Office of Enterprise Assessments Assessment of Nuclear Reactor Facility Operations at the Oak Ridge National Laboratory High Flux Isotope Reactor

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Acronyms

ACTS	Assessment and Commitment Tracking System
APT	Assessment Planning Tool
CFR	Code of Federal Regulations
CMMS	Computer Management Maintenance System
CONOPS	Conduct of Operations
CRAD	Criteria and Review Approach Document
CSE	Cognizant System Engineer
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
EABD	Experiment Authorizations Basis Document
ES&H	Environment, Safety, and Health
eSOMS	Electronic Shift Operations Management System
ESCCEP	Estimated Control Element Position for Criticality
FR	Facility Representative
FY	Fiscal Year
HFIR	High Flux Isotope Reactor
HP	Health Physicist
ISI	In-Service Inspection
ISMS	Integrated Safety Management System
IST	In-Service Testing
LCO	Limiting Condition for Operation
NOP	Normal Operating Procedure
Np	Neptunium
OAA	Operational Awareness Activity
OAC	Operational Awareness Coordinator
OAP	Operational Awareness Program
OAV	Operational Awareness Visits
OFI	Opportunity for Improvement
OJT	On-the-Job Training
OPW	Operational Performance Walkthroughs
ORNL	Oak Ridge National Laboratory
OSO	Oak Ridge National Laboratory Site Office
OSOP	OSO Procedure
PSO	Program Secretarial Officer
Pu	Plutonium
QA	Quality Assurance
RCT	Radiation Control Technician
REDC	Radiochemical Engineering Development Center
RO	Reactor Operator
RRD	Research Reactor Division
RWP	Radiation Work Permit
SME	Subject Matter Expert
SRO	Senior Reactor Operator
SSC	Structures, Systems, and Components
SSO	Safety System Oversight
TIM	Training Implementation Matrix
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question

UT-Battelle	UT-Battelle, LLC
VSS	Vital Safety System

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an oversight assessment of the Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR) operations. This assessment was part of a targeted assessment of nuclear reactor facility operations across the DOE complex.

EA identified nuclear reactor facility operations as a targeted assessment area in a memorandum to DOE senior line management, entitled *Office of Enterprise Assessments Nuclear Safety, Worker Safety and Health, and Emergency Management Assessment Strategies and Activities,* dated February 5, 2015. The memorandum also stated that EA would also evaluate the performance of DOE oversight during these assessments to provide an input to the overall evaluation of DOE Federal assurance capability. Pursuant to this memorandum, EA assessed the effectiveness of nuclear reactor facility operations at HFIR, which is managed and operated by University of Tennessee-Battelle, LLC (UT-Battelle) under the oversight of the ORNL Site Office (OSO). The review evaluated the flowdown and implementation of DOE requirements to ensure that activities are conducted safely and in accordance with those requirements, as well as the effectiveness of OSO's oversight of nuclear reactor facility operations at HFIR.

Overall, ORNL conducts HFIR facility operations safely and in accordance with applicable DOE requirements (i.e., DOE Orders 226.1B, *Implementation of Department of Energy Oversight Policy*; 422.1, *Conduct of Operations*; 426.1, *Federal Technical Capability*; and, 426.2, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*; and, 10 CFR Part 830, *Nuclear Safety Management*). Operators are highly experienced and well informed of conditions. ORNL has generally established adequate self-assessment and corrective action programs at HFIR, and most assessment results and issues are adequately tracked to resolution in a timely manner. ORNL has implemented a satisfactory certification and requalification training program for certified operators and supervisors that meets applicable DOE requirements. HFIR-defined surveillances and limiting conditions for operation are adequate in maintaining the operability and quality of vital safety systems within nuclear safety requirements. The cognizant system engineer program and system health reporting at HFIR are comprehensive. The experiment review and approval process, as implemented at ORNL and HFIR, has been instrumental in ensuring safe operations. Also identified was a best practice by the training department, which developed an electronic relational database that facilitates real time updates to training materials that result from changes in the plant and procedures. In summary, the HFIR staff generally meets, and in some cases exceeds, the DOE nuclear safety requirements for facility operations in the areas assessed.

EA identified one deficiency related to the HFIR operations staff's informal practice of placing a blue cover over a heat exchanger valve switch during Mode 1 reactor startup, which does not conform to the directives in DOE Order 422.1 to formalize operational practices. Formal written guidance for operators is necessary to ensure safe operation of the reactor. In this case, failure to follow the informal guidance could result in an inadvertent reactor scram, thus challenging the safety systems.

OSO has a generally well-documented oversight program that assesses contractor program performance and provides a sound process for establishing functional area oversight activities. EA identified two OSO deficiencies, including not conducting required oversight of oral examinations and walkthroughs for certification and recertification activities for HFIR reactor and senior reactor operators, and not updating oversight program implementing documents to reflect current work practices and requirements.

EA also identified several opportunities for improvement for UT-Battelle and OSO management to consider in further improving their programs and operations.

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1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of nuclear reactor facility operations at Oak Ridge National Laboratory (ORNL), specifically at the High Flux Isotope Reactor (HFIR). This assessment was conducted within the broader context of a series of targeted assessments to ensure that systems and techniques at DOE nuclear reactor facilities are consistent with regulatory requirements and provide acceptable protection of the health and safety of the public and workers. EA performed this targeted assessment at ORNL on November 14-18, 2016.

2.0 SCOPE

This assessment evaluated the flowdown and implementation of applicable DOE requirements to ensure nuclear reactor facility operations are conducted safely and in accordance with these requirements. The assessment also evaluated the effectiveness of DOE ORNL Site Office (OSO) oversight of nuclear reactor facility operations.

3.0 BACKGROUND

University of Tennessee-Battelle, LLC (UT-Battelle), under contract to DOE, manages and is the primary operator for ORNL. ORNL is the largest DOE science and energy laboratory, and its stated mission is to conduct basic and applied research to deliver transformative solutions to compelling problems in energy and security. Operating at 85 megawatts, HFIR is the highest flux reactor-based source of in-core sample location neutrons for research in the United States, and it provides one of the highest steady-state neutron fluxes of any research reactor in the world. More than 500 researchers use HFIR each year to investigate issues in physics, chemistry, materials science, engineering, and biology.

EA identified nuclear reactor facility operations as an area for targeted reviews in a memorandum to DOE senior line management, *Office of Enterprise Assessments Nuclear Safety, Worker Safety and Health, and Emergency Management Assessment Strategies and Activities*, dated February 5, 2015. This memorandum also stated that the performance of DOE oversight would be evaluated during the targeted reviews to provide input to the overall evaluation of DOE Federal assurance capability.

4.0 METHODOLOGY

The DOE independent oversight program is described in, and governed by, DOE Order 227.1A, *Independent Oversight Program*. EA implements the independent oversight program through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. Organizations and programs within DOE use varying terms to document specific assessment results. In this report, EA uses the terms “deficiencies, findings, and opportunities for improvement (OFIs)” as defined in DOE Order 227.1A. In accordance with Section 4.f.(1) of DOE Order 227.1A, DOE line management and/or contractor organizations must develop and implement corrective action plans for any deficiencies identified as findings. Other important deficiencies not meeting the criteria for a finding are highlighted in this report and are summarized in Appendix C. These deficiencies should be addressed consistent with site-specific issues management procedures.

As identified in the assessment plan, *Plan for the Office of Enterprise Assessments Targeted Review of Nuclear Reactor Facility Operations at Oak Ridge National Laboratory*, November 2016, this assessment considered DOE requirements related to the criteria and lines of inquiry of EA Criteria and Review Approach Document (CRAD) 31-08, Rev. 0, *Nuclear Reactor Facility Operations,* for the specified scope. EA CRAD 31-08 provides additional details about each of the objectives and criteria that were assessed, as well as EA's approach. EA used the following sections of EA CRAD 31-08 in performing this assessment:

- 4.3 Operations − Operations Activities, Logs and Records
- 4.5 Operations − Self-Assessments and Reviews
- 4.6 Training and Qualification − Operator Certification and Continuing Training
- 4.7 Safety Basis − Surveillances and Limiting Conditions for Operation
- 4.9 Safety Basis − Experiments
- 4.14 DOE Field Element Oversight.

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 operating and maintenance activities, and walked down significant portions of the HFIR, focusing on facility operations. Section 4.15, *Approach*, of EA CRAD 31-08 provides additional details about the record review, interviews, and observations. The members of the EA review team, the Quality Review Board, and EA management responsible for this review are listed in Appendix A. Appendix B provides a detailed list of the documents reviewed, personnel interviewed, and observations made during this review, relevant to the findings and conclusions of this report.

EA has not recently assessed nuclear reactor facility operations at ORNL and HFIR, so there were no previous operations specific items for follow-up during this assessment. A previous radiation protection program assessment at HFIR had identified a concern with in-beam high radiation area controls. Corrective actions were reviewed and deemed to be effective.

5.0 RESULTS

5.1 Operations − Operations Activities, Logs, and Records

Criterion:
Reactor facility operations practices are established and implemented to ensure that operators are alert, informed of conditions, and operate equipment properly; and to ensure thorough, accurate, and timely recording of equipment information for performance analysis and trend detection. (DOE Order 422.1)

EA found the HFIR facility operational logs and records to be maintained as required by HFIR administrative procedures and technical safety requirements (TSRs). While conducting the assessment, EA observed the operation of the HFIR facility in both shutdown mode and at full power operations (referred to as Mode 1 operation). EA observed multiple startups performed for training purposes and the final startup to full power, which was performed in accordance with Normal Operating Procedure (NOP) 2010, *Mode 1 Reactor Start Up*. The operators followed the applicable procedures and conducted the appropriate pre-job briefs in accordance with the governing procedure, ADM-0108, *Pre-Job and Post-Job Brief*. EA also reviewed the HFIR operational logs, which are maintained in an electronic system called the Electronic Shift Operations Management System (eSOMS). EA found that eSOMS is effective in allowing operators to record pertinent operations information, while also ensuring that the records are securely maintained in a central database.

During the Mode 1 reactor startup, EA noted that the operators placed a blue cover over one of the heat exchanger valve control switches in the control room. HFIR operating procedures state that in Mode 1 operation, three heat exchangers are to be in operation. The fourth, non-operating, heat exchanger is therefore a spare. Operators described the practice of placing a blue cover on the spare heat exchanger's valve switches during Mode 1 reactor startup as an informal mechanism, directed by the HFIR operations manager, to prevent inadvertent opening of the valve for the spare heat exchanger during operation, which would result in inadequate secondary cooling at higher power levels and could lead to a scram signal. The operating and administrative procedures do not describe this practice. As stated in Section 2.o. of Attachment 2 to DOE Order 422.1, *Conduct of Operations*:

> "The operator must establish and implement operations practices for timely written direction and guidance from management to operators, addressing the following elements:…
> (3) Configuration control of timely instructions/orders."

Appendix A to Attachment 2 of DOE Order 422.1 provides further detail on this requirement and specifies, in Section a, "Directives for timely instructions/orders include segregation of timely instructions/orders into daily and long-term categories."

The practice of placing a cover on the heat exchanger valve controls is not described in HFIR procedures, contrary to DOE Order 422.1. EA discussed this deficiency with HFIR management during the assessment, and HFIR management agreed to formalize this practice and integrate it into the Mode 1 reactor startup procedure NOP-2010. **(Deficiency)**

EA reviewed the records for the TSR-required reactor safety system neutron flux instrumentation channels. HFIR TSR 3.3.1.1 requires the flux to flow ratio to be monitored and maintained within specified limits, and HFIR TSR 3.3.1.2 requires two instruments be available for monitoring flux to flow ratio during Mode 1 operation. While observing initial startup to Mode 1 operations, EA verified that HFIR operators appropriately monitored these safety system indications and ensured that the values were within specified limits. EA verified that, in accordance with ADM-0151, *Console Operator Hourly Readings*, HFIR operators recorded the measured values in eSOMS.

During a plan-of-the-day meeting and pre-operation checks, EA noted appropriate communication of current issues, conditions, and events. EA also observed multiple shift turnovers both before and during Mode 1 operations. Operators appropriately performed reactor startup checks and start-of-shift operational checks, with oversight by the on-duty shift supervisor. HFIR staff appropriately communicated any identified issues, conditions, and events. EA also observed instances of informal shift communication and verified that formal conduct-of-operations processes were followed for critical communications, with an appropriate balancing of formal and informal shift communications.

In conclusion, HFIR has adequately established and effectively implemented facility operations activities, logs, and records. Measured parameters for reactor instrumentation adequately meet TSR parameters. Reactor operators are well informed of conditions, properly comply with procedures, and accurately record measured nuclear safety parameters. The HFIR staff also adequately identify and resolve problems in a timely manner in accordance with an established corrective action program. A deficiency was identified with the HFIR operations staff's informal practice of placing a blue cover over a heat exchanger valve switch during Mode 1 reactor startup, which does not conform to the directives in DOE Order 422.1 to formalize operational practices.

5.2 Operations − Self-Assessments and Reviews

Criterion:
Managers assess their management processes and identify and correct problems that hinder the organization from achieving its objectives, including monitoring and self-assessment of reactor facility operations. (10 CFR 830.122(i), DOE Order 422.1)

EA examined the HFIR programs for evaluation of root cause and implementation of corrective actions for identified issues. The HFIR issue tracking system, the Assessment and Commitment Tracking System (ACTS), provides a timely and effective process for evaluating incidents, implementing corrective or preventive actions, and trending and determining the extent of condition. ACTS provides an easily accessible database for managing the resolution of identified issues and notifies staff to complete assigned actions within a specified timeframe. The HFIR staff meets monthly to discuss outstanding issues and to agree on the path to resolve these issues. This system is an effective tool for oversight of outstanding safety issues.

EA observed a weekly meeting of the Plant Health Monitoring Committee and examined the relevant documentation to verify that problems are adequately identified and resolved in a timely manner. There were no unplanned reactor scrams in the past year that resulted in condition reports or corrective actions. During this meeting, EA observed that HFIR staff discussed detailed observations of reactor safety instrumentation and appropriately identified issues for resolution that affect the safety or reliability of systems.

EA reviewed a sample of self-assessments performed over the previous four years, including the *Triennial Internal Assessment of the Nuclear Maintenance Management Program for the High Flux Isotope Reactor*, dated April 2013; *Triennial Nuclear Criticality Safety Assessment Report for Building 7900 Operations*, dated October 2014; and *HFIR Nuclear Safety Culture Improvement Plan*, dated December 2015. EA's observations and interviews indicated that HFIR is addressing the recommendations from these self-assessments. For instance, enhancements to HFIR's nuclear safety culture are being implemented, with increased recognition of staff demonstrating nuclear safety behaviors, as well as improvements in formal and informal communications regarding a safety-conscious work environment. As discussed in Section 5.3, training has also been enhanced to improve the focus on safety.

In conclusion, HFIR has established generally adequate self-assessment and review processes for ensuring compliance with DOE requirements, and appears to be enhancing the effectiveness of performance-based criteria and evaluations in order to identify and prevent problems before they happen. The corrective action program is generally well established and effectively implemented.

5.3 Training and Qualification − Operator Certification and Continuing Training

Criterion:
Reactor operators, senior reactor operators, and fuel handlers (or fissionable material handlers) at hazard category 1 and 2 nuclear reactor facilities are trained and certified to be capable of performing their assigned work. Training for reactor operators and senior reactor operators includes formal classroom-type and on-the-job training to ensure familiarity with all required aspects of reactor operation, including anticipated transients and accident conditions, and written examinations are administered to candidates for certification. Continuing training is provided to personnel to maintain

their job proficiency. Continuing training programs for certified operators and supervisors consist of preplanned classroom-type training, on-the-job training, and operational evaluations on a regular and continuing basis. (10 CFR 830.122(b), DOE Order 426.2)

ORNL/TM-2012/115, *ORNL Training Implementation Matrix (TIM) for DOE Order 426.2, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*, describes how the requirements of DOE Order 426.2 are being implemented for each of the nuclear facilities at ORNL. Tables 3 and 4 in the TIM apply to HFIR and list the implementing procedures for each of the applicable order requirements for a Category A test reactor. ORNL/RRD/INT-10, *Research Reactor Division (RRD) Training Program Manual (TPM)*, describes the overall HFIR training program and, together with additional procedures, implements the requirements of DOE Order 426.2.

Sections 9.11, *Reactor Operator Certification*, and 9.12, *Senior Reactor Operator Certification*, of the RRD Training Program Manual list the positions requiring reactor operator (RO) and senior reactor operator (SRO) certification and the applicable eligibility and initial certification requirements in DOE O 426.2 for these positions. Interviews and review of a sample of the operator fundamentals and systems training and the initial on the job training (OJT) checklists indicate that the RO training was derived from a rigorous job analysis using the systematic approach to training process and includes the applicable requirements of DOE Order 426.2. The RO task list, which was developed using this process and is the foundation for the both the initial and continuing training programs, groups tasks by duty areas; references procedures for performing tasks; notes whether no training, initial training, both initial and continuing training, or specialized training is required for each task; and, notes whether completion of the task is required for initial certification. As expected for a Category A test reactor, the task list is very detailed, identifying 71 duty areas and approximately 800 total tasks. Some of the duty areas, such as responding to alarms, have more than 100 specific associated tasks. To keep track of all these tasks, the RRD Training Manager developed an electronic relational database that provides for real time updates of task lists and that links to, and automatically updates, training materials. The database also facilitates real time updates to the task list and training that result from changes in the plant and procedures. Development and use of this database to update training is a best practice that the RRD Training Manager should consider sharing with the nuclear facility training manager community via the Energy Facility Contractors Group training working group.

DOE Order 426.2 allows inclusion of fuel-handling requirements in RO and SRO training and certification programs instead of a separate certification program for fissile material handlers and their supervisors. Since RO-certified personnel handle and store fuel elements at HFIR, the training requirements for fuel handler certification are included as an integral part of the initial and continuing training programs. The RO task list includes fuel-handling activities in several duty areas, with approximately 100 related tasks. Additionally, RO classroom training addresses fuel-handling tasks and criticality safety. EA concluded that RRD has appropriately integrated fuel-handling training and certification requirements into the RO and SRO training and certification programs at HFIR.

A specific requirement in DOE Order 426.2 for a Category A test reactor is RO candidates' performance of a 90-day on-shift training period with no concurrent duties that are not related to the operation of the reactor facility. At HFIR, the 90-day on-shift training starts after the initial RO classroom training and covers facility orientation, fundamentals, and reactor systems, with the RO assigned to the day shift (training) operating crew. During this 90-day period, the RO candidate studies for checkouts and completes practical factors under the direct supervision of a certified operator or supervisor. At the end of this period, there is a final week of training in the HFIR mockup control room on integrated plant response (e.g., annunciator and abnormal event response procedures) and a final scenario evaluation. EA noted that the trainers who conducted the initial classroom training and the scenario evaluations during the final week of integrated operations training are certified RO/SROs. Allowing the instructors to maintain their operator certifications provides a high level of credibility with the operations staff and helps ensure that the training is accurate, relevant, and effective.

DOE Order 426.2 requires that the operating contractor of a Category A test reactor document an evaluation of the need for a full-scope simulator (see also Section 5.6). The RRD Manager has provided such an evaluation to show why using a control room mockup instead of a full-scope simulator is appropriate, given the operations at HFIR. Although the simulated operator training in the HFIR control room mockup is not as realistic as in a full-scope simulator, EA observed that the training was effective. EA also noted that in response to feedback from recent operators going through the initial certification process, the RRD training department moved integrated plant operations training, including the evaluated shift scenario using the control room mockup, to the end of the training period after the RO candidates gain a working-level knowledge of individual plant systems. Additionally, the RRD training department took the initiative to further enhance the effectiveness of training on alarm, abnormal, and emergency responses in the control room mockup by using notebook computers that can display real-time instrument readings, sound alarms, and provide feedback on changing plant conditions. All of the interviewed ROs who had recently completed certification noted that using the notebook computers significantly increased the effectiveness of the control room mockup in reinforcing and improving event response and team communications skills. The RRD Training Manager stated that the department plans to complete the development of a full suite of scenario-based training in the control room mockup using the notebook computers over the next several years as funds are available.

EA's detailed review of the initial certification files for several RO and SRO candidates showed that the files properly document all required certification activities. The final written examinations included an appropriate sampling of topics based on learning objectives and included questions for all the required topics for a Category A test reactor identified in DOE Order 426.2. EA noted some inconsistencies in the documentation of questions and answers provided by the candidates during the final oral walkthrough examinations, in that the evaluator did not always clearly document the questions asked and the candidate's responses for areas marked as "unsat" (i.e., unsatisfactory) or "sat" (i.e., "satisfactory") with "look-ups" (i.e., the candidate is required to provide additional clarification to a question after reviewing training material). Further, in some cases the evaluator did not clearly document the correct responses to follow-up questions for areas marked as "sat" with "look-ups." (See **OFI-RRD-01**).

Section 5.2 of the RRD Training Program Manual describes the general components for the continuing training program for HFIR certified operating organization personnel, including classroom training on plant fundamentals, system and component knowledge, and abnormal and emergency procedures, as well as completion of an annual and biennial OJT checklist. As noted above, the RRD training department maintains a comprehensive RO task list that identifies required tasks to be completed during continuing training. Specific recertification requirements for ROs and SROs are also identified, including completion of an annual and biennial control manipulation checklist, an annual exam on plant procedures for responding to abnormal plant conditions and emergencies, a comprehensive exam, an operational evaluation, an oral walkthrough examination, and a final abnormal/emergency scenario evaluation.

The recertification files for a sample of ROs and SROs showed that the control manipulation checklists specifically identify the required control manipulations, including significant control manipulations, and that the annual exam covers an appropriate sample of the questions, with questions and answers properly documented. However, EA noted inconsistencies in the documentation of questions and responses for the oral walkthrough evaluation for the recertification of ROs and SROs similar to those noted in the initial certifications. (See **OFI-RRD-01**.)

Although DOE Order 426.2 does not explicitly require the abnormal/emergency scenario evaluation as part of RO/SRO certification, the RRD performs these evaluations to assess individual and crew responses to a facility emergency and crew members' ability to function as part of an operating team. Trainers provide selected abnormal and emergency scenarios to candidates for RO and SRO certification and to HFIR operating crews. The trainers evaluated HFIR operating crews both as a team and as individuals in the following areas:

- Response to abnormal/emergency situations
- Communication
- Problem solving
- Use of facility to control and mitigate situation
- Appropriate use of procedures
- Team skills
- Interpretation of nuclear and process instrumentation indications.

EA's review of documentation for completed scenario evaluations identified that the trainers provided comments and feedback to both the team and the individuals in each of the areas listed above. DOE Order 426.2 requires team skill training for a Category A test reactor, and RRD's individual and team evaluations of an abnormal/emergency scenario represent an effective way to meet this requirement while enhancing RO and SRO candidates' integrated knowledge of the HFIR facility and event response skills.

During interviews and document reviews, EA determined that RRD conducts thorough evaluations of the operator certification and continuing training program that include DOE Order 426.2-required self-assessments using DOE-STD-1070-94, *Criteria for Evaluation of Nuclear Facility Training Programs*, and annual targeted independent assessments by the RRD quality assurance (QA) organization. The RRD Training Manager and training staff conduct one self-assessment every quarter, each addressing one of the performance objectives in DOE-STD-1070 so that all eight performance objectives are addressed every two years (more often than the required three years). All RO/SRO staff receive annual surveys requesting feedback on training effectiveness and areas for improvement. Based on document reviews and interviews, EA concluded that the RRD conducts thorough self-evaluations of the effectiveness of the RO and SRO training program and that these self-evaluations identify and correct issues and identify opportunities for improvement that are implemented on a prioritized bases.

In conclusion, the RRD has developed and implemented a comprehensive, rigorous, and effective initial and continuing training and certification program that meets all DOE Order 426.2 requirements for a Category A test reactor and results in highly competent operators. The development and use of an operator task database to keep training current with changes in procedures and plant systems was noted as a best practice.

5.4 Safety Basis – Surveillances and LCOs

Criteria:
Technical safety requirements are developed that are derived from the documented safety analysis to ensure that the necessary operability and quality of safety structures, systems, and components is maintained; that reactor operations are within safety limits; and that limiting control settings and limiting conditions for operation are met. (10 CFR 830.205(a))

EA reviewed the HFIR TSR limiting conditions for operation (LCOs) and surveillance requirements and their technical bases, which are derived from the documented safety analysis (DSA), and verified that surveillance testing is acceptably conducted. Numerous safety systems must be checked and tested on a periodic basis to ensure their operability, especially during Mode 1 operation. While observing reactor startup to Mode 1 operation, HFIR operators properly conducted the surveillance requirements for the appropriate safety systems, such that they met the conditions of the TSRs. For one of the TSR-required surveillance tests on initial ascension to power, the HFIR operators conducted a channel test of the flux-to-flow ratio. This test was conducted as prescribed in the applicable surveillance procedure (STP-3121A), but an unexpected response was observed in that the test signal failed to induce a scram signal. The operators successfully diagnosed the cause of the failure and appropriately followed the alternate procedure to test the system. The alternate procedures adequately tested the system and satisfied the requirements, and the operators appropriately maintained records in the log keeping system.

EA reviewed several completed surveillances for annual calibrations, verified that they were acceptably conducted, verified that the equipment used was appropriate and acceptably calibrated, and verified that applicable as-built system design documents and supporting documents are kept current using formal change control processes. The Computer Management Maintenance System (CMMS) tool maintains all HFIR TSR required surveillance records and automatically notifies appropriate personnel for scheduling the next required surveillance. EA confirmed that HFIR conducts the required surveillances within the appropriate time intervals.

EA reviewed the HFIR TSR LCOs and found that reactor operations are within the appropriate limits. Overall safety system function, response set points, and interlock features were in place. Following reactor startup to Mode 1 operation, EA observed HFIR operators testing several different safety systems and verifying that the appropriate measurements and responses were received. The HFIR procedures for maintaining TSR systems that contribute to LCOs are sufficient for ensuring safety system functionality. HFIR operators demonstrated during interviews that they are well-trained and knowledgeable of the LCOs, and they routinely interact with engineering staff on unreviewed safety question (USQ) determinations, system modifications, implementation verification reviews, and DSA annual updates.

EA's interviews and review of a sample of relevant documents indicated that HFIR cognizant system engineers (CSEs) effectively support operations and maintenance activities related to their assigned systems, routinely interact with reactor operators and safety basis engineers, and perform periodic system health monitoring and trending. Although HFIR engineering staff and maintenance staff are in separate organizations, they work effectively with each other. EA discussed system health monitoring with the CSEs and reviewed several system health reports. Multiple CSEs raised, as a recurring issue, the staff's ability to effectively maintain the systems with limited budgetary resources. EA found that issues with important safety implications are appropriately addressed, but also noted that the facility is over 50 years old and safety systems are constantly reviewed for age-related degradation. Because of limited budgetary resources, HFIR has implemented a procedure RRM-2500, *Plant Health and Reliability Action Tracking*, which creates a risk rating list of equipment/instrumentation needing replacement, using quantitative and qualitative inputs to determine the priority of equipment replacement issues. This system is effective in applying the available resources to ensure the long-term safe operation of the HFIR facility. HFIR has established an effective system engineering program and a CSE training and qualification program that complies with DOE Order 420.1C, Chg. 1, *Facility Safety*, and DOE Order 426.2. Overall, the CSEs demonstrated acceptable knowledge and ownership of their systems to ensure the operability and quality of safety systems.

In conclusion, HFIR surveillances and LCOs effectively maintain the operability and quality of safety systems within TSR conditions. Reactor operators and CSEs are experienced and knowledgeable, and they have developed an effective working relationship between operations and engineering to ensure that nuclear safety requirements are met. The CMMS tool is a strength in ensuring that safety systems are calibrated within the required timeframe.

5.5 Safety Basis − Experiments

Objective

Experiments are reviewed according to a DOE approved unreviewed safety question process. (10 CFR 830.203(d)(3))

Criteria:

Experiment Reviews: A safety review process is required to review each experiment or class of experiment prior to its conduct. The need for specific experiment review depends on the degree of its complexity and safety significance.

Conduct of Experiments: Guidance is required for operators relative to any unusual hazards associated with an experiment and the methods for identifying and responding to them. During an experiment, the installation of items in the reactor and removal of items from the reactor is dependent on regulatory and administrative limits, the level of radioactivity anticipated or measured, engineered safety features, and the qualifications of the individuals handling the items.

Post-Experiment Activities: In accordance with 10 CFR Part 835, irradiated items are to be controlled until disposal, until they decay to an acceptable level, or until they are acceptably transferred to another facility. Engineering controls for experiments, such as temporary shielding, time, distance, or remote handling devices, will effectively limit occupational exposures to the levels required by 10 CFR Part 835, and the facility's administrative limits. They will also help maintain exposures as low as reasonably achievable (ALARA). Access to areas where radiation is present is required to be posted in accordance with Subpart G of 10 CFR 835 and be limited as required by facility's radiation protection program. Special attention is to be given to experiments that involve the use of neutron beam ports, if there is a reasonable potential for a radiation dose to a major part of the body, gonads, or lens of the eye.

HFIR serves two principal missions. The first is to conduct in-core or in-reflector neutron irradiation of materials for isotope production and materials or component property testing. The second is to conduct studies on material structures and properties using coherent thermal and cold neutron beams outside the biological shield in the thermal beam room and in the cold neutron guide hall. Because the neutron beam experiments do not significantly affect reactor dynamics, cooling systems, reactor controls, or other significant safety basis concerns of the facility, the beam experiments are not the focus of this assessment. The safety of those operations was considered during a previous radiation protection program assessment conducted in 2014. This section of this assessment report deals primarily with the in-core and in-reflector experiments that may impact reactor dynamics and the safety basis for the facility. These include experiments that are placed in fixed flux trap positions for the duration of the operating cycle, as well as pneumatically driven "rabbit" capsules, which are irradiated for a shorter time and removed pneumatically to a remotely operated shielded facility inside the HFIR building (building 7900). Both types of experiments follow similar review and approval processes, although the "rabbits" can require more active operator attention during the transfer processes.

The experiment proposal review and approval process is controlled via two governing procedures: EG-1, *Review and Approval Process for HFIR In-Vessel and Gamma Irradiation Experiments*, and EG-6, *Experiment Review Questionnaire: In-Vessel Experiments*. EG-1 describes roles, responsibilities, authorities, and accountabilities, as well as the processes for experiment proposal, design, preparation, as-built QA review, and experiment approval. EG-6 provides a checklist for calculations and evaluations of the hazards and the safety controls for the experiments. These procedures provide a comprehensive framework for analyzing hazards and establishing controls for in-core and in-reflector experiments.

In accordance with EG-1 and EG-6, each experiment proposal is documented through the Experiment Authorizations Basis Document (EABD), which incorporates the hazard analysis and controls as determined by a variety of documented supporting analyses. These analyses and controls include design and as-built configuration controls; installation, operations, and post-irradiation handling instructions; expected instrumentation and monitoring indications; off-normal condition recognition and response instructions for the operators and experimenters; and various other administrative controls. All experiments require review and approval and/or notification sign-offs by a wide range of individuals and affected organizations, including the lead experimenter, lead QA, RRD EA&C staff, RRD criticality safety, HFIR material balance inventory controls, RRD QA, and HFIR operations. In addition to the EABD reviews, all experiments are reviewed in accordance with the USQ determination processes to ensure conformance to the TSRs and HFIR safety basis. ROs, reactor health physicists (HPs), and radiation control technicians (RCTs) are integrated into planning all activities for installation, operations, and post-irradiation handling for the experiments.

Several areas in the procedures state that the appropriate subject matter experts (SMEs) can directly bypass certain experiment-specific analyses if the experiment is within the bounding conditions of previously analyzed and performed experiments. Some of these bounding conditions are indicated in the EGF-1.7 attachment to EG-1; however, much of the bounding analysis consists of supporting calculations for previously approved EABDs and operational experience with previously conducted experiments. HFIR has not documented a comprehensive matrix of previously analyzed boundary conditions. Instead, the determination that the bounding conditions are satisfied depends on the SME's knowledge of the specific case history and recognition of analogous conditions. As implemented, this process has some potential weaknesses. For example, changes in the level of experience and knowledge of the assigned SMEs (i.e., personnel changes) could result in a loss of institutional knowledge and therefore a loss in the detailed recognition of the pertinent aspects of the bounding condition case studies. Additionally, unrecognized changes in pertinent material, properties, or conditions for a modified experiment could shift the conditions outside the umbrella of the analyzed bounding case. (See **OFI-RRD-02**.)

At the time of the EA assessment, experiments had already been loaded into the core or beryllium reflector positions in preparation for reactor startup, so EA had no opportunity to observe experiment installation or post-irradiation experiment removal and handling. EA observed reactor startup following the procedure NOP-2010. Prior to all startups, an estimated symmetric critical control element position (ESCCEP) is determined based on calculated control rod worth, fuel element loadings, and the composite reactivity of the installed experiments. The calculated reactivity worth of the composite of all the experiments is compared to the TSR limitations. During startup, the actual symmetric critical control element position, ASCCEP, is determined based on a balanced control element configuration and compared to the ESCCEP. If the difference between the actual and estimated control element positions exceeds a specified fraction of reactivity worth limits, the operators are instructed to shut down the reactor. During startup operations, operators followed this process and recorded the results in accordance with NOP-2010.

EA interviewed lead experimenters, QA assessors, RRD operations personnel, and radiation control personnel regarding the in-core experiment processes. Their descriptions of the processes were consistent with the written procedures, and they provided documented records of specific experiment analyses and examples of implementation of the processes. All displayed comprehensive knowledge of their roles and responsibilities within the process.

EA reviewed the documentation for EABD-HFIR-2016-001, which is the change package for the MFE-19J capsule irradiation experiment, and the associated USQ determination USQD-HFIR-2016-044. EA also interviewed the lead experimenter and preparer of the experiment proposal. The analysis was comprehensive, and the lead experimenters were knowledgeable of the expectations for the process, the safety issues associated with the experiment, and the controls required for safe operations. Similarly, EA reviewed the documentation for EABD-HFIR-2016-004, which is the experimental package for irradiation of fully loaded neptunium (Np)-237 targets in the HFIR ISVXF positions for three cycles, and the associated USQ determination USQD-HFIR 2016-052, Rev. 0. This experimental package involves irradiation of Np-237 to produce plutonium (Pu)-238 for use in National Aeronautics and Space Administration radioisotope thermoelectric generators and allows extension of the previously-approved two irradiation cycles to three irradiation cycles. While it improves the yield of Pu-238, it also increases the production of other Pu isotopes, requiring additional determination of the impacts on reactivity, post-irradiation radioactivity, heating, and other parameters. As in the previously discussed experiment, the analysis was comprehensive and the lead experimenter, who performed the supporting analysis, was knowledgeable of the expectations for the process, the safety issues associated with the experiment, and the controls required for safe operations.

After a reactor irradiation cycle, experimental capsules are transferred from the reactor in-core irradiation locations or beryllium reflector locations to the pool, using the water as shielding to minimize exposures. From the pool, the experimental capsules are transferred to the Radiochemical Engineering Development Center (REDC) hot cell facilities in shielded transfer casks. The typical in-core experiment handling processes in the HFIR facility are driven by controls for the external dose rates. Typically, the irradiated capsules emit significant external radiation due to activation of the components. Because of the pre-irradiation cleaning and containment structure of these capsules, there is rarely any significant removable surface contamination or dispersion of the material from inside the capsules, so the engineered controls for remote underwater or shielded handling of the materials inside HFIR are adequate for most expected external radiation conditions.

Post-irradiation experiment controls are communicated to the operators, experimenters, and RCTs via the EABDs. In HFIR, sample handling is required to be conducted under radiation work permit (RWP) controls. Safe handling controls are discussed as part of the RWP read-ins and pre-job briefs associated with sample handling operations. RCTs provide coverage during these activities, using appropriate survey instruments, fixed continuous air monitors and alarming radiation area monitors, and local counting laboratory equipment for analyzing contamination swipes. The EABDs include a section on analysis of off-normal conditions and response procedures. EA interviewed HPs and RCTs regarding their role in experiment planning, handling, and job coverage. EA could not observe RCTs during in-core sample transfers but was able to observe RCT surveillance and measurement activities during startup in support of guide hall experiment development. The RCTs and HPs were well integrated into planning, operations, and assessment. RCTs controlled the areas during the measurements, used appropriate and calibrated instrumentation to perform the measurements, and posted the areas appropriately based on the measurement results. Measurements were consistent with previously calculated estimates of radiation penetration through the shielding. HPs and RCTs reported the results to the experimenters and operations staff promptly, and they worked with the experimenters and operations personnel to plan the follow-up activities and implement controls.

The reviewed EABDs contain assessments of potential off-normal conditions and responses to those conditions. Most of the reviewed off-normal condition responses follow a standard approach, called "SWIMS": Stop operations, Warn others, Isolate or control the hazard, Move to a safe distance, Stop ventilation (if possible and if it will help minimize the spread), and then evaluate and plan a response. On rare occasions, experiment capsules have displayed leakage or gas bubbling; operators have typically identified such off-normal capsule leakage events via visual examination of the capsules as static pressures changed, while transferring from the vessel to the storage pool or from the storage pool to a transfer cask. In one historical case, a significant rupture of a capsule released contaminants into the reactor coolant and pool water. These contaminants were detected during routine coolant sampling and were largely removed by the coolant cleanup filtration and ion exchange systems. Capsule ruptures are very rare, due to the care taken during capsule manufacturing and the QA inspections to verify capsule integrity. However, sample handling is typically governed by a standing RWP that also covers a wide range of other HFIR operational activities, instead of being specifically tailored to the source terms and hazards of the transfer operations. The RWPs and other processes for post-irradiation sample handling in the HFIR do not typically incorporate isotope-specific hazard analysis, monitoring, and controls for an off-normal airborne release of the capsule contents, possibly resulting in delayed detection, recognition, and source-term specific response to an off-normal condition, such as a leaking or ruptured capsule. (See **OFI-RRD-03**.)

Lessons learned from an incident at another DOE facility, the Los Alamos Neutron Science Center (LANSCE)\, identified weaknesses in irradiated material inventory control that resulted in spreadable contamination and personnel exposures. In response, HFIR developed and implemented a detailed inventory, tracking, clearance, and shipment database for thermal neutron beam irradiated samples. However since most in vessel irradiation samples are controlled directly by HFIR operations personnel rather than outside visiting researchers, and since these movements also impact access to spent fuel, a different process is applied to in vessel irradiation experiments.

Irradiated experiment capsules and components from the in-core and in-reflector locations are stored in racks in the fuel pool until transfer to REDC for further processing and analysis. Since the in-pool materials also includes spent fuel, a detailed materials movement plan is required. All movements of materials in the storage pool are controlled via a Pool Work Management Work Plan (PWMWP), and a new PWMWP is developed for all movements to be performed following each operation cycle. The documentation for the reviewed PWMWPs includes designations of what material is present in each pool location and what materials are to be moved. The current in-pool irradiated sample inventory control process uses two long-established Excel spreadsheets to maintain the records. PWP-1167 and -1168 requires data from the PWMWPs to be transferred to the spreadsheets following each operation. RRD provided EA with copies of current PWMWPs and the current versions of two spreadsheets for review: *TargetsSOC469final (002)*, which provides pool storage location information linked to the designators and descriptions of the items, and *ShippingHistory (002)*, which is a chronological record of irradiated capsule transfers dating back to August 1992. While this inventory system is linked to the irradiation capsule designations, it does not directly incorporate activation and up-to-date decay information that may be pertinent to sample handling and movement controls. RRD personnel indicated that efforts are under way to develop a better-integrated inventory management and data control process for in-core sample storage and transfers, but the new process was not yet ready for EA's review and assessment. (See **OFI-RRD-04**.)

In conclusion, RRD has implemented a comprehensive and robust system for evaluating the wide range of potential hazards of proposed experiments, and establishing and verifying implementation of the controls for each in-core or in-reflector experiment that could impact the safety basis of the facility. However, there are a few areas where the experiment review process is not efficient in ensuring that new or modified experiments fall within the umbrella of previously established boundary conditions or assuring that controls for post-experiment off-normal conditions are specifically tailored to the source terms.

5.6 DOE Field Element Oversight

Objectives:
DOE field element line management has established and implemented effective oversight processes that evaluate the adequacy and effectiveness of reactor facility operations. (DOE Order 226.1B, DOE Order 422.1)

The DOE field element has established and implemented an effective safety system oversight program (or comparable program involving Facility Representatives or SMEs) for qualifying staff to apply engineering expertise in its oversight of the assigned safety systems and to monitor performance of the contractor's CSE program.

Criteria:
Oversight Program: Oversight processes are tailored according to the effectiveness of contractor assurance systems, the hazards at the site/activity, and the degree of risk, giving additional emphasis to potentially high consequence activities.

Facility Representatives (FRs): FRs provide effective oversight to determine that the contractor is operating DOE facilities in a safe manner.

Safety System Oversight (SSO): The DOE field element has established and implemented an effective SSO program (or comparable program involving FRs or SMEs) for qualifying staff to apply engineering expertise in its oversight of the assigned safety systems and to monitor performance of the contractor's CSE program.

ORNL Site Office Oversight Program

The OSO oversight program is described in OSO procedure (OSOP) 226, *Oversight*. Per OSOP 226, oversight of contractor activities includes two components: field monitoring through the operational awareness program (OAP), and the contractor formal assessment program.

OSO Work Practice (WP) 450, *Operational Awareness Program (OAP)*, describes how to schedule, perform, and document the results of operational awareness activities (OAAs), and states the purpose of the OAP is to provide personnel a first-hand understanding of the effectiveness of environment, safety, and health (ES&H) program implementation for ongoing activities and to ensure that contractor systems are consistent with integrated safety management system (ISMS) principles, work activities comply with contractual requirements, and adverse conditions and/or trends can be identified at an early stage.

Per WP-450 the OSO OAP consists of three groups of activities: Operational Awareness Visits (OAVs), Operational Performance Walkthroughs (OPWs), and Day-to-Day Oversight and Coordination.

OAVs are coordinated and scheduled walkthroughs of facilities and work areas to observe workplace conditions and the effectiveness of work implementation. OAVs include a combined contractor and OSO team comprised of both SMEs and program management staff. Through the OAV, the safe and compliant condition of the workplace is evaluated and work implementation is observed to assure adequacy of hazard controls. The Contractor is responsible for issuing a formal report summarizing the facilities visited, the activities observed, and any findings identified within 30 days of the completion of all OAV's for a given division.

Operational performance walkthroughs (OPWs) are coordinated walkthroughs, conducted by OSO program, project, and SME staff, of contractor work operations including research, operations, construction, and maintenance. WP-450 requires the OPW lead to submit a report summarizing the results of the OPW within one week of completing the walkthrough.

The third component of the OAP is routine informal walkthroughs of contractor facilities by OSO personnel. The purpose of these walkthroughs is for OSO staff to understand the broad operational requirements and practices associated with the conduct of work within their assigned areas of responsibility, including but not limited to:

- Type of work conducted
- Hazards involved and applicable controls
- Work controls, administrative and engineered (ISMS implementation)
- Self-assessment and feedback and improvement activities.

WP-450 states that the Operational Awareness Coordinator (OAC) has a major role in maintaining the OAV schedule, coordinating the OPW program, trending contractor and OAP data, and ensuring that issues are entered into the electronic systems for trending by appropriate OSO staff.
WP-450 also states that any findings from the OAP are captured in the ORION database and processed per WP-220, Actions/Commitments Tracking. However, the ORION database has been replaced by a locally administered SharePoint site that tracks issues and corrective actions. Also, OSO's oversight program implementing procedures do not describe some of the current work practices and supporting tools such as the scheduling and documenting completion of the various types of OAAs and the identification and tracking of any issues in the local SharePoint site. Also, since the procedures were last revised in 2011 they do not reflect the current versions of applicable DOE oversight directives. Implementing documents for the OSO oversight program have not been updated to reflect current work practices and tools, nor formally reviewed to ensure that they address applicable requirements of DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*. (**Deficiency**) OSO management stated that they are updating the oversight program and supporting implementing procedures and work instructions to reflect current office practices and tools and ensure consistency with the requirements of DOE Order 226.1B.

WP-450 states that detailed expectations for FR walkthroughs are provided in OSOP 411, *Facility Representative Program*, which specifies that FR walkthroughs are to be documented in a biweekly report to OSO management. Attachment 2 of OSOP 411, *Format for FR Biweekly Report*, provides a template and general expectations for the FR biweekly report. Section C of the template, *FR Facility Oversight*, includes a heading for the FR to record the total number of walkthroughs, including the number of walkthroughs conducted with SMEs. The primary purpose of using the template is to give management an overview of FR activities and to gather information, such as amount of time in the field, for the FR quarterly input. EA noted that OSOP 411 does not include expectations for documenting issues identified during FR walkthroughs in the biweekly reports or in the database, unlike the WP-450 expectations for documenting findings during OAVs and OPWs.

EA's discussions with OSO management and a review of the database for documenting completed OAAs indicated that the OSO OAP provides management with an overall awareness of the effectiveness of safety management systems and the safe performance of work activities. However, the OSO OAP does not provide specific expectations for conducting and documenting periodic OAAs in all nuclear safety basis subtopic areas in order to ensure that objective performance information and data analysis are applied to determine whether key program requirements were being met and to effectively scope the OSO biennial assessment of the nuclear safety basis functional area (see discussion below related to assessment planning).(See **OFI-OSO-1**.)

OSOP 453, *Contractor Formal Assessment Program*, provides general guidance on identifying, scheduling, preparing, conducting, and documenting assessment results. The OSO Assessment Planning Tool (APT) database, Part 1, *Oversight Approach*, includes fields for the Safety/Business Management Program, any frequency requirement for assessments and the associated DOE or regulatory driver, the OSO primary assessment approach (program assessment or rotational topic assessments) for required periodic assessments, and comments.

Part 2 of the APT, *Assessment Planning and Scheduling Tool*, lists applicable subtopics for each Safety/Business Management Program and previous assessments conducted by OSO, the contractor, or external organizations such as EA. Part 2 also includes any major issues identified during the previous assessments, along with a determination by OSO management of whether an assessment should be conducted within the next three-year planning window based on an evaluation of oversight data and input from SMEs, whose comments are provided as needed to document the rationale for the assessment schedule.

EA reviewed Part 1 of the APT for the Nuclear and Facility Safety area and noted the following:

- Conduct of Operations (CONOPS): OSO requires at least 2 of the FR quarterly assessments to cover at least 2 of the 18 elements of CONOPS to ensure that all 18 elements are covered in a three-year period. Although DOE Order 422.1 does not specify the scope or periodicity for oversight of CONOPS, this is a sound approach for oversight of this topical area.

- Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities: OSO identifies the requirement in DOE Order 426.2 to ensure that the entire scope of DOE-STD-1070 applicable to the site is assessed every three years.

- Nuclear Safety Basis Implementation: OSO has locally identified a requirement for an assessment of this functional area every two years for the RRD, which includes HFIR. Part 1 of the APT does not list the subtopic drivers for several subtopics in the Nuclear Safety Basis area and does not provide guidance for selecting the scope of this biennial assessment. As previously noted, the OSO OAP does not provide specific expectations for conducting and documenting periodic OAAs in the following sub topical areas in order to ensure that objective performance information and data analysis are applied to effectively scope the OSO biennial assessment:
    - Safety basis implementation verification reviews
    - Control of nuclear material inventory
    - Hazard categorization
    - System engineer program
    - In-service inspection (ISI)/in-service testing (IST) program
    - Operability of Vital Safety System (VSS)
    - TSR/DSA implementation
    - USQ process.

EA reviewed Part 2 of the APT for the Nuclear and Facility Safety area, which provides the basis for selection of planned assessments for fiscal year (FY) 2017. The information documented in APT Part 2 in this area includes:

- DOE Order 426.2: OSO performed the most recent assessment in 2014, so the next triennial assessment by OSO is scheduled in 2017.

- ISI/IST and Operability of VSSs: OSO plans to conduct an assessment in FY 2017 to follow up on findings from assessments of these areas conducted in 2014. The comments in Part 2 of the APT noted that OSO may combine ISI/IST and VSS operability assessments into one assessment.

- Nuclear Criticality Safety Program: OSO participated in a UT-Battelle-led review of this program in 2012. The next assessment is scheduled for 2017, based on the good performance noted in the previous review and the maximum five-year assessment frequency required locally by OSO.

EA noted the following attributes of the implementation of the OSO contractor assessment program, with an emphasis on coverage of the ORNL RRD and HFIR operations:

- The APT, developed locally by the OSO, provides a thorough, repeatable, and documented basis for identifying, scheduling, and tracking the completion of all required periodic assessments.

- The APT includes a basis for selecting specific assessments but does not include the basis for excluding assessments of other areas. (See **OFI-OSO-2**.)

- Subareas under the Nuclear and Facility Safety area are not included in Part 1 (scope) of the APT, even though some of these subareas may be covered by requirements for focused oversight. For example, oversight of the CSE program and oversight of operability of safety systems are required by DOE Order 420.1C, and the USQ implementation guide (invoked as a standard by 10 CFR 830) requires a review of the contractor's annual USQ submittals. These areas are not included in the APT.

- OSO management identified several options for obtaining specialized oversight resources in functional areas where it lacks local SME resources: leveraging external resources from the integrated service centers, as in the CSE and fire protection programs; using FRs at HFIR, as in the VSS and CSE assessments; and requesting SMEs from the other offices, such as National Nuclear Security Administration Production Office staff at the Y-12 National Security Complex. Discussions with OSO management indicated that a criticality safety engineer from Y-12 may support the planned criticality safety program review in 2017.

OSO WP-220 states that OSO uses the ORION database as the issues management system. However, as previously noted, the ORION database was replaced by a locally developed SharePoint system for tracking and trending issues and corrective actions and the pertinent OSO procedures to clarify the expectations and processes for documentation and analysis of oversight results have not been updated to address this change.

EA also assessed whether OSO meets all the specific requirements of DOE Order 426.2 for HFIR. OSO provided evidence that it was completing the required three-year evaluation of the HFIR training program in accordance with DOE-STD-1070. EA also reviewed documentary evidence for the field element's review and approval of the RRD TIM and the RRD procedure for approving exemptions and extensions to certification requirements.

With respect to the TIM and as noted in Section 5.3, section 8.b.(2) of chapter 2 of attachment 1 of DOE Order 426.2 requires the operating contractor to evaluate the need for a full-scope or part-task simulator for a DOE Category A test reactor and the heads of field elements and program secretarial officers (PSOs) to approve this evaluation. The contractor performed the required evaluation and concluded that a control room mock-up instead of a full-scope simulator was appropriate given the nature of the HFIR operations. The results of this evaluation was documented as an attachment to the HFIR TIM, and the OSO Manager approved the evaluation and conclusion that a full-scope simulator was not needed with the approval of the TIM. OSO did not have documentation of the program secretarial officer approval of this evaluation as required by DOE Order 426.2. This was discussed with the site office, and OSO management is ensuring that documentation of the approval is obtained.

With respect to certification requirements, the OSO oversight program does not include periodic operational awareness activities to review the oral examinations and walkthroughs for certification and recertification of shift supervisors, SROs, and ROs for a Category A test reactor using the OAAs specified in Section 5.c.(7) of DOE Order 426. 2. **(Deficiency)** Periodic reviews of operator certification and recertification activities are required in order to provide an objective basis for the field element manager's continued confidence in the effectiveness of the contractor's training, qualification and certification program. This was discussed with the site office, and appropriate awareness activities are now being conducted.

Facility Representative Program

The OSO FR staffing analysis indicated the need for two full-time FRs to cover the HFIR. OSO recently moved one of the fully qualified FRs at HFIR to a new position, hired a new FR from the nuclear industry, and reassigned a fully qualified FR from another facility to HFIR. The FRs currently assigned to HFIR are phase I qualified with experience at other facilities and are working to complete the HFIR facility-specific qualifications. The HFIR FR now assigned to another facility provides OSO safety basis support, is qualified as a nuclear safety specialist, and continues to provide backup to the recently assigned HFIR FRs as needed. The FRs maintain appropriate awareness of plant conditions, technical issues that occurred during startup, and CONOPS implementation. As a recent example of the effectiveness of day-to-day oversight of HFIR by OSO personnel, during a review of occurrence reports, FR observations and questions led to a TSR violation being reported in August 2016. Overall, the assigned FRs and backup FR have the necessary technical competence and knowledge of site and contractor activities to make informed decisions about hazards, risks, and resource allocation; provide direction to the contractor; and evaluate contractor performance as expected by DOE Order 226.1-2B.

Safety System Oversight Program

Per DOE Order 426.1, *Federal Technical Capability*, OSO is not required to establish a formal SSO program since it has no defense nuclear facilities. However, as previously noted, the OSO APT identified the need for a similar level of oversight for the contractor's CSE program; operability of structures, systems, and components (SSC): and the ISI/IST program. The oversight of these areas consists primarily of day-to-day FR operational awareness. OSO conducted a formal assessment of VSS operability in ORNL nuclear facilities, including systems at HFIR, in 2014. The VSS assessment team consisted of five FRs from OSO, and the scope of the HFIR portion of the assessment included surveillance and monitoring, configuration control, system maintenance, and system engineering.

OSO identified planned assessments in FY 2017 of the ISI/IST programs and VSS operability in Part 2 of the ATP for the Nuclear and Facility Safety area. The comments section of the ATP noted that these two assessments could be combined and that the scope would include verification of the effectiveness of completed corrective actions to address the findings from the OSO 2014 VSS assessment report.

The EA team noted that the assigned FRs maintained operational awareness of several system-related issues during the reactor startup, attended a weekly CSE system status meeting, and generally conducted an adequate baseline of oversight of the CSE program and VSS operability. However, during the current assessment, EA did not have the opportunity to observe other SMEs directly supporting the FRs in oversight of the system engineering related disciplines and operability of safety SSCs. For a Category A test reactor, conducting formal baseline OAAs of the implementation of engineering programs provides a basis for confidence in contractor data, such as system health reports and contractor-led VSS assessments, and for scoping and conducting more in-depth assessments using both internal and external SMEs (*see* OFI-OSO-01 and OFI-OSO-02). Further, while OSO management identified several options for obtaining resources in functional areas where it lacks in-house SME capabilities, OSO did not provide evidence that they have sufficient on-staff personnel with specialized expertise to support the planned ISI/IST program and VSS operability assessments given the age and unique nature of many of the HFIR safety systems. (See **OFI-OSO-3**.)

In summary, the OSO oversight program provides management with an overall awareness of the effectiveness of safety management systems and the safety performance of work activities. OSO has assigned appropriate FR coverage for HFIR, and the FRs provide effective day-to-day oversight of HFIR operations. OSO uses FRs and SMEs for oversight of safety systems and the RRD CSE program; however, the SMEs do not conduct formal and structured OAAs to evaluate SSC operability and the implementation of the CSE program and the OSO OAP does not provide expectations for conducting periodic OAAs of nuclear safety basis topical areas to support program evaluation and scoping of related assessments. EA also identified deficiencies related to OSO oversight program documentation, approval of the evaluation of the full-scope simulator for HFIR, and the conduct of required OAAs for the operator certification program.

6.0 FINDINGS

EA identified no findings during this assessment. Deficiencies that did not meet the criteria for a finding are listed in Appendix C of this report, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified some OFIs to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in appraisal reports, they may also address other conditions observed during the appraisal process. EA offers these OFIs 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.

- **OFI-RRD-01:** The RRD Training Manager should consider monitoring and clarifying the expectations for documentation of examiner questions and candidate responses during oral walkthrough examinations.

- **OFI-RRD-02**: RRD should consider compiling a comprehensive matrix of previously analyzed bounding conditions to help ensure that modified or newly proposed experiments remain within the bounding conditions of previous experiments.

- **OFI-RRD-03:** RRD should consider performing more detailed, sample-specific source term hazard analysis for off-normal conditions (e.g., a breached capsule with release of contents). Based on that hazard analysis, RRD should consider tailoring the RWPs and post-irradiation sample handling controls to incorporate off-normal condition detection monitoring and response appropriate for the operations and source-term specific hazards.

- **OFI-RRD-04:** RRD should continue ongoing efforts to develop an improved and integrated inventory management and control system for pool items, and implement the improved system as soon as it is tested and validated to be effective, accurate, and reliable.

- **OFI-OSO-01:** OSO should consider providing specific expectations to FRs and functional area leads for conducting and documenting periodic OAAs in all the nuclear safety basis subtopic areas to ensure adequate coverage of these areas, including verification of key program requirements, while also providing objective data to support analysis and effective scoping the OSO biennial assessment of the nuclear safety basis functional area.

- **OFI-OSO-02:** OSO should consider including focused OAAs as part of oversight of HFIR to provide performance-based information in order to support the scheduling of contractor-led assessments or focused assessments by the field element to address measurable concerns and to justify reducing the scope of planned assessments based on validated good performance.

- **OFI-OSO-03:** OSO should consider identifying external resources to support the planned ISI/IST program and VSS operability assessments.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: November 14-18, 2016

Office of Enterprise Assessments (EA) 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, Deputy Director, Office of Environment, Safety and Health Assessments
C.E. (Gene) Carpenter, Jr., Director, Office of Nuclear Safety and Environmental Assessments
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Appendix B
Key Documents Reviewed, Interviews, and Observations

Documents Reviewed

- EG-1 Rev 10. *Review and Approval Process for HFIR In-Vessel and Gamma Irradiation Experiments,* September 30, 2013
- EG-6 Rev 1. *Experiment Review Questionnaire: In-Vessel Experiments,* April 5, 2007
- EGF-1.4 rev 0. EABD –HFIR-2016-001, *Experiment Authorization Basis Document forMFE-19J Experiment.* May 26, 2016
- USQD-HFIR-2016-044 Rev. 1, *Unreviewed Safety Question Determination (USQD) Change Package for EABD-HFIR-2016-001 "Irradiation of the MFE-19J Experiment Capsule"* July 13, 2016
- EABD-HFIR-2016-004, *Irradiation of Fully Loaded Np-237 Targets in the HFRI ISVXF Position for 3 Cycles*, June 8, 2016
- USQD-HFIR-2016-052 Rev. 0, *Unreviewed Safety Question Determination (USQD) Change Package for EABD-HFIR-2016-004 "Irradiation of Fully Loaded Np237 Targets in the HFIR ISVXF Positions for 3 Cycles"* July5, 2016
- EGF-1.6 Rev 7, *Experiment Information Form Applicable to G-085 and G-086*, June 30, 2016
- ORNL RWP Number HFIR-18675, Rev 16 *Description of Work: Routine Operations Activities*, August 8, 2016
- SBP-1000, Rev. 3, *Preparation, Review, and Handling of Calculations*, May 30, 2014
- Training documentation: *Responding to Unanticipated Continuous Air Monitor (CAM) Alarm*
- *ORNL Radiological Survey (HRIR-440926)* September 12, 2016
- Administrative Procedure (ADM), ADM-0001, Conduct of Operations, Rev. 15, 7/2016
- ADM-0004, Shift Routines, Operating Practices, and Control Station Activities, Rev. 12, 6/2015
- ADM-0005, Control Room Access, Rev. 12, 5/2014
- ADM-0006, Communications, Rev. 15, 5/2015
- ADM-0054, Shift Staffing, Rev. 24, 2/2016
- ADM-0104, Shift Orders, Rev. 17, 6/2015
- ADM-0106, Operator Aid Postings, Rev. 12, 11/2013
- ADM-0108, Pre-Job and Post-Job Brief, Rev. 10, 5/2015
- ADM-0112, Shift Supervisor Turnover, Rev. 33, 11/2016
- ADM-0114, Nuclear Reactor Controller Shift Turnover, Rev. 19, 7/2014
- ADM-0150, Chronological Log Keeping, Rev. 16, 12/2015
- ADM-0151, Console Operator Hourly Readings, Rev. 52, 6/2016
- ADM-0152, Shift Checks, Rev. 108, 11/2016
- ADM-0161, Technical Safety Requirement (TSR) Documenting and Tracking, Rev. 24, 2/2015
- Normal Operating Procedure (NOP), NOP-2010, Mode 1 Reactor Start Up, Rev. 78, 6/2016
- NOP-2010, Attachment E, Mode 1 Reactor Start Up For Training Testing or Dropped Rod Recovery, Rev. 78, 6/2016
- NOP-2010, Attachment A, Startup Checklist Supplement, Rev. 78, 6/2016
- NOP-2016, Operation of the Primary Inlet Temperature Control System , Rev. 3, 9/2008
- NOP-2020, Guidelines for Control of Reactor Power, Rev. 17, 6/2016
- NOP-2024, Positioning of an Ion Chamber During Reactor Operation, Rev. 4, 12/2013
- NOP-2106, Operation of the Primary Coolant Pumps, Rev. 39, 11/2016
- Surveillance Testing Procedure (STP) STP-3110, Calibration of the Safety Monitoring Channels, Rev. 1, 3/2002
- STP-3111, Calibration of the Neutron Flux Channels, Rev. 4, 11/2008
- STP-3117, Calibration of the Power Rate of Rise Channels, Rev. 3, 10/2008

- STP-3121A, Mode 1 Reactor Protection System Testing Reactor Start Up, Rev. 12, 1/2012
- STP-3122, Safety Channel Testing/Post-Maintenance, Rev. 15, 3/2015
- HFR-1204, Safety Neutron Flux System Functional Testing and Calibration, Rev. 17, 3/2015
- HFR-1208, Safety Power (Flux) Rate of Rise System Testing and Calibration, Rev. 9, 7/2011
- HFR-1209, Safety/Servo Ionization Chamber Positioning and Reset Gain Adjustment, Rev. 10, 8/2014
- RRM-2000, Plant Health Committee, Rev. 9, 7/2016
- RRM-2500, Plant Health and Reliability Action Tracking, Rev. 0, 6/2015
- RRM-3000, System Health Reporting, Rev. 8, 7/2016
- Material Work Package (MWP)-603726, Calibration of Channel #1 Safety Neutron Flux System and Spares, 2/2016
- TSR Documenting and Tracking Form #16-145, Repositioning of Ionization Chamber #1, 11/2016
- Electronic Shift Operations Management System (eSOMS) Logs for November 14, 15 and 16, 2016
- System Health Report for Reactor Controls System, 11/2016
- *Triennial Internal Assessment of the Nuclear Maintenance Management Program for the High Flux Isotope Reactor*, dated April 2013
- *Triennial Nuclear Criticality Safety Assessment Report for Building 7900 Operations*, dated October 2014
- *HFIR Nuclear Safety Culture Improvement Plan*, dated December 2015

Interviews

- HFIR Radiation Control (Radcon) Manager
- HFIR Health Physicist
- HFIR Radcon Technicians
- EABD-HFIR-2016-001 Preparer
- USQD-HFIR-2016-044 USQD Reviewer
- EABD-HFIR-2016-004 Preparer
- Lead QA Reviewer
- HFIR Reactor Operations Engineer
- HFIR Safety Basis Engineer
- Experiment Managers and Staff
- HFIR Nuclear Facility Manager
- Criticality Safety Officer
- ORNL Research Reactors Division Director
- ORNL Research Reactors Division Deputy Director
- ORNL HFIR Plant Manager
- ORNL HFIR Operations Manager
- ORNL HFIR Maintenance Manager
- ORNL HFIR Systems Engineering, Design and Fabrication Manager
- ORNL HFIR Instrumentation and Controls Supervisor
- ORNL HFIR Compliance and Assessment Coordinator
- ORNL HFIR Shift Supervisors (2)
- ORNL HFIR Nuclear Reactor Controllers (6)
- ORNL HFIR Operations Engineers (2)
- ORNL HFIR Cold Source Operator (1)
- ORNL HFIR System Engineers (2)
- OSO Facility Representative
- OSO Management

Observations and Associated References

- Reactor Startup, October 18, 2016, using NOP-2010, Rev. 78, *Mode 1 Reactor Startup*
- Radcon Guide Hall experiment developmental shielding adequacy surveys, October 2016
- Radcon Guide Hall Experiment Startup Surveillance, October 18, 2016
- HFIR plan-of-the-day meeting
- HFIR plant health monitoring committee meeting
- HFIR pre-startup checks (NOP-2010)
- HFIR Shift Checks (ADM-0152)
- HFIR Shift Turnover (ADM-0112 & ADM-0114)

Appendix C
Deficiencies

Deficiencies that did not meet the criteria for a finding 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:

The HFIR operations staff's informal practice of placing a blue cover over a heat exchanger valve switch during Mode 1 reactor startup does not conform to the directives in DOE Order 422.1 to formalize operational practices.

Oak Ridge National Laboratory Site Office:

- Implementing documents for the OSO oversight program have not been updated to reflect current work practices and tools, nor formally reviewed to ensure that they address applicable requirements of DOE Order 226.1B.

- The OSO oversight program does not include a periodic operational awareness activities for reviewing the oral examinations and walkthroughs for certification and recertification of shift supervisors, SROs, and ROs for a Category A test reactor using the OAAs specified in Section 5.c.(7) of DOE Order 426.2.