Independent Assessment of the Fire Protection Program at the Oak Ridge National Laboratory High Flux Isotope Reactor

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Office of Enterprise Assessments
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Table of Contents

Acronyms

ACTS	Assessment and Commitment Tracking System
BNA	Baseline Needs Assessment
CAHJ	Contractor Authority Having Jurisdiction
CCA	Combustible Control Area
CFR	Code of Federal Regulations
CM	Corrective Maintenance
CNS	Cold Neutron Source
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FHA	Fire Hazards Analysis
FPE	Fire Protection Engineer
FPEA	Fire Protection Engineering Assessment
FPP	Fire Protection Program
FSSC	Fire Safe Shutdown Capability
HA	Hazards Analysis
HFIR	High Flux Isotope Reactor
ITM	Inspection, Testing, and Maintenance
JN	Judgement of Need
MPFL	Maximum Possible Fire Loss
NFPA	National Fire Protection Association
OFI	Opportunity for Improvement
ORNL	Oak Ridge National Laboratory
OSO	ORNL Site Office
PFP	Pre-fire Plan
PHRAT	Plant Health and Reliability Action Tracking
PM	Preventive Maintenance
PRA	Probabilistic Risk Assessment
SAR	Safety Analysis Report
SSCs	Structures, Systems, and Components
SSECCA	Shutdown Equipment Combustible Control Area
TSR	Technical Safety Requirement
UT-Battelle	UT-Battelle, LLC
VESDA	Very Early Smoke Detection Apparatus

INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE OAK RIDGE NATIONAL LABORATORY HIGH FLUX ISOTOPE REACTOR

Executive Summary

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted an independent assessment of the fire protection program at the Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR) on June 5-15, 2023. This assessment evaluated the effectiveness of the contractor in managing and maintaining the HFIR fire protection program and processes. UT-Battelle, LLC (UT-Battelle) manages and is the primary operator of ORNL for the DOE Office of Science. The DOE ORNL Site Office (OSO) oversees UT-Battelle operations and activities at ORNL.

EA identified the following strengths:

- UT-Battelle has established and implemented a comprehensive fire protection program at HFIR.
- UT-Battelle has established and implemented an effective sitewide impairment control program for fire protection systems.
- UT-Battelle effectively controls combustible materials at HFIR.
- The HFIR fire hazards analysis and safety basis documents are well integrated.
- The Plant Health and Reliability Action Tracking tool is effectively used at HFIR to compile, risk score, track, prioritize, and report reliability threats, including age-related system degradation, component aging, and obsolete systems or components.

EA also identified several weaknesses, as summarized below:

- UT-Battelle has not submitted an exemption request to OSO for the Building 7900 second floor fire area, which lacks required fire protection features to address the large maximum-possible-fire-loss value in this area.
- UT-Battelle does not use a formal issues management process to track all judgements of need and recommendations resulting from baseline needs assessments.
- UT-Battelle has not included all required information associated with fire protection features, specific hazards, and utility disconnect locations on the pre-fire plan drawings for Buildings 7900 and 7977.

In summary, UT-Battelle has implemented an effective fire protection program at HFIR. The identified weaknesses do not substantially detract from the overall effectiveness of the program. Addressing the weaknesses identified by EA will further strengthen UT-Battelle's fire protection program at HFIR.

INDEPENDENT ASSESSMENT OF THE FIRE PROTECTION PROGRAM AT THE OAK RIDGE NATIONAL LABORATORY HIGH FLUX ISOTOPE REACTOR

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 Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR). The assessment was conducted on June 5-15, 2023.

Consistent with the *Plan for the Independent Assessment of the Fire Protection Program at the Oak Ridge National Laboratory High Flux Isotope Reactor, June 2023*, this assessment evaluated the effectiveness of ORNL in managing and maintaining the FPP and related processes, including pre-planning for fire emergency response; integration of the fire hazards analysis (FHA) with the safety basis documents; design and implementation of engineered design features for fire protection; technical safety requirement (TSR) surveillances; inspection, testing, and maintenance (ITM) of fire protection systems; and contractor self-assessments of the program.

UT-Battelle, LLC (UT-Battelle) manages and is the primary operator of ORNL for the DOE Office of Science. The DOE ORNL Site Office (OSO) oversees UT-Battelle operations and activities at ORNL. HFIR is a DOE hazard category 1 nuclear facility designed to provide a source of high thermal neutron fluxes to produce transuranic elements. HFIR is a highly enriched, light-water moderated reactor that operates at 85 megawatts (thermal). It is the highest flux reactor-based source of neutrons for condensed matter research in the United States and provides one of the highest steady-state neutron fluxes of any research reactor in the world. The thermal and cold neutrons produced by HFIR are used to study physics, chemistry, materials science, engineering, and biology.

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 FPP's implementation at HFIR. EA used the following sections of EA Criteria and Review Approach Document (CRAD) 31-12, Revision 2, *Fire Protection Program*: FP. 1, FP. 2, FP. 3, FP. 4, FP. 5, and FP. 6.

EA examined key documents, such as system descriptions, work packages, procedures, manuals, analyses, policies, and training and qualification records. EA also interviewed key personnel responsible for developing and executing the associated programs, observed fire protection-related activities, and walked down significant portions of HFIR. 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 whether UT-Battelle established and implemented an effective FPP, including policy and administration documents, implementing procedures, equivalencies and exemptions, an FHA, building fire protection assessments, a baseline needs assessment (BNA), and pre-incident plans.

Fire Protection Program Policy and Administration Documents

UT-Battelle has established and implemented a comprehensive sitewide policy and FPP to ensure the effective implementation of ORNL FPP requirements in accordance with DOE Order 420.1C, *Facility Safety*, attachment 2, chapter II; DOE-STD-1066-2016, *Fire Protection*; applicable National Fire Protection Association (NFPA) codes and standards; and other applicable industry codes and standards. OSO approval of the UT-Battelle 10 CFR 851, *Worker Safety and Health Program*, appropriately includes approval of the FPP in accordance with DOE Order 420.1C, section 5.d.(5). The roles, responsibilities, and limitations of fire protection authorities having jurisdiction as delegated to UT-Battelle are adequately documented in the OSO Letter of Technical Direction (*Contract Number DE-AC05-00OR22725, Letter of Technical Direction Concerning Fire Protection (FP)*) and appropriately incorporated into FPP documents and procedures.

Implementing Procedures

UT-Battelle implements the FPP through a collection of sitewide procedures that appropriately address housekeeping, handling and storage of combustible materials, flammable and combustible liquids, compressed gases, radiological and hazardous materials, "hot work" and ignition source control, design control and configuration management, and ITM. Standards-Based Management System (SBMS) Program Description - *Fire Protection*, Revision January 2023, adequately defines the FPP staffing, resources, roles and responsibilities, and training appropriate for effective FPP implementation.

ADM-0405, *HFIR Fire Protection*, appropriately invokes the sitewide FPP procedures and implements an adequate facility-level fire protection safety management program for the HFIR facilities. ADM-0405 adequately addresses the requirements of the HFIR safety analysis report (SAR), cold neutron source (CNS) documented safety analysis (DSA), TSRs, and NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*. ADM-0405 and MMP-1402, *Fire Hazard Work Controls*, appropriately establish facility-specific FPP requirements.

The HFIR combustible materials control program is an appropriate key element of the HFIR FPP for the protection of fire safe shutdown capability (FSSC). ADM-0405 appropriately identifies the HFIR and CNS buildings as limited combustible areas as part of an overall strategy to minimize combustibles and eliminate them, where possible. Furthermore, specific facility areas are appropriately designated as safe shutdown equipment combustible control areas (SSECCAs) or combustible control areas (CCAs) for enhanced control of transient combustible materials. SSECCAs and CCAs are appropriately designated by markings and posted limitations determined by the fire protection engineer (FPE) and approved by operations. Observed facility conditions of SSECCAs and CCAs were consistent with postings.

HFIR personnel demonstrated effective implementation of combustible material control procedures. HFIR operators appropriately reviewed combustible material controls within SSECCAs and CCAs during observed shift checks in accordance with ADM-0152, *HFIR Operations Shift Checklist*. The ORNL fire department also evaluates combustible materials management through completion of monthly

documented fire safety/prevention inspections of the HFIR and CNS buildings. Four previous ORNL fire department *Fire Prevention Inspection Reports* for inspections conducted between November 2022 and February 2023 at the HFIR and CNS buildings identified no adverse concerns with respect to combustible materials management.

Equivalencies and Exemptions

UT-Battelle has established and implemented an adequate process for the development, submission, and maintenance of FPP-related equivalencies and exemptions. SBMS Program Description - *Fire Protection* adequately describes the process for developing and submitting FPP-related equivalencies and exemptions in accordance with DOE Order 420.1C. One sitewide equivalency associated with FP ITM is applied at HFIR.

SBMS Program Description - *Fire Protection* and EMD-P-FPP-07, *UT-Battelle Fire Protection AHJ Determination Process*, define a generally adequate process for performing and documenting delegated contractor-authority-having-jurisdiction (CAHJ) determinations. EMP-P-FPP-08, *Fire Protection Deficiency Rating System*, provides an effective five-level approach for risk rating and dispositioning issues through CAHJ determinations. The OSO Letter of Technical Direction specifies OSO as the approval authority for Level I (imminent) and Level II (serious) issues and that UT-Battelle will engage OSO on the proposed disposition of Level III (moderate) issues. Further, CAHJ determinations may be completed and approved by UT-Battelle without OSO engagement or approval for issues considered to be Level IV (code noncompliance, less serious) or Level V (technical deficiency, non-serious). However, the EMP-P-FPP-08 description of Level IV deficiencies inappropriately includes large-loss-potential (high dollar loss) issues derived from DOE Order 420.1C, attachment 2, chapter II, section 3.c.(2) for property protection thresholds. As a result, this risk rating methodology would allow a CAHJ determination for a high-dollar-loss issue without DOE engagement or approval instead of a required exemption approved by OSO and DOE Program Secretarial Officer. (See **OFI-UT-Battelle-1**.)

The reviewed FHA (ORNL/RRD/INT-122, *Fire Hazards Analysis for the High Flux Isotope Reactor, Building 7900, and Cold Source Equipment Building, Building 7977*) and building fire protection assessment demonstrated that HFIR CAHJ determinations are appropriately reviewed for continued applicability, sustainment of compensatory measures, and completion of embedded commitments. The FHA clearly identified the FPP compliance approach for HFIR, which relies on 6 legacy CAHJ deviations for specific facility conditions and 28 CAHJ determinations. Selected elements of the approved sitewide performance-based equivalency to NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, and NFPA 72, *National Fire Alarm and Signaling Code*, are appropriately applied in combination with a related CAHJ determination, forming the basis of the HFIR fire protection ITM program.

Fire Hazards Analysis

UT-Battelle has developed and implemented a generally adequate FHA for HFIR facilities in accordance with EMD-P-FPP-03, *Fire Hazards Analysis Internal Operating Procedure*, and appropriately based on the applicable requirements of DOE Order 420.1C, DOE-STD-1066-2016, and NFPA 801. The FHA for HFIR facilities was documented through the combination of ORNL/RRD/INT-122 and ORNL/RRD/INT-151, *High Flux Isotope Reactor (HFIR) Fire Safe Shutdown Capability*; both documents are current. The HFIR FHA and FSSC adequately analyze facility fire hazards; define the design basis of fire protection structures, systems, and components (SSCs) (fire sprinkler and standpipe systems, fire detection and alarm/notification systems, fire barriers, life safety SSCs, fire extinguishers, and other features); describe the supporting fire protection water supply; and provide a conclusion with respect to the adequacy of protection based on the hazards protected. Issues, deficiencies, and recommendations resulting from the

last HFIR FHA (September 2022) and FSSC (August 2019) were adequately entered into the UT-Battelle issues management program (i.e., Assessment and Commitment Tracking System, or ACTS), where they are tracked until closure. However, contrary to DOE Order 420.1C, attachment 2, chapter II, sections 3.c.(2)(d) and (e), the OSO Letter of Technical Direction, and SBMS Program Description - *Fire Protection*, sections 4.3.3, 4.5.1, 4.5.2, and 4.5.5, two property protection noncompliances for Building 7900 were partially dispositioned in the FHA as a CAHJ determination instead of a DOE directive exemption request approved by DOE. (See **Deficiency D-UT-Battelle-1**.) The lack of an approved exemption request for property protection noncompliances precludes the formal risk transfer from UT-Battelle to DOE in the following ways:

- FHA section 6.4 designates the second floor of Building 7900 as a fire area with a maximum possible fire loss (MPFL) of $450 million, which exceeds the DOE Order 420.1C, attachment 2, chapter II, section 3.c.(2)(e) limitation of $412 million (in 2018 dollars). This noncompliance was inappropriately dispositioned in FHA section 8.3.7 as a CAHJ determination (EMD-P-FPP-008 Level IV code noncompliance) instead of a DOE exemption.
- The FHA does not address the lack of additional/redundant fire protection for the second-floor fire area, which has an MPFL of more than $177 million (in 2018 dollars), as required by DOE Order 420.1C, attachment 2, chapter II, section 3.c.(2)(d).

Building Fire Protection Assessments

UT-Battelle has developed and implemented a generally adequate building fire protection assessment program for HFIR facilities in accordance with EMD-P-FPP-02, *Fire Protection Building Assessment Program*, and appropriately based on the applicable requirements of DOE Order 420.1C and DOE-STD-1066-2016, section 7.2. SBMS Program Description - *Fire Protection* appropriately requires building fire protection assessments, known as fire protection engineering assessments (FPEAs), to be completed annually for the HFIR and CNS buildings. Because the HFIR SAR requires the HFIR FHA to be reviewed and updated annually, the current FPEAs for HFIR buildings were effectively incorporated into the current FHA update as a combined document.

While the FPEA aspects of the HFIR FHA were generally adequate, EA identified the following weaknesses:

- FHA section 3.7 does not include the ITM status of the following SSCs as part of the FPEA ITM program topical area (see **OFI-UT-Battelle-2**):
    - HFIR fire protection water supply control valves
    - HFIR facility portable fire extinguishers
    - HFIR facility dry-pipe fire sprinkler system air compressors
    - Building 7991 dry chemical fire extinguishing system
    - HFIR and CNS oxygen concentration and hydrogen gas detection devices and alarms
    - HFIR facility public address system (occupant emergency notification).
- The FHA does not address the potential facility-specific impact to fire detection and alarm system reliability and any associated compensatory actions as an FPEA ITM program topical element. The issue of incomplete annual testing of the HFIR fire detection and alarm system under battery power was self-identified within the ORNL fire department BNA. (See **OFI-UT-Battelle-3**.)

Baseline Needs Assessment

Emergency Services

UT-Battelle has performed and maintains a comprehensive OSO-approved BNA of the ORNL fire department and emergency services. ORNL/LPD-FD/PLAN-002, *Oak Ridge National Laboratory Fire Department Baseline Needs Assessment*, appropriately addresses the requirements in accordance with DOE Order 420.1C, attachment 2, chapter II, section 3.e.(1), DOE-STD-1066-2016, section 6.1, and the applicable requirements of NFPA codes and standards, and has been reviewed and updated within the last three years. The BNA adequately defines and documents roles and responsibilities, command and control, communications protocols, available apparatus and equipment, emergency medical response, and training for the ORNL fire department and site emergency services. The BNA also specifies minimum on-shift fire department and emergency response staffing, apparatus and equipment requirements, tactics, procedures, and mutual aid agreements appropriately based on bounding fire emergencies. The BNA appropriately justifies the ORNL fire department staffing and resources in accordance with DOE-STD-1066-2016, section 5.2.1, and NFPA requirements, with seven stated "Accepted Risks" that have been approved by OSO.

A walkdown of ORNL Fire Station Building 7130 confirmed that station staffing, apparatus inventory, and equipment are consistent with most BNA descriptions. HFIR is approximately two miles from Fire Station Building 7130, which is within a five-minute response time according to the BNA. Emergency response conclusions from the BNA were adequately incorporated into the FHA. Notably, since release of the current BNA, ORNL has placed into service a new aerial apparatus unit that enhances fire department response capabilities.

Open BNA improvement actions, identified as judgements of need (JNs) or recommendations, assigned to the ORNL fire department are being appropriately managed within the UT-Battelle issues management program. However, contrary to SBMS Program Description – *Fire Protection*, section 3.0, JNs and recommendations associated with the ORNL Hazardous Materials Response Team are not being managed within ACTS. (See **Deficiency D-UT-Battelle-2**.) Using the UT-Battelle issues management program ensures that all the BNA JNs and recommendations are thoroughly addressed in a timely manner.

ITM Services

The BNA adequately describes the roles, responsibilities, and resources of the ORNL fire department, as well as the resources supplied by other organizations, with respect to performing assigned ITM of fire protection SSCs and equipment. The BNA also appropriately self-identifies that annual testing of fire alarm systems under battery power per NFPA 72, table 14.4.3.2, item 8, is not being routinely performed due to the lack of fire alarm electrician availability during non-business hours when ITM considered disruptive to building occupants is generally performed. Although this NFPA 72 noncompliance has been identified in the ITM staffing plan as a JN (JN1, ACTS 43834.1), no associated evaluation of risk or identification of compensatory actions or alternative test methods has been implemented since November 2021, when the BNA was issued. (See **OFI-UT-Battelle-4**.) This annual test has not been performed for an extended period, with no clear timeline for restarting this specific NFPA 72 testing requirement.

Pre-Incident Plans

The ORNL fire department has developed and implemented a generally adequate pre-incident planning program that enhances the effectiveness and safety of emergency response activities. LPD-FD-ADM-020104, *Pre-Fire Plans* [PFPs], appropriately implements the pre-incident planning program in accordance with DOE-STD-1066-2016, section 6.3, and NFPA 1620, *Standard for Pre-Incident*

Planning. ORNL PFPs are appropriately subject to input and review by FPEs and facility subject matter experts to enhance the safety and effectiveness of emergency response activities.

The PFPs for HFIR (Building 7900) and CNS (Building 7977) adequately considered credible fire scenarios and established appropriate tactics and strategies for effective emergency response. Physical access and equipment for manual firefighting were consistent with descriptions within the HFIR and CNS PFPs and were verified during facility walkdowns. However, contrary to NFPA 1620, sections 5.2.2 and 5.3.2, and LPD-FD-ADM-020104, section 5.1, HFIR PFP site and floor plan drawings did not address the following six observed conditions (see **Deficiency D-UT-Battelle-3**):

- The locations of the Building 7900 interior fire barriers/walls were not indicated on floor plan drawings. (NFPA 1620, section 5.2.2.2(1))
- The locations of hydrogen compressed gas cylinders at the 7977A pad were not indicated on Building 7900 and 7977 site drawings. (NFPA 1620, section 5.3.2.6, and LPD-FD-ADM-020104, section 5.1)
- The locations of the main and backup diesel generator electrical disconnects for Building 7900 were not indicated on the site drawing. (NFPA 1620, sections 5.3.2, 5.3.2.4, and 5.3.2.4.1(6), and LPD-FD-ADM-020104, section 5.1)
- The locations of potable water control valves 08-1040 (Building 7900) and 08-1571 (Building 7977) were not indicated on site drawings. (NFPA 1620, section 5.3.2.5, and LPD-FD-ADM-020104, section 5.1)
- Designation of Building 7900 fire sprinkler riser numbers and associated fire department connections is incomplete on the site drawing. (LPD-FD-ADM-020104, section 5.1)

Initial emergency response to an HFIR event could be negatively impacted if PFPs contain incomplete information.

Fire Protection Program Conclusions

UT-Battelle has established and implemented a comprehensive sitewide policy and FPP approved by OSO, assigned an appropriate individual as the fire protection CAHJ, and implemented an adequate set of sitewide and facility-specific FPP procedures. UT-Battelle has completed a generally adequate FHA and building fire protection assessment for HFIR facilities, developed and implemented an adequate FPP-related equivalency and other compliance documents in support of the HFIR FPP, maintains a comprehensive BNA, and implements a generally adequate pre-incident planning program. However, EA identified weaknesses associated with inadequate fire protection deficiency risk rating of high-dollar-loss compliance issues, incomplete processing of exemptions, missing ITM evaluations, incomplete issues management program entries of BNA improvement actions, lack of risk evaluations for self-identified issues with respect to ITM for HFIR and facilities across the site, and incomplete information on PFP drawings.

3.2 Fire Hazards Analysis and Safety Basis Integration

This portion of the assessment evaluated whether UT-Battelle has integrated the FHA into the safety basis documentation and evaluated the adequacy of fire safety controls for the implementation of the facility safety basis.

UT-Battelle has appropriately integrated the FHA into the respective safety basis documents to ensure that analyzed fire hazards are prevented or sufficiently mitigated for normal, abnormal, and accident conditions. The current DOE-approved safety basis documents for Buildings 7900 and 7977 are

ORNL/HFIR/SAR-2344, *High Flux Isotope Reactor Safety Analysis Report (SAR)*; ORNL/RRD/INT-138, *High Flux Isotope Reactor Cold Neutron Source Documented Safety Analysis (DSA)*; and ORNL/TM-12841, *High Flux Isotope Reactor Technical Safety Requirements (TSRs)*. The HFIR FHA adequately evaluates important fire scenarios, their possible locations, and the consequences of those fires on the reactor and its operation. The FHA fire scenarios include diesel spills in the reactor bay, fire in the main control room, and fires involving the hydrogen storage vessel. The FHA appropriately cites ORNL/RRD/INT-36, *High Flux Reactor Probabilistic Risk Assessment (PRA)*, as guidance for estimating the frequency category of events that deal with fuel damage.

Further, fire hazards are appropriately considered as initiators for certain scenarios in the hazards analysis (HA) (ORNL/RRD/INT-123, *High Flux Isotope Reactor Hazard Analysis and Facility Classification*). The HA appropriately documents the evaluation of radiological and non-radiological hazards for HFIR. The HA appropriately identifies required safety significant and safety class SSCs and administrative controls for preventing or minimizing consequences from hazardous events to ensure the protection of onsite personnel and the public. The HA also includes a determination of whether a given event will be retained for further evaluation in the SAR accident analysis based on the potential for significant offsite consequences. Both the HA and FHA appropriately conclude that no safety significant or safety class fire protection SSCs are required for risk mitigation based on the consequences for the analyzed fire events and that no fire events are carried forward into the accident analysis of the SAR (chapter 15). However, fire protection SSCs, including detectors, annunciators, and fire suppression systems, are appropriately identified as defense-in-depth.

Additionally, the CNS DSA addresses new hazards introduced by the CNS and adequately integrates fire hazards identified in the FHA. The CNS DSA adequately identifies hydrogen combustion and explosion as potential accident initiators, and both active and passive SSCs (e.g., transfer lines, the vacuum tube relief system, and the reactor building) for hazard prevention and mitigation.

Although the FHA is consistent with the conclusions of the HA and the PRA regarding the credited fire protection system controls, EA identified that the TSR and supporting safety basis documents are inconsistent in the following ways (see **OFI-UT-Battelle-5**):

- The TSR identifies the pony motor battery room fire barrier associated with Limiting Condition for Operation 3.7.1 as a system required for operation and when forced cooling is necessary during shutdown. However, the SAR does not identify the pony motor battery room fire barrier as a credited system or a requirement in the TSR in accordance with 10 CFR 830.205, *Technical safety requirements*, which states, "Develop technical safety requirements that are derived from the documented safety analysis."
- The bases for the limiting condition for operation state that the pony motor battery room fire barrier is credited in the HFIR PRA. However, the PRA does not identify this component as a credited SSC. Additionally, the HA, the safety-related equipment list (ORNL/RRD/INT-70, *HFIR Safety-Related Systems and Equipment Definition Report and Safety-Related Equipment List*), and the SAR accident analysis (chapter 15) do not identify the pony motor battery room barrier as a credited component for fire protection.

Fire Hazards Analysis and Safety Basis Integration Conclusions

In general, UT-Battelle has appropriately integrated the FHA into the HFIR SAR and the CNS DSA. The HFIR HA and CNS DSA evaluate and analyze accident events to adequately support the development of required controls for prevention or mitigation of hazard events. Hazards analyzed in the HA that are initiated by fire are adequately identified as not requiring safety significant or safety class controls based

on the low consequences for credible fire events. However, EA identified an inconsistency between a TSR and supporting safety basis documentation.

3.3 Fire Protection Structures, Systems, and Components, and Design Requirements

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

Design Requirements

HFIR fire protection design requirements are adequate. Reviewed procedures used to operate, test, and inspect fire protection SSCs contained design requirements that were aligned with corresponding calculations, and HFIR FPEs demonstrated that they are familiar with the design requirements in these procedures. Design requirements for the sprinkler system are adequately documented in engineering evaluation ES HFIR-2010-197, *HFIR Water Supply Analysis for Fire Protection*. Water flow tests are appropriately performed annually by the ORNL fire department to determine the available water flow for fire protection. For the most recent test, all test zones met the minimum water supply requirements for manual and automatic fire sprinkler demands. The HFIR fire water system appropriately includes redundant, gravity-fed supplies to meet system demand.

While most design requirements are adequate, the FHA does not fully describe a fire water containment strategy. (See **OFI-UT-Battelle-6**.) The FHA states that there are no engineered systems to control liquid runoff and expects that any contaminated liquid runoff would be contained within the Oak Ridge Reservation. The FPE explained that engineered systems for containment are not required based on the code of record applicable to the facility. Current requirements for fire water drainage design in areas handling radioactive materials are addressed in NFPA 801, section 5.10.

Engineering

UT-Battelle has established and implemented an adequate change control and comprehensive modification process. Changes to the facility are controlled by SEP-0100, *Configuration Management*, and SEP-0200, *Modification Process*. SEP-0100 adequately addresses responsibilities and procedures for design control, work control, change control, document control, and assessments. SEP-0200 adequately establishes the process for initiating, controlling, and documenting modifications to HFIR SSCs. The approved modification package used to replace very early smoke detection apparatus (VESDA) detectors for auxiliary and main control rooms demonstrated adherence to the change process.

Design Verification

HFIR engineering personnel adequately verified the fire protection design of the modification package used to replace auxiliary and main control room VESDA detectors. The new VESDA detectors were installed in accordance with the current editions of industry codes applicable to the design and installation of the HFIR fire alarm system: NFPA 70, *National Electrical Code*, and NFPA 72. In accordance with MMP-0801, *Preparing and Processing a Maintenance Work Package*, the modification package effectively documented the adequacy of the fire protection design, and implementation was appropriately verified by individuals and groups other than those who performed the work.

Fire Protection Structures, Systems, and Components, and Design Requirements Conclusions

HFIR fire protection design requirements are adequate. Test data and supporting calculations demonstrate that the sprinkler fire water supply system is adequate to meet system demands for manual

and automatic actuation. Further, UT-Battelle has established and implemented an adequate change control and comprehensive modification process, and adequately verified the fire protection design of the modification package used to replace auxiliary and main control room VESDA detectors. However, the FHA does not fully describe a strategy for controlling potentially contaminated liquid runoff from firefighting activities.

3.4 Surveillance Requirements, and Inspection, Testing, and Maintenance

This portion of the assessment evaluated the performance of TSR surveillances and ITM associated with fire protection SSCs, along with their installation and operation in accordance with safety basis documents and the FHA.

TSR Surveillance Testing

UT-Battelle properly plans, schedules, and performs TSR surveillances to ensure that fire protection SSCs can reliably perform their intended safety functions when required. Two reviewed TSR surveillance test records for the functional testing of fire dampers and fire louvers in HFIR Building 7900 demonstrated proper planning, scheduling, performance methods, and acceptance criteria to adequately verify the TSR performance requirements. Embedded acceptance criteria were appropriately aligned with performance requirements in the DSA and supporting engineering calculations, drawings, and specifications, and adequately verified that performance requirements were satisfied (e.g., verification that each fire damper and each fire louver closed satisfactorily). Observed performance of the comprehensive HFIR shift check surveillance rounds demonstrated that the status of plant process equipment was adequately verified for the plant operating mode. The scope of the shift check surveillance appropriately included fire alarm panels, fire barriers, and comprehensive TSR-mandated inspections of SSCs in the as-found condition (not pre-conditioned), with acceptance criteria confirming that the safety/operability requirements were satisfied.

Inspection, Testing, and Maintenance

UT-Battelle properly plans, schedules, and performs ITM of the HFIR fire protection SSCs to demonstrate that they are adequate to accomplish their safety functions and reliable. Reviewed ITM schedules for the fire protection systems demonstrated that the work was adequately planned and controlled. A review of all 86 preventive maintenance (PM) and corrective maintenance (CM) work packages that were closed in May 2023 confirmed that they were completed on time or within the grace period. An observed UT-Battelle outage coordination meeting for the next planned HFIR refueling outage and an observed Research Reactors Division plan-of-the day meeting were well-executed with detailed schedule reviews, including adequate planning for upcoming fire protection maintenance.

UT-Battelle adequately manages ITM issues and uses trend data and metrics to minimize component failure rates. UT-Battelle appropriately monitors ITM issues for fire protection systems using two issues management systems: ACTS (ORNL sitewide) and the Plant Health and Reliability Action Tracking (PHRAT) tool (HFIR-specific). UT-Battelle effectively uses the PHRAT tool to comprehensively compile, risk score, track, prioritize, and report reliability threats, including age-related system degradation, component aging, and obsolete systems or components, in accordance with procedure RRM-2500, *Plant Health and Reliability Action Tracking*. The fire suppression and fire alarm system performance summary report for fiscal year 2022 included adequate maintenance program metrics generated by the FPE to track backlogs, failure rates, and negative trends associated with ITM, along with age-related system degradation issues to ensure effective prioritization of maintenance. These metrics showed that there was no overdue PM during fiscal year 2022. At the time of this assessment, the CM backlog demonstrated effective management, with only two work orders for repairs to fire barriers and broken electrical conduit fittings in HFIR Building 7900. UT-Battelle is appropriately replacing aging, obsolete fire alarm system components,

particularly VESDA detectors that had been failing and are obsolete but still have functional fire alarm control panels. Overall, though, the percentage of total failures compared to the number of fire protection system components installed has been low (less than 1%).

UT-Battelle appropriately identifies and plans for needed PM and CM and prioritizes maintenance resources to ensure the timely inspection and repair of defective fire protection SSCs to verify and restore system functionality. Eleven reviewed ITM procedures contained adequate instructions and acceptance criteria, in accordance with NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, and NFPA 25, to ensure that fire protection systems will function as designed. Four reviewed CM/modification work packages demonstrated that repair and modification work was adequately planned and performed. Three reviewed maintenance issues in HFIR Building 7900 demonstrated the appropriate use of ACTS to track and resolve ITM issues. Furthermore, review of a maintenance history report generated from the HFIR master equipment list showed that UT-Battelle effectively used this database to track CM work performance until closure. An observed pre-job brief and the quarterly main drain flow test PM on a HFIR Building 7900 wet pipe sprinkler system riser were properly performed in accordance with governing work instructions. The pre-job brief by the HFIR FPE adequately addressed the hazards and precautions of the job. The FPE and ORNL fire department crew communicated effectively with the control room to coordinate this work.

Installation and Operation of Fire Protection SSCs

UT-Battelle has adequately installed and effectively operates fixed fire protection features as required by the DSA and FHA and in accordance with applicable fire safety criteria. UT-Battelle maintains a suite of adequate procedures to implement the FHA and DSA fire protection controls based on NFPA codes and standards in accordance with DOE Order 420.1C, attachment 2, chapter II, section 3.a.(2). Fourteen reviewed maintenance work package test records for determining fire safety feature operability appropriately documented repairs made to restore operability (e.g., fire door louver mechanism replacement) and demonstrated that fire safety feature repairs, such as to fire barriers, pony motor battery bank fire dampers, fire door louvers, alarm systems, smoke detectors, sprinklers, sprinkler compressors, standpipes, and piping/valves, had been completed as needed and operability had been confirmed.

Further, fire hazards unique to HFIR (i.e., the hydrogen gas system associated with the CNS facility, and fresh fuel handling in the reactor bay) are not addressed by industry standards but are properly controlled through isolation, segregation, and special administrative controls. For example, the hydrogen gas system associated with the CNS facility, which poses the greatest potential fire hazard at HFIR, appropriately uses electrical equipment classified for hazardous locations, combustible material controls, and fire barriers to mitigate fire risks. The risk of a fire hazard due to a vehicle diesel fuel spill during fresh nuclear fuel handling in the reactor bay, which is not specifically addressed by NFPA standards, is addressed adequately with an administrative control (ADM-0405), which requires the nuclear fuel to remain in a closed shipping cask when a gas or liquid fueled vehicle is brought into the reactor bay or its truck air lock.

The fire protection system ITM program at HFIR appropriately addresses requirements in accordance with applicable NFPA codes and as specified in UT-Battelle's FPP. Thirteen reviewed ITM records demonstrated that key elements of NFPA 25 and NFPA 72, including the scope and frequency of ITM, were adequately addressed. UT-Battelle adequately performs tests and inspections of fire detection/alarm systems in accordance with procedure LPD-ADM-030604, *Fire Alarm Systems Inspection and Testing*, and NFPA 72. A review of the most recent ITM results (annual, semiannual, and quarterly) for the HFIR fire alarm and sprinkler systems confirmed that the systems were inspected and found to be in satisfactory condition. UT-Battelle adequately performs ITM of portable fire extinguishers according to procedure LPD-FD-ADM-030401, *Portable Fire Extinguisher Inspection, Testing, and Maintenance/Facility Hazard Recognition*, in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. Twenty

observed fire extinguishers installed in Building 7900 were accessible and had their required annual inspections done between January and March 2023.

Fixed fire protection features required by the DSA and FHA were complete, operable, and properly maintained. Eleven reviewed ITM procedures contained appropriate instructions to ensure that fire protection systems function as designed. Two completed ITM records for functional testing of fire dampers, along with two completed ITM records for passive fire barrier doors, walls, and floors, demonstrated that personnel properly completed the procedures as written and that data was appropriately documented, reviewed, approved, and verified to meet the acceptance criteria. Reviewed inspection records for HFIR Building 7900 fire barriers and fire door inspections adequately documented inspection results and completed repairs. Two reviewed system health reports for the HFIR fire protection system effectively documented that it was in good overall health, and that there were no known issues with respect to overall system performance or reliability. A walkdown of the HFIR facility with the FPE demonstrated that adequate fixed fire protection features were installed.

UT-Battelle has established and implemented an effective impairment control program for fire protection systems, including compensatory actions for planned, unplanned, and emergency impairments. UT-Battelle's fire protection impairment control program is documented in a suite of adequate procedures and is in accordance with DOE Order 420.1C, DOE-STD-1066-2016, and applicable NFPA codes and standards. The reviewed fire impairment log properly identified 88 impairments of fire alarm and fire suppression systems over the past two years, including 83 planned impairments and 5 unplanned impairments, along with identified compensatory measures and controls. An observed status board used at the fire station by the ORNL fire department to monitor and issue tags for impaired fire protection system components (e.g., valves, alarm pulls) demonstrated an adequate tracking system to manage active impairments.

Surveillance Requirements, and Inspection, Testing, and Maintenance Conclusions

UT-Battelle adequately performs TSR surveillances and ITM for fire protection SSCs and ensures their installation and operation in accordance with safety basis documents and the FHA. UT-Battelle appropriately identifies needed PM and CM, prioritizes maintenance resources, and effectively uses the ACTS database and PHRAT tool to track ITM work performance. UT-Battelle has also established and implemented an effective impairment control program for fire protection systems.

3.5 Contractor Self-Assessment

This portion of the assessment evaluated UT-Battelle's performance of triennial FPP assessments.

UT-Battelle is required by DOE Order 420.1C, attachment 2, chapter II, to perform FFP assessments at least every three years. The last two triennial FPP assessments were completed in 2018 and 2021, with the next triennial assessment planned for 2024, demonstrating compliance with the three-year periodicity requirement. The 2018 and 2021 triennial assessments were joint OSO/UT-Battelle assessments led by OSO, an approach promoted by OSO. The joint assessments were appropriately credited to meet the DOE Order 420.1C requirement for the contractor to perform triennial FPP assessments. The 2018 and 2021 triennial assessments were appropriately staffed with qualified FPEs from both OSO and UT-Battelle. The scope developed for the two triennial assessments was sufficiently broad to encompass all the elements of an FPP established in accordance with DOE Order 420.1C and DOE-STD-1066-2016. The lines of inquiry for the assessments and the results documented in the two assessment reports demonstrated that the assessments were of sufficient depth and rigor to critically evaluate the effectiveness of the UT-Battelle FPP.

Contractor Self-Assessment Conclusions

UT-Battelle is effectively performing triennial assessments of the FPP that are of sufficient breadth, depth, and rigor to meet the requirements of DOE Order 420.1C.

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.

UT-Battelle, LLC

Deficiency D-UT-Battelle-1: UT-Battelle has not submitted an exemption request to OSO for the Building 7900 second floor fire area, which currently (1) exceeds maximum-loss-potential limits and (2) lacks additional/redundant fire protection for the large MPFL value associated with this fire area. (DOE Order 420.1C, att. 2, chap. II, secs. 3.c.(2)(d) and (e); the OSO Letter of Technical Direction; and SBMS Program Description - *Fire Protection*, secs. 4.3.3, 4.5.1, 4.5.2, and 4.5.5)

Deficiency D-UT-Battelle-2: UT-Battelle has not entered the BNA JNs and recommendations assigned to the ORNL Hazardous Materials Response Team into ACTS. (SBMS Program Description – *Fire Protection*, section 3.0)

Deficiency D-UT-Battelle-3: UT-Battelle has not included the locations of all fire hazards, fire protection features, and utility control devices on the PFP drawings for Buildings 7900 and 7977. (NFPA 1620, secs. 5.2.2.2(1), 5.3.2, 5.3.2.4, 5.3.2.4.1(6), 5.3.2.5, and 5.3.2.6, and LPD-FD-ADM-020104, sec. 5.1)

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.

UT-Battelle, LLC

OFI-UT-Battelle-1: Consider elevating large asset/property-loss-potential (high dollar loss) issues within the EMP-P-FPP-08 risk rating system to a level that requires OSO engagement and concurrence on CAHJ determinations for these issues.

OFI-UT-Battelle-2: Consider including in the HFIR FHA the ITM status of fire protection water supply control valves, portable fire extinguishers, dry-pipe fire sprinkler system air compressors, the Building 7991 dry chemical fire extinguishing system, oxygen concentration and hydrogen detection devices and alarms, and the public address system to ensure completeness of the building fire protection assessment element.

OFI-UT-Battelle-3: Consider including in the HFIR FHA an evaluation of the potential impact to system reliability posed by the lack of annual testing of the HFIR fire detection and alarm system under battery power.

OFI-UT-Battelle-4: Consider formally evaluating the risk associated with not conducting annual tests of fire alarm systems under battery power as specified by NFPA 72, table 14.4.3.2, item 8, and also implementing interim compensatory actions, as needed, until annual testing is resumed.

OFI-UT-Battelle-5: Consider revising the HA to clearly identify the derivation of the TSR requirement and updating the supporting safety basis document to accurately reflect the functional classification of the pony motor battery room fire barrier.

OFI-UT-Battelle-6: Consider addressing the strategy for confinement of water from firefighting activities in the FHA, including, for example, an evaluation of the facility drainage system's (Process Waste Storage Tanks) ability to contain expected fire water discharge, discussion of possible mitigating actions to prevent release of contaminated water to the environment, and an evaluation of potential design modifications that would ensure the containment of discharged firewater.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: June 5-9, 2023
Remote Assessment: June 12-15, 2023

Office of Enterprise Assessments (EA) Management

John E. Dupuy, Director, Office of Enterprise Assessments
William F. West, Deputy Director, Office of Enterprise Assessments
Kevin G. Kilp, Director, Office of Environment, Safety and Health Assessments
David A. Young, Deputy Director, Office of Environment, Safety and Health Assessments
Thomas E. Sowinski, Director, Office of Nuclear Safety and Environmental Assessments
Kimberly G. Nelson, Director, Office of Worker Safety and Health Assessments
Jack E. Winston, Director, Office of Emergency Management Assessments
Brent L. Jones, Director, Office of Nuclear Engineering and Safety Basis Assessments

Quality Review Board

William F. West, Advisor
Kevin G. Kilp, Chair
Christopher E. McFearin
Timothy B. Schwab
Michael A. Kilpatrick

EA Site Lead for Oak Ridge National Laboratory

Sarah C. R. Gately

EA Assessment Team

Ronald G. Bostic, Lead
Kevin E. Bartling
Gregory L. Smith
Barry L. Snook
James R. Streit