Office of Enterprise Assessments Targeted Review of the Fire Protection Program at the Oak Ridge National Laboratory Irradiated Fuels Examination Laboratory, Building 3525

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Table of Contents

Acronyms

ACTS	Assessment & Commitment Tracking System
ARRF	Airborne Release and Respirable Fractions
AHJ	Authority Having Jurisdiction
BLEVE	Boiling Liquid Expanding Vapor Explosion
BNA	Baseline Needs Assessment
CAS	Contractor Assurance System
CFR	Code of Federal Regulations
CRAD	Criteria, Review, and Approach Document
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FHA	Fire Hazards Analysis
FPE	Fire Protection Engineer
FPP	Fire Protection Program
FR	Facility Representative
GMR	Glove Maintenance Room
HEPA	High-Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
HPR	Highly Protected Risk
IFEL	Irradiated Fuels Examination Laboratory
ISC	Integrated Support Center
ITM	Inspection, Testing, and Maintenance
LEL	Lower Explosive Limit
MAR	Material at Risk
MPFL	Maximum Possible Fire Loss
MSD	Management Systems Description
NFPA	National Fire Protection Association
OFI	Opportunity for Improvement
OOD	Operations and Oversight Division
ORNL	Oak Ridge National Laboratory
OSO	ORNL Site Office
OSOP	ORNL Site Office Procedures
PIV	Post Indicating Valve
RSS	Research Safety Summaries
SAR	Safety Analysis Report
SBMS	Standards Based Management System
SCMS	Office of Science Management System
SME	Subject Matter Expert
SS	Safety Significant
SSC	Structures, Systems, and Components
TSR	Technical Safety Requirement
WP	Work Practice

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA), Office of Environment, Safety and Health, conducted an independent review of the fire protection program implemented by UT-Battelle at the Oak Ridge National Laboratory (ORNL) Irradiated Fuels Examination Laboratory (IFEL), Building 3525 as part of a complex wide independent targeted review of fire protection at nuclear facilities. The review included an evaluation of key program elements including adequacy and integration of the fire hazards analysis with the safety basis controls; the baseline needs assessments; fire pre-plans; the exemption and equivalency process; combustible controls; technical safety requirements surveillance and testing; and the inspection, testing, and maintenance of fire detection and prevention safety structures, systems, and components and supporting infrastructure. The assessment also evaluated the Office of Science oversight processes that are intended to verify the adequacy of the UT-Battelle fire protection program.

The IFEL was constructed in 1961-1962 as a hot cell facility for studying changes in materials and associated physical properties that occur during the irradiation of nuclear reactor fuels. Because of its age, the IFEL lacks full coverage by many of the active engineered safety systems and components that would be required by consensus codes for a newer facility, such as automatic fire detection and alarm systems, and automatic fire suppression systems. Instead, the safety basis relies significantly on passive structures and inventory and administrative controls. The isotopic source terms in the IFEL range from transuranic alpha emitters to high dose rate fission and activation product gamma emitters. Most research specimens that are used are solid metals or oxides with relatively few processes resulting in volatile liquid, powdered, or gaseous products. Therefore, the airborne respirable release fractions used in the facility safety basis analysis are relatively low.

The Fire Protection Program (FPP) implemented at the IFEL is generally adequate and capable of protecting the facility from most potential fire hazards. UT-Battelle is staffed by well qualified and knowledgeable fire protection engineers who are actively engaged in evaluating and maintaining the facilities and the program. Staff members have a good understanding of how fire protection systems function to protect the facility, and appropriate documentation is in place to support the implementation of an effective program. The onsite fire department is appropriately staffed and equipped to satisfy the base line needs assessment. With a few exceptions, Building 3525 fire protection is adequate including using passive controls to address most fire hazards.

Although generally adequate, EA identified some vulnerability in the FPP. An exemption or equivalency has not been approved to address the legacy concern that Building 3525 is not fully covered by sprinkler protection. Other vulnerabilities include inadequate performance of the main drain test, inadequate maintenance of the manual fire suppression system and challenges with maintaining an aged water supply system.

The DOE field element has implemented oversight processes that conform to the Office of Science model to evaluate contractor and DOE programs and management systems. According to the ORNL site office Management Systems Description document, the Office of Science oversight program places substantial emphasis on the contractor assurance processes and partnered assessments, along with facility representative (FR) lead quarterly targeted assessments routine FR operational awareness. The DOE field element line oversight program includes written plans and schedules for planned assessments, focus areas for operational oversight, and reviews of the contractor's self-assessment of processes and systems. The ORNL site office's approach for Federal fire protection engineering support is to utilize the integrated

support center subject matter expert on an as requested basis under an umbrella services agreement. The site office's processes generally include analyzing work hazards such as fire hazards and identifying oversight priorities including walkthroughs and assessments. The most recent triennial programmatic reviews were performed as partnered site office and contractor evaluations.

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1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA), Office of Environment, Safety and Health, conducted an independent review of the Fire Protection Program (FPP) implemented by UT-Battelle at the Oak Ridge National Laboratory (ORNL) Irradiated Fuels Examination Laboratory (IFEL), Building 3525. The purpose of the EA targeted review was to evaluate the implementation of program requirements and the adequacy of controls designed to reduce the risk resulting from a fire or explosion at nuclear facilities. EA adapted existing criteria, review, and approach documents (CRADs) to establish a focused set of inspection criteria, activities, and lines of inquiry for the targeted review in coordination with a facility specific review plan. The initial scoping and planning was conducted from June 2 to 6, 2014, and the onsite data collection and observations were conducted from August 25 to 29, 2014. This targeted review was designed to evaluate the selected core fire protection elements and to provide information to the site and responsible DOE line management organizations for benchmarking their program's effectiveness. This review was one part of a larger targeted review of fire protection at nuclear facilities across the DOE complex.

2.0 BACKGROUND

The EA program is designed to enhance DOE safety and security programs by providing DOE and contractor managers, Congress, and other stakeholders with an independent evaluation of the adequacy of DOE policy and requirements as well as the effectiveness of DOE and contractor line management performance in safety and security and other critical functions as directed by the Secretary of Energy. The EA Independent Assessment Program is described in and governed by DOE Order 227.1, *Independent Oversight Program*, and a comprehensive set of internal protocols and CRADs.

ORNL is managed by UT-Battelle for the DOE Office of Science. The IFEL was selected for this targeted review as a vertical slice example of implementation of the UT-Battelle FPP. The IFEL is a hot cell facility originally designed for analyzing the physical materials properties of irradiated fuels. The laboratory started active operations in 1964. The facility is a two story brick building with approximately 27,000 square feet of floor space. The facility includes three main hot cells, a loading area, operational areas, office space, gloveboxes (that have not yet been placed in service), and a variety of additional shielded examination, maintenance, and loading areas.

Current analyses capabilities at IFEL include the study of metallurgic and crystallographic changes due to temperature, irradiation, and fission product impacts on the mechanical properties of reactor fuel. Most activities are mechanical or thermal in nature with relatively little use of chemical processes. However, activities can include oxidation of spent nuclear fuel and dissolution of materials for further analysis and examination. The IFEL also performs operations involving the receipt and handling of irradiated materials, processing of radioactive materials, transfer of materials, packaging and shipment of materials, waste packaging, maintenance of remote equipment, and decontamination of the facility and equipment.

The manual pull stations and the fire suppression sprinkler system flow alarm are the principal means of fire detection and alarm notification in the IFEL. Only the cell loading area has active heat based fire detectors independent of the sprinkler system. Most of the hot cells and certain other areas of the facility are not covered by the automatic fire suppression sprinkler system because of potential criticality

concerns or lack of easy access for maintainability and testing. Therefore, the principal fire protection control is through administrative limitations on the material at risk inventory and through administrative controls on combustible loading in areas without sprinkler protection. The safety basis designates the fire suppression system and alarm system as defense in depth. The safety significant (SS) effluent filters of the HCV system that maintain hot cell confinement are located in the partial basement and feed through tunnels into blowers and a central stack located across the street that also provides effluent suction for several other facilities.

3.0 SCOPE

EA's predecessor organization identified fire protection as a targeted review area in 2013. As part of that effort, EA reviewed and assessed the effectiveness of selected elements of the FPP at the ORNL IFEL and UT-Battelle's implementation of the program. EA evaluated key elements of the FPP including the program documentation; authority having jurisdiction (AHJ) determinations and exemption and equivalency processes; baseline needs assessments (BNAs); life safety assessments; pre-fire plans; ignition source and combustibles controls; fire system impairment process; inspection, testing, and maintenance (ITM) of suppression and alarm systems; and ITM of supporting infrastructure. EA also evaluated the integration of the fire hazards analysis (FHA) documented safety analysis (DSA) and flowdown of the safety basis requirements into the FPP. EA also considered the UT-Battelle self-assessment program and ORNL Site Office (OSO) oversight of the UT-Battelle FPP.

4.0 METHODOLOGY

EA reviewed FPP documentation including the FHA, Safety Analysis Report (SAR), procedures, and records; conducted interviews with personnel responsible for program implementation and oversight; performed facility and system walkdowns; and observed performance of ITM activities and combustible loading weekly rounds. The review considered the requirements of 10 CFR 851, *Worker Safety and Health Program*; DOE Order 420.1C, *Facility Safety*; and National Fire Protection Association (NFPA) codes and standards.

EA assessed the FPP using the objectives and criteria identified below. These criteria are based on program elements from DOE Orders 420.1C and 226.1B and are grouped together under an overall objective.

EA used selected applicable sections of CRAD 45-34, *Fire Protection*, Revision 1, for this targeted assessment with particular emphasis on the programmatic elements:

- Section I, Programmatic Elements, FP-1, Program Documentation
- Section I, Programmatic Elements, FP-2, Program Implementation - Fire and Related Safety Hazards and Self-Assessments
- Section I, Programmatic Elements, FP-3, Program Implementation - Fire Prevention and Protection
- Section II, FHA/DSA Integration, FP-4
- Section III, Engineered System Design Features

- Section IV, TSR Surveillance and Testing

- Section V., Configuration Management

EA also used select elements of HSS CRAD 45-21, *Feedback and Continuous Improvement Inspection Criteria and Approach – DOE Field Element*, Revision 1, to collect and analyze data on OSO oversight activities for the FPP.

5.0 RESULTS

5.1 Fire Protection Program

This portion of the review was to determine whether the following inspection criteria were satisfied:

- ***Inspection Criterion:*** *A documented fire safety program exists as required by applicable safety criteria. (DOE Order 420.1C, DOE-STD-1066-2012)*

- ***Inspection Criterion:*** *A baseline needs assessment (BNA) of the fire protection emergency response organization has been documented and updated every 3 years. The plan should describe in sufficient detail fire-fighting operations for the respective facilities. (10 CFR 851, DOE Order 420.1C, DOE-STD-1066-2012)*

Program Documentation

ORNL has implemented a FPP designed to provide a level of fire protection consistent with the industrial risks as required by DOE Order 420.1C, *Facility Safety*. 10 CFR 851, *Worker Safety and Health Program*, provides additional fire protection requirements for worker protection. The FPP includes fire protection policies, requirements, technical criteria, analyses, administrative procedures, systems and hardware, apparatus and equipment, plans, and personnel that ensure the program achieves DOE objectives relating to fire safety. The FPP as implemented at the IFEL is expected to provide a level of fire protection that is sufficient to fulfill the requirements for the best protected class of industrial risks (i.e., "Highly Protected Risk" or "Improved Risk"). Accordingly the IFEL FPP includes both active and passive fire protection SSCs which are classified as providing "defense-in- depth" as well as administrative controls to limit the material at risk and the combustible loading in the facility. Individual elements of the FPP are integrated throughout the Standards Based Management System (SBMS) subject areas, internal operating procedures, and lower tier organizational procedures and manuals. The SBMS serves as the depository of policies, standards, requirements, and support information regarding fire protection for UT-Battelle.

UT-Battelle Management is responsible for training individuals, making appropriate job procedures and equipment available so that each assignment can be completed in a fire-safe manner, and ensuring that fire protection requirements fully comply with UT-Battelle directives. The Environment, Safety, Health and Quality Directorate manages the FPP through the Worker Safety and Health Management System within SBMS. The ES&H Director reports directly to the Laboratory Director. The ES&H Directorate maintains a qualified fire protection engineering staff to support program development and implementation.

The FPP applies to DOE facilities at ORNL, including IFEL. Any special Highly Protected Risk (HPR) criteria or fire protection codes and standards applied in UT-Battelle facilities are required to be

consistent with the general fire protection philosophy described in DOE Order 420.1C. In addition to facilities, the ORNL FPP also applies to equipment, items, and services provided related to fire protection. Decisions pertinent to effectively applying administrative controls in a tailored manner are based on the risks related to using materials or conducting work that is associated with facilities, equipment, items, or services.

EA observed two noteworthy practices during the assessment. While performing ITM services, the ORNL Fire Department used portable electronic tablets to verify the accuracy of the building fire pre-fire plans and locations of facility fire protection equipment being tested and inspected. This methodology allowed a more efficient process for locating equipment being tested and confirmed the accuracy of fire safety building features that were documented on the fire preplan. The second noteworthy practice involved a rating system for risk associated with fire protection. The Fire Protection Assessment Deficiency Rating System procedure is a tool used by the UT-Battelle Fire Protection Engineering to assign a rating based on severity and probability. The Fire Protection Deficiency Rating Matrix helps the user identify the appropriate priority, using specific categories including: imminent; code noncompliance – serious; code noncompliance – moderate; code noncompliance - less serious; and non-serious technical deficiency. Each priority has representative examples to help the fire engineer determine the appropriate rating. This tool assists the contractor and the OSO AHJ with approval of non-compliant conditions, specifically for minor deficiencies that would not constitute an equivalency or exemption.

Exemption and Equivalency Process

ORNL issues equivalencies where strict compliance with the specified fire protection regulations, codes, and standards cannot be met or is not practical. The UT-Battelle AHJ develops equivalency requests in cases where the facility accomplishes compliance with the intent of the requirement or standard using an alternative means that provides an equivalent level of protection. The Oak Ridge Fire Protection AHJ (Head of Field Element) is responsible for approving equivalencies. Contractors who request an equivalency must coordinate the submittal of such documents with the OSO and the applicable Office of Science program office as outlined in the ORNL FPP. Exemption and equivalency requests that are programmatic in nature are generally consistent with and supported by the facility FHAs and scheduled fire protection engineering assessments (FPEA).

Building 3525 lacks complete sprinkler protection in certain significant operational areas, including the hoist way (basement level), Airlock 131A, hot cells (the north hot cell is provided with four manually operated water spray nozzles that are not used), Irradiated Microsphere Gamma Analyzer and Core Conduction Cool Down Test Facility cells, Core Conduction Cool Down Test Facility cell entry enclosure, Room 207, and the crane maintenance glovebox. The Fire Hazard Analysis, ORNL/3525/FHA, prepared by the UT-Battelle Fire Protection Engineering group, evaluated the issue of incomplete sprinkler protection for the building and determined that the non-compliance was equivalent to a Fire Protection Risk Ranking IV – Less Serious, in part because many of the non-sprinklered operational areas (like the hot cells) are typically unoccupied. However, the FHA credits the building as being “fully sprinklered” with respect to life safety requirements identified in the Life Safety Code including maximum travel distance, common path, and dead ends, etc. Contrary to DOE Order 420.1C, a formal exemption or equivalency has not been submitted and approved by DOE documenting their acceptance of the risk. **(**See **Finding F-ORNL-01**.)

Pre-Fire Plans

The ORNL Fire Department is responsible for issuing pre-fire plans in accordance with LPD-FD-ADM-020104, *Pre-Fire Plans*. Designated emergency response vehicles carry the pre-fire plans. UT-Battelle uses pre-fire plans to develop periodic drill/training and ensure all fire department personnel are familiar

with the building, its physical layout and design, fire protection features, and its associated hazards. The pre-fire plan specifically addresses the hazardous conditions, construction features, potential fire exposures, fire protection features, and tactical considerations related to a major building fire. UT-Battelle bases the frequency for updating the pre-fire plans on the nuclear category of the building and monetary cost for replacing the facility if lost due to a major fire incident.

The current pre-fire plan for Building 3525 notes that the facility is partially protected by an automatic wet-pipe sprinkler system with the riser located in Room 123. The system includes an available sprinkler and standpipe with ORNL Fire Department hose connections. The pre-fire plan indicates availability to stand pipes and hose connections; however, UT-Battelle does not currently exercise the hose connection valves as required by NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. In addition, the pre-fire plans for Building 3525 does not document other facility features such as safe areas of refuge that are provided by the fire rated stairway enclosures. (See **OFI-ORNL-01.**)

Control of Combustibles

DOE Order 420.1C requires that each FPP include comprehensive, written fire protection criteria or procedures that address controls on the use and storage of combustible, flammable, radioactive, and hazardous materials to minimize risk from fire. DOE-STD-1066-2012, *Fire Protection,* reinforces this requirement; stating that a combustible control program is a required element of all FPPs, and that general housekeeping practices, control of transient combustibles, and control of flammable and combustible liquids and gases must be documented. DOE Guide 420.1-3, *Fire Protection,* further states that the quantity and associated hazards of flammable and combustible materials that are often found within the fire area should be factored into FHAs. NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials,* requires that the FPP establish administrative controls governing general fire prevention activities, such as control of combustibles and control of ignition sources. The quantity and associated hazards of flammable and combustible materials that are expected within the fire area should be factored into the FHAs and considered when selecting fire accident control strategies. The presence of transient combustibles associated with storage and maintenance activities should also be considered.

Overall, the combustible loading within the Building 3525 facility was maintained sufficiently low. UT-Battelle implemented the combustible control procedure NNFD-3525-AP-001, *Building 3525 Combustible Control Inspection Program,* in June 2004. However, EA identified specific opportunities for improvement in the implementation of the program.

Workers routinely use equipment within the hot cells that could be ignition sources. This equipment includes electrical furnaces, metal cutting saws, guides, polishers, and heating elements, and other test equipment. Most furnaces are small (less than 44 kilowatts) and not subject to NFPA 86 requirements. Other furnaces have been modified and are operated in accordance with Research Safety Summaries (RSS) for the specific operations. Laboratory heating devices located in other parts of the IFEL facility are also used in accordance with specific RSS. A single paragraph in the FPP description document covers ignition sources and is principally directed toward hot work permits, open flames, and grinding operations. Operations and fire protection staff manage other potential sources, such as furnaces, on a case-by-case basis. While specific ignition sources are identified in some RSS, no implemented facility specific inventory, surveillance, monitoring, or use process systematically addresses potential ignition sources in the IFEL facility. (See **OFI-ORNL-2**.)

Workers occasionally use flammable liquids within the hot cells. UT-Battelle conducted specific calculations for each liquid to ensure that 25% of the respective lower explosive limit (LEL) is not exceeded. Isopropyl alcohol is considered as the worst case scenario. Based on these calculations, up to

1.59 liters of a flammable liquid in the hot cells at any given time would avoid reaching 25% of the LEL. Therefore the combustible controls program procedure limits no more than 1,000 milliliters of a flammable liquid to be introduced into the hot cells at any given time.

EA observed operations personnel conducting a combustible inspection walkdown for Building 3525 and reviewed the associated documentation. EA observed the following deficiencies: (See **OFI-ORNL-03**.)

- Operations personnel observed conducting the combustible loading walkdown were not familiar with the technical requirements that formed the basis for the procedure. Performance was less than adequate to ensure implementation of the procedural requirements.

- The FHA takes credit for a lack of continuity of combustibles in the hot cells that would support propagation of a flame plume. However, no apparent or quantifiable controls are in place to ensure a lack of continuity of combustibles in the hot cells. For example, there was no guidance on the proximity of combustibles with respect to ignition sources. EA observed Class A combustibles on tables and exposed to potential ignition sources, and metal containers filled with trash were left uncovered when the cell was unattended.

- The TSR implementing procedure, NNFD-3525-AP-001, *Building3525 Combustible Control Inspection Program*, which limits the quantity of flammable liquids, is inconsistent with and less conservative than the FHA. The FHA limit for flammable liquids in the cells is listed as "less than 1 liter." However the TSR procedure indicates "less than or equal to 1 liter." Several entries in the logbook indicated that the flammable liquid quantity was equal to 1 liter, exceeding the limits noted in the FHA.

- The operators use an uncontrolled logbook to manage and record flammable liquid inventory for the hot cell. There is no procedural requirement for periodic verification or reconciliation of inventory and no verification is performed. This method of managing and recording flammable liquid inventory does not adequately ensure the TSR procedure limit of less than 1 liter is implemented.

5.2 Fire and Related Safety Hazards Analyses

This portion of the review was intended to determine whether the following inspection criteria were satisfied:

- ***Inspection Criterion:*** *Fire Hazard Analyses (FHA) have been prepared for each nuclear facility and the results coordinated and integrated into the Documented Safety Analysis as required. (DOE Order 420.1C, DOE-STD-1066-2012, DOE-HDBK-1163, NFPA 801)*

- ***Inspection Criterion:*** *Fire and related safety hazards on site (or within the facility) have been identified and evaluated in conjunction with a current and comprehensive FHA. (DOE Order 420.1C)*

- ***Inspection Criterion:*** *The FHA and self-assessments address all essential elements for a complete analysis as delineated in DOE Order 420.1 and its implementation guide. (DOE Order 420.1C)*

- ***Inspection Criterion:*** *The information contained in the FHA and assessment is accurate, as required by applicable fire safety criteria. (DOE Order 420.1C)*

UT-Battelle requirements for preparing FHAs are contained in Internal Operating Procedure SSD-P-

FPPP-03, *Fire Hazard Analysis.* This procedure provides the criteria and suggested format for the FHAs for all ORNL facilities managed by UT-Battelle. The ORNL Building 3525 FHA evaluation of the potential fire scenarios include a fire in the processing hot cells, the Glove Maintenance Room (GMR) glovebox, the truck bay, and the charging area. Overall, the FHA and DSA are acceptably integrated (refer to Section 5.4 for further discussion regarding FHA-DSA integration). However, EA noted that hazard identification and accident scenarios are sometimes based on qualitative analogies to other facilities, rather than quantitative analysis based on facility specific conditions and components. For example: (See **OFI-ORNL-04**.)

- The analysis for hot cells does not provide a unique bounding scenario describing critical attributes of fire and explosion consequences.

- The bounding fire analysis (e.g., time duration and heat release rate) for the hot cells refers to another building with similar attributes. Reconciliation of differences between facilities, the quantitative analyses of impacts, and applicability of the test scenario to Building 3525 is incomplete.

- Neither the FHA nor the DSA provides a quantitative analysis for a fire in an unattended hot cell. Unattended after hours operations are permitted. Combustible materials and ignition sources are continuously in the hot cells, and ignition sources may be operational while the facility is unattended. The hot cells do not have automated fire detection or suppression systems to assure fire alarm notifications or suppression of incipient fires during unattended operations. Consequently, an incipient fire could burn for an extended period of time before discovery or entry and response (potentially until all combustibles are expended). However, there is no quantitative analysis of the consequences of a hot cell fire during unattended operations and no quantitative limit on the heat content of potential combustible loading materials.

5.3 Fire Prevention and Protection SSCs and Controls

This portion of the review was intended to determine whether the following inspection criteria were satisfied:

- ***Inspection Criterion:*** *A complete spectrum of fire prevention controls and procedures are in existence and have been implemented as required by applicable fire safety criteria. (DOE Order 420.1C, Site & Facility DSA)*

- ***Inspection Criterion:*** *All fixed fire protection features (appropriate construction types, fire barriers, fire alarm and signaling systems, manual and automatic fire suppression systems, etc.) that are required by authorization basis documents and fire hazards analyses, have been installed and are tested and maintained, as required by applicable fire safety criteria. (DOE Order 420.1C, Site & Facility DSA)*

The primary control for facility safety is the established limit for material at risk (MAR). The MAR inventory and type limits used for Building 3525 are not typical in format. The referenced control limit is based on projected doses rather than isotope specific activities or masses. The projected doses are highly susceptible to assumptions for the material types and the associated release fractions. The efficacy of this specific administrative control depends on the ability of the inventory control processes and the material physical forms classifications (e.g., solid oxide or metal spent fuels) to accurately describe the true inventory. For the material types assumed in the inventory, the Airborne Release and Respirable Fractions (ARRFs) are lower than typical default values used in codes such as Hot Spot. Therefore, assurance that the material types and physical forms are accurate and maintained throughout the analytical

processes is a significant safety aspect of the facility's administrative controls. EA reviewed the processes and performed sample confirmatory calculations. Based on the assumed material types and ARRFs, the calculated doses to members of the public and co-located workers were within the acceptable ranges.

Fire protection within the IFEL depends on the passive structure of the hot cells to contain releases from a fire, and on administrative controls for fire prevention and mitigation. The hierarchy of hazard controls established in DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, recommends that engineering controls with an emphasis on safety-related structures, systems, and components (SSCs) are preferable to administrative controls or specific administrative controls, due to the inherent uncertainty of human performance. Passive controls are preferred over active engineered controls if engineering analysis can demonstrate that the required safety function and performance criteria are achieved. While passive controls address most scenarios, acceptance of these passive controls is based on engineering assumptions that are not fully supported by quantitative analysis. Active detection systems are minimally used in the IFEL and suppression systems do not provide full coverage to the small percentage of the facility where much of the MAR activity is performed. No active automatic detection or suppression systems are installed inside the hot cells where the primary sources are located. As a result, the criterion for a complete spectrum of controls is not fully satisfied.

Fire Protection Controls Implementation

EA reviewed fire protection systems at ORNL Building 3525 to assess whether they are appropriate for the facility fire scenarios identified in the FHA and that an appropriate inspection testing and maintenance (ITM) program for fire protection features is in place and is being conducted. Fire protection systems and controls are not credited as SS features in the DSA, but rather are classified as administrative controls. However, regardless of the nuclear safety classification for SSCs and safety management programs, the facility FPP is expected to conform to the requirements of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*; NFPA 72, *National Fire Alarm Code*; and other applicable NFPA standards and code ITM requirements. Administrative control criteria that apply include the FPP, periodic ITM of fire protection equipment, and control of combustible materials and ignition sources. EA identified weaknesses, deficiencies, and/or vulnerabilities regarding certain fire protection design features, namely:

- Contrary to DOE-STD-3009 that prescribes engineered safety features before administrative controls, the hot cells lack active engineered fire protection controls in the hot cells (suppression and detection). (See **OFI-ORNL-05**.)

- No fire detection or fire alarm notification capability addresses incipient fires inside the hot cells. This is of special concern because of unattended off-hour operations that occur inside the hot cells. The only smoke detector is located near the fire alarm control panel at the entrance, and two heat detectors are located at the loading dock. Heat detectors on the operating floor have been disabled. These heat detectors were formerly the activation mechanism for the old pre-action system that has since been converted to a wet pipe system. (Note: no posting or labeling indicates that these heat detectors are disconnected.) The principal means of fire detection and alarm communications in the facility depends on manual pull stations or actuation of the sprinkler system located outside the hot cells. (See **OFI-ORNL-06**.)

- DOE-STD-1066-2012, *Fire Protection*, and NFPA 801 currently requires potentially radioactive water runoff from new or modified facilities to be contained. These controls are not required to be applied retroactively unless the facility is modified. As a pre-existing facility (built in 1961-1962),

no engineered containment systems control liquid runoff at Building 3525. ORNL currently uses White Oak Lake as a settling basin for storm drain waste effluent. The FHA states that fire suppression water runoff will likely flow by gravity (slope) to the multiple open gratings to the storm drain system surrounding the perimeter of Building 3525. From there, the discharged water would gravity flow to the Melton Branch and into White Oak Lake. (See **OFI-ORNL-07**.)

- As described in section 5.1 of this report, Building 3525 lacks complete sprinkler protection. (See **Finding F-ORNL-01**.)

- The hot cell drains to a local waste tank have been removed from service. Therefore, if the manual sprinkler protection inside the north hot cell is activated, water will collect to a depth of approximately 12 inches and enter the ventilation system, possibly compromising hot cell confinement. (See **OFI-ORNL-08**.)

- The FHA states that the manual fire suppression valve for the north hot cell contributes to the adequate control set. However, ITM for the hot cell water spray system is not documented. UT-Battelle does not maintain or test the manual fire suppression valve according to NFPA 25 requirements, and facility operators are insufficiently trained on when to activate the manual water spray system. (See **Finding F-ORNL-02**.)

- Smoke from a hot cell fire could plug hot cell pre-filters or the SS high-efficiency particulate air (HEPA) filters, possibly disrupting the required negative pressure differentials in the hot cells as a result of reduced airflow. While considered a remote possibility, no means of detection of filter plugging is discussed, no smoke detectors are contained in the hot cell, and no compensatory measures for this event are discussed in the FHA. The impacts of a positive pressure excursion on cell leak rates and integrity have not been fully analyzed. (See **OFI-ORNL-09**.)

- The quarterly main drain test, as currently performed, does not comply with NFPA 25. Specifically, UT-Battelle performs no comparison of prior test results as required by NFPA 25. Additionally, NFPA does not recognize the facility practice of comparing the static to the residual pressure to be within 10%, and the test procedure does not contain a step to bleed down the system before the test begins. (See **Finding F-ORNL-03**.)

- NFPA 25 requires the Building 3525 Standpipe System Flow Test to be performed every five years. This test includes a flow test and measurement of pressure to be recorded at the hydraulically most remote hose location to verify that the water supply still provides the initial design pressure at the required flow. During the last test, the pressure and flow were recorded (ref. Work Order 1522456), but contrary to NFPA 25, the procedure did not include verifying acceptance of the test data by comparison with the initial design conditions or verification of the location of the hose connection specified for the test. (See **OFI-ORNL-10**.)

Infrastructure Water Supply

EA evaluated the fire suppression water supply, including the water supply infrastructure and the specific piping supplying Building 3525. EA reviewed system description documents and drawings and reviewed ITM procedures and records. EA also interviewed ORNL Utilities department personnel about general water supply characteristics, operation, emergency operations, and ITM. The ORNL potable water system, a combination type system providing potable and fire protection water needs, supplies water to Building 3525. The ORNL distribution system receives water from the City of Oak Ridge via a single 24-inch cast iron/ductile iron transmission feed line. This single feed line supplies five water storage

reservoirs at ORNL, two 1.5-million gallon reservoirs on Chestnut Ridge, two 1.5-million gallon reservoirs on Haw Ridge, and the Spallation Neutron Source water storage tank. Water then flows through two water mains to the ORNL water distribution system. Water is also supplied to the ORNL grid by a water main from the two 1.5 million gallon reservoirs on Haw Ridge. Of the 6 million gallons of reserve water supply that is maintained on the ORNL site, 1 million gallons is retained in reserve and designated strictly for fire protection purposes. The grid infrastructure throughout the ORNL site includes numerous zone sectional valves to facilitate piping isolation for routine or emergency maintenance as well as post indicator valves serving individual facilities. The grid piping mains are a combination of concrete, cast iron, or ductile iron, with mechanical or caulked joints. Most portions of the grid piping mains are 40 to 50 years old. Portions of the infrastructure consist of cast iron piping that is more vulnerable to breaks than is ductile iron or PVC. Over the last decade, notable pipe breaks have threatened to disrupt operations at important facilities, although all were repaired in a timely manner. Considering materials of construction, aging infrastructure, and the HPR type sensitivity of the facilities served, the integrity and reliability of the system is not assured.

The system physical description, operation, and ITM are described in the document UT-MECH-ADM-002, Revision 1, *ORNL Water Distribution System Description*, dated September 10, 2013. An Emergency Operations Plan (*UT-T-MECH-068, Revision 2, 9-2011*) identifies potential emergency situations and requirements to alert users of impacts to the water supply. The system description document requires tailored compliance (i.e., a graded approach) to NFPA 24, *Installation of Private Fire Service Mains and Appurtenances*, and requires the ORNL water distribution system mains and associated components to be inspected, tested, and maintained in accordance with NFPA 25 to provide at least the same level of performance and protection as designed.

In 2012, EA's predecessor organization assessed the ORNL water supply during an assessment of the Transuranic Waste Processing Center (which also receives its water supply from the ORNL grid). At that time, ITM deficiencies coupled with an aged infrastructure challenged meeting the requirement of a reliable water supply. A water main break in the City of Oak Ridge utility system in February 2014 combined with the inability to operate one sectional shutoff valve at Y-12 illustrated operational vulnerabilities that could have led to the temporary shutdown of the High Flux Isotope Reactor and the Spallation Neutron Source if the operational water supply in the reservoirs had been depleted. Since then, the Utilities department has made some noted improvements in identifying non-functional sectional valves and prioritizing work. Although UT-Battelle has begun to implement some corrective actions, the Fire Protection Engineering group and Utilities department have yet to ensure that reliability issues have been adequately evaluated based on appropriate ITM criteria and fully implemented corrective actions plan. EA noted deficiencies still exist, namely: (See **Finding F-ORNL-04**.)

- ORNL's water supply piping infrastructure is aged, and since no redundancy exists, any significant failure that could not be repaired in a timely manner could significantly impact ORNL facilities and their missions.

- ORNL Utilities Division lacks a proactive system of monitoring, testing, maintenance, and planned replacement. A large portion of the onsite infrastructure underground piping is over fifty years old. Many valve vaults are known to be in disrepair. Other sectional control valves have not been cycled for an extended period of time, greater than the annual ITM frequency required. Sectional control valves that do not hold or cannot be closed for piping repairs may increase the affected number of buildings impacted in the event of a pipe break. The underground infrastructure (i.e., the grid piping mains) is largely cast iron, ductile iron, or steel. Buried aged pipe can, over time, undergo gradual degradation in the form of corrosion that can lead to reduction in effective cross-section and loss of mechanical strength. Accordingly, as the water distribution system ages, the number of pipe failures can be expected to increase.

- NFPA 25, Section 13.3.3.1, requires each sectional control valve to be operated annually through its full range and returned to its normal position. These normally open sectional control valves must be closed to facilitate isolation of water branch mains for routine or emergency maintenance. Some previously identified deficient sectional control valves have not been repaired or replaced and remain frozen or nonfunctional. Testing and exercising of the remaining control valves is not routinely performed. The backlog of incomplete annual maintenance of sectional control valves is now being addressed, but untested valves still remain.

- UT-Battelle has begun an initial testing and identification process to determine which valves and components are deficient or nonfunctional, but UT-Battelle has yet to identify the ITM code criteria for those determinations.

5.4 FHA/DSA Integration

This portion of the review was intended to determine whether the following inspection criteria were satisfied:

- ***Inspection Criterion:*** *Within the scope of the review, the FHA conclusions shall be incorporated into the safety authorization (preliminary safety design review, preliminary DSA, or DSA, as appropriate) and demonstrate the adequacy of controls provided by the system to eliminate, limit, or mitigate identified hazards, and define the process for maintaining the controls and controlling their use.*

- ***Inspection Criterion:*** *The safety authorization basis is consistent with the fire hazards analysis; demonstrates the adequacy of controls provided by the system to eliminate, limit, or mitigate identified hazards; and defines the processes for maintaining the controls current at all times and controlling their use.*

Fire hazards are identified in the FHA and generally are consistent with those evaluated in the DSA. The ORNL Building 3525 FHA evaluates the potential fire scenarios for the facility including a fire in the processing hot cells, the GMR glovebox, the truck bay, and the Charging Area. Overall, the fire scenarios and consequences evaluated in the FHA are appropriately included in the hazard evaluation and accident analysis section in DSA Chapter 3 and associated appendices. However, certain design features and control strategies sometimes lacked appropriate quantified analysis/testing that forms an acceptable basis to verify their functionality. Some assessments of controls were founded on engineering assumptions that were not fully supportable. Other assessments did not fully carry FHA analyzed scenarios into the DSA specified control sets. For example, the FHA evaluation of the maximum possible fire loss (MPFL) was inadequately considered in the DSA hazard and accident analysis. The FHA determined that the MPFL is based on a boiling liquid expanding vapor explosion (BLEVE) initiated by a fire in the Charging Area involving a propane powered forklift and combustible waste. This forklift is not routinely used, but is available for use, according to the FHA and safety basis. As documented in the FHA, the BLEVE causes a significant pressure increase within the building that cannot be contained by the building structure. This event may have obvious radiological consequences as well as life safety consequences to the workers. However, contrary to the FHA conclusion that this fire scenario results in the maximum monetary loss to the facility, the DSA does not specifically evaluate this specific fire hazard scenario. The DSA accident analysis does not explicitly consider the BLEVE in the charging area directly outside the cell as identified in the FHA. Therefore, no preventive control strategy was identified in the DSA for when the propane powered forklift is in use. From DSA Hazard Screening, Appendix A, page A-5, the DSA states that to avoid unnecessary consideration of benign or commonly accepted substances in hazard identification, any amount of propane, natural gas, petroleum oil, or gasoline used for vehicle propulsion were excluded

from hazard identification. The FHA conclusions are required to be integrated into the safety basis. Based on the FHA evaluation of the significance of the BLEVE event, this event should be included in the DSA and appropriate safety controls are required to be established. In response to the EA team observation the site issued a PISA and noted it in an ORPS report (SC-ORO--ORNL-X10NUCLEAR-2015-0002). Follow up corrective action is under development.

EA further reviewed the use of various flammable liquids that have been used in the past and that are currently used in the hot cells. Because of the inherent potential for fire and/or explosions of flammable liquids, controls are necessary to maintain the flammable liquid concentration out of the flammable concentration range that is unique to each flammable gas and vapor. The FHA identifies isopropyl alcohol in excess of 1.59 liters as the worst case liquid that may be used in the hot cell. Analyses that support the use of up to 1.59 liters of isopropyl alcohol are presented in Attachment I of the FHA to demonstrate that the LEL is not exceeded. These calculations are used to establish an administrative control that no more than 1000 milliliters of a flammable liquid is permitted to be introduced into a hot cell bank at any given time. However, the analysis assumes full and even mixing and distribution of the vapors throughout the cell. This may not necessarily be the case for all materials with a newly opened container or newly introduced vapor. In these cases, full and evenly distributed mixing may not readily occur. Instead a wave front or stratification is likely to occur during the initial mixing and distribution. The assumption of full and even mixing and distribution is unverified, lacks a firm basis in the physics of vapor distribution, and may be non-conservative. This unverified assumption could result in undesired or inadequately evaluated safety consequences for some operations. (See **OFI-ORNL-11**.)

Another related analysis concerns the previous use of anhydrous ammonia that was located in cylinders in the Charging Area and piped through tubing into the north hot cell. (Refer to observation Item 1 below.) Limits for anhydrous ammonia are based on 1.7 gallons in the north hot cell that was connected by tubing to a 40 pound fill weight cylinder and one spare cylinder in the Charging Area. The analysis for the maximum quantity of anhydrous ammonia is not covered by the analysis in the FHA but was evaluated by a separate calculation, 3525/FPA/Anhydrous Ammonia, Revision 3, *Anhydrous Ammonia Assessment Charging Area and North Cell*. The anhydrous ammonia supply system arrangement has not been used since 2011, the anhydrous ammonia cylinders are no longer on the premises, and facility management does not anticipate its use in the foreseeable future. However, the charging apparatus remains in place, and operations are still considered acceptable within the safety basis authorization.

Observations regarding the anhydrous ammonia transfer configuration arrangement (that has been used in the past and portions of which are still installed allowing potential for future use) are presented below. (See **OFI-ORNL-12**.)

- The anhydrous ammonia calculation (3525/FPA/Anhydrous Ammonia) was performed by UT-Battelle FPEs to determine the maximum allowable quantity of liquid ammonia (NH_3) that could be stored in the charging area without reaching 50% of the LEL or used in the north hot cell without reaching 25% of the LEL. The calculation assumes no stratification of anhydrous ammonia gas within the Charging Area and also assumes the stoichiometric mixture of gas in air is uniform across the room volume. Typically, anhydrous ammonia gas is lighter than air and will rise, so that generally it dissipates and does not settle in low areas. However, in the presence of moisture, such as high relative humidity, the liquefied anhydrous ammonia gas forms vapors that are heavier than air. Poor airflow may cause these vapors to spread along the floor. Recognizing that the blowers for the hot cell ventilation system are not considered SS SSCs, the assumption of full mixing with no stratification of anhydrous ammonia is an unverified assumption without a firm technical basis. (See **OFI-ORNL-11**.)

- The service plug penetrating the hot cell wall and the associated anhydrous ammonia transfer tubing

extends the hot cell system boundary into the Charging Area when valves are open. Therefore, classification of the tubing in the Charging Area should have been considered as part of the SS boundary.

- The potential for fire or explosion in the hot cell existed with the presence of anhydrous ammonia. The magnitude of the explosive force is a function of the fuel characteristics. In this case anhydrous ammonia, its quantity, the pressure, temperature, and the presence of moisture can initiate an explosion. The magnitude of the explosive force unique to the hot cell anhydrous ammonia use was not determined and compared to the ability of the enclosure including the windows and other penetrations to withstand the blast.

The presumption of negative pressure into the hot cells and motive force for mixing vapors is maintained by blowers that are not classified as SS and therefore cannot be ensured. However, multiple penetrations into the cells, including the inlet filters, are similarly not classified as SS. Therefore, a SS passive confinement of the cells cannot be ensured in the case of a positive pressure event. Evaluations of a positive pressure wave and its impacts on the passive confinement, including components that are not qualified as SS (such as the inlet filters), and determination of the penetrations leak rates of the cell have not been fully considered and quantified.

5.5 Fire Protection Self-Assessment Program

This portion of the review was intended to determine whether the following inspection criteria were satisfied:

- ***Inspection Criterion:*** *A documented comprehensive self-assessment of the fire protection program is performed by the DOE site office and the facility contractor at least every 3 years, or at a frequency with appropriate justification approved by the DOE head of field element. [DOE Order 420.1 C]*

- ***Inspection Criterion:*** *Proper controls are incorporated to prioritize and monitor the status of the fire protection assessments and associated findings until final resolution.[DOE Order 420.1 C]*

- ***Inspection Criterion:*** *Processes are developed and implemented that prioritizes and monitors the status of fire protection assessment findings, recommendations, and corrective actions until final resolution. [DOE Order 420.1C, CRD]*

- ***Inspection Criterion:*** *Program issues identified during previous assessments or program reviews have been appropriately resolved, corrective actions have been completed, and are adequate, or a clear path to completion is indicated. (DOE Order 226.1C)*

UT-Battelle Self-Assessment Program

UT-Battelle has implemented a regular process of program oversight. A joint OSO and UT-Battelle triennial FPP review was conducted in 2012. OSO FR personnel led the review with substantial UT-Battelle fire protection engineer (FPE) team contributions. The FPP description establishes facility specific assessments and analysis frequencies of 1, 3, or 5 years for FHAs and FPEA depending on the hazard category and property value of the facility. A review of the records indicates that these are routinely being performed in accordance with the requirements.

Issues Management

UT-Battelle maintains the Assessment and Commitment Tracking System (ACTS) for recording, tracking, and trending issues identified during various forms of assessments. Any findings identified in the fire program assessments are entered into the ACTS. Available metrics data complied annually extending back to April 2000 indicate the number of issues identified and the number closed. In recent years, UT-Battelle has placed significant emphasis on the areas of chemical inventory management as well as fire and smoke barrier penetration controls and maintenance.

5.6 DOE Oversight

This portion of the review was intended to determine whether the following inspection criteria were satisfied:

- ***Inspection Criterion:*** *DOE field element line management has established and implemented oversight processes that evaluate contractor and DOE programs and management systems, including site assurance systems, for effectiveness of performance (including compliance with requirements). [DOE Order 226.1B 4b (1)]*

- ***Inspection Criterion:*** *DOE field element line oversight program includes written plans and schedules for planned assessments, focus areas for operational oversight, and reviews of the contractor's self-assessment of processes and systems. [DOE Order 226.1B 4b (2)]*

- ***Inspection Criterion:*** *Oversight processes are tailored according to the effectiveness of the laboratory assurance systems, the hazards at the site/activity, and the degree of risk, giving additional emphasis to potentially high consequence activities. [DOE Order 226.1.B 4b (5)]*

- ***Inspection Criterion:*** *DOE field element staff are adequately trained and qualified to perform assigned oversight activities. (DOE Order 226.1B, DOE Order 360.1C, and DOE Order 426.1 chg 1)*

DOE Order 420.1 C details the responsibilities of the heads of field elements with respect to fire protection safety systems and FPP safety management programs as follows:

- Fulfill the roles and responsibilities for the AHJ for matters involving fire protection, as defined by the NFPA, including documentation of any delegation or assignment of related responsibilities.

- Fulfill the roles and responsibilities for the building code official, as defined in DOE-STD-1066-2012, including documentation of any delegation or assignment of related responsibilities.

- Perform responsibilities of 'owner', or other equivalent term in the application of DOE technical standards or industry codes and standards, unless delegated.

- Provide oversight for contractor Cognizant System Engineer (CSE) programs and the operability of associated safety systems.

- Consistent with DOE Order 226.1B, establish and implement an appropriate self-assessment and oversight program for the elements of this Order.

In accordance with DOE Order 420.1C, OSO has documented delegation of certain AHJ responsibilities to the UT-Battelle AHJ under a Letter of Technical Direction Concerning Fire Protection dated September 5, 2013. This delegation includes requirements for the UT-Battelle AHJ to document all decisions and provide that documentation to the federal site manager annually.
DOE Order 226.1 B requires line management to establish and implement an effective oversight program. Oversight processes implemented by applicable DOE line management organizations are required to: evaluate contractor and DOE programs and management systems, including site assurance systems, for effectiveness of performance (including compliance with requirements). Such evaluations are to be based on the results of operational awareness activities; assessments of facilities, operations, and programs; and assessments of the contractor's assurance system.

The structures for implementation of these requirements by OSO are described in the *Management System Description* dated May 2013. The Management Systems Description (MSD) performance assurance process indicates that the OSO assurance oversight program structure is based on a triad of Contractor Oversight, Federal Self Assessments, and Corrective Action Management and Performance Trending. The document states: "The OSO Oversight Program places a substantial emphasis on the contractor's ability to conduct effective self-assessments through the maintenance of a strong CAS." The Contractor Oversight component is describe as including field monitoring, formal assessments, performance evaluations.

OSO safety oversight is principally assigned to the Operations and Oversight Division (OOD). Among the duties are the Safety and Health Programs; Contractor Assurance, Contractor Formal Assessments; Directives Management; Facility Safety Basis approval and implementation, and environmental protection. OOD staffing includes the FRs, safety basis reviewers, and specific environmental safety health and quality subject matter experts (SMEs). For certain specific areas including FPEs, OOD relies on support from the integrated support center (ISC). For example the MSD section on fire protection notes that OSO obtains support from Fire Protection SMEs at the ISC OR to assist in contractor oversight and evaluation of code equivalency requests and other technical manners in accordance with an umbrella service agreement between OSO and the ISC-OR.

OOD has established a set of internal ORNL Site Office Procedures (OSOP) and Work Practices (WP) procedures for implementation of the MSD. Among these are OSOP 226 *Oversight*, OSOP 411 *Facility Representative Program,* and WP 453 *Contractor Formal Assessment Program.*

In accordance with OSOP 226 and OSOP 411, DOE FRs perform routine operational awareness and report weekly on their activities. Per the OSOPs, SMEs including FPEs are to periodically participate on these walkthroughs. Records indicated four of these were performed in the last year at various ORNL facilities. No significant FP deficiencies were identified either by the ISC FPE or the FRs from these operational awareness activities.

In accordance with WP453, OOD has established an Assessment Planning Tool that incorporates DOE regulatory drivers as well as results from CAS assessments and contractor self-assessments to establish an annual integrated assessment schedule. Although the adoption of DOE Order 420.1C changes the requirement for a triennial FPP assessment to "periodic", the FY-2014 assessment planning tool indicates that the Office of Science Management System (SCMS) procedures will retain the three year frequency.

Overall based on the preceding evaluation, DOE field element management processes have adequately addressed the first three inspection criteria: line management has established and implemented oversight processes that evaluate contractor and DOE programs and management systems; the DOE field element line oversight program includes written plans and schedules for planned assessments, focus areas for

operational oversight, and reviews of the contractor's self-assessment of processes and systems: and assessment processes are tailored to the contractor assurance systems and address high hazard activities.

While OSO has established and implemented a structure for oversight that conforms to the policies and expectations of the Office of Science model for oversight, there are areas for potential improvements. EA noted that some of the OSOP and WP documents included references to obsolete reporting programs and structures and discontinued procedures. OSO is in the process of revising these procedures to address these issues.

As noted in the previous section, the triennial FPP assessments have been regularly performed. Typically these had been a review of the fire protection program led by an ISC FPE. In accordance with the DOE O 420 CRD for a contractor triennial FPP, the 2012 review of the FPP was performed as a joint OSO – UT-Battelle assessment. The team was led by an OSO FR and consisted of three staff for OOD, two UT-Battelle FPEs, one ISC FPE, and one ISC maintenance SME. Review was conducted based on an established plan with a specified scope and lines of inquiry. The review included interviews with key FPP related personnel, review of multiple documents, and walkdown of several facilities verifying pre fire plans and FPP implementation. The assessment identified three "Notable Practices." The assessment identified two findings related to the ORNL implementation of the OSO Letter of Technical direction and frequency of (FPEAs), and three Observations related to pre-fire plan documentation, closure of past assessment findings, and records archiving. The assessment included sections on ITM frequency for FP system components, aging equipment planning, and fire protection water system reliability. With respect to ITM frequency, they noted increasing trends in outage activities from 2010 through 2012, but noted these were an acceptably small percentage of components. With respect to the water system reliability, the assessment referenced a 2011 DOE –ORO report "Water Supply and Distribution Systems at the Oak Ridge National Laboratory" and concluded the water supply was adequate to meet known demands, although there were some areas of improvement in function and/or reliability. While the 2012 triennial assessment reviewed documentation of ITM on specific fire protection SSC, the assessment did not assess code requirements or UT-Battelle practices for ITM for water distribution systems that supply the fire suppression systems. As such there was a missed opportunity for the assessment to identify vulnerability in the reliability of the water infrastructure noted previously in this EA report and in a similar EA report from 2013 on the fire protection program at the Transuranic Waste Processing Center.

The remaining inspection criteria for this section addressees the training commensurate with assigned oversight responsibilities. DOE Order 226.1B details the expectations for performing Federal line management oversight. These expectations include maintaining sufficient technical capability and knowledge of site and contractor activities to make informed decisions about hazards, risks, and resource allocations; providing direction to contractors; and evaluating contractor performance. OSO does not have in house FPEs and relies on the ISC for FPE support. Under the current organization, these services are provided on an "as requested" basis. Typically, the OSO FR or the OSO safety basis reviewer initiates the requests for FPE support. The FRs conduct routine operational awareness activities and the safety basis reviewers evaluate submittals of safety basis updates annually. Since 2013 there has been a reduced involvement of a federal FPE in the routine assessment and review activities for fire protection programs, facility level fire protection system operations walkdowns, or evaluation of contractor FPE performance.

The local ISC was established as part of the reorganization of the Oak Ridge Reservation federal management in 2011. Through 2013 the ISC FPE duties were comprehensive and included review and advice to the federal AHJ (site manager) for issues related to fire protection as identified in DOE Order 420.1 B. Duties also included management of independent reviews of the contractor's FPP; observation of the contractor's annual or triennial facility fire protection system/program reviews and FPEAs; routine walkdown inspections of the fire suppression and fire detection system SSCs; review of the facility FPE

system awareness actions and ITM of FP SSCs; direct participation in the review of the annual updates of the BNA, facility FHAs, and facility DSAs (safety analysis reports); and direct review of the AHJ decisions delegated by the OSO AHJ to the UT-Battelle AHJ. After the local ISC field level FPE left federal service (2013), the SC HQ management chose not to fill the position. Instead OSO currently relies on reach back to the Chicago ISC office for formal triennial assessment support and the local ISC manager who is also a qualified FPE who, on request, will assist with facility walkdown support, supplemented by FR routine facility operational awareness, and the annual OSO safety basis review and approvals.

6.0 CONCLUSIONS

Overall, the FPP for ORNL was implemented and well established, addressing the respective DOE requirements while minimizing the likelihood and consequences of a fire-related event. The UT-Battelle FPP is supported with a well-qualified staff of FPEs who have significant years of fire engineering and risk management experience. Many of these engineers have provided engineering services for DOE as well as commercial and industrial facilities and inherently understand how to implement a fire program that meets the intent of the Highly Protective Risk criteria. Key documents including the ORNL BNAs and FHAs are well maintained and current.

EA observed specific areas for improvement at the facility level and for UT-Battelle departments having ancillary responsibilities for fire protection. Many of these areas for improvement stem from the age of the facility and lack of full facility coverage with active engineered features such as automatic fire detection and notification systems and automatic fire suppression systems. As a result, increased oversight for facility operations and administrative controls should be considered, including managing combustible loading and ignition source controls supported by quantifiable analysis and fire system testing improvements to ensure appropriate controls have been established and are being routinely assessed. Coordinating fire engineering resources with departments having ancillary responsibilities for fire protection including the Utilities department will provide the necessary technical knowledge to address the recognized issue of reliability and maintainability for the water supply infrastructure.

DOE field element line management has established and implemented oversight processes that evaluate contractor and DOE programs and management systems. DOE field element line oversight program includes written plans and schedules for planned assessments, focus areas for operational oversight, and reviews of the contractor's self-assessment of processes and systems. The OSO oversight processes generally follow the oversight system approved and implemented by the Office of Science, but some procedures need to be updated. OSO has partnered with UT-Battelle to ensure that the contractor's FPEs are knowledgeable of the facilities and capable of implementing a generally effective FPP. OSO has worked with the ORNL Fire Department to ensure baseline needs are satisfied and that pre-fire plans are generally adequate for most anticipated responses. OSO has missed opportunities to identify and respond to weaknesses in the infrastructure for fire protection water. OSO has missed opportunities to identify variance from NFPA code requirements requiring exemptions or equivalencies.

7.0 FINDINGS

As defined in DOE Order 227.1, *Independent Oversight Program*, findings are significant deficiencies or safety issues 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. Findings may identify aspects of a program that do not meet the intent of DOE policy, DOE orders, or Federal regulations. Corrective action plans are required to be developed and

implemented for EA appraisal findings. Cognizant DOE managers are expected to use site- and program-specific issues management processes and systems developed in accordance with DOE Order 227.1 to manage these corrective action plans and track them to completion.

ORNL Findings

F-ORNL-01: Building 3525 lacks a complete sprinkler protection. Contrary to full building sprinkler requirements mandated by the building code classification of Group H-4 high hazard occupancy and Special Purpose Industrial by NFPA 101 Life Safety Code, specific operational areas of the facility have no sprinkler protection. However the Fire Hazard Analysis (ref. ORNL/3525/FHA) takes credit for the building being fully sprinklered with respect to life safety requirements including maximum travel distance, common path, and dead ends. Contrary to DOE Order 420.1C an equivalency or exemption has not been approved to document this area of noncompliance and identify appropriate compensatory measures to address the risk.

F-ORNL-02: The manual fire suppression system and valve for the Building 3525 north hot cell is not maintained in accordance with NFPA 25 as referenced in the FHA. Additionally, facility operators are insufficiently trained for when to activate the manual water spray system.

F-ORNL-03: Contrary to NFPA 25, the annual main drain test is not performed as required, namely no comparison is performed of prior test results to ensure adequate trending of potential water supply degradation. Additionally the facility's use of comparing the static to the residual pressure to be within 10% is not recognized by NFPA, and no step in the test procedure bleeds down the system before starting the test.

F-ORNL-04: Contrary to DOE Order 420.1C, NFPA standards, and AWWA standards, ORNL has not fully addressed ITM deficiencies and an aged infrastructure that puts the reliability of the water supply system in question.

8.0 OPPORTUNITIES FOR IMPROVEMENT

Opportunities for improvement (OFIs) are intended to assist site management in implementing best practices, or provide potential solutions to minor issues identified during the conduct of the review that if left uncorrected could degrade the safety of the facilities. In some cases, opportunities for improvement address areas where program or process improvements can be achieved through minimal effort. These potential enhancements are not intended to be prescriptive or mandatory. Rather, they are offered to the site to be reviewed and evaluated by the responsible line management organizations and accepted, rejected, or modified as appropriate, in accordance with site-specific program objectives and priorities. EA identified the following OFIs:

ORNL OFIs

OFI-ORNL-01: The ORNL Fire Department should consider modifying the Pre-Plans for Building 3525 to address facility features such as safe areas of refuge that are provided by the fire rated stairway enclosures, and to remove reverences to firefighting capabilities such as the stand pipes, that are not tested to assure availability and functionality
OFI-ORNL-2: Consider implementing specific administrative controls to address the potential ignition sources in the hot cells.

OFI-ORNL-3: Consider enhancing the combustible loading program to address the following areas:

- Train facility operations regarding the technical bases and requirements to be implemented by of the procedure.

- Implement controls to ensure a lack of continuity of combustibles and prevent exposure to ignition sources in the hot cells.

- Improve inventory audit and logbook verification processes for managing flammable liquid inventory for the hot cell.

- Resolve inconsistencies between the FHA and technical bases requirements and the flammable liquids control procedure.

OFI-ORNL-04: Consider performing quantitative facility hazard evaluations to address the following potentially incomplete analyses and unverified assumptions of scenarios:

- Develop an analysis for hot cells passive confinement integrity that provides a unique facility-specific bounding scenario describing critical attributes of fire and explosion consequences (e.g., potential positive pressures, leak rates, and structural integrity of cell components). Ensure assumptions are quantified and justified by in a documented analysis rather than relying on engineering judgments and unverified legacy assumptions.

- Document reconciliation of differences between the bounding fire hot cell analyses (i.e., time duration and heat release rate) for Building 3525 and the building with similar attributes used for the analysis.

- Provide a quantitative analysis for an unattended hot cell fire.

OFI-ORNL-05: Consider documenting in the FHA and DSA the rationale for absence of active engineered fire protection controls (suppression and detection) in the hot cells since the absence of these controls is contrary to DOE-STD-3009 hierarchy that recommends engineered safety features over administrative controls.

OFI-ORNL-06: Consider upgrading the hot cell fire detection and notification capabilities.

OFI-ORNL-07: Consider implementing a modification or controls consistent with DOE-STD-1066-2012 and NFPA 801 to contain potentially radioactive water that could be discharged by the facility sprinkler systems. DOE-STD-1066-2012, Fire Protection, and NFPA 801 requires containment of potentially radioactive water that could be discharged by the facility sprinkler systems for new or substantially modified facilities. As a pre-existing facility this is not required for building 3525, but may be considered.

OFI-ORNL-08: Consider evaluating the potential for manual activation of the north hot cell sprinkler heads to introduce water into the ventilation system and compromise hot cell confinement.

OFI-ORNL-09: Consider addressing the vulnerability of smoke from a hot cell fire that could plug HEPA filters and disrupt the required negative pressure differentials in the hot cells as a result of reduced airflow.

OFI-ORNL-10: Consider revising the Building 3525 Standpipe System Flow Test to compare the recorded pressure and flow to the initial design conditions to verify that the water supply still provides the

design pressure at the required flow.

OFI-ORNL-11: Consider evaluating and verifying the assumption of complete mixing and even distribution that is intended to prevent a potentially explosive concentration of isopropyl alcohol vapor (or similar flammable vapors), as required by 10 CFR 830.122 Criterion 6 and NQA-1 Sections 402(d) and 501.1(b). Consider providing a firm physical basis of assumptions on mixing and concentrations for newly introduced or opened containers or similar processes that could result in wave front dispersion or stratification of specific vapors.

OFI-ORNL-12: Consider performing additional analysis as necessary to address identified concerns regarding the anhydrous ammonia transfer configuration arrangement:

- Ensure the calculation assumes all scenarios of stratification of anhydrous ammonia gas within the Charging Area, including stratification due to its lighter density when anhydrous and the denser vapors in the presence of moisture.

- Analyze the service plug used to penetrate the hot cell wall and the associated anhydrous ammonia transfer tubing to show whether classification of the tubing in the Charging Area should have been considered as part of the SS boundary. Other penetrations to the cells, such as the inlet filters, are similarly not classified as SS. Clearly define the SS boundary and identify all the components that are expected to provide a SS passive confinement function.

- Evaluate and determine the magnitude of the explosive force unique to the hot cell anhydrous ammonia use and compare it to the ability of the enclosure to withstand the blast.

9.0 ITEMS FOR FOLLOW-UP

EA will monitor corrective actions and follow-up responses through operational awareness activities. Specifically, a PISA was issued in response to the EA team observation that the FHA analysis and evaluation of the significance of the BLEVE event had not been carried over to the DSA to ensure that appropriate controls are established and maintained. EA will maintain operational awareness of implementation corrective actions related to the BLEVE. Additionally EA will observe progress on improvements in the water infrastructure ITM.

Appendix A
Supplemental Information

Dates of Review

Onsite Review: June 2-6, 2014
August 24-29, 2014

Office of Enterprise Assessments Management

Glenn S. Podonsky, Director, Office of Enterprise Assessments
William A. Eckroade, Deputy Director, Office of Enterprise Assessments
Thomas R. Staker, Director, Office of Environment, Safety and Health Assessments
William E. Miller, Director, Office of Nuclear Safety and Environmental Assessments

Quality Review Board

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Appendix B
Documents Reviewed and Interviews

Contractor's Documents Reviewed:

- Oak Ridge National Laboratory (ORNL), *Technical Safety Requirements, Irradiated Fuels Examination Laboratory, Building 3525* (ORNL/3525/TSR, Rev. 7a), Oak Ridge, TN
- Oak Ridge National Laboratory (ORNL), Nonreactor Nuclear Facilities Division, NNFD-3525-SDD-001, *Building 3525 K-15 Cell Exhaust System*, Revision 6, 03/08/2012
- Oak Ridge National Laboratory (ORNL), Nonreactor Nuclear Facilities Division, NNFD-3525-SDD-002, *Building 3525 Wet Pipe Sprinkler System*, Revision 2, 11/07/2013
- Oak Ridge National Laboratory (ORNL), Nonreactor Nuclear Facilities Division, NNFD-3525-SDD-003, *Building 3525 Fire Alarm System*, Revision 2, 04/26/2011
- Oak Ridge National Laboratory (ORNL), *Building 3525 Combustible Control Inspection Program*, NNFD-3525-AP-001-R2-CN-4, 11/07/2013
- Oak Ridge National Laboratory (ORNL), *NNFD-3525-AP-001, Combustible Control Inspection Program, Revision 2, Change No. 4* (*training* (via required reading)
- Oak Ridge National Laboratory (ORNL), Building 3525 – *Second Floor Mezzanine Sprinkler Water Release Calculation*, NNFD/3525/DAC/2009-010, Rev. 0, 12/04/2009
- Oak Ridge National Laboratory (ORNL), *Building 3525 PC-3 NPH Analysis & SSC Checks*, NNFD-3525-DAC-2011-003, Rev. 0, 08/31/2011
- ORNL Building 3525 Fire Hazards Analysis, Revision 8, 3/27/2014
- ORNL Building 3525 Safety Analysis Report, Revision 4d, 12/12/2013
- Building 3525 Anhydrous Ammonia Assessment Charging Area and North Cell, Revision 3, 1/31/2011
- USQD-3525-10-018, Ammonia Supply to Hot Cells, Revision 0, 4/13/2010
- USQD-3525-11-002, Work Control Documents for Experiment 15J Disassembly, Revision 0, 1/28/2011
- Oak Ridge National Laboratory (ORNL), *Building 3525 PC-3 NPH Analysis & SSC Checks*, NNFD-3525-DAC-2011-003 Addendum, Rev. 0, 11/29/2011
- Oak Ridge National Laboratory (ORNL), Fire Protection Engineering, *Fire Barrier Condition Assessment- Building 3525.* Revision 0, 05/27/2010
- Anhydrous Ammonia Service Plug Installation Drawing N3E020566A186, Rev B, 2/23/2010
- Anhydrous Ammonia Service Plug Assembly & Details Drawing N3E020566A183, Rev 0, 3/28/2006
- High Radiation Level Examination Lab First Floor Fire Barrier Composite Drawing F3E020566A002, Rev A, 5/12/2011
- High Radiation Level Examination Lab Second Floor Fire Barrier Composite Drawing F3E020566A003, Rev A, 5/12/2011
- High Radiation Level Examination Lab Basement Fire Barrier Composite Drawing F3E020566A001, Rev A, 5/12/2011
- DOE ORNL Site Office Triennial Assessment of the ORNL FPP, August 2012
- ORNL Water Distribution System Description, UT-MECH-ADM-002, Rev 1, 9/10,2013
- Building 3525 First Floor Sprinkler System, Drawing N3E020566A100, Rev B, 8/21/2010
- Building 3525 Basement Sprinkler System, Drawing N3E020566A099, Rev A, 8/21/2010
- Building 3525 Second Floor Sprinkler System, Drawing N3E020566A102, Rev A, 8/21/2010

- Building 7920 In Cell Fire Test to Evaluate Fire Threat and Effects on HEPA Filter Integrity,

DOE Documents Reviewed:

- ORNL Site Office Umbrella Service Agreement with the Integrated Support Center – Oak Ridge
- Various Service Delivery Records for ISC FPE support task orders through 2013
- SCMS Rev 3.0 M&O contract Management and Administration Procedure 5 Developing and Executing the SC Laboratory Performance Appraisal Process
- SCMS Rev 2.0 Management System Description: Facility Safety, Operations, and Infrastructure
- FY 2013 OSO Oversight Assessment Plan
- FY 14 Assessment Planning Tool for ORNL
- OSOP 411 Facility Representative Program
- OSOP 226 Rev 2 Oversight
- Draft Oversight Program Description Sept 2014
- WP 453 Rev 1 Contractor Formal Assessment Program
- OSO-MSD-100 R0 Management System Description
- DE-AC05-00OR22725 Modification No. 0825 Section J, Appendix E: Laws Regulations, and DOE Directives
- DE-AC05-00OR22725 Modification No. 341 Section I Laws Regulations, and DOE Directives (deviations (List A and List B related variations)
- SBMS ORNL Work Smart Standards: 7. Irradiated Materials Examination and Testing Facility and Irradiated Fuels Examination Laboratory (Buildings 3025E, 3525, and Support Areas) (Approved 05-07-1997) through Rev/Change 27 (10-16-2013)
- 2006 Triennial FPP review report and CAP "Assessment of the Implementation of the Fire Protection Program at the Oak Ridge National Laboratory
- 2009 Triennial FPP review report and CAP "Assessment of the Implementation of the Fire Protection Program at the Oak Ridge National Laboratory
- 20012 Triennial FPP review report and CAP "Assessment of the Implementation of the Fire Protection Program at the Oak Ridge National Laboratory
- Letter of Technical Direction Concerning Fire Protection , Sept 5, 2013

Key Interviews:

UT-Battelle, Nuclear Safety Manager
UT-Battelle, Fire Protection SME
UT-Battelle, Fire Protection and Fire Water System Engineer
UT-Battelle, Building 3525 operations representative
UT-Battelle, Fire Chief
UT-Battelle Safety Basis Engineer
ISC-Division Director
OSO-Facility Representative
OSO-Safety Basis Reviewer
OSO-Triennial team lead