Independent Assessment of Safety System Management at the Oak Ridge National Laboratory Radiochemical Engineering Development Center – Building 7920

July 2025

U.S. DEPARTMENT of ENERGY | Office of Enterprise Assessments

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Acronyms

ACTS	Assessment and Commitment Tracking System
APR	Assigned Procedure Reading
CCP	Change Control Package
CFAP	Contractor Formal Assessment Program
CFR	Code of Federal Regulations
CM	Configuration Management
COG	Cell Off-gas
CRAD	Criteria and Review Approach Document
CSE	Cognizant System Engineer
DBA	Design Basis Accident
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FR	Facility Representative
HCSA	Hot Cell Support Area
HEPA	High Efficiency Particulate Air
LCO	Limiting Condition for Operation
M&TE	Measurement and Test Equipment
NNFD	Non-reactor Nuclear Facilities Division
OFI	Opportunity for Improvement
ORNL	Oak Ridge National Laboratory
OSO	ORNL Site Office
PM	Preventive Maintenance
PMT	Post-maintenance Testing
QA	Quality Assurance
REDC	Radiochemical Engineering Development Center
SAC	Specific Administrative Control
SBMS	Standards-based Management System
SC	Safety Class
SSCs	Structures, Systems, and Components
SSM	Safety System Management
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question
UT-Battelle	UT-Battelle, LLC
VAC	Volts Alternating Current
VOG	Vessel Off-gas

INDEPENDENT ASSESSMENT OF SAFETY SYSTEM MANAGEMENT AT THE OAK RIDGE NATIONAL LABORATORY RADIOCHEMICAL ENGINEERING DEVELOPMENT CENTER – BUILDING 7920

Executive Summary

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted an independent assessment of safety system management (SSM) at the Oak Ridge National Laboratory (ORNL) Radiochemical Engineering Development Center (REDC) – Building 7920 from January to April 2025. ORNL is managed and operated by UT-Battelle, LLC (UT-Battelle) and is overseen by the ORNL Site Office (OSO). This assessment was performed within the broader context of targeted SSM assessments at selected high hazard (i.e., hazard category 1 and 2) nuclear facilities across the DOE complex. The purpose of this assessment was to evaluate whether the selected safety systems (i.e., the safety class vessel off-gas system, cell off-gas system, and hot cell support area exhaust system) were appropriately functionally classified and are operated and maintained in a manner that ensures they can reliably perform their intended safety function of protecting workers and the public from analyzed hazards. This assessment also evaluated the effectiveness of applicable OSO oversight processes.

EA identified the following strengths, including one best practice:

- The Non-reactor Nuclear Facilities Division (NNFD) reliability and predictive maintenance program is advanced, with adequate resources and mature processes. The program applies a variety of state-of-the-art industry practices in support of a preventive maintenance optimization program. (Best Practice)
- UT-Battelle REDC Building 7920 operations technicians demonstrated a high level of knowledge about hot cell operations and the building structures, systems, and components.
- UT-Battelle has significantly improved its training program by addressing previously identified weaknesses and timely implementation of the recently released DOE Order 426.2A, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities*.
- The UT-Battelle lessons learned reporting process is well-developed and effectively implemented.
- UT-Battelle trends safety systems parameters and conducts monthly system health review meetings effectively
- UT-Battelle proactively entered several of the issues identified during this assessment into its Assessment and Commitment Tracking System as soon as they were identified.
- The OSO Facility Representative (FR) for REDC Building 7920 demonstrated thorough knowledge of the selected safety systems and recent issues with these systems.
- The OSO FR maintains an additional qualification as a nuclear safety specialist to support field element oversight responsibilities.

EA also identified the following weaknesses, including two findings:

- In the documented safety analysis (DSA) design basis accident analysis, UT-Battelle has not evaluated all design basis accidents for which safety controls must be identified to protect the workers and public. (Finding)
- In the DSA, UT-Battelle does not provide functional requirements, performance criteria, a system evaluation, or technical safety requirements for the safety class 480 volts alternating current (VAC) electrical power supply system. (Finding)

- In the DSA, UT-Battelle does not justify crediting only one specific administrative control in lieu of a safety structure, system, or component to prevent an anticipated event with high unmitigated dose consequences to the public.
- In the DSA, UT-Battelle does not evaluate whether the vessel off-gas system scrubber is required to prevent degradation of safety class downstream components (e.g., filters, fans) from an acidic environment.
- UT-Battelle does not adequately maintain configuration management of the 480 VAC electrical power supply system.
- UT-Battelle does not adequately calibrate and maintain all measurement and test equipment used for inspections, testing, and maintenance of safety systems.
- UT-Battelle has not submitted the NNFD conduct of operations matrix to OSO within the past three years for review and approval.
- UT-Battelle includes conflicting requirements for the use of procedures to perform operations in procedure NNFD-011, *Nonreactor Nuclear Facilities Division Conduct of Operations Manual*.
- The UT-Battelle qualification program does not require retraining on some procedures when updated.

In summary, the safety class vessel off-gas system, cell off-gas system, and hot cell support area exhaust system were appropriately functionally classified and are operated and maintained in conformance with applicable requirements. However, the identified weaknesses have the potential to reduce the reliability of the evaluated safety systems in performing their intended safety functions. Resolution of the identified weaknesses will result in a more robust safety basis and increased assurance that the systems will operate reliably.

INDEPENDENT ASSESSMENT OF SAFETY SYSTEM MANAGEMENT AT THE OAK RIDGE NATIONAL LABORATORY RADIOCHEMICAL ENGINEERING DEVELOPMENT CENTER – BUILDING 7920

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Nuclear Engineering and Safety Basis Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the effectiveness of safety system management (SSM) at the Oak Ridge National Laboratory (ORNL) Radiochemical Engineering Development Center (REDC) – Building 7920. This assessment was performed within the broader context of SSM assessments at selected high hazard (i.e., hazard category 1 and 2) nuclear facilities across the DOE complex in accordance with the *Plan for the Independent Assessment of Safety System Management Across the DOE Complex Fiscal Year 2025*. The assessment was conducted from January to April 2025.

The primary purpose of the assessment was to evaluate whether selected safety system controls were appropriately developed into technical safety requirements (TSRs), and whether the structures, systems, and components (SSCs) required for the controls are operated and maintained in a manner that ensures they can reliably perform the intended safety functions of protecting workers and the public from analyzed hazards. Programs within the scope of the assessment that support safety system operability and reliability are TSR surveillance, engineering design, cognizant system engineer (CSE), configuration management (CM), maintenance, operations/training, procurement quality assurance (QA), feedback and improvement, and Federal oversight. The assessment focused on the effectiveness of DOE and contractor line management in managing and implementing SSM requirements.

ORNL is managed and operated by UT-Battelle, LLC (UT-Battelle) and is overseen by the ORNL Site Office (OSO). REDC Building 7920, located in the Melton Valley of ORNL, is a glovebox laboratory and hot cell facility used for the recovery and purification of transuranium (also called transuranic) elements.

2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which EA implements through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. This report uses the terms "best practices, deficiencies, findings, and opportunities for improvement (OFIs)" as defined in the order.

As identified in the assessment plan, this assessment considered requirements from EA CRAD 30-11, Revision 1, *Safety Systems Management Review*, in assessing the adequacy of selected programs related to SSM at REDC Building 7920. The assessment was conducted using a sampling of data and is not intended to represent a full programmatic assessment of all SSM-relevant programs.

EA selected three safety class (SC) systems:

- Vessel off-gas (VOG) system – TSR limiting condition for operation (LCO) 3.1.1
- Cell off-gas (COG) system – TSR LCO 3.1.2
- Hot cell support area (HCSA) exhaust system – TSR LCO 3.1.3.

EA used a written comment and response process to address significant issues identified before the onsite portion of the assessment. Follow-on discussions were conducted with UT-Battelle and OSO personnel to clarify and resolve comments. Additional issues were identified during the onsite portion of the assessment.

EA examined the development of the selected controls as TSRs based on the hazard and accident analyses and the flowdown of safety basis requirements into technical baseline documents. EA reviewed key documents, including the documented safety analysis (DSA), the TSR document, TSR surveillance records, selected program description documents, system design documents, procedures, and training and qualification records. EA interviewed personnel responsible for developing and executing the assessed programs; observed performance demonstrations related to operations and surveillance; participated in detailed discussions of procedures and process implementation; and performed walkdowns of accessible areas of the selected systems. EA also conducted interviews and reviewed oversight records to determine whether OSO provided adequate oversight of the UT-Battelle CSE program and the operability of associated safety systems. The members of the assessment team, the Quality Review Board, and the management responsible for the assessment are listed in appendix A.

There were no previous findings for follow-up addressed during this assessment.

3.0 RESULTS

3.1 Safety Basis

This portion of the assessment evaluated the safety basis, including control derivation and description, safety control functional classification, and TSR development for the selected systems to determine whether they can fulfill their required safety functions for normal operations and accident conditions, and to verify compliance with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*.

Control Derivation and Description

The REDC Building 7920 SC VOG, COG, and HCSA exhaust systems mitigate potential radiological consequences by directing exhaust air streams from cubicles, gloveboxes, and hot cells through HEPA filters to remove airborne particulates before discharge. The VOG, COG, and HCSA systems are appropriately credited for protection of the public and workers from radiological consequences based on the analyzed potential accidents. The DSA hazard and accident analyses are, in general, sufficiently conservative to support the derivation of adequate safety controls, with the following two exceptions:

- Contrary to the requirements of DOE-STD-3009-94, section 3.4.2.X.1, which requires evaluation of "secondary events directly caused by natural events, such as earthquake induced fires, based on their physical possibility for facility conditions," the DSA seismic design basis accident (DBA) analysis excludes seismic induced fires without any justification. (See **Finding F-UT-Battelle-1**.) Due to the presence of combustible organic solvents and ignition sources, a seismic induced fire is a physical possibility, and thus associated releases must be considered in the DBA. A seismic induced fire could result in mitigated dose consequences that exceed 25 rem to the public based on credited safety controls. Incomplete analysis of DBAs could result in uncharacterized risk and inadequate control selection to protect the public and workers.
- Contrary to the requirements of DOE-STD-3009-94, section 4.5.X.2, the DSA credits only one specific administrative control (SAC) in lieu of a safety SSC without discussing consideration of SSCs or providing justification that this SAC alone is sufficient to prevent an anticipated event with

high unmitigated dose consequences to the public. (See **Deficiency D-UT-Battelle-1**.) Relying solely on an administrative control may not prevent the accident scenario, and thus may not adequately protect the public and workers. Specifically, the DSA concludes that dropping a heavy load on a hot cell bank, waste tank pit, or building roof is an anticipated event that results in unmitigated consequences greater than 25 rem to the public. The only identified control for this event is a critical lift SAC, and no discussion was provided to demonstrate that any safety SSCs or other controls (e.g., MAR limits) were considered.

With one exception, the DSA, chapter 4, appropriately provides the safety functions, system description, functional requirements, and system evaluation with specific performance criteria for the selected systems. Contrary to DOE-STD-3009-94, sections 4.3.X.3, 4.3.X.4, and 4.3.X.5, for the SC 480 volts alternating current (VAC) electrical power supply system, the DSA does not provide functional requirements, performance criteria, or a system evaluation, and it does not identify TSR controls. (See **Finding F-UT-Battelle-2**.) Insufficient evaluation of an SC system and lack of appropriate TSR controls could result in the system not performing its safety function. Although the DSA, chapter 4, identifies the 480 VAC electrical power supply system as a SC support system to the VOG, COG, and HCSA systems, the system's primary power source is from offsite (non-safety), its alternate power sources are non-safety diesel generators, and it powers safety and non-safety equipment from the same buses.

Safety basis calculations that support derivation of safety controls in the DSA are technically adequate. However, ORNL/7920/DAC-2003-01, *Radiochemical Engineering Development Center (REDC) Building 7920 - Safety Analysis Report - Preliminary Hazard Analysis and Accident Analysis Consequence*, which is the primary reference for the accident analysis, includes handwritten notes and analysis assumptions that are not easily reviewable. (See **OFI-UT-Battelle-1**.)

Safety Control Functional Classification

In general, the selected systems are appropriately functionally classified as SC in the hazard and accident analyses. Several postulated accidents described in chapter 3 of the DSA result in unmitigated radiological consequences exceeding the Evaluation Guideline of 25 rem specified in DOE-STD-3009-94; therefore, the VOG, COG, and HCSA systems are appropriately identified as SC to mitigate these events. However, contrary to DOE-STD-3009-94, section 4.3.X.2, the scrubber is not functionally classified even though scrubbing of acid fumes from the VOG stream may be necessary to prevent degradation of SC downstream components (e.g., filter housing, fans). Further, chapter 4 of the DSA requires the HEPA filters to be acid resistant but does not include an evaluation of the impact of the VOG acidic environment on downstream components. (See **Deficiency D-UT-Battelle-2**.) Without a thorough evaluation of downstream components in the expected environments, their ability to perform their safety functions may not be ensured.

Technical Safety Requirement Development

The information provided in chapters 4 and 5 of the DSA and the TSR bases is sufficient to derive the TSR LCOs for each of the selected systems. The TSR operability and surveillance requirements developed for the selected systems are generally adequate to ensure that the required safety functions will be met. The TSR bases adequately describe the reasons for the operating limits and surveillance requirements with one exception. Contrary to DOE-STD-3009-94, section 5.5.X.2, there are no designated surveillance requirements for the SC 480 VAC electrical power supply system. The observation of this non-compliance is captured in Finding F-UT-Battelle-2.

Safety Basis Conclusions

In general, the safety basis for the selected systems is appropriately developed, and the safety functions, functional requirements, and system evaluations are adequately documented. The selected systems are appropriately functionally classified. However, the accident analysis does not evaluate all DBAs for which safety controls must be identified to protect workers and the public, and a SAC is credited with excessive risk reduction as the only control to prevent an anticipated event with high dose consequences to the public. Further, the SC 480 VAC electrical power supply system is not properly evaluated in the DSA, and the scrubber is not evaluated to determine whether functional classification is required to protect VOG system downstream components.

3.2 Technical Safety Requirement Surveillance

This portion of the assessment evaluated the REDC Building 7920 TSR surveillance processes for the selected systems to determine compliance with the TSR document.

The reviewed TSR surveillance procedures and their implementation are adequate to ensure that the selected systems can accomplish their safety functions. The surveillance procedures appropriately identify system and test conditions and include clear performance steps. The procedures were appropriately developed, reviewed, and approved. UT-Battelle schedules, tracks, and documents surveillances effectively to ensure compliance with the TSR-required frequencies, considering allowable extensions of surveillance requirements (i.e., TSR-defined grace periods). Notably, instruments used for TSR surveillance are labeled with TSR limits and setpoints.

Technical Safety Requirement Surveillance Conclusions

UT-Battelle's surveillance procedures are effective, and performance of required surveillances is adequate in accordance with established frequencies and procedure*s.*

3.3 Engineering Design Process

This portion of the assessment evaluated the REDC Building 7920 engineering design process for the selected systems to determine whether they incorporate applicable safety basis requirements and comply with 10 CFR 830.122, *Quality assurance criteria*, and appropriate consensus standards.

UT-Battelle appropriately implements conduct of engineering procedures that meet the requirements of 10 CFR 830.122, criterion 6, for design performance. These procedures provide adequate processes for incorporation of appropriate consensus standards, developing and controlling engineering design criteria, performing calculations, and developing drawings for the selected systems.

Reviewed drawings were complete and appropriately signed by independent checkers. Design inputs and standards were adequately identified and are appropriate to allow qualified individuals to understand the design requirements. The UT-Battelle engineering organization performed adequate independent design verifications for reviewed calculations and drawings to ensure that engineering products are technically accurate. Design calculations appropriately determined the accuracy of instrumentation used for TSR surveillances. The instrumentation accuracies are correctly accounted for in the TSR surveillance procedures.

Engineering Design Process Conclusions

Engineering procedures provide adequate processes for performing calculations, developing drawings, and managing design changes. The reviewed calculations and drawings were appropriately signed by independent engineers and incorporated applicable requirements from the facility safety design basis and consensus standards.

3.4 Cognizant System Engineer Program

This portion of the assessment evaluated the implementation of the CSE program to determine its effectiveness in ensuring that the selected systems can reliably perform as intended, and to determine compliance with DOE Order 420.1C, *Facility Safety*.

UT-Battelle has adequately established and implemented procedures for the REDC Building 7920 CSE program that meet the requirements of DOE Order 420.1C, attachment 2, chapter V, section 3.b, for the selected systems. The CSE assigned to the VOG, COG, and HCSA systems is appropriately trained and qualified in accordance with UT-Battelle training procedures.

The interviewed CSE and system engineers demonstrated adequate knowledge of the reliability, operational readiness, and required configurations of their assigned systems. Reviewed monthly system health checklists and annual safety assessment reports demonstrated appropriate CSE review of system operability, maintenance activities, system reliability, TSR surveillances, modifications, post-maintenance testing (PMT), configuration control, and trends. The monthly system health checklist review meeting is considered a strength of the program, as it is used to review robust trending data that has been tracked for key safety system parameters.

The CSE works closely with the operations and maintenance organizations to troubleshoot equipment issues. The CSE appropriately monitors the physical configuration of assigned systems using walkdowns and performing adequate system condition assessments to verify the adequacy of configuration-controlled SSCs and processes. Configuration-controlled documents that require updates when impacted by system modifications are appropriately identified. System walkdowns are documented in logs and appropriately identify physical or documentation discrepancies and their resolutions.

Additionally, aging equipment plans for SC SSCs have been adequately developed to evaluate components' remaining design life, degradation of components, consequences of component failure, spare parts status, and anticipated repair or replacement issues and costs. However, the reviewed plans have not been recently updated. Aging equipment plans identify obsolete components and the potential need for system modifications upon failure. In particular, the aging equipment plan for the scrubber system noted that a potential scrubber failure could result in a possible change in mission for the facility. The plan states that a significant engineering effort would be required for a replacement system, and no engineering evaluation had been completed at the time of the assessment. (See **OFI-UT-Battelle-2**.)

Finally, due to a lack of full system engineering staffing, the review of initial balance-of-plant maintenance work packages by the electrical system engineer is not always timely. The electrical system engineer position responsibilities include reviewing safety and non-safety work packages. At the time of the assessment, there was a backlog of 80 work packages to be reviewed, all of which are related to non-safety systems. The system engineering manager has one electrical system engineer and is appropriately recruiting additional personnel. The system engineering manager appropriately prioritizes the review of SC SSCs to help ensure the timely completion of SC work packages.

Cognizant System Engineer Program Conclusions

The CSE program, as described in reviewed implementing procedures and program manuals, meets the requirements of DOE Order 420.1C. The CSE assigned to the VOG, COG, and HCSA systems is appropriately trained and qualified and adequately monitors the physical configuration of the systems. A shortage of electrical engineers may be contributing to delays in work package reviews; however, the system engineering manager is appropriately addressing this issue.

3.5 Configuration Management

This portion of the assessment evaluated CM processes, technical baseline documents, change control, work control, document control, and assessments to ensure that changes are properly controlled in accordance with DOE Order 420.1C and DOE-STD-1073-2016, *Configuration Management*, such that the selected systems continue to meet their safety functions.

Configuration Management Processes

UT-Battelle has established and implemented adequate CM processes to maintain consistency between requirements, engineering documents, operations implementing procedures, and physical configuration, ensuring that the selected systems can reliably perform their intended safety functions. The UT-Battelle CM implementation plan adequately addresses system requirements and performance criteria identified in the DSA and the TSRs. The CM processes meet the requirements of DOE Order 420.1C, attachment 2, chapter V, section 3.c, and DOE-STD-1073-2016.

The unreviewed safety question (USQ) process is adequately established and implemented as required by 10 CFR 830.203, *Unreviewed safety question process*, and is appropriately applied within the change control, surveillance report testing, and field modification processes. Reviewed USQ determinations demonstrated adequate review of surveillance requirement testing procedures, change control packages, maintenance modifications, temporary modifications, equivalency evaluations of replacement SSCs, and maintenance repair work orders.

Technical Baseline Documents

In general, the reviewed technical baseline documents (i.e., system design descriptions, piping and instrumentation diagrams, elementary control diagrams, control logic drawings, and calculations) for the selected systems were adequately identified, developed, approved, and maintained to support SSM programs, operations, and safety basis implementation. Technical baseline documents are also, in general, appropriately tracked in a configured items list and maintained in the document control system. However, the design documentation for the 480 VAC electrical power supply system does not include essential system requirements and performance criteria, the basis for these requirements, or a description of how the system configuration satisfies these requirements. Additionally, periodic system assessments of system operability, reliability, and material condition are not being performed. Consequently, contrary to DOE Order 420.1C, attachment 2, chapter V, sections 3.c.(2) and 3.c.(3), UT-Battelle does not adequately maintain CM of the 480 VAC electrical power supply system. (See **Deficiency D-UT-Battelle-3**.) Without appropriate design documentation and system assessments, the ability of a system to perform its safety function cannot be ensured.

Change Control

Reviewed change control packages (CCPs) were appropriately developed, reviewed, approved, tested, implemented, and documented as required by DOE-STD-1073-2016. Reviewed CCPs included adequate

scopes of work that demonstrated appropriate control of design changes. Affected design documents were included in the packages and received appropriate safety and technical reviews and approval. Appropriate acceptance criteria and testing requirements were included in the packages. USQ determinations were also included in the reviewed CCPs. Affected documents (including implementing documents) are appropriately tracked to maintain adequate change control.

Work Control

The reviewed work control documents were adequate for field modifications. Other aspects of work control are discussed in section 3.6 of this report.

Document Control

Document control is appropriately implemented for reviewed CCPs, temporary modification packages, work packages, design drawings, and calculations. The latest versions of the technical baseline documents and amendments are contained in a document control system.

Assessments

As discussed in section 3.4, the CSE appropriately performs monthly system health checklists and submits annual safety assessment reports (except on the 480 VAC electrical power supply system) to demonstrate review of SSC configurations on the selected systems. These checklists and annual reports are intended to conclude that the system is either performing in a reliable manner or that additional management attention is warranted to return the system to a reliable condition.

Additional assessments conducted by UT-Battelle and OSO appropriately reviewed functional areas of the CM program (design control, change control, work control, document control, and assessments) and resulted in identified issues and subsequent effective corrective actions.

Configuration Management Conclusions

UT-Battelle implements a generally adequate CM program. Reviewed periodic CM assessments were appropriately conducted, and subsequent corrective actions improved the CM program. The USQ process is adequately implemented. Reviewed technical baseline documents for the selected systems were generally consistent with design requirements. However, a weakness was identified with the lack of appropriate technical baseline design documentation and system assessments for the SC 480 VAC electrical power supply system.

3.6 Maintenance

This portion of the assessment evaluated the maintenance program and processes used at REDC Building 7920, and control of maintenance, repairs, and modifications to determine whether maintenance of the selected systems is properly planned, scheduled, and performed in accordance with DOE Order 433.1B, *Maintenance Management Program for DOE Nuclear Facilities*, to ensure that those systems can reliably perform their intended safety functions.

Maintenance Program

The OSO-approved sitewide standards-based management system (SBMS) and nuclear maintenance management program, NNFD-PDD-075, *Nonreactor Nuclear Facilities Division Nuclear Maintenance Management Program (NMMP) Description Document*, establish adequate requirements for the safe

conduct of maintenance for the selected systems. These programs provide a comprehensive suite of system-specific inspection, testing, and maintenance procedures to ensure that the safety systems can perform their intended safety functions. The NMMP adequately addresses the 17 elements of DOE Order 433.1B.

Maintenance Processes

The UT-Battelle maintenance processes for the selected systems are adequate to conduct maintenance consistent with these systems' functional classifications. The maintenance organization supporting REDC Building 7920 adequately coordinates maintenance planning and scheduling with facility management and uses a graded approach to prioritize maintenance of safety SSCs. In general, UT-Battelle performs preventive maintenance (PM), predictive maintenance, and corrective maintenance appropriately for the selected systems to ensure their safe, efficient, and reliable operation considering aging systems in a building commissioned almost 60 years ago. PM appropriately includes filter replacement, calibration of instruments, and inspections and maintenance of components. UT-Battelle effectively performs operational checks and PM for inspection and functional testing. UT-Battelle is effectively managing maintenance performance by reducing the existing backlog and consistently performing maintenance on time. The Non-reactor Nuclear Facilities Division (NNFD) reliability and predictive maintenance program is advanced, with adequate resources and mature processes. The program is considered a **Best Practice** because it applies a variety of state-of-the-art industry practices, including vibration analysis, an ultrasonic bearing re-greasing program, infrared analysis, motor testing and circuit analysis, root cause analysis, and failure mode and effect analysis in support of a PM optimization program. UT-Battelle prioritizes maintenance work orders appropriately using the plan of the day/week schedules and a ranking process that places highest priority levels on the correction or mitigation of imminent safety hazards, and maintenance of safety SSCs.

Control of Maintenance, Repairs, and Modifications

The UT-Battelle maintenance process is adequate for controlling and performing maintenance, and it appropriately implements approved modifications, PM, corrective maintenance, and QA hold points. Maintenance, repair, and modification work performed at REDC Building 7920 is controlled in accordance with the ORNL sitewide safety program work planning and control procedures, job-specific work control documents, and the facility activity schedule. The NNFD administrative procedure governing work control at REDC Building 7920, NNFD-004, *Work Control*, provides a graded approach to work control, including instructions for planning, scheduling, initiating, controlling, and documenting work control activities and appropriately requires PMT for safety SSCs. NNFD-004, appendix C, provides a comprehensive set of guidelines and recommendations pertaining to PMT, including acceptance criteria, recommendations for PMT to be completed following various types of maintenance, and guidance for proper PMT references. Procurement and handling of maintenance material items and services are adequately addressed by NNFD-004 and NNFD-010, *Procurement, Receipt Inspection, and Commercial Grade Dedication for NNFD Supplies*. The computerized maintenance management system is an appropriate tool to retrieve maintenance records and develop metrics but has some functional limitations; an active project is underway to upgrade this system with the current software version and enhanced functionality tailored to NNFD maintenance management needs.

Information from interviewed maintenance managers and review of completed work packages demonstrated adequate performance, control, and documentation of maintenance to ensure system operability. During the observed performance of monthly vibration route PMs, corrective maintenance to replace exhaust fan bearings, and field simulations of other PMs for exhaust fans, motors, belts, dampers, and other components of the selected safety SSCs, UT-Battelle personnel demonstrated thorough pre-job briefings and disciplined execution, including procedural compliance, formal communications, PMT, and system restoration.

NNFD-025, *Control and Storage of NNFD Components and Items*, adequately describes the UT-Battelle process used at REDC Building 7920 for controlling critical measurement and test equipment (M&TE). However, contrary to 10 CFR 830.122(h)(2) and NNFD-025, section 4.9.3, UT-Battelle does not adequately calibrate and maintain all M&TE used for inspections, testing, and maintenance of the REDC Building 7920 safety systems. (See **Deficiency D-UT-Battelle-4**.) Inadequate control of M&TE could result in unknown usage history, a loss of calibration and traceability, and potentially degraded equipment performance. Specifically, 2 of the 10 reviewed M&TE instruments (torque wrenches) in a designated cabinet for calibrated hand tools were out of calibration and had not been tagged out, segregated from other M&TE, and investigated to validate any previous inspections or test results, as required.

During a facility walkdown, items were observed to have been stored in 480 VAC electrical equipment rooms (i.e., Building 7921 and Room 207 in Building 7920). In accordance with UT-Battelle housekeeping processes, electrical equipment rooms should be maintained on a continuing basis. Items stored in 480 VAC electrical equipment rooms may impact worker safety and pose a hazard to installed safety SSCs during a seismic event. (See **OFI-UT-Battelle-3**.)

Maintenance Conclusions

The maintenance program is generally adequate to maintain the selected systems in REDC Building 7920. In general, maintenance is properly planned, scheduled, and performed to ensure that the selected systems can perform their intended safety functions. UT-Battelle has adequate controls in place for the conduct of maintenance and modifications for the selected systems. However, UT-Battelle does not adequately calibrate and maintain all M&TE used for inspections, testing, and maintenance of the REDC Building 7920 safety systems.

3.7 Operations

This portion of the assessment evaluated REDC Building 7920 operating practices, procedures, and operations program training to determine whether operations are conducted in a manner that ensures that the selected systems can reliably perform their intended safety functions.

Operating Practices and Procedures

UT-Battelle's conduct of operations program is adequately described by the SBMS Program Description, *Conduct of Operations*. More specific to NNFD operations, the NNFD Conduct of Operations Matrix appropriately provides a crosswalk between DOE Order 422.1, *Conduct of Operations*, site-level procedures, and NNFD procedures. However, contrary to DOE Order 422.1, chapter 4, section 4.e, and the UT-Battelle conduct of operations program description, UT-Battelle has not submitted the NNFD Conduct of Operations Matrix to OSO within the past three years for review and approval. (See **Deficiency D-UT-Battelle-5**.) OSO approval ensures that the NNFD conduct of operations program meets all DOE Order 422.1 requirements and allows OSO an opportunity to review expectations and provide feedback on the safety management program at REDC.

NNFD-011, *Nonreactor Nuclear Facilities Division Conduct of Operations Manual*, provides a generally adequate set of tailored conduct of operations requirements for NNFD-managed facilities. However, conflicting requirements were identified in NNFD-011, section 17, between steps 7 and 8: step 7 allows for action steps to be completed in any order while step 8 requires sequential completion. Consequently, contrary to DOE Order 422.1, attachment 2, section 2.p.(1), NNFD-011 includes conflicting requirements and does not consistently identify expectations for the use of procedures to perform operations. (See

Deficiency D-UT-Battelle-6.) Conflicting requirements for procedure use could lead to inadvertent system operations and unexpected outcomes.

NNFD-011 also provides requirements for administering shift orders, identifying systems requiring independent verification, log keeping, and controlling equipment and system status. Observations of procedure performance, tabletops, walkdowns, and shift turnover inspections (including selected SSC logs), demonstrated adequate performance. Several out-of-specification ventilation system readings were marked in accordance with NNFD-011, and the Shift Supervisor was knowledgeable of these readings and their impact to operations and TSR compliance. NNFD-011 states that "Check marks, or other marks, may be used, e.g., placed in the margins of the procedure, for place keeping purposes." Rather than more formal placekeeping methods, some REDC technicians use a single initial with an arrow to indicate completion of follow-on steps instead of marking each step. (See **OFI-UT-Battelle-4**.)

Overall, the REDC Building 7920 management and operating personnel responsible for TSR implementation and compliance are knowledgeable and experienced, as demonstrated by interviews and observations. The reviewed logs, shift turnover checklists, building and facility status control, and TSR surveillances were generally adequate. However, during a system status review in the REDC Building 7920 control room, 2 minor discrepancies out of more than 100 entries were identified in the lockout/tagout status binder; these discrepancies did not impact worker safety.

Although NNFD-7920-AOP-401, *Abnormal Condition Operations*, captures significant institutional knowledge pertaining to abnormal conditions affecting REDC safety SSCs, aspects of the procedure are incongruent with the need to restore systems to normal following an abnormal condition. In particular, the headings corresponding to specific abnormal conditions for each system are not indexed within the table of contents, and several listed conditions provide lengthy narrative statements containing vague language. (See **OFI-UT-Battelle-5**.)

Training Program

UT-Battelle has generally established an adequate training program for operations staff (facility operators). The training implementation matrix for REDC Building 7920 adequately addresses each element of DOE Order 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities*. In 2025, UT-Battelle rewrote NNFD-009, *NNFD Training Program Manual*, and associated procedures, as appropriate, to incorporate new requirements specified in DOE Order 426.2A. NNFD-009 comprehensively identifies roles and responsibilities as appropriate for training staff and nuclear staff. UT-Battelle appropriately uses an electronic learning management system (SAP SuccessFactors) to document training plans, identify training needs, and to schedule and track personnel qualification. Personnel qualification and certification records are adequately maintained to document the completion of qualifications and periodic requalification. Reviewed staff training plans provide adequate training requirements for the various staff positions.

REDC Building 7920 operator qualifications appropriately include classroom training, web-based training, and performance demonstrations for LCO requirements. Training programs appropriately include safety basis fundamentals. The operator qualification records document completion of required training and qualification activities. Personnel interviews, observed activities, and facility walkdowns demonstrated that operators are knowledgeable of their assigned tasks.

In general, the training program appropriately implements continuing training on procedure changes using the assigned procedure reading (APR) process, which identifies the documents needed to support each qualification and issues the appropriate documents for reading whenever they are revised. For example, NNFD-015, *Corrective Action Management, Trending, and Causal Analysis*, is included in the APR for

several qualifications, including Task Leader, Operational Safety Board, and Basic System Engineer. The SBMS Subject Area, *Issues Management and Analysis*, is currently included only in the APR for the Operational Safety Board qualification. However, contrary to DOE Order 426.2, attachment 1, section 7.a.(2), and NNFD-009, section 7.3.3, these documents are not identified as required continuing training when they are changed. (See **Deficiency D-UT-Battelle-7** and **OFI-UT-Battelle-6**.) Not requiring continuing training on procedure changes could result in gaps in knowledge and skills of operating personnel relative to safety system operability and management. After EA identified this issue, UT-Battelle management entered it into the Assessment and Commitment Tracking System (ACTS) and assigned number 28639.1 for corrective action.

Operations Conclusions

Conduct of operations and training programs used in REDC Building 7920 are generally adequate. However, weaknesses were identified in UT-Battelle's implementation of processes used to submit documentation to DOE for review and approval, establish clear expectations for the use of procedures to perform operations, and require continual training when procedures changed.

3.8 Procurement Quality Assurance and Feedback and Improvement

This portion of the assessment evaluated UT-Battelle's procurement QA and feedback and improvement processes, including issues management and performance assurance, to determine whether they comply with 10 CFR 830, subpart A, *Quality Assurance Requirements*; DOE Order 414.1D, *Quality Assurance*; and DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*.

Procurement Quality Assurance

UT-Battelle has established a DOE-approved QA program based on the requirements of DOE Order 414.1D and 10 CFR 830, subpart A. Consensus standard International Standards Organization (ISO) 9001:2015, *Quality Management Systems*, is applicable for laboratory functions, and American Society of Mechanical Engineers consensus standard Nuclear Quality Assurance (NQA)-1-2000, *Requirements for Quality Assurance Programs for Nuclear Facilities*, is applicable for nuclear facilities. Reviewed procurement procedures demonstrated appropriate requirements for implementing this approach. UT-Battelle appropriately identifies critical spare parts and stores them under controlled environment storage in a limited access warehouse. An adequate commercial grade dedication process is in place for safety systems in nuclear facilities, as is a program for detection and control of suspect/counterfeit items. An adequate procedure is in place for evaluating suppliers on a triennial basis; this process is required for each supplier to remain on the controlled evaluated supplier list. Reviewed procurement-specific information for a sample of safety-related procurements was adequate. Four reviewed nonconformance reports adequately addressed the identified issues.

SBMS Procedure, *HEPA Filters Used in Fixed Nuclear/Radiological Applications*, contains requirements to support meeting DOE requirements for HEPA filter testing during the filter procurement process. However, this procedure references out-of-date revisions of two applicable DOE standards: DOE-STD-3020-2005, *Specification for HEPA Filters Used by DOE Contractors*, and DOE-STD-3025-99, *Quality Assurance Inspection and Performance Testing of High Efficiency Particulate Air and Ultra Low Penetrating Air Filters*. The procedure also references DOE-STD-3022-98, *DOE HEPA Filter Test Program*, which was cancelled and replaced by DOE-STD-3025-2007. After EA identified this issue, UT-Battelle management agreed to update this procedure and documented the planned action under ORNL ACTS number 0.48836.

Issues Management Processes

UT-Battelle has established generally adequate processes in SBMS Procedure, *Issues Management and Analysis*, to identify and correct problems. This procedure is supplemented at REDC Building 7920 by NNFD-015, *Corrective Action Management, Trending, and Causal Analysis*. Reviewed corrective action documents and supporting information showed adequate attention to detail in identifying appropriate corrective actions and documenting actions performed/completed. This demonstrated that conditions adverse to quality, safety, and operability are adequately managed and tracked. However, as discussed in section 3.7 above, a review of training requirements regarding issues management identified no training requirements beyond a one-time initial reading for new employees.

Lessons Learned

Thirty reviewed lessons learned reports issued in calendar years 2023 and 2024 showed that the lessons learned process is well developed at ORNL and is actively and adequately implemented. These reports examined a broad range of onsite activities/occurrences and provided some related appropriate cautions based on external events.

Trending

SBMS Procedure, *Issues Management and Analysis*, provides limited guidance on trending that may not be sufficient to prevent recurrence of problems as required by DOE Order 414.1D, criterion 3. Reviewed NNFD quarterly trending reports focused on the short term (three months), with no consideration of events recurring outside that window. As a result, trends developing over a longer time period may not be identified. For example, during the review of lessons learned documents described above (which are laboratory-wide documents), two potential trends were noted: (1) six reviewed documents described security/safeguards issues, and (2) seven reviewed documents described events related to hazardous energy control. The number of events in these topical areas over a two-year period is sufficiently high, and UT-Batelle management concluded that the NNFD trending process could be improved by widening the window examined when performing trending analyses. After EA identified this issue, UT-Battelle management agreed to update procedure NNFD-015 and documented the planned action under ORNL ACTS number 28639.4.

Performance Assurance

UT-Battelle adequately assesses and evaluates organizational performance to ensure that applicable requirements and standards for environment, safety, and health, including QA and integrated safety management, are met. UT-Battelle assessment programs are appropriately risk-informed and formally documented. Assessments are adequately scheduled, managed, and performed in accordance with an integrated assessment plan. The integrated assessment plan is prepared annually, and adequately includes external assessments, internal independent assessments, joint functional area manager/line management assessments, and management self-assessments.

Reviewed assessments completed over the past three years for the selected systems were sufficiently critical of the assessed areas. However, two reviewed assessment reports reiterated issues that had remained uncorrected from earlier assessment reports. During interviews, UT-Battelle indicated that this condition was mostly due to delays in completing the corrective actions from the earlier reports. After EA identified this issue, UT-Battelle management agreed and concluded that this process could be improved by requiring division director approval of due date extensions after the second extension request. UT-Battelle documented the planned action under ORNL ACTS number 28639.2.

Further, issues documented in internal assessment reports are not entered into ACTS prior to issuance of the report. This practice has introduced the following weakness and potential vulnerabilities:

- A 2022 EA assessment of management of safety issues at ORNL identified an instance where findings and OFIs from an assessment were entered into ACTS four years after the assessment was completed.
- Findings and OFIs may not be entered into ACTS because this requires a distinct action by other individuals following assessment report issuance.
- Issues determined to be OFIs may be canceled by the issue owner with no actions taken. In this case, the assessment report cannot be updated to reflect the decision not to take action because it was issued prior to this decision.

After EA identified this issue, UT-Battelle management agreed and concluded that a revision to NNFD-015 was appropriate to ensure that findings and OFIs are entered into ACTS concurrently with the assessment being marked as performed. UT-Battelle documented the planned action under ORNL ACTS number 28639.3.

Procurement Quality Assurance and Feedback and Improvement Conclusions

UT-Battelle has established generally adequate processes to procure safety-related components from qualified vendors. Appropriate issues management processes are also in place to identify and correct problems, with effective lessons learned reporting. Conditions adverse to quality, safety, and operability are adequately managed and tracked. Appropriate feedback and improvement processes are in place to address safety system performance.

3.9 Federal Oversight

This portion of the assessment evaluated OSO oversight to determine whether OSO effectively ensures that the selected systems reliably perform their safety functions.

The OSO Facility Representatives (FRs) appropriately implement the safety system oversight requirements with assistance from subject matter experts within the Operations Division. Although OSO does not have a safety system oversight program, OSO's oversight is consistent with DOE Order 420.1C. The FR program is adequately established in OSOP 411, *ORNL Site Office Procedure Facility Representative Program*.

Assessments of contractor programs, referred to as Contractor Formal Assessment Program (CFAP) assessments, are planned and conducted in accordance with work practice (WP) 453, *Contractor Formal Assessment Program*. The reviewed assessment plans were generally effective in identifying assessments for the next fiscal year. Recent CFAP assessments relevant to safety system oversight include safety basis implementation, nuclear maintenance, natural phenomena, and design control assessments. Additionally, CM is covered as part of the required conduct of operations assessments. Issues from these assessments were appropriately tracked and effectively monitored to closure.

Topics included in CFAP assessments are also covered by the FRs as part of their field monitoring work. The FR for REDC Building 7920 focuses primarily on the most significant issues facing the facility, such as deferred maintenance, while maintaining overall awareness. The FR demonstrated thorough knowledge of the selected safety systems and recent issues associated with these systems. During a walkdown of the facility, the FR appropriately noted and communicated issues to the associated subject matter expert, who addressed them in a timely fashion. The FR and backup FR attend the monthly

system health meetings conducted by UT-Battelle. Eight reviewed operational awareness activities of the selected systems conducted between 2022 and 2024 demonstrate that the FR maintains adequate operational awareness of safety systems status.

Both the current and previous FRs are appropriately qualified in accordance with DOE-STD-1151, *Facility Representative Functional Area Qualification Standard*. The current FR is also qualified in accordance with DOE-STD-1183-2019, *Nuclear Safety Specialist Functional Area Qualification Standard*. The current FR was assigned to the facility in August 2024 in an interim status, based on previous qualification as an FR on other hot cell facilities at ORNL. A deadline to complete full qualification and an appropriate compensatory measure were set. The FR staffing analysis for REDC Building 7920 meets the recommendations of DOE-STD-1063-2021, *Facility Representatives*. The FR staffing analysis does not specifically take into consideration the additional expectations to cover safety system oversight responsibilities, which are not required by the standard. Instead, these responsibilities are performed using the staff time allocated to non-FR duties.

Federal Oversight Conclusions

Overall, OSO adequately performs oversight of the selected systems. OSO appropriately communicates its oversight findings and monitors associated corrective action development, execution, and closure through close coordination with UT-Battelle. OSO oversight is effective and is appropriately documented.

4.0 BEST PRACTICES

Best practices are safety-related practices, techniques, processes, or program attributes observed during an assessment that may merit consideration by other DOE and contractor organizations for implementation. The following best practice was identified as part of this assessment:

- The NNFD reliability and predictive maintenance program is advanced, with adequate resources and mature processes. The program applies a variety of state-of-the-art industry practices, including vibration analysis, an ultrasonic bearing re-greasing program, infrared analysis, motor testing and circuit analysis, root cause analysis, and failure mode and effects analysis in support of a PM optimization program.

5.0 FINDINGS

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

UT-Battelle, LLC

Finding F-UT-Battelle-1: In the DSA DBA analysis, UT-Battelle does not evaluate all DBAs for which safety controls must be identified to protect the workers and public. (DOE-STD-3009-94, sec. 3.4.2.X.1)

Finding F-UT-Battelle-2: In the DSA, UT-Battelle does not provide functional requirements, performance criteria, a system evaluation, or TSR controls for the SC 480 VAC electrical power supply system. (DOE-STD-3009-94, secs. 4.3.X.3, 4.3.X.4, and 4.3.X.5)

6.0 DEFICIENCIES

Deficiencies are inadequacies in the implementation of an applicable requirement or standard. Deficiencies that did not meet the criteria for findings are listed below, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

UT-Battelle, LLC

Deficiency D-UT-Battelle-1: In the DSA, UT-Battelle credits only one SAC in lieu of a safety SSC without discussing consideration of SSCs or providing justification that this SAC alone is sufficient to prevent an anticipated event with high unmitigated dose consequences to the public. (DOE-STD-3009-94, sec. 4.5.X.2)

Deficiency D-UT-Battelle-2: In the DSA, UT-Battelle does not functionally classify the scrubber's function of removing acidic fumes and does not contain an evaluation of the ability for VOG system components downstream of the scrubber (e.g., HEPA filters and housing, fans) to withstand an acidic environment. (DOE-STD-3009-94, sec. 4.3.X.2)

Deficiency D-UT-Battelle-3: UT-Battelle does not adequately maintain CM of the 480 VAC electrical power supply system. (DOE Order 420.1C, att. 2, ch. V, secs. 3.c.(2) and 3.c.(3))

Deficiency D-UT-Battelle-4: UT-Battelle does not adequately calibrate and maintain all M&TE used for inspections, testing, and maintenance of the REDC Building 7920 safety systems. (10 CFR 830.122(h)(2) and NNFD-025, sec. 4.9.3)

Deficiency D-UT-Battelle-5: UT-Battelle has not submitted the NNFD Conduct of Operations Matrix to OSO within the past three years for review and approval. (DOE Order 422.1, Chg. 4, att. 2, sec. 1.c, and UT-Battelle Conduct of Operations Program Description)

Deficiency D-UT-Battelle-6: UT-Battelle procedure NNFD-011 includes conflicting requirements and does not consistently identify expectations for the use of procedures to perform operations. (DOE Order 422.1, att. 2, sec. 2.p.(1))

Deficiency D-UT-Battelle-7: The UT-Battelle qualification program does not require retraining on all procedures when they are changed. (DOE Order 426.2, att. 1, sec. 7.a.(2), and NNFD-009, sec. 7.3.3)

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified the OFIs shown below to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in assessment reports, they may also address other conditions observed during the assessment process. These OFIs are offered only as a recommendation for line management consideration; they do not require formal resolution by management through a corrective action process and are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to issues identified during the assessment.

UT-Battelle, LLC

OFI-UT-Battelle-1: Consider updating calculation ORNL/7920/DAC-2003-01 by digitizing handwritten analyses to improve quality, ensure clarity of analysis bases, and avoid potential propagation of errors.

OFI-UT-Battelle-2: Consider updating aging equipment plans and performing an engineering evaluation to determine the level of effort required to replace aging SC SSCs.

OFI-UT-Battelle-3: Consider performing housekeeping in Buildings 7921 and 7920 (Room 207) to ensure that SC 480 VAC equipment remains undamaged and there is no impact to worker safety. In addition, consider establishing clear housekeeping requirements to prevent electrical equipment areas from being used as ongoing storage facilities and to ensure that such areas are maintained in a clean, unobstructed condition.

OFI-UT-Battelle-4: Consider integrating more robust human performance error reduction tools into the REDC Building 7920 conduct of operations program, such as prescribed placekeeping methods during the execution of specified technical procedures.

OFI-UT-Battelle-5: Consider making usability improvements to procedure NNFD-7920-AOP-401, table of contents and section 5.0, *Action Steps*, such as indexing specific abnormal conditions in the table of contents, evaluating the necessary level of detail provided in narrative statements prior to each condition's actions steps (and also consider that a portion of this detail may be more appropriate for an appendix), and ensuring that the vocabulary and tone used in these narrative statements are tailored for comprehension by the target reader/user.

OFI-UT-Battelle-6: Consider evaluating the extent of condition regarding gaps in the APR process for requiring continuing training when procedures are revised, and updating training requirements as needed for all qualifications.

Appendix A
Supplemental Information

Dates of Assessment

January 13 to April 11, 2025

Office of Enterprise Assessments (EA) Management

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

Quality Review Board

William F. West, Advisor
Kevin G. Kilp, Chair
Christopher E. McFearin
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Gregory L. Smith
Marc R. Woodworth