts.

2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which EA implements 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 the order.

As identified in the assessment plan, this assessment considered requirements related to 10 CFR 830, *Nuclear Safety Management*, and DOE Order 420.1C, *Facility Safety*, and guidance related to DOE-STD-1066-2016, *Fire Protection*. EA used objectives 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 of EA CRAD 31-12, Revision 2, *Fire Protection Program*, and objectives SS.1 and SS.9 of EA CRAD 30-11, Revision 0, *Safety Systems Management Review*.

EA examined key documents, such as the FHA, DSA, technical safety requirements (TSRs), system design descriptions, work packages, procedures, manuals, assessments, policies, and training and qualification records. EA interviewed key personnel responsible for developing and executing the FPP; observed fire protection-related activities; and walked down significant portions of B332, focusing on aspects of the FPP. EA also conducted interviews and reviewed assessment records to evaluate the effectiveness of the Federal oversight program to ensure that fire safety systems can reliably perform as

intended. The members of the assessment team, the Quality Review Board, and the management responsible for this assessment are listed in appendix A.

At LFO's request, EA reviewed the analysis of the safety class (SC) HEPA filters supporting LLNS' basis for considering downgrading a safety significant (SS) fire suppression system (FSS). EA also examined the effectiveness of HEPA filter design to ensure that the installed filters would meet the DSA requirement to withstand the effects of an evaluation-basis room fire, and the effectiveness of LLNS's management of safety issues related to credited fire protection safety systems documented in the previously cited 2021 EA report on fire protection at LLNL.

3.0 RESULTS

3.1 Fire Protection Program

This portion of the assessment evaluated the effectiveness of the LLNS FPP policy and implementing procedures, codes and standards, organization, training and qualification, impairment control and compensatory actions, the FHA program, combustible controls, pre-incident plans, and the facility fire protection assessment (FFPA).

Fire Protection Program Policy and Implementing Procedures

LLNS has established and implemented generally adequate FPP policy and procedures in accordance with DOE Order 420.1C, attachment 2, chapter II. LLNL-MI-856725, *DES-8320 LLNL Fire Protection Program*, adequately describes organizational components with roles and responsibilities, including the contracted Alameda County Fire Department (ACFD) response to onsite emergencies. LLNL-MI-855960, *Policy No. 30-101 LLNL-AR-704489*, adequately documents the ACFD emergency response to the unique hazards of the Superblock.

LLNS has also established and implemented generally adequate program procedures for water spray/deluge systems, Vortex glovebox FSSs, fire barriers and doors, and smoke and fire dampers. The reviewed procedures generally contain clear instructions and data recording sheets, and the reviewed data sheets associated with those procedures typically include defined acceptance criteria, space for data recording, comment sections, and required signature and dates. However, LLNS has not revised LLNL-MI-856725 to reference the updated FPP manual, LLNL-AM-847521, *Fire Protection Program Manual* [hereafter referred to as the FPPM], approved by LFO on June 30, 2023. LLNL-MI-856725 references LLNL-AM-704480 instead of the current FPPM, resulting in an incorrect document hierarchy. (See **OFI-LLNS-1**.)

Codes and Standards

The FPPM, section 8.1, invokes the appropriate building codes and National Fire Protection Association (NFPA) codes for fire protection and emergency response programs. Policy 1.2.1, *Adoption of Fire Protection Codes and Standards*, directs LLNS to use NFPA standards. Additionally, the FPPM appropriately identifies handbooks, guides, manuals, and recommended practices. DOE-STD-1066-2016 is identified as one of several additional fire safety references and guidance. The FPPM, appendix A, appropriately identifies 10 "generic equivalencies" approved by the Fire Marshal, who serves as the authority having jurisdiction (AHJ) for fire protection at LLNL. LLNS defines a generic equivalency as "technically a deficiency" because it deviates from a recognized code or standard but does "not rise to the level of requiring immediate correction. LLNS has determined the cost of correction of these minor deficiencies is not merited when compared to the value of increased protection."

Organization

The FPPM, section 4.2, and LLNL-MI-855961, *EMD* [Emergency Management Division] *Org. Chart - October 2023*, provide adequate descriptions of the organization. The organization, roles, and responsibilities are adequately described in the FPPM, section 4.0, and LLNL-MI-856725, section 2.0, identifies LLNL's Fire Marshal as the AHJ, to whom LFO has formally delegated routine day-to-day operations for matters concerning building codes and fire protection. Multiple interviews confirmed effective interfaces for those LLNS organizational units (e.g., emergency management, engineering, maintenance) responsible for managing, implementing, and assessing the FPP.

Training and Qualification

LLNS has provided generally adequate training and qualification for fire protection engineers (FPEs) and alarm technicians who perform ITM of the Vortex glovebox FSSs, and for plumbers who perform ITM of the wet pipe and deluge/water spray systems. Two reviewed completed FPE qualification records adequately address requisite standards, experience, and knowledge, meeting DOE Order 420.1C, attachment 2, chapter II, section 3.d.(2)(a) requirements. All 4 reviewed alarm technician's training and qualification cards for the stand-alone fire suppression system (SAFSS) documented appropriate training on the monthly and semiannual/annual ITM procedures; the procedures were developed with assistance from a Vortex manufacturer's representative. This required training includes classroom and on-the-job training covering all requisite functional elements of the SAFSS. Training course PU6410-C, *SRP-B332-4.16.2/4.10.1.g, Semiannually, FDAS Input Switch Appliance Alarm Verification, SR* [Surveillance Requirement] *4.16.2 Annually, Increment 1 GBES* [Glovebox Exhaust System] *Spray Plenum Deluge Valves, SR 4.10.1.g*, provides a comprehensive presentation to plumbers on B332 ITM procedures that includes wet pipe and deluge/water spray systems. Increment 1 GBES is a defined area of the Radioactive Materials Area (RMA) within B332. The PU6410-C training presentation appropriately draws attention to comparing current ITM pressure and flow measurements to previous ITM results and addresses investigating measurements that have reduced by 10% or more. All 26 reviewed plumbers' training records demonstrated completion of required classroom and on-the-job training. However, the PU6410-C course title and content does not specifically identify the inclusion of the B332 wet pipe sprinkler systems. (See **OFI-LLNS-2**.)

Impairment Control and Compensatory Actions

LLNS has implemented a generally adequate impairment control program for fire protection SSCs using Policy 420.00, *Impairment of the LLNL Health and Safety Alarm*; Policy 430.00, *Automatic Sprinkler System Impairment Control & Restoration*; and Policy 1.6, *Compensatory Measures for Fire and Life Safety*. The impairment control program appropriately implements DOE Order 420.1C, attachment 2, chapter II, section 3.d.(1)(f), and applicable NFPA codes and standards, and is based on the guidance in DOE-STD-1066-2016. The impairment control program adequately describes coordination, communication, and approval requirements for planned and unplanned impairments, including the determination of appropriate compensatory actions. No completed or active impairments were in place at the time of this assessment, so the implementation of these policies and procedures could not be verified. However, the impairment control program does not address passive fire protection SSCs, including the B332 SC fire barriers. (See **OFI-LLNS-3**.)

Fire Hazards Analysis Program

LLNS has developed and implemented a generally adequate FHA program for B332. LLNS Fire Protection Engineering Standard 5.3.1, *Review of Fire Hazards Analysis*, establishes a graded approach for the FHA program and is appropriately based on DOE Order 420.1C and NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*. Issues and recommendations resulting from the most recently performed FHA have been appropriately entered into the LLNS Issues Tracking System. LLNL-MI-856684, *B332 Fire Hazards Analysis*, appropriately includes two approved exemptions and four equivalencies including the bases, approval status, and validation of approval conditions. The B332 FHA content demonstrates compliance with DOE orders, building code requirements, and industry fire protection standards addressing such elements as maximum fire loss, sprinkler systems, fire barriers, flammable and pyrophoric materials, ventilation systems, contaminated sprinkler water runoff, and fire water supply. The FHA adequately and appropriately analyzes most facility fire hazards, consistent with the current DSA. The FHA also adequately describes the fire protection SSCs (e.g., automatic fire sprinklers, fire detection and alarm, Vortex glovebox FSSs and fire barriers) and provides a conclusion with respect to the adequacy of protection.

While the program documents and FHA are generally adequate, EA identified the following weaknesses:

- Contrary to NFPA 801, LLNS procedures do not contain requirements or instructions for developing fire hazards evaluations (FHEs) for glovebox operations, and no such FHEs have been documented. (See **Deficiency D-LLNS-1**.) Incomplete integration of glovebox FHEs into the FHA could result in the omission of key fire protection controls.
- Contrary to DOE Order 420.1C, attachment 2, chapter II, section 3.f.(1), LLNS has not revised the FHA to identify the hazards associated with the recovery glovebox line (RGL) Vortex glovebox FSSs and reflect the proper safety classification of the FSS. (See **Deficiency D-LLNS-2**.) An incomplete FHA can result in the omission of necessary safety controls. The current version of the FHA does not address the RGL but addresses only the FSS for the centralized waste processing line. The FHA, sections 2.4.2 and 2.5.8, incorrectly refer to SC FSS equipment, in contrast to the SS designation in the DSA, section 4.4.5.
- The FHA does not adequately address protection of vital safety systems (VSSs) that have a safety function during or following a fire as recommended in DOE-STD-1066-2016, section B.2.11. (See **OFI-LLNS-4**.)

Combustible Controls

LLNS has adequately developed and implemented a combustible loading program through an established specific administrative control (SAC) and a facility-level fire protection procedure for B332 as required by the DSA, TSRs, and Fire Protection Engineering Standard 5.2.3, *Control of Combustible Loading*. The *Combustible Loading Limits* SAC establishes combustible levels within specific rooms of B332 to protect bounding assumptions for the design basis room fire event as analyzed in the DSA. The FPE performs periodic walkdowns to ensure that combustible loading is below what is specified in the SAC. Eight reviewed quarterly fire safety inspections for B332 were adequately performed in accordance with Fire Protection Engineering Standard 5.2.3 and ACP-B332-019, *B332 Housekeeping and Flammable/Combustible Materials Control Procedure*, and documented on ACP-B332-019, attachment 1, *Visual Inspection Checklist*.

Pre-incident Plans

The FHA generally addresses pre-fire planning with the ACFD. LLNS appropriately uses ACFD "Building and Trailer Runcards" to record important information necessary for an effective emergency response to the facility. Department Policy 30.101, *Response to Emergencies in the Superblock at Lawrence Livermore National Laboratory*, adequately addresses the procedures to ensure that unique hazards of the Superblock (e.g., criticality, pyrophoric materials) are addressed in a safe and acceptable manner; the document is appropriately signed by the Superblock Facility Representative and the Criticality Safety Division Director. LLNL-MI-856695, *B332 Runcard*, includes instructions and floor plans for an ACFD emergency response and appropriately identifies hazards and firefighting techniques for workstations within each room. The runcard is kept current (revised in September 2023) with anticipated hazards for emergency response personnel. However, contrary to NFPA 1620, *Standard for Pre-Incident Planning*, the runcard facility layout plans do not designate the primary and secondary assembly points for evacuation of facility personnel or identify the location of the main electrical power disconnect(s). (See **Deficiency D-LLNS-3**.) Not designating the primary and secondary assembly points on the runcard layout plans can complicate verification that a building is fully evacuated, and not identifying main electrical power disconnects could compromise the safety of emergency response personnel.

Facility Fire Protection Assessment

The FPPM, section 12.1.1, appropriately specifies the conduct of FHAs, which is defined as a detailed FFPA. DOE Order 420.1C, attachment 2, chapter II, section 3.f.(2)(e) requires that FFPAs be conducted annually, or at a frequency with appropriate justification approved by the DOE Head of Field Element. LFO has approved LLNS's equivalency request (COR-ESH-8/3/2016-686385, Subject: *Contract DE-AC52-07NA27344. Clause I.084, Facility Fire Protection Assessment Frequency*) to change the FFPA frequency from annual to every three years. The recent 2020 FHA adequately addresses most of the DOE-STD-1066 recommended programmatic and physical fire protection features but does not address evaluation of the FSS ITM procedures and records.

Fire Protection Program Conclusions

LLNS has established and implemented a generally adequate FPP in accordance with DOE Order 420.1C, attachment 2, chapter II, addressing policy and procedures, codes and standards, organization, training and qualification, impairment control and compensatory actions, the FHA, combustible controls, pre-incident plans, and requirements for FFPAs. However, EA identified weaknesses associated with the lack of requirements or instructions for developing FHEs for glovebox operations, omission of RGL Vortex glovebox FSS hazards in the FHA, improper safety classification of the RGL Vortex glovebox FSS, and missing information on runcard facility layout plans.

3.2 Fire Hazards Analysis and Documented Safety Analysis Integration

This portion of the assessment evaluated the integration of the B332 FHA into associated safety basis documentation, and the adequacy of fire protection controls for implementation of the facility safety bases.

Overall, LLNS has appropriately integrated LLNL-MI-856029, *Fire Hazards Analysis Building 332*, into the DSA to ensure that analyzed fire hazards are prevented or sufficiently mitigated through controls for normal, abnormal, and accident conditions. The FHA and DSA appropriately evaluate credited fire systems and associated fire scenarios, their possible locations, and the consequences of those fires. The evaluated fire scenarios and supporting conclusions in the FHA are appropriately included in the DSA

hazard evaluation and accident analysis sections in accordance with *Environmental, Safety and Health Volume V, Part 51*: *Safety Analysis, Limits, and Authorization*, Document 51.1, *Documented Safety Analysis Program Plan*. The B332 credited fire suppression alarm and barrier systems, and the combustible loading and solvent SACs, are adequately based on fire hazard identification and supporting accident analyses to ensure the 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 Safety Analysis Reports*, and 10 CFR 830.

Fire Hazards Analysis and Documented Safety Analysis Integration Conclusions

LLNS has appropriately integrated the FHA into the DSA. The DSA evaluates and analyzes accidents to adequately support the development of required controls for the prevention or mitigation of hazard events for the implementation of the facility safety bases.

3.3 Fire Protection Structures, Systems, and Components Design

This portion of the assessment evaluated design requirements, engineering, and design verification for fire protection SSCs.

Design Requirements

LLNS has established and implemented an appropriate set of fire protection system design requirements. The reviewed procedures for operating, testing, and inspecting the fire protection SSCs contain design requirements aligned with corresponding calculations. LLNS FPEs and cognizant system engineers (CSEs) demonstrated adequate knowledge of the design requirements during interviews.

Engineering

LLNS has established and implemented generally adequate programs for conduct of engineering and configuration management (CM) of fire protection SSCs. UCRL-AM-133867, *Environment, Safety and Health (ES&H) Manual*, and CMU09-000052, *NMTP Superblock System Engineering Program Manual*, appropriately incorporate requirements for fire protection design, design control, review and approval, and acceptance. Site-specific fire protection design criteria and guidance are appropriately established within the FPPM and procedure PMO.DE-PR-02, *Design and Engineering*, and implemented through the ES&H Manual, Document 2.2, *LLNL Institution-Wide Work Planning.*

Three reviewed design change packages appropriately included unreviewed safety question (USQ) determinations, identification of affected documents, engineering instructions detailing the scopes of work, SSC grade levels, materials for installation, and design requirements with NFPA code references. The USQs supporting the design change packages included adequate descriptions for the proposed activities, justifications, and screening, as required by Document 51.3, *LLNL Unreviewed Safety Question (USQ) Procedure*.

The defense-in-depth RGL Vortex glovebox FSSs include a vendor-supplied hybrid suppression system, isolation valves, nitrogen cylinders, water tanks, and manual hybrid system release stations, all of which are adequately documented in the *LLNL Fabricate and Test the Fire Suppression System for the Recovery Laboratory Gloveboxes* design drawings and specifications. The Vortex glovebox FSSs were installed using references from NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, and NFPA 750, *Standard on Water Mist Fire Protection Systems*, because no recognized standard for these systems existed at the time of installation.

The interviewed CSEs for the B332 FSS, fire detection and alarm system, and building structure (fire barriers) were qualified and knowledgeable of their systems, including the status of current maintenance activities, procurement of replacement parts, and ongoing challenges to system operability and reliability. The CSEs are qualified to Level III, meeting the LLNS training and qualification requirements established through CMU05-000095, *Superblock Training Manual*, as described in Manual 4B, *Training and Qualification Program*, and in accordance with DOE Order 420.1C and DOE Order 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities.*

LLNS has established and implemented an adequate program for routine performance monitoring of B332's VSSs as directed in CMU09-000052. VSSs are appropriately identified, and CSEs perform monthly VSS walkdowns and annual condition assessments. Five reviewed system condition assessments for the credited fire water spray and the fire barriers in B332 appropriately included metrics for system reliability, trends of key parameters, summaries of preventive and corrective maintenance, tracking of corrective action commitments, and identification of ongoing performance issues in accordance with NMTP-FMP-0212, *System Assessments, Tracking, & Trending.*

While LLNS has a generally adequate engineering program, EA identified the following weaknesses:

- Contrary to CMU09-000052, which implements DOE Order 420.1C, attachment 2, chapter II, section 3.f.(2), LLNS has not performed annual system condition assessments of the fire alarm system. (See **Deficiency D-LLNS-4**.) Incomplete system condition assessments could adversely impact the operability and reliability of VSSs. CMU09-000052 requires annual system condition assessments. LLNS has no objective evidence demonstrating the completion of this requirement for the past three years.
- Contrary to NFPA 2001 and NFPA 750, LLNS did not install the Vortex glovebox FSSs following NFPA requirements for non-listed systems or obtain AHJ approval for the use of such systems. (See **Deficiency D-LLNS-5**.) A non-listed FSS lacks the necessary acceptance testing and design or installation standards for reliable performance in extinguishing Class A, B, C, and D fires. The installed Vortex glovebox FSS design drawing (DWG.16375-FP-0001, *Lawrence Livermore National Laboratory Fabricate and Test the Fire Suppression System for the Recovery Laboratory Gloveboxes*) did not identify any FSS components as listed items and does not include an AHJ approval.
- Contrary to CMU09-000052, LLNS has not documented the design basis for the Increment 1 room bypass damper. (See **Deficiency D-LLNS-6**.) An incomplete system design and technical basis can result in an increased fire risk and adverse impact to facility operations. The system design and supporting analysis is not documented to demonstrate that the 165°F ceiling sprinklers will activate prior to the exhaust bypass opening and prevent delayed sprinkler activation. The exhaust inlets are controlled by a spring-loaded panel that is held closed by a 160°F fusible link and designed to maintain a negative pressure differential to adjacent spaces during fire conditions.
- Contrary to DOE Order 433.1B, *Maintenance Management Program for DOE Nuclear Facilities*, attachment 2, section 2.m, LLNS has not adequately planned for the replacement of the obsolete B332 fire alarm panel and emergency voice alarm system. (See **Deficiency D-LLNS-7**.) Ineffective maintenance strategies for safety systems may impact operability and the ability to perform its credited safety function. The SS Siemens MXL fire alarm panel and emergency voice alarm system is beyond its life expectancy as addressed in the *Lawrence Livermore National Laboratory Fire Protection and Life Safety Strategic Plan*. Also, spare parts for this system are no longer available through the manufacturer. The design for the system replacement and project deliverables were not well understood by interviewed alarms division, project controls, and B332 facility personnel.

Design Verification

LLNS has established and implemented an effective design verification and CM process for fire protection SSCs. CMU09-000052 appropriately ensures that CSEs are involved in design development and design changes. Three reviewed engineering design packages for SSC modifications (approved during the 2018 and 2022 timeframe) properly documented the adequacy of the fire protection design, engineering review, and independent design verification.

ES&H Manual 52.2, *Nuclear Facility Configuration Management Program*, appropriately establishes the CM program for LLNS fire protection SSCs. CMU07-000284, *NMTP Nuclear Facilities Configured System List*, provides a list of VSS and configured item systems, which are considered configured systems subject to the *NMTP Nuclear Facility Configuration Management Plan* and include all the credited fire SSCs.

Fire Protection Structures, Systems, and Components Design Conclusions

LLNS has established and implemented an appropriate set of fire protection system design requirements and generally adequate programs for FPP conduct of engineering and CM. However, EA identified weaknesses associated with LLNS not assessing the fire alarm system, not installing the Vortex glovebox FSSs following applicable NFPA requirements, not documenting the design basis for the Increment 1 room bypass damper, and not adequately planning for replacing the obsolete B332 fire alarm panel and emergency voice alarm system.

3.4 Surveillances and Inspection, Testing, and Maintenance

This portion of the assessment evaluated LLNS's TSR surveillances and ITM of fire protection systems and equipment.

TSR Surveillances

LLNS appropriately completes TSR surveillances to demonstrate that DSA-credited fire sprinkler, alarm, and fire barrier systems in B332 provide adequate fire protection for other SS SSCs, critical process equipment, and high-value property, and can prevent a major fire from impacting the remainder of the facility. The LLNS Alarms Division ITM procedures for the fire systems contain detailed steps for performing and documenting TSR surveillance requirements (SRs) to verify system operability. Acceptance criteria are well defined and serve as baseline requirements. The reviewed surveillance procedures and interviews confirmed that ITM is performed by trained personnel and supported by qualified design authority engineers to satisfy NFPA requirements. An observed simulated performance of surveillance procedure SRP-B332-4.16.2/4.10.1g, *Annual, Increment 1 GBES Spray Plenum Deluge Valves, SR 4.10.1.g*, demonstrated that ITM personnel have adequate knowledge of system operability limits and equipment control settings.

The reviewed surveillances for the credited fire water spray, fire alarm, and fire barriers for B332 performance over the past three years (water spray and fire alarm) and past four years (fire barriers/dampers) confirmed that the systems have met their respective TSR acceptance criteria as currently defined. However, contrary to DOE Order 420.1C, attachment 2, chapter II, section 3.d(1)(c) and SR 4.10.1(f), LLNS does not perform adequate visual inspections of the FSS fusible plug for the Increment 1 GBES spray plenum deluge valve for corrosion or degradation that could impact proper operation, because ITM personnel do not have the clear line of sight needed to satisfy the SRs. (See **Deficiency D-LLNS-8**.) An insufficient or incomplete surveillance can result in undetected equipment issues that may impact proper system operation.

Inspection, Testing, and Maintenance

LLNS has established and implemented generally adequate ITM work procedures associated with the Vortex glovebox FSSs and associated fire alarms, fire barriers, fire hydrants, water spray/deluge and wet pipe systems, and utility water supply system valves.

Vortex Glovebox Fire Suppression Systems and Associated Fire Alarms

The performance steps in the reviewed ITM procedures and records for the Vortex glovebox FSSs are clear and concise. The results of annual maintenance completed in January 2023 demonstrate adequate completion of ITM on the R1377 Vortex glovebox FSS in accordance with MP-B332-033, *B332 R1377 Recovery Glovebox Line (RGL) Stand Alone Fire Suppression System (SAFSS) Annual Maintenance Procedure*. Additionally, monthly maintenance records and valve system lineups completed from February 2022 through October 2023 demonstrate adequate completion.

Fire Barriers

LLNS has established and implemented specific procedures and data sheets for the ITM of fire walls, fire doors, fire dampers, and smoke dampers. The completed ITM records that EA reviewed provided clear and concise instructions and appropriate acceptance criteria, and the results were well-documented. Specifically, abnormal fire door clearance measurements that exceeded the acceptance criteria were documented, and the data sheet included recorded measurements. However, the completed data sheets (SRP-B332-4.1.1.a,b,c, *Annually and Promptly After a Major Event, Test/Inspection of the Safety-Class RMA Exit Doors and Building Structure Doors, SR 4.1.1.a,b,c*) for November 2020, November 2022, May 2023, August 2023, and September 2023 do not contain evidence of an AHJ approval or an equivalency reference for credited fire doors with clearances exceeding test/inspection acceptance criteria. (See **OFI-LLNS-5**.)

Fire Hydrants

LLNS Policy No. 320.00, *Inspection and Maintenance of Fire Hydrants*, appropriately establishes most inspection criteria for performing annual maintenance inspections of fire hydrants in accordance with the recommendations provided in NFPA codes and standards. LLNS also appropriately implements a color code for fire hydrants, as recommended by NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, to categorize them by their flow rates. The colors categorize hydrants by the gallons per minute of their flow. However, Policy No. 320.00 instructions exhibit the following weaknesses (see **OFI-LLNS-6**):

- Section II, *Procedure for Hydrant Flow Tests*, requires the use of a diffuser on the flow test hydrant to direct the stream while flowing water, precluding the use of a pitot tube to measure flow velocity "properly centered" in the stream. Additionally, instructions for hydrants with a single outlet invoke the use of a pitot tube, instead of a pressure gauge, for measuring residual pressure.
- Section III, *Procedure for Inspection and Maintenance of Hydrants*, does not provide instructions for recording the number of turns to fully close and number of turns to fully open the hydrant isolation block valve, specifying instead the approximate number of turns for valve closure. Additionally, the section does not require flowing water from the hydrant when operating the isolation block valve (open to closed) to verify confinement of water flow to the hydrant.
- The included hydrant flow and inspections field work sheet form has no provision for recording the technicians' names/signatures/date, hydrant color coding, measurement gauges (hydrant pressure gauge and pitot water flow velocity gauge) with associated calibration dates, pressure and flow

acceptance criteria, block valve number, number of turns to fully open/fully close, or verification of acceptable isolation of the hydrant when closing the block valve.

Water Spray/Deluge and Wet Pipe Sprinkler Systems

LLNS performs generally adequate ITM on the B332 water spray/deluge and wet pipe sprinkler systems. SRP-B332-4.16.2/4.10.1.g, *Semiannually, FDAS Input Switch Appliance Alarm Verification, SR 4.16.2 Annually, Increment 1 GBES Spray Plenum Deluge Valves*, *SR 4.10.1.g*, embeds generally adequate ITM procedural instructions that protect the HEPA filter banks, as well as data sheets for recording requisite performance of the GBES spray plenum deluge valves and the wet pipe sprinkler system. The data sheets appropriately include the semiannual alarm verification and the location of inspector test valves and plenum deluge valves. Associated ITM records for the last two semiannual alarm test verifications were appropriately completed and signed by the designated personnel.

Work order 518338 (completed October 14, 2022) for SRP-B332-4.16.2/4.10.1.g contains the appropriate current data sheets and the March 2022 semiannual ITM evolution data sheets, which provides the previous ITM data for results comparisons. Similarly, work order 561364 (completed March 24, 2023) contains the appropriate data sheets. However, two additional provided work orders, containing completed data sheets for semiannual and annual ITM, are each improperly entitled, IE-118, *BSS – SBK B332 Wet Sprinkler Quarterly PM (SPRINK0003-Q)*. LLNS interviewees explained that these titles are incorrect and should be reclassified as semiannual maintenance to match the frequency specified in SRP-B332-4.16.2/4.10.1.g. Additionally, SRP-B332-4.16.2/4.10.1.g's title, purpose (section 1.0), and scope (section 2.0) do not identify the inclusion of wet pipe system ITM, as embedded in this procedure.

Utility Water Supply System Valves

LLNS has demonstrated the availability of a reliable and adequate water supply for fire protection through properly maintained facility water supply valves. The DSA states that the B332 facility FSS interfaces with the LLNL domestic water supply at supervisory valves SV-04-07 and SV-4-13, as illustrated in DSA figure 4-154. Procedure SRP-B332-4.16.2/4.10.1.g, section 7.2.6.1 and the recorded data for valves SV-04-07 and SV-4-13 demonstrate the appropriate closing and opening of the valves semiannually, which is more frequent than NFPA 25 guidance.

LLNS has adequately analyzed the water utility infrastructure provided by the local community. The FPPM, section 9.6.7, states: "The LLNL water system is considered a water utility and is to be maintained in accordance with standards of the American Water Works Association [AWWA]." AWWA's Manual of Water Supply Practices M44, *Distribution Valves: Selection, Installatio*n, *Field Testing, and Maintenance*, states, in part: "All gate valves should be cycled from full open to full close and back to open at least once every five years." LLNL Policy 2.8.0, *Water Utility and Fire Protection System Water Supply*, section 5.0, adequately describes the water supply infrastructure system (assigned to the water utility using M44), and the facility fire water system (assigned to LLNS in accordance with NFPA 25). LLNS appropriately engaged a subcontractor to conduct a water system piping and valve study for *Site 200 (S200) and Site 300 (S300), Water System Piping and Valve Study [WSPVS]*, September 18, 2023 (no document number). The WSPVS provides an extensive analysis of the underground water supply distribution system and recommended, in part, that LLNS "use the total risk score and criticality classification to guide valve operation" and "develop a valve exercising frequency schedule based on the current valve criticality results."

While the LLNS facility and LLNL utility water infrastructure documentation is generally adequate, EA identified the following weaknesses:

- The FPPM, section 9.6.7, does not reference LLNL Policy 2.8.0 to provide a logical flowdown of programmatic documents.
- The WSPVS, appendix C, *S200 Valve Inventory Database*, shows all 577 valves as "last exercised" on January 1, 2023, but that date could not be validated.
- LLNS did not provide a valve exercising frequency schedule for valves TB-2-332E and TB-2-332W or any water utility ITM performance records in accordance with LLNL Policy 2.8.0, which adopts the AWWA guidance.
- LLNS did not provide any objective evidence of maintenance performed on these infrastructure water supply valves.

Surveillances and Inspection, Testing, and Maintenance Conclusions

LLNS adequately completes TSR surveillances to demonstrate that DSA-credited fire suppression, alarm, and fire barrier systems in B332 provide appropriate fire protection for critical process equipment and high-value property. Also, LLNS has established and implemented generally adequate ITM work procedures associated with the Vortex glovebox FSSs and associated fire alarms, fire barriers, fire hydrants, water spray/deluge and wet pipe systems, and utility water supply system valves. However, EA identified a weakness associated with inadequate visual inspection of the FSS fusible plug for the Increment 1 GBES spray plenum deluge valve.

3.5 HEPA Filters

This portion of the assessment evaluated whether engineering design documents and analysis applicable to the HEPA filters in the final HEPA filtration stages (FHFSs) serving the GBES are technically adequate and incorporate applicable safety design bases that demonstrate the HEPA filters will provide the required safety function.

HEPA Filter Design Requirements

LLNS has adequately identified design requirements applicable to the FHFS. Document CMU07-000320, *Building 332 System Design Description for the Final HEPA Filtration Stages*, includes applicable industry codes/standards, such as American Society of Mechanical Engineers (ASME) N509, *Nuclear Power Plant Air-Cleaning Units and Components*; ASME N510, *Testing of Nuclear Air Treatment Systems*; ASME AG-1, *Code on Nuclear Air and Gas Treatment*; and LLNS standard UCRL-AR-133354, *HEPA Filter and In-Place Leak Testing Standard*, for the design and testing of the FHFS HEPA filters. CMU07-000320 also appropriately includes applicable system requirements and performance criteria from the safety analysis. The interviewed GBES and FHFS CSEs were familiar with the requirements.

HEPA Filter Design Engineering/Analysis

LLNS conducted generally adequate evaluations of the GBES FHFS using sound engineering and scientific principles. Calculations were adequately developed using appropriate methodologies in accordance with LLNS procedure AB-006, *Safety Basis Calculation Procedure for Hazard Category 2 and 3 Nuclear Facilities*. The DSA establishes a functional requirement (4.3.2.3, #3) for the FHFS that states that the "[f]inal HEPA filtration stages for each GBES and room ventilation system shall withstand the effects of an evaluation-basis fire." However, contrary to DOE-STD-3009-94, section 3.4, which implements 10 CFR 830.204(b)(3), some LLNS safety analyses did not evaluate the adequacy of the HEPA filtration stages under postulated accident conditions. (See **Deficiency D-LLNS-9**.) If worst case

scenarios are not considered, actual dose consequences can be higher than calculated. For example:

- The calculation of maximum air temperature at the HEPA filter stages for a postulated fire is non-conservative in AB-B332-23-005, *Glovebox Exhaust (GBE) Stream Maximum Bulk Temperature Prior to Increment 1 GBE Final HEPA Filter Plenums Based on a Hypothetical Large Fire in an Increment 1 RMA Glovebox/Room*. The calculation uses an appropriate methodology to model the mixing of hot gases from the room fire with cooler air in adjacent rooms. However, the calculation non-conservatively assumes maximum adjacent rooms air flow (through exhaust fans with volumetric flowrate capacity of 2,000 cubic feet per minute (CFM)) instead of normal air flow (about 700-800 CFM as recorded in the annual in-place aerosol test data). Further, the calculation does not consider the effect of the fire on the amount of exhaust flow from the room fire, even though the DSA assumes that gloveboxes fail during a fire scenario, resulting in a significant increase in hot gas exhaust flow. Consequently, the calculated HEPA filter air temperature, assuming a significant increase in hot gas flow and normal flow from adjacent rooms, could exceed the maximum HEPA filter operating temperature, resulting in filter stage failure.
- LLNS calculation NMTP-SBK-2023-003, *Vital Safety System Operability Determination*, incorrectly assumes successful HEPA filter performance based on an Underwriters Laboratory (UL) testing per UL-586, *Standard for Safety High-Efficiency, Particulate, Air Filter Units*. This UL testing methodology does not test filters at full flow and uses only hot air. Additionally, the UL testing cools the filter before performance testing. This test protocol does not consider the postulated accident conditions of other combustion products, such as moisture and smoke. Consequently, the HEPA filter performance during the postulated fire may be degraded or fail and result in releases greater than calculated.
- The interviewed safety basis and engineering personnel explained that the impacts of smoke exposure have not been evaluated for HEPA filters, contrary to the DSA, which notes in section 4.3.2.4, *System Evaluation*, that "[s]ome loading on the HEPA filters, particularly in the first stage, from soot and smoke particles can be expected during postulated fire accident scenarios."

HEPA Filter SSC Evaluation

The HEPA filter design has been adequately evaluated and demonstrates their capability to fulfill the required safety function for temperature. The reviewed quality assurance records in the HEPA filter procurement receipt inspection package (RIP 19-055, *Receiving Inspection Package for Quality Level 1 or 2 Order*) adequately demonstrate that the HEPA filters serving the FHFS comply with the design requirements of DOE-STD-3020, *Specification for HEPA Filters Used by DOE Contractors*, and ASME AG-1. Specifically, records include evidence of successfully completed design qualification testing to demonstrate that the HEPA filters meet the required performance criteria to "withstand exposure to air at 250°F for two hours while still meeting efficiency performance."

Additionally, LLNS adequately conducts TSR surveillances (LCO 3.2.1/SR 4.2.1) to demonstrate HEPA filter operability. In general, the surveillance, frequency, and criteria are adequately defined for evaluating operability of the HEPA filters in the FHFS. Actual field testing conducted by LLNS using procedure WSH-IH-IHIL-PRO-02, *In-Service HEPA Filter Testing*, to implement SRP-B332-4.2.1.a complies with ASME N510 in-place leak testing protocols. However, contrary to ASME N510 and LLNS standard UCRL-AR-133354 (which are invoked by the DSA), DSA section 4.3.2.4, and the corresponding TSR surveillance (LCO 3.2.1(a)/SR 4.2.1.a) allow the use of in-place HEPA filter test aerosols that may contain particle size distributions that exceed those specified in these standards. (See **Deficiency D-LLNS-10**.) Use of these TSR-specified performance testing values may not ensure that DSA requirements are met, resulting in radiological dose consequences greater than assumed for a postulated design basis room fire. ASME N510 and UCRL-AR-133354 specify a particle size

distribution (99% less than 3.0 μm, 50% less than 0.7 μm, and 10% less than 0.4 μm). In contrast, the DSA and TSRs state that "The filtration efficiency for particle sizes 0.3 μm or greater [emphasis added] in diameter (0.3×10^{-6} m) shall be at least 99.9% for the first-stage filters and 99.8% for the second-stage filters," allowing the use of test aerosols with particle sizes outside this acceptable distribution and resulting in inaccurate test results. While the documentation is inadequate, the LLNS in-place HEPA filter testing is being performed with the proper aerosols that meet these standards.

HEPA Filters Conclusions

Generally, the engineering design documents and analysis applicable to the FHFS HEPA filters serving GBES are technically adequate and incorporate applicable safety design bases. LLNS has conducted generally adequate evaluations of the GBES FHFS using sound engineering and scientific principles, adequately evaluated the HEPA filter design demonstrating their capability to fulfill the required safety function for temperature, and adequately conducts TSR surveillances to demonstrate HEPA filter operability. However, EA identified weaknesses in LLNS's evaluation of HEPA filtration stages under postulated accident conditions and the DSA/TSR specifications of in-place HEPA filter test aerosols.

3.6 DOE Field Element Oversight

This portion of the assessment evaluated the adequacy of LFO's oversight of LLNS's implementation of the FPP at B332, including program and field oversight of FPP-related activities.

LFO adequately describes its operations through LFO Manual 450.2, *Functions, Responsibilities and Authorities Document for Safety Management at the Livermore Field Office* (FRA). In addition, the FRA appropriately identifies any deliverables from the referenced order/standard that must be developed by the management and operating contractor and/or approved by the field office. The FRA states that the Assistant Manager for Operations is responsible for ensuring the implementation of DOE Order 420.1C, and the Assistant Manager for ES&H has a shared responsibility for overseeing the FPP. The responsibility for oversight of the FPP is assigned to the fire protection SME, who reports to the Assistant Manager for ES&H.

LFO has established and implemented adequate processes and procedures for the oversight of the LLNS FPP at B332. LFO uses LFO Process (P) 226.1, *Risked Based Oversight*, to perform risk-based oversight of the management and operating contractor. Oversight programs include, but are not limited to, operational awareness activities, onsite reviews, assessments, self-assessments, and performance evaluations. LFO has several work instructions (WIs) in place that LFO staff use to perform oversight duties. For oversight of the LLNS FPP, LFO has developed and approved an LFO fire protection management plan (FPMP) that describes roles and responsibilities to ensure that LLNL executes a safe and effective FPP and establishes the requirements and expectation for the LFO FPE. The FPMP provides a clear integration of the requirements of DOE Order 226.1B and DOE Order 420.1C, and the guidance of DOE-STD-1066-2016. The FPMP also describes how fire protection oversight is conducted. Section 5, *Oversight Approach*, of the FPMP describes that oversight of LLNL fire protection operations consists of two levels. The primary level of oversight is conducted by Facility Representatives (FRs) using various types of assessments, including operational awareness (e.g., attending meetings, observing work/activities, performing shadow assessments) and traditional assessments, which usually consist of verifying the implementation of requirements. The secondary and higher (system) level of oversight is conducted by the LFO FPE, which includes coordinating and working with the LLNL fire protection SME on interpretation, FPP direction, and continuing improvement of procedures and requirements through work with the DOE Fire Protection Program Committee.

Roles and responsibilities for the safety system oversight engineer (SSO) are detailed in LFO P 420.1, *Safety System Oversight Program*. LFO P 420.1 states that the SSO is responsible for routine oversight operational awareness of VSSs. This includes the oversight functions of the fire protection systems that are part of the VSS assigned to the SSO, as defined by LFO P 420.1. Currently, the FPMP is the only LFO document that specifies the roles and responsibilities for oversight of fire protection safety systems at LLNL facilities, and it is not in alignment with LFO's processes and procedures that describe the oversight of LLNS's FPP. (See **OFI-LFO-1**.) The LFO oversight processes, procedures, and WIs appropriately provide for the rigor and frequency of nuclear safety oversight, including FPP oversight, tailored to facility hazards in accordance with DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*.

LFO has one FPE position to provide programmatic oversight of LLNS's FPP implementation. LFO requires that the FPE qualify to DOE-STD-1137-2014, *Fire Protection Engineering Functional Area Qualification Standard as part of the Technical Qualification Program (TQP)*. The LFO FPE completed the TQP in fire protection engineering in September 2021. During interviews and discussions, the FPE demonstrated strong fire protection experience and training.

For B332, LFO has assigned three FRs; two FRs are fully qualified, and the third FR is currently completing the TQP. FRs are appropriately qualified per both DOE-STD-1151, *Facility Representative Functional Area Qualification Standard*, and LFO P 1063.1, *Facility Representative Training and Qualification Program*, which includes generally applicable FR competencies and facility-specific appendices that FRs complete for their assigned facilities. The LFO qualification card includes competencies relating to both the B332 FPP and specific components of the facility's fire detection and suppression systems. During an interview, the B332 FR demonstrated a thorough knowledge of the FSSs and recent fire protection issues at the facility.

Currently, LFO has two SSO positions; at the time of this assessment, one position was open, and the other position was occupied by an SSO who was in the process of completing the TQP. The TQP requires that the SSO complete the requirements established in DOE-STD-8000-2021, *Safety System Oversight, Functional Area Qualification Standard*, and QS 002, *Safety System Oversight Position Qualification Program* (PSQ). During an interview, the SSO was generally knowledgeable of the FSSs and recent fire protection issues at the facility. Until LFO successfully fills the open SSO position and the current SSO becomes fully qualified, LFO has placed the following compensatory measure: "The individual(s) in TQP while conducting oversight activities shall not present to the contractor any proposed contractor direction or evaluation of the contractor without review by a qualified Senior Technical Safey Manager or qualified SSO."

LFO personnel who provide fire protection oversight are appropriately qualified (or pursuing qualifications) and sufficiently experienced to perform their roles. The FPE and SSO for fire protection systems work collaboratively with FRs and other LLNS staff to evaluate FPP implementation at B332. EA evaluated LFO assessment activities pertinent to the LLNS FPP from 2018 to 2023. Based on a review of the LFO FPP assessment results, issues were appropriately entered into the LLNS Issues Tracking System, assigned a unique number for development and tracking of corrective actions, and are effectively monitored to closure.

DOE Field Element Oversight Conclusions

Overall, LFO performs effective Federal oversight of LLNS FPP activities in accordance with DOE Order 226.1B. LFO appropriately communicates its fire protection oversight findings and monitors associated corrective action development, execution, and closure through close coordination with LLNS.

3.7 Follow-up on Previous EA Finding

This portion of the assessment examined the status and corrective actions for the finding documented in EA report *Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory, September 2021*.

Background

In 2016, a fusible plug, installed in the SS water spray system protecting the Increment 1 GBES FHFSs, had to be replaced as the result of a deficient plug found during a required inspection by LLNS technicians. The DSA, Table 4-10, includes a performance criterion for the SS FSS: "The Increment 1 GBES spray plenum fusible plugs shall be capable of activating the deluge valves in fire conditions." Section 4.4.5.4, *System Evaluation*, further explains: "The fusible plugs activate at approximately 210°F, which is lower than the maximum operating temperature of the final stage HEPA filters." LLNS fire protection personnel developed replacement component procurement documentation using like-in-kind (LIK) determination (LIK-16-002), with the replacement determined as Globe Technologies Corporation fusible plug 370017-SS, rated to 212°F +/- 10°F melting temperature. However, the procurement documentation did not specify the requirement for the fusible plug to be listed for the intended purpose by an approved organization. The manufacturer's data on the installed fusible plug indicated that the fusible plug is listed by UL for refrigerant service, but not for fire service.

Finding F-LLNS-1 of the 2021 EA report stated that LLNS did not ensure that the replacement fusible plug was listed by an approved organization as suitable for the intended purpose, as required by NFPA 15. Not ensuring the suitability of the replacement plug is contrary to quality assurance requirements (10 CFR 830.122, criterion 7) to ensure that items are procured that meet established requirements and perform as specified.

Status: The finding has since been closed by LLNS based on corrective actions.

Corrective Actions

In October 2021, LLNL personnel performed a bench test using a heat gun, a thermometer, and a 370017-SS fusible plug connected to a pipe; the plug was noted to melt when the thermometer read approximately 230°F. Further testing of the fusible plugs, performed June 2023 by UL Solutions personnel, concluded that the time required to melt the alloy inside the fusible plug was 23 minutes and 18 seconds when exposed to a constant air temperature of 325+/- 2°F at a flow velocity of 4.2 +/- 0.5 feet per second. This failed to meet the temperature sensitivity performance of a sprinkler, which brought into question the ability of the deluge system to actuate before the FHFS filters would be exposed to 250°F air. A rated temperature of 212°F was needed to ensure that the GBES air temperature did not exceed the qualification temperature of the HEPA filters of 250°F. The B332 Facility Manager promptly declared a potential inadequacy in the safety analysis, and the B332 RMA was placed in standby and did not return to operation until an operability determination was completed in accordance with NMTP-SBK-2023-003, *Vital Safety System Operability Determination*, which resulted in the FSS being "operable." This operability determination was based on the issuance of calculation AB-B332-23-005, which concluded that even if the SS water spray system did not actuate, the maximum GBES air temperature during a postulated fire would not reach 250°F. Consequently, LLNS explained that they are considering changing the classification of the system from safety-significant to defense-in-depth equipment important to safety. However, as discussed in section 3.5 of this report, the calculation of maximum GBES air temperature for a postulated fire is non-conservative, and the maximum HEPA filter operating temperature could be exceeded, resulting in filter stage failure.

EA concluded that LLNS inappropriately closed the 2021 finding. LLNS corrective actions have not ensured the suitability of the replacement fusible plug for its intended use. Consequently, there is no reasonable assurance that the replacement fusible plug would perform its intended function which is to actuate the FSS to protect the FHFS filters from a postulated fire event.

Follow-up on Previous EA Finding Conclusions

LLNS implemented its graded, structured approach to close the EA finding. However, weaknesses were identified in the corrective actions taken to address the deficient design basis for the FSS fusible plug. EA will continue to evaluate the effectiveness of corrective actions associated with this finding in future oversight activities.

4.0 BEST PRACTICES

No best practices were identified during this assessment.

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.

Lawrence Livermore National Security, LLC

Deficiency D-LLNS-1: LLNS procedures do not contain requirements or instructions for developing FHEs for glovebox operations, and no such FHEs have been documented. (NFPA 801)

Deficiency D-LLNS-2: LLNS has not revised the FHA to identify the hazards associated with the RGL Vortex glovebox FSSs and reflect the proper safety classification of the FSS. (DOE Order 420.1C, att. 2, chap. II, sec. 3.f.(1))

Deficiency D-LLNS-3: The runcard facility layout plans do not designate the primary and secondary assembly points for evacuation of facility personnel or identify the location of the main electrical power disconnect(s). (NFPA 1620)

Deficiency D-LLNS-4: LLNS has not performed annual system condition assessments of the fire alarm system. (DOE Order 420.1C, att. 2, chap. II, sec. 3.f.(2), and CMU09-000052)

Deficiency D-LLNS-5: LLNS did not install the Vortex glovebox FSSs following NFPA requirements for non-listed systems or obtain AHJ approval for the use of such systems. (NFPA 2001 and NFPA 750)

Deficiency D-LLNS-6: LLNS has not documented the design basis for the Increment 1 room bypass damper. (CMU09-000052)

Deficiency D-LLNS-7: LLNS has not developed adequate planning for replacing the obsolete B332 fire alarm panel and emergency voice alarm system. (DOE Order 433.1B, att. 2, sec. 2.m)

Deficiency D-LLNS-8: LLNS does not perform adequate visual inspections of the FSS fusible plug for the Increment 1 GBES spray plenum deluge valve for corrosion or degradation that could prevent operation. (DOE Order 420.1C, att. 2, chap. II, sec. 3.d(1)(c), and SR 4.10.1(f))

Deficiency D-LLNS-9: Some LLNS safety analyses did not evaluate the adequacy of the HEPA filtration stages under postulated accident conditions. (10 CFR 830.204(b)(3), DOE-STD-3009-94, sec. 3.4)

Deficiency D-LLNS-10: DSA section 4.3.2.4 and the corresponding TSR surveillance (LCO 3.2.1(a)/SR 4.2.1.a) allow the use of in-place HEPA filter test aerosols that may contain particle size distributions that exceed those specified in these standards. (ASME N510 and UCRL-AR-133354)

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified the OFIs shown below 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.

Lawrence Livermore National Security, LLC

OFI-LLNS-1: Consider revising LLNL-MI-856725 to reference the current FPPM (LLNL-AM-847521).

OFI-LLNS-2: Consider revising training course PU6410-C to address or clarify the inclusion of applicable B332 wet pipe FSSs.

OFI-LLNS-3: Consider addressing passive fire protection SSCs, including the B332 SC fire barriers, in the impairment control program.

OFI-LLNS-4: Consider revising the FHA to address the protection of VSSs that have a safety function during or following a fire.

OFI-LLNS-5: Consider including the AHJ review and approval for completed data sheets that contain inspection results outside defined acceptance criteria.

OFI-LLNS-6: Consider revising Policy No. 320.00 to align with recommended practices in NFPA 25 and NFPA 291.

Livermore Field Office

OFI-LFO-1: Consider revising the FPMP to include the roles and responsibilities of the SSO as stated by LFO P 420.1, to ensure adequate oversight of LLNS implementation of the FPP and management of the fire protection safety systems at LLNL facilities.

8.0 ITEMS FOR FOLLOW-UP

Because LLNS did not provide a valve exercising frequency schedule for valves TB-2-332E and TB-2-332W or any water utility ITM performance records, EA will examine maintenance performance on these water supply valves during a future LLNL fire protection assessment. Also, EA will evaluate the effectiveness of corrective actions related to the replacement fusible plug, installed in the SS water spray system protecting the Increment 1 GBES FHFSs in future oversight activities.

Appendix A
Supplemental Information

Dates of Assessment

October 23 to December 8, 2023

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