Independent Assessment of the Fire Protection Program at the Idaho National Laboratory Transient Reactor Test Facility

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Office of Enterprise Assessments
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Acronyms

AC	Administrative Control
AHJ	Authority Having Jurisdiction
BEA	Battelle Energy Alliance, LLC
BNA	Baseline Needs Assessment
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOE-ID	DOE Idaho Operations Office
EA	Office of Enterprise Assessments
FHA	Fire Hazard Analysis
FPE	Fire Protection Engineer
FPP	Fire Protection Program
FSAR	Final Safety Analysis Report
FW	Fire Water
GA	General Action
gpm	Gallons Per Minute
INL	Idaho National Laboratory
ITM	Inspection, Testing, and Maintenance
MFC	Materials and Fuels Complex
NFPA	National Fire Protection Association
OFI	Opportunity for Improvement
PIP	Pre-incident Plan
QAP	Quick Access Plan
RTS	Reactor Trip System
SSCs	Structures, Systems, and Components
TREAT	Transient Reactor Test Facility
TS	Technical Specification

INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE IDAHO NATIONAL LABORATORY TRANSIENT REACTOR TEST FACILITY

Executive Summary

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted an independent assessment of the fire protection program (FPP) at the Idaho National Laboratory (INL) Transient Reactor Test Facility (TREAT) from March to April 2023. INL is managed and operated by Battelle Energy Alliance, LLC (BEA) for the DOE Office of Nuclear Energy and is overseen by the DOE Idaho Operations Office (DOE-ID). TREAT is designed to study the response of material exposure to high neutron fluxes and extreme transient events, such as power excursions. This assessment included the evaluation of overall FPP implementation as well as FPP documentation, design documentation, and inspection, testing, and maintenance (ITM) performance.

EA identified the following strengths, including one best practice:

- BEA developed an extensive drawing of the TREAT fire barriers, floor plans, elevations, and penetration schedule that clearly identifies rated fire barrier locations, assigned penetration numbers for tracking and/or reference, and types of penetration (e.g., fire dampers, conduits, fire doors). Such detail provides readily available information on through-penetration fire-rated seals and facilitates an effective reference for appropriate ITM to ensure that fire barriers are maintained according to work instructions and design requirements. (Best Practice)
- BEA has established a generally comprehensive sitewide FPP, approved by DOE-ID to ensure the effectiveness of its fire protection activities at INL.
- BEA has developed and implemented an adequate process for developing, submitting, and maintaining FPP-related equivalencies and exemptions that is appropriately based on DOE requirements. Reviewed exemptions and equivalencies were appropriately prepared and approved by DOE-ID.
- BEA has developed and implemented an adequately integrated sitewide wildland fire management plan in accordance with relevant DOE and national standards; the plan has been approved by DOE-ID. The wildland fire exposure risk has been adequately evaluated within the fire hazard analysis (FHA) and the final safety analysis report with appropriate mitigating actions identified. Walkdowns confirmed that the specified minimum defensible space and vegetation controls were adequately maintained at the TREAT facility.
- BEA has established and implemented a generally effective ITM program that is appropriately based on applicable National Fire Protection Association standards. Most activities are properly performed to ensure that fire protection systems can meet their intended design requirements.

EA also identified several weaknesses, including one finding, as summarized below:

- BEA could not provide any documented analysis of the sprinkler systems water demand to demonstrate that the TREAT fire protection sprinkler system can perform its design basis function. (Finding)
- TREAT's facility-specific procedures do not include a monthly verification of an established administrative control to ensure that combustible materials do not accumulate in the facility.

- The BEA TREAT FHA does not fully assess the hazards of and potential damage from fire, demonstrate that compliance with applicable requirements is satisfied, or verify that fire safety objectives are met.
- BEA has not consistently documented the technical bases for important TREAT fire protection analyses and controls. These include a non-conservative analysis for the diesel transport vehicle design basis accident (fire), a non-conservative analysis for the required amount of water in the fire water (FW) storage tank, and two annual fire pump flow procedures that may not demonstrate the pumps can deliver FW as assumed in the sprinkler design basis. In addition, BEA could not provide the reactor trip system technical design basis and supporting assumptions to demonstrate that the system can perform its safety function.

In summary, BEA has established a comprehensive FPP at TREAT that is consistent with INL's overarching FPP, but this assessment identified numerous implementation weaknesses including the lack of a documented analysis of the sprinkler systems' water demand; verification of a technical safety requirement administrative control; omissions in the FHA; and some deficient engineering products. Resolution of the weaknesses documented in this report will provide further assurance that the system can fulfill its design basis function.

INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE IDAHO NATIONAL LABORATORY TRANSIENT REACTOR TEST FACILITY

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), assessed the fire protection program (FPP) at the Idaho National Laboratory (INL) Transient Reactor Test Facility (TREAT). Assessment planning and document collection began in February 2023, and onsite and remote assessment activities were conducted March 13-16, 2023, and April 17-21, 2023, respectively. This assessment was part of an ongoing review of fire protection at hazard category 1, 2, and 3 nuclear facilities across the DOE complex.

INL is managed and operated by Battelle Energy Alliance, LLC (BEA) for the DOE Office of Nuclear Energy and is overseen by the DOE Idaho Operations Office (DOE-ID). The primary buildings making up the TREAT facility include the Reactor Building (materials and fuels complex [MFC]-720) and the Control Building (MFC-724). TREAT is designed to study the response of material exposure to high neutron fluxes and extreme transient events, such as power excursions. This assessment was conducted in accordance with the *Plan for the Independent Assessment of the Fire Protection Program at the Idaho National Laboratory Transient Reactor Test Facility*, *March 2023*.

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 the INL FPP as implemented at TREAT. EA used sections of EA criteria and review approach document (CRAD) 31-12, Rev. 2, *Fire Protection Program*, including review of contractor self-assessments (objectives 4.1 and 4.5); preplanning for emergency response (objective 4.1); wildland fire management (objective 4.1); fire protection structures, systems, and components (SSCs) and design requirements (objective 4.3); inspection, testing, and maintenance (ITM) of fire protection systems (objective 4.4); and fire hazard analysis (FHA) and final safety analysis report (FSAR) integration and technical specification (TS) requirements (objectives 4.2 and 4.4). EA examined key documents, specifically 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 activities, and walked down significant portions of selected TREAT and support facilities. The focus was on the design and condition of fire protection systems, potential fire hazards and controls, including the management of transient combustibles, and other observable FPP elements. The members of the assessment team, the Quality Review Board, and the 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

This portion of the assessment evaluated the BEA FPP at TREAT, including established policy and program documents, FHA/facility assessments, equivalencies and exemptions, emergency services baseline needs assessment (BNA), pre-incident plans (PIPs), wildland fire management, and program self-assessment.

3.1.1 Policy and Program Documents

BEA has established and implemented a generally comprehensive sitewide fire protection policy and FPP to ensure the effectiveness of its fire protection activities at INL. PDD-14401, *INL Fire Protection Program*, and PRD-14401, *INL Fire Protection Program Requirements*, effectively define BEA's FPP, consistent with DOE Order 420.1C, *Facility Safety*, att. 2, chap. II. PRD-14401 directly supports the implementation of the FPP and it received DOE-ID approval per DOE Order 420.1C, sec. 5.d.(5). The FPP appropriately identifies applicable codes and standards, including DOE technical standards, building codes, National Fire Protection Association (NFPA) codes and standards, and other industry codes and standards. The FPP is implemented site wide through a collection of generally adequate procedures.

BEA, assigned as the authority having jurisdiction (AHJ) for fire protection by DOE-ID, appropriately delegated assignments to two qualified personnel. BEA assigned its Fire Marshal with responsibilities for INL facilities and operations, and its Fire Chief with responsibilities for interpreting and ensuring the implementation of NFPA codes and standards that pertain to the INL Fire Department. PDD-197, *INL Authority Having Jurisdiction Program*, adequately describes the AHJ program, and PRD-14402, *INL Fire Protection Authority Having Jurisdiction*, clearly defines roles, responsibilities, and authorities.

In support of TREAT operations, BEA has further identified a generally appropriate set of facility-specific procedures for the use, handling, and storage of combustible, flammable, hazardous, and radiological materials that implement the controls cited in HAD-470, *TREAT Fire Hazard Analysis* (FHA), and SAR/TS-420, *Transient Test Reactor (TREAT) Final Safety Analysis Report* (FSAR). However, contrary to TREAT-ADM-4942, *TREAT Facility Inspections*, secs. 1 and 2.1.5, FRM-1753, *TREAT 720 & 724 Facility Zone Monthly Inspection Checklist*, does not implement TS-420, *Technical Specifications for the TREAT Facility*, administrative control (AC) 5.7.3 for the control of combustible materials. (See **Deficiency D-BEA-1**.) Allowing combustible materials to potentially accumulate in facility areas is contrary to FSAR and FHA assumptions and can promote rapid incipient fire growth and may adversely expose reactor safety-related SSCs to fire damage. Specifically, FSAR sections 8.4.4.2, 9.6.1.3.1, 9.6.1.3.5, and 9.6.1.3.8 require critical areas (e.g., hodoscope area; diesel generator, as well as electrical and mechanical equipment rooms) to be devoid of transient combustibles. FSAR sections 3.3.2.9, 3.3.3.9, and 5.3.3.3 require combustible materials to be stringently minimized in the vicinity of reactor trip system (RTS) components and the filtration/cooling system.

Additionally, FRM-1753 does not address the following important controls for combustible materials:

- Requirement from section 6 of the FHA that the second, or upper, mezzanine of the TREAT building be devoid of transient combustibles. EA observed transient combustible materials in this area, even though this area was appropriately posted as a "No Combustibles Area." The shift supervisor and fire protection engineer (FPE) explained that these combustibles are legacy radiologically contaminated materials that predate the restart of TREAT, and facility personnel are actively working to remove them as resources allow.

- Limitations on combustible loading within TREAT basement areas that support the approved equivalency for continued use of non-fire-rated hydraulic fluids.
- Current compensatory actions associated with a missing fire damper to limit transient combustible materials within five feet on both sides of the wall for room 114.

▪ **Fire Hazard Analysis/Facility Assessments**

BEA has established an adequate FHA and facility fire protection assessment program description in PRD-14401 and MCP-14401, *Performing Fire Hazards Analysis/Facility Assessments*, which is appropriately based on the requirements in DOE Order 420.1C, att. 2, chap. II; DOE-STD-1066-2016, *Fire Protection*, secs. 7.1 and 7.2; and NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, sec. 4.3. PRD-14401, sec. 3.8.1 specifies a three-year assessment frequency approved by DOE-ID (CLN 210065), which is consistent with DOE Order 420.1C, att. 2, chap. II, sec. 3.f.(2)(e). The last triennial facility fire protection assessment for TREAT was documented in the FHA as a combined FHA/facility assessment per MCP-14401 and was appropriately performed by a qualified FPE in March 2022.

The FHA contains a concise description of the TREAT building construction, although building code construction classification is lacking, and identifies fire-rated separations as required by DOE-STD-1066-2016. Building fire areas are defined and bounded by fire-rated construction; openings are protected by appropriately rated fire doors, dampers, and penetration seals, with one exception noted below. The FHA references drawing 815065, *MFC-720 Transient Reactor Test Facility (TREAT) Fire Barriers Floor Plans, Elevations, and Penetration Schedule.* It is a series of drawings that clearly identifies rated fire barrier locations, penetration numbers assigned for tracking and/or reference, and types of penetrations (e.g., fire dampers, conduits, fire doors), and is cited as a **Best Practice**. These drawings provide details on the rated construction, penetration seal numbering (corresponding to labels in the field), and the related Underwriters Laboratory system number or drawing number. Having readily available information on through-penetration fire-rated seals facilitates an effective reference for appropriate ITM to ensure that fire barriers are maintained according to work instructions and design requirements.

While BEA's FHA/facility assessment program is adequate, EA identified implementation weaknesses discussed below. Contrary to DOE Order 420.1C, att. 2, chap. II, sec. 3.f; DOE-STD-1066-2016, secs. 7.1, 7.2, and app. B; NFPA 801, sec. 4.3.2; and MCP-14401, sec. 4.6.4 and app. A, the FHA does not adequately analyze and evaluate TREAT facility FPP implementation. (See **Deficiency D-BEA-2**.) An incomplete FHA does not fully assess the hazards of and potential damage from fire, nor does it demonstrate that compliance with applicable requirements is satisfied. An incomplete FHA does not verify that fire safety objectives are met. In addition, an incomplete facility assessment fails to critically evaluate and strengthen implementation of the FPP by identifying improvement actions and lessons learned. Specifically, EA identified the following implementation weaknesses within the TREAT FHA:

- Building Construction. Model building code construction classifications are not provided for analyzed structures in the FHA. A description of the fire-proof coating(s) applied to the MFC-720 diesel generator room building structure to achieve the stated two-hour fire-resistance rating and a basis for the MFC-720 roof assembly construction as non-combustible are not provided.
- Fire Protection of Safety-Related Equipment. The FHA lacks discussion of fire separation requirements between combustible materials (solids, liquids, and gases) and RTS components and the safety-related reactor control system. The FHA also erroneously designates the non-safety-related RTS components as safety-related.

- Life Safety Analysis/Considerations. A deficiency, or rationale for acceptability, is not cited for the legacy staging of combustible materials on the second, or upper, mezzanine of MFC-720. The FHA states that this area cannot be used for combustible storage with the single means of egress provided.
- Fire Suppression Equipment. The FHA lacks a description and evaluation of the fire protection water supply to TREAT, and a conclusion of adequacy. In addition, the FHA lacks a description of the design bases of the automatic sprinkler systems protecting MFC-720 per NFPA 13, and a conclusion of adequacy with respect to the hazard(s) protection and the available fire protection water supply (see the Finding F-BEA-1 discussion in section 3.3.1 of this report). Finally, the FHA lacks a description of the design bases for the MFC-720 and MFC-724 Novec-1230 automatic fire extinguishing systems per NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, and a conclusion of adequacy with respect to the hazard(s) protected.
- Fire Detection and Alarm Systems and Equipment. The FHA lacks a complete description of the MFC-720 fire detection and alarm system auxiliary functions, and the MFC-720 basement area oil-mist detection system, its control functions, and the interface with the fire detection and alarm system.
- Environmental Impacts (water runoff). The FHA is missing justification for the lack of retention of potentially contaminated firefighting water runoff from MFC-720, and a description of methods and materials that the fire department can deploy to manage and minimize potentially contaminated firefighting water runoff (see the related discussion in section 3.3.1 of this report).
- Emergency Response Capabilities. The FHA lacks a discussion of the basis for the MFC-720 fire department pre-incident planning document limitations on the use of water for manual fire suppression operations above the reactor and other locations, and the benefit of the FSAR, section 9.6-described, MFC-720 floor channels near the fuel storage holes.
- Fire Barriers. An evaluation of fire barrier and opening protectives (e.g., fire doors, fire dampers) ITM program adequacy as a facility assessment topic is also not provided. The FHA does not include as a deficiency the unprotected ventilation system penetration at the southwest corner of MFC-720 room 114 self-identified by BEA in January 2019 (MWP-2019-0080, *TREAT 720 Add Fire Stop Insulation to Ventilation Duct*) and the status of corrective actions (e.g., tracking per EJ 17-0009 2826-1 and work order 272261). A BEA FPE explained during the facility walkdown that a compensatory action to restrict transient combustible materials within five feet on each side of the opening was established in response to the unprotected fire barrier penetration.
- Fire Loss Potential Determination. The MCP-14401, app. B, table C1 suggested values for post-fire clean-up costs that were developed by another DOE site in the early 1990s likely underestimate current costs (e.g., escalation of the early 1990 era costs to account for inflation).
- Equivalencies and Exemptions. A description, validation of continued implementation, and status of compensatory measures and conditions of approval for each facility-specific document as an ongoing FHA narrative and a facility assessment topic is not provided.
- TREAT Combustible Loading Program. An evaluation of the effectiveness and maturity of the combustible materials control program as implemented through TREAT-ADM-4933, *Combustible Loading Program*, and TREAT-ADM-4942; a facility assessment topic is not provided.
- TREAT Fire System ITM. A discussion and the evaluation of ITM program adequacy for the fire protection water supply system supporting TREAT fire protection systems and equipment (e.g., automatic sprinkler systems, fire flow availability) is not provided as a facility assessment topic. Also, an evaluation of ITM program adequacy for the TREAT fire detection and alarm system, Novec-1230 fire extinguishing system, and oil-mist detection system is not provided as a facility assessment topic.

During walkdowns, EA observed general alignment with the facility description in the FHA with individual exceptions identified in the preceding list.

3.1.2 Equivalencies and Exemptions

BEA has developed and implemented an adequate process for developing, submitting, and maintaining FPP-related equivalencies and exemptions that is appropriately based on DOE Order 420.1C, att. 2, chap. II, secs. 3.d.(1)(j) and 3.d.(2)(c). Two reviewed facility-specific equivalencies, one facility-specific exemption, and one INL-wide equivalency associated with fire protection SSC ITM were appropriately approved by DOE-ID. Specifically:

- BEA IFM-15-003/DOE-ID-FPEQ-15-21, *Increase of Occupant Load in MFC-720 Basement*, is an equivalency to NFPA 101, *Life Safety Code*®, that appropriately addresses means of egress limitations within the basement and allows for increased occupant loading subject to specific compensatory measures. The compensatory measures include use of a posted operator aid, Basement Auxiliary Room (*BAR*) *Access Requirements*, and corresponding occupant accountability. EA observed that these compensatory measures were appropriately implemented during two different walkdowns.
- BEA IFM-16-002/DOE-ID-FPEQ-16-22, *Use of Non-Fire Rated Hydraulic Fluids in Transient Rod Drives and Compensation Rod Latches*, is an equivalency to NFPA 801 that appropriately addresses the use of non-fire-resistant hydraulic fluids within the TREAT reactor transient rod drives and compensation rod latches, subject to specific compensatory measures. Compensatory measures include a basement-area oil mist detection system with associated auxiliary functions and reporting, automatic sprinkler protection, and a combustible loading control program for the basement areas. Combustible loading is controlled through implementation of TREAT-ADM-4933 and completion of FRM-1753, although some transient combustibles were observed to be stored under the basement auxiliary room stairwell. (See **Deficiency D-BEA-1**.) These combustibles were correctly identified for removal/cleanup by the FPE during the observed quarterly combustible loading inspection.
- BEA-16-007/DOE-ID-FPEX-15-22.1, *Lack of Fire Suppression in Building MFC-720 High Bays*, is an exemption to DOE Order 420.1C and NFPA 801 that addresses the lack of automatic sprinkler protection within TREAT high bay areas. Compensatory measures include a combustible loading program and associated ACs, and infrared fire detection coverage in the non-sprinkler-protected areas. BEA technical evaluation TEV-4040, *Fire Protection Exemption Request Lack of Fire Suppression in the Building MFC-720 High Bays*, contains four DOE-approved ACs: FPE quarterly combustible loading walkdowns, restrictions and management of flammable/combustible liquids and flammable gases, combustible loading limits per facility-specific procedure, and controls on the admittance of fossil- and propane-fueled vehicles.
- DOE-ID-FPEQ-03-06.02 is a long-standing sitewide equivalency to NFPA requirements for the ITM of fire protection SSCs comprehensively summarized in PRD-14401, sec. 3.4.7, and detailed within PRD-14403, *Inspection, Testing, and Maintenance of Fire Protection Systems and Equipment*, and applicable to TREAT facilities. An evaluation of the ITM program for TREAT fire protection SSCs is discussed in section 3.4 of this report.

3.1.3 Baseline Needs Assessment

BEA has performed and maintains an adequate and comprehensive BNA of the fire protection and emergency response organizations. INL/EXT-21-62192, *INL Emergency Response Baseline Needs Assessment*, is appropriately based on DOE Order 420.1C, DOE-STD-1066-2016, DOE Order 151.1D, *Comprehensive Emergency Management System*, and the applicable requirements of NFPA codes and standards; it has been reviewed and updated within the last three years. The BNA was appropriately developed in conjunction with the INL fire protection, Fire Department, and emergency response

organizations, and DOE-ID conditionally approved it on March 4, 2022. DOE-ID conditionally approved the BNA with the expectation that BEA semi-annually report on the status of the resolutions to six open BNA recommendations.

In response to DOE-ID's conditions of approval, BEA appropriately entered the six open BNA recommendations into the BEA issues management system (CO 2022-0420 for five recommendations, and CO 2022-0421 for one recommendation) and provided two semi-annual status reports to DOE-ID (BEA letters CCN 251223 and CCN 252161) in 2022. The recommendation to revise minimum on-shift emergency medical technician staffing (general action [GA] 2022-0406) is closed within the issues management system. Issues management system entries for fire station upgrades (GA 2022-0407), apparatus replacement (GA 2022-0408), and new incident reporting software (GA 2022-0410) are closed with identified actions still outstanding. As GAs within the BEA issues management program, these BNA recommendations did not require improvement action completion or objective evidence for closure. This practice was previously cited as a finding in EA report, *Independent Assessment of the Battelle Energy Alliance, LLC Management of Safety Issues at the Idaho National Laboratory Materials and Fuels Complex, May 2022*. Fire Department leadership explained how they are actively managing these BNA recommendations, even though they are closed within the issues management system. EA will perform a follow-on assessment at the INL Materials and Fuels complex to assess corrective actions implemented as a result of the assessment mentioned above.

The BNA adequately defines and documents roles and responsibilities, command and control, communications protocols, available apparatus and equipment, emergency medical response, and training for site emergency services and the INL Fire Department. The BNA also specifies minimum fire department and emergency response staffing, apparatus and equipment requirements, tactics, and procedures appropriately based on bounding fire emergencies as described within DOE-STD-1066-2016, sec. 6.1, and NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. The BNA appropriately justifies the long-standing INL Fire Department staffing, response time, and resource equivalency approach to NFPA 1710 requirements based on site facility construction, the presence of fixed fire protection systems, apparatus flexibility, firefighter cross-training, and emergency medical service delivery approaches that have been accepted by DOE-ID. The BNA is appropriately referenced by the TREAT FHA, with the closest INL Fire Department engine company located within a four-minute response time from Fire Station 2 at the MFC site. Observed apparatus and staffing levels at Fire Station 2 were consistent with the BNA.

3.1.4 Pre-incident Plans

BEA has established and implemented generally adequate fire department pre-incident planning for TREAT that enhances the effectiveness and safety of emergency response activities. FDOP17, *Fire Department Pre-Incident Plan*, and its related SOP-2.1.3, *Incident Planning Process*, are appropriately based on DOE-STD-1066-2016, sec. 6.3, and NFPA 1620, *Standard for Pre-Incident Planning*. The INL Fire Department developed generally adequate emergency response plans for TREAT, consisting of quick access plans (QAPs) for all TREAT facilities and an additional detailed PIP for MFC-720, in accordance with DOE Order 420.1C, att. 2, chap. II, sec. 3.e.(2). INL Fire Department physical access and equipment for manual firefighting were consistent with descriptions contained within the QAPs and PIP and verified as appropriate during facility walkdowns.

INL Fire Department personnel appropriately complete routine familiarization training of TREAT as an important element of pre-incident planning. Fire Department leadership explained that crew members assigned to MFC Fire Station 2 complete a documented initial facility access tour of TREAT and then complete annual computer-based refresher training. In addition, TREAT is appropriately identified in a

fire department master list of "Target Hazard Buildings" (approximately 55 structures) that crew members are periodically scheduled for familiarization touring per SOP-2.1.3, secs. 3.8 and 3.9. Within the past two years, TREAT was one of ten "Target Hazard Buildings" scheduled for touring; participation records provided by the INL Fire Department reflect greater than 80% participation by crew members in this tour set.

While fire department pre-incident planning was generally adequate, there are inaccuracies in the following planning documents (see **OFI-BEA-1**):

- The MFC-720 QAP and PIP and the MFC-723 QAP incorrectly state that the building construction classification is Type-I fire-resistive, which is contrary to the FHA description for these structures (i.e., unprotected steel frame/truss and metal panel), which is Type-II non-combustible.
- Contrary to FDOP17, the MFC-720 PIP contains no information on site fire protection water supply availability (e.g., fire flow requirements or availability, flow and pressure capability from fire hydrants), although fire hydrant flow testing results are available (e.g., work order 00294942).
- The MFC-720 PIP shows that a maximum fire hose lay of 250 feet is applicable to this facility; however, the Fire Department did not have a rationale for this information.
- The MFC-720 PIP does not include the 80 gallons of mineral oil used for reactor shielding as a potential fire hazard, and states that a forklift is not parked within the facility (contrary to the observation cited in section 3.1.1 of this report).
- The MFC-720 and MFC-723 QAPs incorrectly state that a criticality potential is present within these facilities, whereas the TREAT FSAR and MFC-720 PIP state that no criticality concerns are present.
- The MFC-720 QAP and PIP and the MFC-723 QAP do not state that closure of post-indicator valve 3370, for control of the west side sprinkler system in MFC-720, will concurrently shut off the supply to the MFC-723 sprinkler system.
- The MFC-724 QAP incorrectly states that the building sprinkler system control valve is located in an adjacent building (it is noted as "MFC-721, room #???"), whereas the control valve is located in the MFC-724 riser room.

3.1.5 Wildland Fire Management

BEA has developed and implemented an adequately integrated sitewide wildland fire management plan in accordance with relevant portions of NFPA 1143, *Standards for Wildland Fire Management*, as required by DOE Order 420.1C, att. 2, chap. II. PLN-14401, *Idaho National Laboratory Wildland Fire Management Plan*, appropriately addresses the applicable elements of DOE-STD-1066-2016 and was approved by DOE-ID on March 24, 2022. PLN-14401 is effectively implemented at the site, and interviews confirmed that the INL Fire Department understands the site-specific wildland fire prevention and mitigation requirements for TREAT. The wildland fire exposure risk has been adequately evaluated within the FHA and FSAR with appropriate mitigating actions identified. Walkdowns confirmed that the specified minimum defensible space and vegetation controls were adequately maintained.

3.1.6 Contractor Fire Protection Program Self-Assessment

In 2021, BEA completed generally adequate FPP self-assessment reports as required by DOE Order 420.1C, att. 2, chap. II, and PRD-14401, sec. 3.12. GA 2021-0369, *INL Triennial Comprehensive Fire Protection Assessments Summary Report*, is a roll-up of 12 individual FPP topical area self-assessments completed within the prior three years; the report appropriately covers the minimum elements in DOE-STD-1066-2016, sec. 3.2.2. GA 2021-0369 was appropriately prepared under the direction of and

reviewed by an FPE, as required by PRD-14401, sec. 3.12, and DOE Order 420.1C. GA 2021-0369 also appropriately reflects the use of the INL issues management program as required by PRD-14401, sec. 3.13 by including the assigned issues management numbers. The three topical area self-assessments reviewed adequately evaluated the intended program elements. For example, ASMT 2021-0248 adequately evaluated the ITM of fire protection SSCs (primarily fire alarm and suppression systems), including representative procedures, work orders, and technician training and qualifications. However, the following weaknesses were identified in two of the reviewed topical area self-assessments:

- The BEA assessment, ASMT 2020-0186, of equivalencies, exemptions, and compensatory measure implementation mistakenly concluded that AHJ record 01-13 for the MFC-720 second, or upper, mezzanine could be retired due to a second means of egress that had been installed; however, only a single means of egress is provided.
- The BEA assessment, ASMT 2021-0253, of the FHA program, primarily associated with procedures, document approvals and management, and adherence to schedules, did not fully evaluate the technical completeness of the TREAT FHA as evidenced by the issues identified in section 3.1.2 of this report.

Fire Protection Program Conclusions

BEA has established and implemented a generally comprehensive sitewide FPP, approved by DOE-ID. BEA assigned appropriate personnel as the AHJ and identified a generally appropriate set of facility-specific procedures. BEA has established an adequate FHA and facility fire protection assessment program description and developed and implemented adequate FPP-related equivalencies and exemptions. BEA maintains a BNA and ensures that INL Fire Department personnel are familiar with TREAT as an important element of pre-incident planning. BEA has also developed and implemented an adequately integrated sitewide wildland fire management plan and completed a generally adequate triennial FPP self-assessment. TREAT fire barrier drawings were identified as a best practice. However, there are weaknesses related to controlling combustible materials, and analyzing and evaluating FPP implementation for TREAT in the FHA.

3.2 Fire Hazard Analysis Integration into the Final Safety Analysis Report

This portion of the assessment evaluated whether the TREAT FHA is integrated into the design basis documentation and evaluated the adequacy of fire safety controls for the implementation of the facility safety basis.

In general, BEA has appropriately integrated the FHA into the FSAR to ensure that analyzed fire hazards are sufficiently mitigated through controls for normal, abnormal, and accident conditions. The FHA and FSAR appropriately evaluate fire protection of safety-related equipment. The FHA adequately evaluates important potential fire scenarios for the facility, including interior (electrical/mechanical), high bay, high efficiency particulate air (HEPA) filter, sodium, and external fires. The evaluated fire scenarios and conclusions in the FHA are appropriately included in the FSAR hazard evaluation and accident analysis sections in accordance with MCP-18121, *Safety Analysis Process*. Fire safety controls are adequately based on fire hazard identification and supporting analysis to ensure the protection of workers, the public, and the environment in accordance with NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*, and 10 CFR 830, *Nuclear Safety Management*.

While the FHA and supporting technical documents are generally consistent with the FSAR, EA identified the following weaknesses:

- Contrary to 10 CFR 830.204(b)(3), *Documented Safety Analysis*, which requires the contractor to evaluate normal, abnormal, and accident conditions, the diesel transport vehicle supporting analysis

for the FHA is deficient for the design basis accident (fire) involving casks containing an experiment assembly. (See **Deficiency-D-BEA-3**.) A non-conservative FHA carried forward to an accident analysis for a design basis fire may result in an incomplete set of safety controls. This event is described in the FSAR and is bounding for TREAT fires. DOE-STD-1066-2016, app. B, sec. B.4.3 provides guidance in the development of FHAs, stating, "The quantity and associated hazards of flammable liquids and gases, as well as combustible liquids and other materials that may be found within the fire area should be factored into the analyses." Specifically:

- The FHA does not account for all potential combustible material (e.g., forklift tires, hydraulic fluid) and limits the combustible loading in the analysis to 50 gallons of diesel fuel, resulting in a four-minute fire and a heat release of approximately 35,000 kilowatts. Published fire analysis data cited at other INL facilities for similar forklift fires results in significantly higher consequences than the corresponding TREAT data when comparing the postulated four-minute fire to durations greater than an hour. Applied at TREAT, these higher consequences could result in structural damage to the high bay ceiling and subsequent flashover conditions (exposing the majority of the interior building to autoignition temperatures), a scenario that is currently not postulated in the FHA.
- Although the FSAR states that the fuel-handling casks/TREAT loop-handling casks will be damaged, the FHA does not address consequences resulting from thermal exposure to the casks.

When EA informed BEA of this weakness, the TREAT facility management appropriately evaluated the issue as a potential inadequacy in the safety analysis (PISA). BEA's subsequent actions, including discovery of new information and a PISA determination and subsequent approvals, appropriately followed procedure LWP-10801, *INL Unreviewed Safety Question Process*, and was adequately documented on the *INL USQ Process Reasonability Determination/Potential Inadequacy in the Safety Analysis (PISA)* form.

- Contrary to DOE Order 420.1C, att. 3, 3.a.(4), BEA has not developed a technical design basis to demonstrate that the RTS can perform its TS-related function. (See **Deficiency D-BEA-4**.) Without a technical basis, BEA cannot demonstrate that the RTS can ensure reactor safety limits are not exceeded during startup, steady-state, and transient operations. The FHA asserts that there are no scenarios that would adversely impact the function of SSCs with safety functions, including the RTS. Likewise, the FSAR asserts that the fire protection design for the RTS is adequate due to the separation of wires and components and the redundant features of the RTS, ensuring that fire-induced common-mode failures will not occur. However, the FHA and FSAR assertions that the fire protection design for the RTS is adequate cannot be confirmed because BEA could not provide the associated technical design basis, such as drawings that show cable separations with respect to fire barriers.

Fire Hazard Analysis Integration into the Final Safety Analysis Report Conclusions

In general, BEA has appropriately integrated the FHA into the FSAR. The TREAT FSAR evaluates and analyzes most accident events to support the implementation of the safety bases. However, the analysis for the diesel transport vehicle design basis accident (fire) is non-conservative, and BEA has not developed a technical design basis to demonstrate that the RTS can perform its TS-related function under all fire-related accident scenarios.

3.3 Design

This portion of the assessment evaluated design requirements, engineering, and design verification.

3.3.1 Design Requirements

BEA has established generally adequate fire protection design requirements. Reviewed procedures used to operate, test, and inspect the facility contained design requirements that were aligned with corresponding calculations. TREAT FPEs and cognizant system engineers demonstrated during interviews that they are familiar with the design requirements in these procedures. However, FPEs and cognizant system engineers have not validated existing analyses that produced the safety SSC requirements in these procedures, which are credited in the FSAR. Further, EA identified the following weaknesses:

- Contrary to NFPA 13, which requires the water demand of sprinkler systems to be determined by either the pipe schedule method or hydraulic calculation method, BEA could not provide any analysis of the water demand for the TREAT fire sprinkler systems. (See **Finding F-BEA-1**.) Without such an analysis, BEA cannot demonstrate that the TREAT fire protection sprinkler system can perform its design basis function. Engineering work request (EWR)-7241, *(no title)*, generated in September 2017, requested a hydraulic analysis of the TREAT fire protection sprinkler system to be produced by November 2017; however, EWR-7241 is still open with no firm completion date.
- Expectations for fire water drainage design in areas handling radioactive materials have not been addressed in accordance with NFPA 801, sec. 5.10. DOE-STD-1066 states in part, "The design objectives of both NFPA 801 and DOE-STD-1066 standards is to prevent the spread of hazardous materials via the fire suppression water. Consider incorporating the secondary containment design features into the TREAT pre-plans for facility emergency activities to minimize the spread of contaminated water." (See **OFI-BEA-2**.)

3.3.2 Engineering

EA's review of the BEA design change process used at the Advanced Test Reactor, MFC, and TREAT facilities was performed in 2022 and documented in EA report, *Independent Assessment of Safety System Management for the Advanced Test Reactor at Idaho National Laboratory, January 2023*. This 2022 assessment concluded that "BEA has established a generally appropriate conduct of engineering program framework that automates and integrates many company processes." However, this current assessment identified the following TREAT implementation weaknesses:

- Contrary to LWP-10200, *Engineering Calculations and Analysis Report*, BEA calculation TEV-4309, *MFC Fire Water Tank Capacity*, is non-conservative. (See **Deficiency D-BEA-5**.) Because of the non-conservatism, the calculated volume of water in the FW storage tank may not be sufficient to last the required 120 minutes. Specific issues with the FW supply system calculations are summarized below:
    - The TEV-4309 calculated volume of water required in the FW storage tank does not account for the FW pump-supplied water that cools the FW pump diesel engine that is then exhausted as wastewater. Vendor data specifies that 30 gallons per minute (gpm) of cooling water is required for the larger of the two diesel engines, which would be 3,600 gallons over the assumed two-hour fire duration.
    - BEA has no calculation that demonstrates that the diesel-driven FW pump required net positive suction head requirements will be met when pressure losses in the suction piping and any vortex limitations of the tank internal suction piping configuration are considered. TEV-4309 assumes that the FW pumps can remove water from the tank down to the top of the suction pipe without cavitation occurring in the pumps.
    - The TEV-4309 high-level alarm setpoint for the FW storage tank lacks a technical basis and could result in overflow. The alarm is set at 36 feet and the tank overflow pipes are at 36.5 and

36.37 feet. When the instrument error of 0.92 feet is considered, the alarm is not guaranteed to actuate until the actual water level in the tank reaches 36.92 feet. Water overflow to the ground from the 800-gpm well water pump could become a hazard to workers, especially in the winter when the water could freeze.

  - TEV-4309 contains an unverified and undocumented assumption that the potable water flow rate, based on historical information, will be no more than 100 gpm. This assumption is not periodically verified. (See **OFI-BEA-3**.)

- Contrary to NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, the two annual fire pump flow test procedures (PS-OI-56, *MFC-707 Diesel Fire Pump Operation*, and PS-OI-60, *MFC-1740 Diesel Driven Fire Pump Operation*) contain acceptance criteria for head versus flow rates that are not supported by calculations, analysis, or other engineering documents. (See **Deficiency D-BEA-6**.) Without an analytical basis, the two annual fire pump flow tests may not correctly demonstrate that the FW flow rate assumed in the sprinkler design bases can be delivered by the pumps. Specifically:
  - Test instrument accuracy is not accounted for in these two procedures, nor is the calibration of the instruments used for the pump test verified to be current.
  - Procedure PS-OI-56 tests the MFC-707 fire pump at 4,000 gpm and 6,000 gpm even though its credited flow rate is 2,000 gpm.
  - Procedure PS-OI-56, app. C, *Fire Pump Hydraulic Performance Curve*, does not contain an acceptance criteria curve.
    - Neither of these two procedures reference the system hydraulic analysis or pipe standard document where the minimum credited pump head curve is specified.
  - Procedure PS-OI-56 has a note after step 5.5.2 stating that the minimum required level in the FW tank is 22 feet, yet the design bases minimum limit is 25 feet.

3.3.3 Design Verification

BEA adequately verified the fire protection design of the modification package currently being constructed to add a hydrogen supply system to TREAT for future experiments. The hydrogen supply system design includes automatic fire detection and an automatic means of notification of facility occupants in accordance with NFPA 72, *National Fire Alarm and Signaling Code*. In accordance with PDD-10000, *Conduct of Engineering*, which governs the design change process, the modification package documented that the adequacy of the fire protection design was verified by individuals and groups other than those who performed the work.

3.3.4 Design Conclusions

BEA has established a generally adequate process for developing design requirements, producing engineering products, and performing design verification. However, weaknesses associated with design calculations and test procedures exist that result in an indeterminate design basis for the TREAT sprinkler systems.

3.4 Inspection, Testing, and Maintenance

This portion of the assessment evaluated whether BEA performs effective fire protection ITM for TREAT through defining ITM requirements, conducting visual inspections, and maintaining the water supply system to ensure that fire protection systems will operate and perform as designed. BEA has established

and implemented a generally effective ITM program. PDD-14401 effectively defines BEA's ITM requirements in accordance with DOE Order 420.1C, att. 2, chap. II, sec. 3.d.(c). PRD-14403 provides adequate implementation instructions to ensure the proper operability of fire protection systems, equipment, and features as designed in accordance with NFPA codes and standards.
BEA performs generally effective ITM for TREAT fire protection and life safety SSCs, appropriately based on NFPA codes and standards and DOE requirements. The ITM of the fire alarm system, clean agent suppression and facility portable fire extinguishers, and FHA-designated fire barriers and associated opening protectives (doors, dampers, and penetrations seals) are generally consistent with NFPA requirements.

The ITM program for water-based fire protection systems (automatic sprinklers and the supporting two-main water supply system) is appropriately based on NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, and generally well documented. Interviews and reviewed training records for the Life Safety System supervisor and two technicians demonstrate that they have an adequate level of fire system knowledge and are qualified in accordance with PDD-241, *Life Safety Systems Training and Qualification Program*. Twelve completed maintenance work orders demonstrated that the system engineer and FPE adequately reviewed identified ITM deficiencies and recommended compensatory measures.

Twenty-six reviewed ITM documents completed over the past five years for the fire alarm and FW system (semi-annual and annual), clean agent suppression (semi-annual, annual, and five-year), facility portable fire extinguishers (monthly and annual), and FHA-designated fire barriers (monthly, annual, and 4-year) demonstrated that NFPA-prescribed testing is being performed in accordance with facility procedures. However, contrary to NFPA 72, 25, and 80 (*Standard for Fire Doors and Other Opening Protectives*), test requirements for the fire alarm system, wet pipe sprinkler system, and fire dampers are not being met. (See **Deficiency D-BEA-7**.) Specifically:

- The TREAT hydraulic oil mist detector annual preventative maintenance (MWO 324117, *TREAT Hydraulic Oil Mist Detector*) did not include verifying receipt of the alarm signal within 90 seconds and ensuring that area notification devices operate in accordance with NFPA 72 requirements. The defense-in-depth oil mist detection system detects concentrations below combustible levels and automatically shuts off the lube oil pumps (which scrams the reactor) and closes the filtration/cooling system bypass valve to reduce the risk of fire. Omission of NFPA 72 test criteria may affect the required minimum time for transmission of fire alarms/signals and dispatching of emergency personnel.
- The wet pipe sprinkler system main drain test (MWO 242697-01, *3M Wet System Main Drain Test*) did not evaluate the static pressure conditions to reduce the risk for potential obstructions within the FW supply piping, as required by NFPA 25. By not recording the static pressure before performing the two-inch main drain test, BEA cannot take advantage of a measurement that provides an indicator for potential obstructions to the FW supply.
- The 4Y Reactor fire damper test is not currently tested with design air flow conditions (MWO 114969, *4Y TREAT Reactor Fire Damper*) as required by NFPA 80. Without testing the dynamic fire dampers with the design air flow, BEA cannot ensure that the increased resistance will not affect the performance of the damper to fully close.

Inspections, Testing and Maintenance Conclusions

The ITM program for TREAT is generally effective and appropriately based on NFPA 72, 25, and 80. Most ITM activities are properly performed to ensure that fire protection systems can meet their intended design requirements. However, there are weaknesses in the application of testing criteria.

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 practice was identified as part of this assessment:

- BEA developed an extensive drawing of the TREAT fire barriers, floor plans, elevations, and penetration schedule that clearly identifies rated fire barrier locations, assigned penetration numbers for tracking and/or reference, and types of penetration (e.g., fire dampers, conduits, fire doors). Such detail provides readily available information on through-penetration fire-rated seals and facilitates an effective reference for appropriate ITM to ensure that fire barriers are maintained according to work instructions and design requirements. Drawing 815065 clearly identifies rated fire barrier locations, assigned penetration numbers for tracking and/or reference, and types of penetrations (e.g., fire dampers, conduits, fire doors).

5.0 FINDINGS

Findings are deficiencies that warrant a high level of attention from management. If left uncorrected, findings could adversely affect the DOE mission, the environment, the safety or health of workers and the public, or national security. DOE line management and/or contractor organizations must develop and implement corrective action plans for findings. Cognizant DOE managers must use site- and program-specific issues management processes and systems developed in accordance with DOE Order 226.1, *Implementation of Department of Energy Oversight Policy*, to manage the corrective actions and track them to completion.

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Finding F-BEA-1: BEA does not have an analysis of the water demand for the TREAT fire sprinkler systems. (NFPA 13)

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.

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Deficiency D-BEA-1: BEA checklist FRM-1753 does not implement SAR/TS-420 AC 5.7.3 for the control of combustible materials. (TREAT-ADM-4942, secs. 1 and 2.1.5; FSAR secs. 8.4.4.2, 9.6.1.3.1, 9.6.1.3.5, 9.6.1.3.8, 3.3.2.9, 3.3.3.9, and 5.3.3.3)

Deficiency D-BEA-2: The BEA TREAT FHA does not adequately analyze and evaluate FPP implementation. (DOE Order 420.1C, att. 2, chap. II, sec. 3.f; DOE-STD-1066-2016, secs. 7.1, 7.2, and app. B; NFPA 801, sec. 4.3.2; MCP-14401, sec. 4.6.4 and app. A)

Deficiency D-BEA-3: BEA's diesel transport vehicle supporting analysis for the TREAT FHA is non-conservative for the design basis accident (fire) involving casks containing an experiment assembly. (10 CFR 830.204(b)(3) and DOE-STD-1066-2016, app. B, sec. B.4.3)

Deficiency D-BEA-4: BEA has not developed a technical design basis to demonstrate that the RTS can perform its TS-related function. (DOE Order 420.1C, att. 3, 3.a.(4))

Deficiency D-BEA-5: BEA calculation TEV-4309 for the required amount of water in the FW storage tank is non-conservative. (LWP-10200)

Deficiency D-BEA-6: BEA's two annual fire pump flow test procedures (PS-OI-56 and PS-OI-60) contain acceptance criteria for head versus flow rates that are not supported by calculations, analysis, or other engineering documents. (NFPA 20)

Deficiency D-BEA-7: BEA did not ensure that test requirements for fire alarm and notification devices, wet pipe sprinkler system main drain, and annual fire damper tests were met. (NFPA 72, 25, and 80)

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.

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OFI-BEA-1: Consider revising the current MFC-720, MFC-723, and MFC-724 pre-incident planning documents to (1) accurately reflect the building construction classification of MFC-720 and MFC-723, (2) provide fire flow availability for TREAT facilities, (3) clarify hazards, and (4) provide the accurate fire protection system control valve location for MFC-724.

OFI-BEA-2: Consider incorporating the secondary containment design features into the TREAT pre-plans for facility emergency activities to minimize the spread of contaminated water. DOE-STD-1066 states in part, "The design objective of both NFPA 801 and DOE-STD-1066 standards is to prevent the spread of hazardous materials via the fire suppression water. The design basis for the secondary containment should be documented and incorporated into the pre-fire plans to facilitate emergency activities to minimize the spread of contaminated water."

OFI-BEA-3: Consider periodically verifying the potable water flow rate assumption of 100 gpm, as documented in calculation TEV-4309. This flow rate can be calculated using available data from the plant control system (i.e., amount of water that the well pump adds to the tank divided by the number of minutes since the last well pump operation).

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: March 13-17, 2023
Remote Assessment: April 17-21, 2023

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