Work Planning and Control Assessment at the Oak Ridge National Laboratory

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Office of Enterprise Assessments
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Table of Contents

Acronyms

ABHA	Activity-Based Hazard Analysis
Ac	Actinium
ACTS	Assessment and Commitment Tracking System
ALARA	As Low As Reasonably Achievable
ARA	Airborne Radioactivity Area
CAS	Contractor Assurance System
CFR	Code of Federal Regulations
CRAD	Criteria and Review Approach Document
CSD	Chemical Sciences Division
DOE	U.S. Department of Energy
DWA	Divisional Work Authority
EA	Office of Enterprise Assessments
F&O	Facilities and Operations Directorate
FY	Fiscal Year
HAZOP	Hazard and Operability
HF	Hydrofluoric Acid
iCAM	Intelligent Alpha/Beta Continuous Air Monitor
IFCTD	Isotope and Fuel Cycle Technology Division
ISM	Integrated Safety Management
JHE	Job Hazard Evaluation
LTV	Lock, Tag, Verify
NNFD	Nonreactor Nuclear Facilities Division
NRPD	Nuclear and Radiological Protection Division
OFI	Opportunity for Improvement
OM&S	Operations, Maintenance and Services
ORNL	Oak Ridge National Laboratory
POC	Point of Contact
POD	Plan of the Day
PPE	Personal Protective Equipment
PSD	Physical Sciences Directorate
Pu	Plutonium
QEA	Qualitative Exposure Assessment
QHSP	Qualified Health and Safety Professional
RCT	Radiological Control Technician
REDC	Radiochemical Engineering Development Center
RF	Radio Frequency
RHACS	Research Hazards Analysis and Controls System
RMAL	Radioactive Materials Analytical Laboratory
RSS	Research Safety Summary
RWP	Radiological Work Permit
SBMS	Standards-Based Management System
SME	Subject Matter Expert
TPP	Technical Position Paper
UT-Battelle	UT-Battelle, LLC
WO	Work Order
WP&C	Work Planning and Control
WPS	Work Plan System

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at the Oak Ridge National Laboratory

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Worker Safety and Health Assessments, within the independent Office of Enterprise Assessments, conducted an assessment of work planning and control (WP&C) and selected elements of the contractor assurance system and feedback and improvement at the Oak Ridge National Laboratory (ORNL), which is operated by UT-Battelle, LLC (UT-Battelle). Work activities including research and maintenance were observed within the Radiochemical Engineering Development Center, the Chemical Sciences Division, the Facilities Management Division, and the Utilities Division. This assessment was conducted within the broader context of a series of targeted assessments of WP&C at sites across the DOE complex. The onsite portions of this assessment were conducted January 14-18 and 28-31, 2019.

UT-Battelle's Standards-Based Management System provides the requirements for conducting work at ORNL, including the required procedures for proposing, planning, managing, and controlling work at the activity level. Work observed during this assessment was managed under two different work control categories with separate Standards-Based Management System work control requirements:

- Activities associated with research and development programs and projects.
- Activities associated with maintenance.

A Best Practice is warranted for UT-Battelle's requirement that all work ("every task, every time") be reviewed for safety, regardless of the hazard level of the work.

The UT-Battelle WP&C programs for both research and development and maintenance include adequate processes for the safe performance of work. Both programs include an electronic system to guide users through the process of identifying hazards and selecting controls. The automated systems provide a framework for identifying and controlling a broad array of hazards for individual work plans, with the involvement of subject matter experts as needed for further review. At the research and development project level, UT-Battelle's Standards-Based Management System provides clear descriptions of the types of research to be performed, establishes and defines the safety envelope under which experiments are to be conducted, and documents the applicable hazard controls and requirements.

UT-Battelle's WP&C processes were adequately implemented for the work observed during this assessment. Overall, ORNL researchers, operators, and workers demonstrate good work practices, including the effective use of engineering controls; thorough pre-job briefings for maintenance work; and the willingness to use stop-work authority. UT-Battelle's work planning proceeds with the assistance of highly skilled and experienced subject matter experts in environment, safety, and health. Two deficiencies were noted with implementation of the WP&C processes, one with the application of hazard controls in the Radiochemical Engineering Development Center with regard to radiological air sampling, and one with the identification of activity-level hazards and controls for maintenance work.

Safety and health information is shared through many forms of communication, such as safety talks, pre-job briefings, Safety Toolbox presentations, newsletters, and video displays. UT-Battelle's commitment to continuous improvement is evident in its rigorous self-assessment program, its lessons-learned programs, and the corrective actions it has taken as a result of causal analysis of unplanned events.

Work Planning and Control Assessment
at the Oak Ridge National Laboratory

1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Worker Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the work planning and control (WP&C) program at the Oak Ridge National Laboratory (ORNL). The WP&C program assessment is within the broader context of EA's targeted assessments of programs at DOE sites that have high-consequence activities or whose performance may present significant risks, in accordance with DOE Order 227.1A, *Independent Oversight Program*. EA conducted the onsite portions of this assessment January 14-18 and 28-31, 2019.

2.0 SCOPE

EA conducted this assessment in accordance with the *Plan for the Office of Enterprise Assessments, Assessment of the Work Planning and Control Program at the Oak Ridge National Laboratory September 2018 – January 2019.* This assessment evaluated the effectiveness of the UT-Battelle, LLC (UT-Battelle) implementation of the integrated safety management (ISM) core functions (define scope of work, identify and analyze hazards, identify and implement controls, perform work safely within controls, and feedback and improvement) with respect to WP&C implementation. This assessment also included an evaluation of elements of UT-Battelle's contractor assurance system (CAS) and feedback and improvement program.

3.0 BACKGROUND

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 deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in clean energy and global security while creating economic opportunities for the nation. This assessment included activities conducted within the Radiochemical Engineering Development Center (REDC) and those conducted by: the Chemical Science Division (CSD), and the Mechanical Utilities Complex within the Utilities Division. Nonreactor Nuclear Facilities Division (NNFD) is responsible for REDC operations. REDC has operated since 1966 and currently serves as a multipurpose radiochemical processing and research facility, producing unique radionuclides for use in research, defense, medical, and industrial applications. The Utilities Division Mechanical Utilities Complex manages the steam plant and sewage treatment plant.

4.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A. 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 DOE Order 227.1A, DOE line management and/or contractor organizations must develop and implement corrective action plans for the deficiencies identified as findings. Other important deficiencies not meeting the criteria for a finding are also highlighted in the report and summarized in Appendix C. These deficiencies should be addressed consistent with site-specific issues management procedures.

As identified in the EA assessment plan, this assessment considered requirements based on selected objectives and criteria from DOE Guide 226.1-2A, *Federal Line Management Oversight of Department of Energy Nuclear Facilities*, Appendix D, *Activity-Level Work Planning and Control Criterion Review and Approach Documents with Lines of Inquiry*. The assessment team also selected objectives and criteria from sections of EA Criteria and Review Approach Document (CRAD) EA-32-03, *Industrial Hygiene Program Criteria and Review Approach Document*; CRAD EA-45-35, *Occupational Radiation Protection Criteria Review and Approach Document*; and CRAD EA-30-01, *Contractor Assurance System*, as well as selected feedback and improvement criteria from DOE Guide 226.1-2A.

EA reviewed key documents, including work packages and research safety summaries, procedures, analyses, policies, and training and qualification records; interviewed key personnel responsible for developing and executing the associated programs; observed research, operations, and maintenance activities; and walked down significant portions of the REDC, CSD laboratories, and the Utilities steam plant and sewage treatment facilities. The members of the EA assessment team, the Quality Review Board, and EA management responsible for this assessment are listed in Appendix A. A detailed list of the documents reviewed, personnel interviewed, and observations made during this assessment, relevant to the findings and conclusions of this report, is provided in Appendix B.

EA has not conducted a recent assessment of WP&C at ORNL, so there were no items for follow-up during this assessment.

5.0 RESULTS

5.1 Work Planning and Control Program

Objective:

The Organization has developed and approved WP&C processes to enable safe performance of work.

UT-Battelle's Standards-Based Management System (SBMS) Subject Area on Work Control provides clearly defined and logical requirements and processes for conducting work safely at ORNL, including the required procedures for proposing, planning, managing, and controlling work at the activity level. The work that the assessment team observed was managed under two different SBMS work control categories with separate SBMS work control requirements:

- Activities associated with research and development programs and projects,
- Activities associated with maintenance.

The 2014 Battelle Practices, *The Safe Conduct of Research*, includes the principle that "hazards are identified and evaluated for every task, every time". UT-Battelle has institutionalized this principle in the SBMS subject area on Work Control for both research and development and maintenance activities. For research and development activities, every Research Safety Summary (RSS), regardless of level of risk, must be reviewed by a Qualified Safety and Health Professional (QSHP) as well as the point of contact and initiating principal investigator. SBMS procedure, *Implement Work Control for Operations, Maintenance and Services*, requires a job hazard evaluation for Grades 1, 2, and 3 work. The lowest level of maintenance work, Grade 4, does not require a work plan or JHE, however, UT-Battelle has established the expectation that all work will be reviewed for safety. For Grade 4 work, workers are required to perform their own informal pre-job safety review which includes as a minimum an evaluation of six safety questions. EA considers the use of these practices to enhance the effectiveness of the WP&C process at ORNL to be a **Best Practice**.

5.1.1 Research Work Planning and Control

The SBMS subject area *Implement ISM in Research and Development* provides adequate step-by-step procedures and exhibits for incorporating the Core Functions of ISM into the planning, development and execution of ORNL research activities. The RSS provides the work scope description and boundaries, hazards, and hazard controls, and serves as the primary mechanism for authorizing and enabling the safe performance of research. An RSS is developed by a work planning team (principal investigator, point of contact, and SMEs) using the Research Hazard Analysis and Control System (RHACS) web-based tool. Overall, the RHACS is an effective mechanism for identifying SBMS and ORNL divisional work control requirements, and the RSS provides a useful and practical summary of hazards and controls for research activities. For activities at REDC with a narrowly defined work scope, the RSS also serves as an effective activity-level hazard analysis that describes the specific tasks, hazards, and controls.

For RSSs with broader work scopes, such as those in CSD that govern a multitude of experimental work at the laboratory level, the RSS itself is often too broad, and not sufficient to document all activity-level hazards and controls, and in these cases, SBMS requires supplemental activity-level hazard analyses to identify all task-level work scope, hazards, and controls. The Physical Sciences Directorate (PSD), which includes CSD, recognizes this SBMS requirement and uses the activity-based hazard analysis (ABHA), as defined in SBMS, to supplement those RSSs with a broad scope.

5.1.2 Maintenance Work Planning and Control

The SBMS subject area Implement Work Control for Operations, Maintenance and Services provides adequate step-by-step procedures, exhibits, and guidelines for the work control system used for activities other than research and development. For the purposes of this review, these include maintenance activities at NNFD/REDC, the CSD/Chemical and Material Sciences Building, and the steam plant and waste water treatment plant.

The Operations, Maintenance and Services (OM&S) WP&C process includes a thorough work planning checklist covering such areas as regulatory concerns (e.g., NEPA); the potential to impact other systems or operations; and environment, safety, and health compliance. UT-Battelle provides a work grading guideline to determine job grades ranging from Grade 1, the most rigorous, to Grade 4, which only requires a work order to proceed. All work performed on a nuclear facility is considered Grade 1 work. The work grading guideline provides criteria for distinguishing between Grade 2, 3, and 4 work. However, the guidance is too broad to be useful (e.g., "No PPE [personal protective equipment] exceeding that used for day-to-day activities is needed to perform the job safely") and does not indicate specific work activities. Also, one criterion states that Grade 4 work will not typically involve consultation with or support of SMEs, thereby potentially discouraging the planner from seeking SME input (see **OFI-MU-1**).

The same SBMS subject area references an electronic Work Plan System (WPS), which is the primary vehicle for preparing work plans. UT-Battelle provided a demonstration of the WPS, which is a user-friendly and straightforward system that includes an automated job hazard evaluation (JHE) process providing a comprehensive list of hazards, potential controls, and links to source documents, such as training and procedures. This useful feature also provides for SME involvement in additional analysis of selected hazards through the qualitative exposure assessment (QEA) process. Safety and health professionals are matrixed to the REDC and Utilities organizations and provide expert support to the hazard analysis and control selection process.

5.2 Work Planning and Control Implementation

5.2.1 Radiochemical Engineering Development Center

Numerous ORNL divisions conduct research and process radioactive isotopes at the REDC which is operated by NNFD. Hazards for the observed work consisted primarily of internal and external radiation hazards associated with glovebox glove manipulations, bag-in/bag-outs, and/or open-face hood work with radioactive materials, as well as chemical hazards. Observed work included plutonium (Pu)-238 pellet production, actinium (Ac)-225 medical isotope production, radiochemical processing and separation and purification of radionuclides, as well as radiochemical analysis of samples. A listing of the observed work evolutions is provided in Appendix B.

Objective:

The scope of work is described in sufficient detail to allow the work planning process to identify hazards associated with the work and to develop necessary schedules, priorities, and work instructions.

RSSs governing the observed work at REDC contain well-defined scopes of work and include reference to required activity-level procedures detailing the specific tasks and work instructions necessary to complete the work. Collectively, the RSS and associated procedures are sufficiently detailed to permit effective identification of all potential hazards. For example, RSS 11316.7, for Pu pellet production, describes the specific production steps, with options for manual operations or use of automated processes. More details of the production process are provided in a specific operating procedure, NMP-PF-AP-001, *NpO2 Pellet Fabrication*, which describes each needed task in detail. The radiological work permit (RWP) covering this work is also sufficiently tailored to the scope of work defined in the RSS. Work scope limits, such as laboratory and glovebox radioactive material and flammable liquid limits, are also bounded within "control notes" sections in the RSS.

For complex, hazardous jobs, REDC has used appropriate modeling to improve planning, training, and related activities. A planning meeting for the loadout and packaging of Pu-238 included a demonstration of a three-dimensional computer model to simulate a mockup of the cell. The assessment team also saw a physical three-dimensional model for a planned activity. The use of modeling helps in the identification of hazards, as well as the development of work instructions.

Objective:

All hazards that could adversely impact workers, the public, the environment, and the facility and its equipment are documented and analyzed for severity/significance.

Internal and external radiological hazards are prevalent across REDC activities and operations. UT-Battelle's safety and health and radiation protection resources are well staffed and qualified to effectively support hazard analysis activities. In addition, a number of Nuclear and Radiation Protection Division (NRPD) staff members, including the Director and Group Leads, have professional certifications and/or advanced degrees in health physics or related disciplines, as well as years of applied radiation protection experience. The NRPD Group lead for Non-Reactor Nuclear Facilities (NNFD) is supported by two professional radiological engineers, facility Radiological Control Technician (RCT) Supervisors, and RCTs deployed to the field, who routinely participate in radiological work planning and RWP development.

Hazards associated with the observed work at REDC were appropriately identified and analyzed through the RHACS and RSS processes, much of which is initiated and performed by principal investigators who are also research workers, with assistance from designated points of contact (POCs) and SMEs. For non-radiological hazards, specific chemicals are well identified in the control notes sections of the RSS, including chemicals with unique characteristics and significant health hazards. For example, RSS 2497.*17*, for chemical processing, separation, and purification, Section 7.8, *Caustic or Corrosive Chemicals*, mentions molten salt expansion during melting and the need to use suitably sized containers to prevent spillage, as well as avoidance of water contact due to high temperatures. Similarly, the occasional use of hydrofluoric acid (HF) is called out with a statement that the possibility of exposure would be very low because it is used only within a glovebox. However, the control notes provide a detailed summary of the HF hazards and the required controls, including HF training and the availability and proper use of calcium gluconate.

The RSS and the RWP development process defined in NRPD-IOP-2401, *Radiological Work Permits* were also used effectively to identify and analyze radiological hazards. In addition, Nuclear and Radiological Protection Division (NRPD)-IOP-2203, *Radiation Surveys*, and the REDC Radiological Facility Surveillance Plan require radiological control technicians (RCTs) to perform routine and job-specific radiological surveys to characterize dose rates and contamination levels within each laboratory and during work, with the results applied to development of RWP controls. NRPD-IOP-2401 also requires RWPs that meet specific radiological criteria for dose rates, collective doses, and contamination levels to undergo a formal As Low As Reasonably Achievable (ALARA) review by radiological engineers. As an example of effective radiological hazard analysis, RSS 11316.7, *Target Fabrication for Pu-238 Pellet Production*, Section 2.1, *Hazard Notes*, discusses the radioactive material composition to be handled in Lab 109 gloveboxes, as well as the presence of specific gamma-emitting decay products that contribute to external dose. RWP REDC-20968-14, for Ac processing in Lab 201, specifies both the expected general area radiological conditions and the expected changes during different work phases. The RWP was subjected to a formal ALARA review based on expected cumulative external dose to workers, and it provides information on specific RWP controls and glovebox shielding. A weekly radiological survey map was posted at the entrance to Lab 201, and similar routine survey maps and results were also posted at entrances to other REDC processing with the results of dose rates and contamination levels.

Objective:

Controls are identified and implemented that effectively protect against identified hazards and approved activity-level work control documents can be performed as written.

REDC applied the proper hierarchy of controls during the observed work, including engineered controls, administrative controls, and PPE. Engineered controls, such as gloveboxes and hoods, are prevalent in all radiochemical processing areas and are used extensively to mitigate radiological and chemical hazards associated with operations. Also, as discussed under the first objective in Section 5.2.1, activity-level work control procedures at REDC supplement RSSs to define specific tasks necessary to accomplish the work scope. Such procedures were effectively referenced in the RSSs for observed work. The procedures reviewed contain adequate detail such as scope, boundaries, hazards, prerequisites, precautions, limitations, cautions, warnings and related instructions needed to perform the work effectively.

Radiological administrative controls were also used effectively to aid in controlling contamination and external exposures. Electronic pocket dosimeters with integrating and alarming functions are required for evolutions performed within radiation areas and are used extensively to track and manage individual external radiation exposures for each RWP entry. Radiological postings and boundary controls were appropriate for laboratory spaces and observed radiological hazards. RWPs for observed work are well tailored to specific RSS work scopes.

Internal exposure to airborne radioactive material, including transuranic isotopes, processed at REDC is a significant potential hazard in the event of a failure or breach of an engineered control. REDC radiological processing labs include intelligent alpha/beta continuous air monitors (iCAMs), which, like traditional continuous air monitors, have appropriate alarm set points programmed in to provide an early warning to workers to exit an area with unexpected alpha or beta airborne radioactivity. The iCAMs also have unique capabilities for radon discrimination and historical data analyses that are routinely used to evaluate airborne radioactivity levels and trends that fall below alarm set points, a function that has traditionally required routine retrospective air sampling.

While iCAMs are a positive attribute and effective early warning tool, existing procedural requirements for job coverage air sampling and breathing zone air sampling contained in NRPD-IOP-2004, *Monitoring for Airborne Radioactivity*, Appendix 7 were not followed as written and/or effectively implemented during observed REDC work. While some of the practices implemented were authorized by a technical position paper (TPP), they also conflicted with existing procedure requirements, which is contrary to conduct of operations procedure adherence requirements. There was no formal linkage or reference established between the TPP and other applicable technical procedures. (**Deficiency**).

- RCTs followed an allowance in technical position paper NRPD-TPP-6024 that did not require job coverage air sampling to remove an Airborne Radioactivity Area (ARA) posting following a non-routine bag-out in Lab 109. The TPP, developed in 2012, authorized the use of negative contamination survey results and the lack of a CAM alarm as sufficient to down post an ARA after a bag out that required respiratory protection. However, this practice conflicts with existing NRPD-IOP-2004, which requires job coverage air sampling to remove an ARA posting.
- While consistent with information presented in NRPD-TPP-6024, RCTs did not perform job coverage air sampling during routine glovebox operations, including during bag outs in Labs 109, 201, 211, and 209. The lack of job coverage air sampling during breach of contaminated systems is also contrary to NRPD-IOP-2004 Appendix 7. The TPP is currently outdated and incorrect in taking credit for the presence of routine fixed retrospective air samplers in each laboratory as one justification for not requiring additional job coverage air sampling. While each laboratory did have fixed air samplers when the TPP was developed in 2012, it does not reflect the recent removal of fixed location air samplers from various REDC laboratories, including Labs 109 and 201.
- RCTs did not perform job coverage air sampling during work in Lab 201 with Ac-225, an isotope for which there is no approved bioassay method. The RWP prospective bioassay determination was exceeded, requiring both job coverage and PAS sampling to be performed. While the RWP did require breathing zone air sampling for purposes of internal dose assessment, the sample was not representative of the breathing zone as noted in the following bullet.
- Breathing zone air sampling required by RWPs for bag-out operations in Labs 201 and 109 was not performed at a location representative of the highest exposed workers' breathing zone as required. In both cases, the personal air sampler was placed above the glove port on the glovebox, not within the workers breathing zone where the actual bag cut was being performed.

As mentioned in the above deficiency, fixed location air sampling has recently been reduced at REDC, and there is no current documented technical basis for the current locations and placement of fixed air samplers, as suggested by NRPD-2100, *Technical Basis for Radiological Air Monitoring at the Oak*

Ridge National Laboratory and implied by NRPD-IOP-2005, *Air Sampler/Monitor Placement*. This was discussed with NRPD management who agree that more detailed documentation for REDC facility air sampler/monitor placement may be warranted.

Objective:

Work is conducted diligently in accordance with approved work instructions and within established controls.

Authorization to perform work within REDC is granted during plan-of-the-day (POD) meetings held each morning. REDC publishes a daily POD defining the activities that may occur during the work shift. At each POD, facility status and conditions are reviewed and line items from the POD are discussed and authorized, along with the resources needed, such as RCTs and instrument techs. Immediately after the POD meeting, a smaller REDC processing and status meeting is held to discuss operational and laboratory status, such as ongoing repairs, material moves, and changes in radiological conditions. These mechanisms provide adequate assurance of readiness to perform work within the facility and individual lab spaces.

Researchers who were observed and interviewed by the assessment team at REDC understood their responsibilities for ensuring that work is performed safely and as written, including response actions in the event of unexpected conditions or iCAM alarms, as well as their right to stop work. Most observed work was performed diligently and within established controls. For example, open hood work associated with uranium sealed-source fabrication in 7930 Lab 212 involved evaporation to prepare a concentrated uranium solution to be injected onto a plate, converted to an oxide, and sealed. The hood was a posted High Contamination Area surrounded by a posted Radiological Buffer Area. The researcher donned PPE according to the RWP, including a lab coat, booties, and double gloves. The researcher also exercised proper contamination control practices.

However, there were a few exceptions involving research workers not rigorously following required hand and arm frisking requirements contained in departmental procedure NNFD-REDC-001, *Glovebox Operations*. The precautions and limitations section of NNFD-REDC-001 requires workers to frisk their hands and forearms each time they are removed from the gloves. However, during initial work observations, only one of five observed workers performing routine glovebox handling actually frisked their hands and arms consistent with this requirement. When interviewed, these workers were not fully aware of this procedural requirement. EA conveyed this observation during initial daily debriefs, and the frisking practices improved during the remainder of the assessment.

Radiochemical Engineering Development Center Conclusions

RSS work scopes at REDC are well defined by sufficiently narrow RSSs and subordinate procedures that permit effective identification of hazards, which are also appropriately identified and analyzed through the RHACS tool and the RWP and ALARA review processes. Engineered controls are prevalent in all radiochemical processing areas and used extensively to mitigate radiological and chemical hazards associated with operations. Radiological administrative controls are also used effectively to aid in controlling contamination and external exposures. However, some institutional requirements associated with various types of required radiological air sampling were not effectively followed and/or implemented. With few exceptions, the observed work was performed diligently and within established controls.

5.2.2 Chemical Sciences Division

The EA assessment of WP&C process being implemented in CSD is based on a review of five experiments in five separate CSD research groups, as well as reviews of work documents and interviews. A listing of the research experiments reviewed is provided in Appendix B.

Within the Physical Sciences Directorate, which includes CSD, research work planning and control is typically implemented at two levels: (1) at the research project level, in which the work scope, hazards and controls are defined in a Research Safety Summary; and (2) at the activity level, in which the work scope, hazards, and controls for a specific experiment are defined through the ABHA process. Most research projects encompass a multitude of experiments, in which work scope, hazards, and controls are identified and discussed within the RSS, but not necessarily detailed at the experiment level. At the research project level, ORNL and CSD requirements for WP&C are well defined. Overall, experimental work observed was performed safety, and a number of positive attributes in implementing the core functions of ISM in CSD laboratories were also identified.

Objective:

The scope of work is described in sufficient detail to allow the work planning process to identify hazards associated with the work and to develop necessary schedules, priorities, and work instructions.

At the research project level, the RSSs developed in CSD groups are broadly written and cover a wide scope of research work and hazards (e.g., human carcinogens, corrosive chemicals, or ergonomic hazards). They are effective in describing the nature of the research project. In addition, the RSSs clearly identify both the research project scope and the research project boundaries. Each CSD research group typically operates under one broad RSS that is likely to cover dozens of bench-level research experiments performed in multiple laboratories used by the group. When serving as a broad safety envelope for the research project, the RSS process, as observed in CSD research laboratories, is an effective mechanism for identifying, conveying, and documenting UT-Battelle institutional safety requirements, as well as documenting safety and training requirements and expectations unique to the CSD groups.

Since the RSSs in CSD are typically project-related, hazard-based, and not task- or experiment-based, most activity-level experiments in CSD rely on an ABHA to supplement the broad RSS and tailor the work scope, hazards, and controls for an individual experiment. The ABHA is one of the methods or tools defined in the SBMS subject area on *Work Control* that can be used to supplement a RSS, when an additional level of detail is needed to ensure appropriate focus on a particular sub-task or experiment. Within CSD, the observed forms of an ABHA employed included operating procedures, standard analytical methods, work practices, and the use of the ABHA template, a form provided in the SBMS subject area on *Work Control* for documenting the overview, chemicals, hazards and controls of an experiment. This work practice meets the intent of the PSD *Guide on Examples of Activity-Based Hazard Analyses (ABHA)*, which states that "RSSs set the bounding conditions for a scope of work, but do not include details on the hazards and controls for each task performed under the RSS. Instead the researcher ensures there is an [ABHA] that is specific to the task."

Each of the five experiments that EA reviewed had an ABHA mechanism of some type as required; two experiments used the SBMS ABHA template (included in laboratory notebooks), two relied on standard operating procedures, and one employed a unique "research work practice requirements paper" to describe the experimental work scope, hazards, and controls. In two of the five experiments, there was insufficient detail of specific work tasks to allow the work planning process to identify hazards associated with the work and to develop work instructions.

Objective:

All hazards that could adversely impact workers, the public, the environment, and the facility and its equipment are documented and analyzed for severity/significance.

CSD personnel involved in research work planning activities have the appropriate technical and research backgrounds and expertise in the research to be performed, and are knowledgeable of the hazards associated with the work. An Integrated Research Operations group consisting of SMEs assists research staff in WP&C activities. In addition, CSD has a full-time POC who is an experienced and knowledgeable chemist, and a Division Safety Officer who is a certified industrial hygienist, to help research staff develop and revise RSSs and to serve as a health and safety focal point. All RSSs also require a review by a qualified health and safety professional (QHSP).

CSD has implemented a robust training program to accommodate its diverse population of research staff, post-doctorates, and students from a wide spectrum of educational and cultural backgrounds. All CSD researchers are required to complete a curriculum of ORNL and CSD laboratory-specific training before gaining laboratory access. In addition, all of the CSD groups that EA reviewed require mentoring of new researchers and an assessment of proficiency by CSD group leaders, principal investigators, laboratory space managers, and the CSD Division Director to ensure that the researchers are adequately trained and knowledgeable of hazards and controls in laboratory spaces. The RSSs identify any unique training requirements for specific hazards based on SBMS institutional and CSD-specific requirements. A Division Training Officer serves as the POC for all CSD training activities, and computer-based training systems are used effectively to track, trend, and notify CSD group leaders of individual training status.

At the research project level, the RSS provides the bounding hazard analysis document for all activity-level research experiments conducted within the scope of the RSS. As previously discussed, EA's assessment of work control within CSD involved five research experiments, each performed within a separate CSD research group, and each bounded by a separate RSS. Each RSS was constructed by a team of CSD research and support staff, typically including the principal investigator, the lab space manager, the Division Safety Officer, CSD research support staff, and applicable SMEs using the RHACS computer-based interactive tool. CSD health and safety SMEs were effectively engaged in the preparation and review of each RSS, and changes made in the *Exposure Assessment* and *Work Control* subject areas in 2018 (as well as to the RHACS) have improved the formality and consistency of QSHP involvement in RSSs and in the preparation of QEAs. In each of the five CSD groups, the RHACS tool and RSS development process resulted in a detailed RSS that provided the research staff with useful information on hazards and controls at the research project level.

At the experiment or activity level, the ABHA mechanisms employed to document experimental hazards included ABHA templates pasted in the researcher's laboratory notebook, standard operating procedures or analytical methods, or documented work practices. When the ABHA included operating procedures or documented work practices, the hazards to workers were generally well-defined, quantified, analyzed, and documented. For example, the Sono-Tek Exactacoat Ultrasonic Spray Coating System experiment incorporated a detailed work description and work scope and identification and discussion of applicable hazards (e.g., nanomaterials) and expected controls. A QEA unique to this experiment was also prepared. However, in two of the five observed experiments, the ABHA did not adequately identify, quantify or document all of the applicable hazards for the observed experiment.

The potential health risks to a researcher exposed to hazardous chemicals, lasers, ergonomic hazards, etc. are evaluated through the Qualitative Exposure Assessment (QEA) process. When a QEA is developed for a specific experiment, such as the previously described Sono-Tek Exactacoat Ultrasonic Spray Coating System experiment, the QEA process is an effective process for analyzing the severity/significance of hazards and documenting the appropriate hazard controls for specific experimental work tasks and hazards. However, when a QEA is aligned with a broad-scope RSS covering a number of experiments, each with many different hazards, the QEA often lacks specificity in defining hazards and hazard controls at the experiment level. For example, the QEA associated with the RSS for the CSD Chemical Separation Group, involving experiments with dozens of hazardous chemicals, identified the activity-level "Process/Job/Task" as "lab scale chemistry with corrosives, toxics, carcinogens, reproductive and skin absorption hazards." The QEA assigns a single set of hazard controls, regardless of the nature of the chemical hazard (carcinogen, reproductive hazard, etc.) or route of exposure (inhalation, skin or eye exposure), based on the assumption that work with these hazardous chemicals will be performed within a chemical fume hood, with PPE, for short durations and in low quantities. These assumptions, however, lack any specificity on identifying unique controls required of some hazardous chemicals that may be in use (e.g., hydrofluoric acid identified in the RSS for this research project) or for highly toxic chemicals that are primarily skin and absorption hazards. The American Board of Industrial Hygiene (ABIH) has addressed these concerns through the use of control banding (see **OFI-CSD-1**).

Objective:

Controls are identified and implemented that effectively protect against identified hazards and approved activity-level work control documents can be performed as written.

CSD has effectively implemented a hierarchy of controls by first attempting to eliminate and/or reduce the level of hazards and then to control the hazards through the hierarchy of controls, starting with engineering controls, then administrative controls, and finally PPE. Most of the significant hazards common to work in research laboratories have been reduced or eliminated though engineering controls. Many of the over 100 CSD research laboratories are located in ORNL Building 4100, which was completed in 2011 and is equipped with state-of-the-art engineering controls for reducing researcher exposures to a wide range of hazards. CSD managers and research staff were instrumental in the design of these engineering controls. For example, the building incorporates service corridors for storing and dispensing hazardous compressed gases that otherwise would be housed in the laboratories. CSD managers and research staff were directly involved in the selection of state-of-the-art chemical fume hoods with horizontal sliding sashes and flow control alarms, which are more abundant and provide greater protection from inhalation and splash exposure to chemical hazards than previously used chemical fume hoods. Four of the five experiments that EA observed involved using hazardous chemicals were performed within chemical fume hoods.

At the research project level, the RSS provides an effective mechanism for identifying the appropriate administrative, engineering, and PPE controls required by SBMS and CSD for a spectrum of hazards likely to be encountered during research activities. Furthermore, since research methods and equipment and experimental setups are continually changing within the CSD labs, the CSD research support staff routinely interfaces with the research staff to update RSSs to reflect changing conditions and hazard controls.

At the experiment level, hazard controls were generally well defined and adequate for those experiments which relied on ABHAs with detailed work instructions or procedures (e.g., Sono-Tek Exactacoat Ultrasonic Spray Coating System experiment). However, for other experiments which relied on the ABHA template, hazard controls were not well defined or effectively integrated into the activity level work control documents. The SBMS Subject Area on Work Control (*Acceptable Forms of Supporting Documentation*) requires that "unique controls used to mitigate hazards" must be included and described in an ABHA.

Objective:

Work is conducted diligently in accordance with approved work instructions and within established controls.

The process for authorizing and releasing research work is well documented within SBMS and CSD procedures. For example, authorization to perform research work in the CSD laboratories is provided by the Divisional Work Authority's (DWA) approval of the RSS under which the research is performed, and this process is well defined in the *Implement ISM in Research and Development* procedure within the SBMS Work Control Subject Area. Within CSD, the DWA is the Division Director or his designee, and each RSS is reviewed and reauthorized by the DWA at least annually. For the observed experiments in CSD, all RSSs that EA reviewed had a current DWA authorization, and each had been appropriately re-authorized during the past 12 months.

For the observed research experiments within CSD, researchers understood their responsibilities for ensuring that work is performed safely.

Chemical Sciences Division Conclusion

At the research project level, within CSD, RSSs provide clear descriptions of the types of research to be performed, establish and define the safety envelope under which experiments are to be conducted, and document the applicable SBMS and CSD hazard controls and requirements. The CSD research support staff and CSD Division Safety Officer are engaged in assisting the research staff in planning and executing research work. At the activity or experiment level, CSD researchers are knowledgeable of the hazards and hazard controls, although work control documents, such as the ABHA, did not always adequately document or communicate the experimental work scopes, hazards, and/or required hazard controls as required by the SBMS Work Control Subject Area (Acceptable Forms of Supporting Documentation), and opportunities for improvement were noted.

5.2.3 Facilities and Operations Directorate/Maintenance

Responsibility for facility operations and maintenance resides with NNFD for the REDC Complex; with Facilities Management Division for conventional facilities; and the Utilities Division for sitewide utilities. Maintenance support is provided through a combination of dedicated and loaned resources and specialty services, depending upon the organization.

Objective:

The scope of work is described in sufficient detail to allow the work planning process to identify hazards associated with the work and to develop necessary schedules, priorities, and work instructions.

The work scope was appropriately described for three observed maintenance jobs at REDC. The first job involved a modification to the fire alarm system to install fiber optic cables, which was performed under the REDC Minor Maintenance work plan. Work Order (WO) 3593522 included a brief work description that was adequate for this straightforward job. The second phase of the fiber optic work involved modification of the fire alarm control panel to install the fiber optic hardware. The associated job-specific work plan (MWP051933/0) included an appropriate description of the scope of work. The third observation was of the Q-ball transfer of radioactive material via SRP-25T, which was accomplished with both a maintenance work plan and an operations procedure. The maintenance work plan (SMWP033934/2) is a pre-approved work package covering ordinary and critical lifts, and procedure

NNFD-7920-OP-132, *Transfer of Radioactive Material via SRP-25T*, includes an adequate description of the work scope.

An additional work observation included a Grade 4 electrical job in Building 4100, which consisted of reversing phases in a 480-volt, three-phase plug to establish the correct phase rotation of the equipment. The work description in WO 3601865 was sufficient to describe this activity.

The OM&S WP&C process allows the use of pre-approved work plans, some of which cover a broad range of activities. Both of the observed Grade 3 steam plant work activities used the pre-approved work plan for the steam production system, which has a work scope covering all routine maintenance activities for the crafts (e.g., millwrights, pipefitters and welders, electricians, instrumentation and controls technicians). The two work orders observed included: 1) work order, WO 3602078, which adequately described the work scope for corrective maintenance on the reverse osmosis water filtration unit, and 2) work order WO 3593250, which included a brief work description for installation of the continuous blowdown flowmeter.

Objectives:

All hazards that could adversely impact workers, the public, the environment, and the facility and its equipment are documented and analyzed for severity/significance.

Safety and health professionals are assigned to the NNFD and Utilities Division and provide expert support to the hazard analysis and control selection process. UT-Battelle is making substantial progress on coming into compliance with NFPA 70E 130.5 requirements to perform arc flash hazard analyses and provide warning labels for all of its electrical equipment. These labels provide valuable electrical hazard information and PPE requirements for protecting the workers who operate and maintain the equipment.

Job-specific work plans appropriately identify the associated hazards. The JHE for work plan MWP051933, *7920 and 7930 modification of the fire and trouble alarm signals*, appropriately identified the hazards and possible controls for this work, and the QEA provided an adequate evaluation of the chemicals and lifting hazards. The JHE for the maintenance portion (e.g., critical lift) associated with the transfer of the SRP-25T cask appropriately identified potential hazards. Appropriate SMEs (e.g., industrial safety/health, radiological protection, fire protection engineering) signed the work packages.

The JHEs associated with the broad-scoped pre-approved work plans (e.g., REDC Minor Maintenance work package and the steam production system) included the hazards for all of the potential work activities, so they did not provide a task-specific analysis of the hazards. The JHE for the REDC Minor Maintenance work package (SMWP045523/1) identified hazards associated with all of the activities that could be performed under this work package: 22 hazards and associated permits/controls. Of these hazards, only four were applicable to the fiber optic task (elevated work, manual material handling, potential eye injury, and insects/animals). Similarly, the JHE for the work plan for the Utilities steam production system identified hazards associated with all potential work activities (e.g., pressure vessels, compressed gas, flammables, power equipment, electrical): 28 potential hazards and associated permits/controls. It also included three hazards assessments for electrical work and six QEAs.

Examples of observed work with unidentified or unanalyzed hazards included personnel standing unnecessarily close to an excavator during a trenching activity and a worker connecting a pump to a Kubota battery while the unguarded engine was running (both contrary to 10 CFR 851.10, General Requirements, which states that employers shall furnish a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm). These observations were discussed with the safety SMEs. The QEA for the ORNL work plan MWP051933/0, *7920 and 7930 modification of the fire and trouble alarm signals*, did not address ergonomics although the worker kneeled for an extended period. The QEA in the Sewage Treatment Plant Operation Procedure UT-T-MECH-039 did not address three of the chemical agents (ozone, carbon monoxide, and propanol). Also, the REDC Minor Maintenance work package QEA did not address chemicals or heat/cold stress, even though covered tasks could involve these hazards (e.g., painting, insulation, refrigeration mechanic, etc.). (**Deficiency)**

Objective:

Controls are identified and implemented that effectively protect against identified hazards, and approved activity-level work control documents can be performed as written.

Controls were appropriately identified for most of the observed work. The JHE for work plan MWP051933, *7920 and 7930 modification of the fire and trouble alarm signals*, appropriately identified the possible controls for this work, and the QEA provided an acceptable evaluation of the chemicals and lifting hazards. The work area was barricaded, and workers wore appropriate PPE. The JHE for the maintenance portion (e.g., critical lift) associated with the transfer of the SRP-25T cask appropriately identified controls, including a critical lift plan and RWP (REDC-21618-7).

Supervisors are responsible for tailoring the hazards and controls for Grade 2 or 3 maintenance jobs performed with pre-approved work plans, and for all Grade 4 work. The supervisors were diligent in identifying and conveying the appropriate controls to the workers during the pre-job briefings, including the correct PPE, barricades, and permits, including hot work, RWPs, and “lock, tag, verify” (LTVs – also known as lockout/tagout).

EA observed some work where UT-Battelle did not implement required controls. WO 3593250, *Boiler 7 Continuous Blowdown Flowmeter*, contained conflicting QEAs for welding fumes. One required point source ventilation for welding of carbon steel when the work was performed inside a building, and the other stated that general ventilation was adequate. The observed activity did not have point source ventilation, instead relying upon ventilation from an open garage door and exhaust fan On this same job, workers were observed wearing flammable/ignitable hats prior to performing hot work activities, contrary to NFPA 51B, *Standard for Fire Prevention During Welding, Cutting and Other Hot Work*. The job superintendent had the workers remove these hats when EA brought this to his attention. On WO 3316770, *Tie-in CHX Line to East DA Work Package*, insulation work was performed with inadequate hand protection to protect against the chemical hazards, contrary to 10 CFR 851.10, General Requirements. Also, requirements for occupational noise exposure were not met for a pipefitter and an insulator who were either not included in the training or not enrolled in the hearing conservation program, even though their work routinely involves proximity to loud equipment. **(Deficiency**)

NNFD personnel use form NNFD-FRM-058, *REDC work package index*, to ensure that the work package contains all of the necessary documents and is complete. The form lists the permits that are required to be included in the package but does not include the LTV permit. The REDC facility supervisor stated that this could be interpreted to mean that the LTV permit is not required to be with the work package, and concurred that it should be added to the form.

Objective:

Work is conducted diligently in accordance with approved work instructions and within established controls.

UT-Battelle schedules and integrates work at REDC and Utilities through a combination of POD meetings and weekly scheduling meetings. The assessment team observed six PODs (four at REDC and two at Mechanical Utilities). The REDC and Mechanical Utilities PODs, process status meetings, and Utilities Shift Superintendent turnover process are adequate for scheduling, integrating, and deconflicting work performed by dedicated resources.

The assessment team observed seven pre-job briefings - three at REDC and four at Mechanical Utilities. In all cases, these briefings addressed the work to be conducted, the expected hazards and controls, and stop-work authority. The job supervisors appropriately tailored the pre-job briefings to the work performed.

UT-Battelle demonstrates a strong commitment to stop-work authority, from senior management positions to the worker levels. Interviewed employees were willing to utilize their stop-work authority if needed, which the supervisors emphasized during pre-job briefings, and some of the divisions have developed tools, such as the Utilities orange “STOP” card, to reinforce a worker’s right to stop work. Also, the managers, supervisors and workers have substantial relevant work experience and are well qualified and trained.

The Grade 1 minor maintenance work activity to pull fiber optic cable for the fire alarm panels in Buildings 7920 and 7930 was performed efficiently, with effective communications between workers, engineers, and supervision. Workers wore appropriate PPE and adhered to required safe work practices, including the proper use of ladders, which were field inspected before use. Another work activity involved the fiber optic hardware installation and termination in the fire alarm panel in Building 7920. The area was appropriately barricaded to prevent people from walking through. Support staff, including fire protection engineering, were at the job site. The workers wore appropriate PPE, and the fire alarm technician demonstrated proficiency in the task. The assessment team also observed the movement of the Q-ball shipping cask and transfer of californium-252 into a hot cell. REDC performs this operation every two years, which involves a critical lift of a 48,000-pound shipping cask and has the potential for significant worker and mission impact. All involved employees wore appropriate PPE and followed safe work practices. The work was well coordinated, good communication was established, and ALARA principles were used to minimize the potential for worker exposure.

Similarly, the observed Mechanical Utilities jobs were conducted in a controlled and careful manner, in accordance with the work control documents. The supervisor and workers walked down the job site and verified LTV where applicable before commencing work. The workers wore appropriate PPE, including flame resistant clothing. For hot work, a fire watch was stationed, and combustibles in the area were covered. Electricians conducted a proper zero-energy test for electrical work.

Facilities and Operations Directorate/Maintenance Conclusion

Overall, the OM&S WP&C processes were adequately implemented for the observed maintenance work. The work plans/work orders sufficiently described the scope of work. Safety and health professionals are matrixed to the REDC and Utilities organizations and provide expert support to the hazard analysis and control selection process. The JHE is an effective tool that aids in selecting potential hazards and controls; however, the JHEs and QEAs did not identify all of the hazards and controls for some of the observed work. UT-Battelle is making significant progress on performing arc flash hazard analyses and providing warning labels for all of its electrical equipment. The PODs effectively integrate and deconflict work. The managers, supervisors, SMEs, and workers are well qualified. The pre-job briefings at REDC and Utilities appropriately addressed the work scope, tailored the hazards and controls to the work being performed, and reinforced stop-work authority. UT-Battelle demonstrates a strong commitment to stop-work authority, from senior management positions to the worker levels. The maintenance personnel conducted work in a careful and controlled manner in accordance with the work control documents.

5.3 CAS/Feedback and Improvement

Objective:

The contractor assurance system produces periodic scheduled and non-scheduled evaluations (e.g., self-assessment, independent assessment, management walkthroughs) of WP&C activities that identify issues, concerns, and opportunities for improvement in the WP&C program.

The ORNL CAS is defined in the UT-Battelle Contract with DOE, DE-AC05-00OR22725, Section H-15, *Contractor Assurance*, which sets expectations for "a comprehensive description of the assurance system with processes, key activities, and accountabilities clearly identified." The CAS describes the use of third-party audits, peer reviews, independent assessments, and external certification (such as the DOE voluntary protection program and International Standards Organization 9001 or 14001). For elements pertaining to WP&C, UT-Battelle conducts rigorous, risk-based, credible self-assessments, as well as feedback and improvement activities, that use nationally recognized experts and other independent reviews to assess and improve the contractor's work process and to carry out independent risk and vulnerability studies to measure performance. The assessments are appropriately prioritized by risk and are tailored for the internal ORNL organization to maximize their effectiveness. Based on interviews with personnel conducting the assessments in PSD, F&O, and NNFD, the internal assessments lay the appropriate groundwork for continuous improvement activities. PSD, for example, conducted assessments to determine the effectiveness of researchers performing ABHAs by adequately reviewing laboratory notebooks to determine whether experiments had the proper identified hazards and the proper controls to mitigate them. Additionally, the results of these assessments were reported to upper management three times a year as required, and corrective actions were put into the Assessment and Commitment Tracking System (ACTS) database to track completion and effectiveness. Based on the maturity of ORNL's assessment and corrective action processes, ORNL has a robust capability for determining its effectiveness in WP&C and also has demonstrated a strong ability to continuously improve its processes.

Objective:

External and internal feedback and lessons learned are factored into ongoing and future WP&C activities. The contractor has established WP&C programmatic performance objectives and expectations (i.e., measures or metrics) in order to evaluate the program's effectiveness and promote continued improvement.

PROG-130, *Lessons Learned/Operating Experience Program*, establishes the process for identifying and disseminating lessons-learned information to all levels of the organization. For WP&C processes, external and internal lessons learned are effectively captured, documented, and distributed to parties within UT-Battelle and are incorporated into supervisors' Safety Talks, which is a program designed to increase employee/supervisor engagement. An innovative trending analysis conducted by ORNL looks at the topics of these supervisor Safety Talks as key indicators of safety and health issues throughout the Laboratory.

The F&O Directorate appropriately solicits feedback through an electronic survey request sent to the requestor when a work order is closed. The requestors can rate the service from "extremely satisfied" to "dissatisfied" and express whether their expectations were met, the work was performed in a timely manner, and the time charges were appropriate. F&O tracks the survey responses as one of its performance metrics. Also, a formal post-job review for the REDC Q-ball transfer demonstrated good interaction and feedback from the workers and resulted in suggestions for improving the process the next time it is performed.

UT-Battelle also effectively uses other methods for communicating safety and health information related to WP&C, depending on the needed timeliness, specificity, and amount of information conveyed. The pre-job briefings are an opportunity to pass along specific, real-time safety and health guidance to help workers accomplish their daily tasks safely. Other examples are the Safety Toolbox weekly briefings delivered during safety meetings, the Performance Monday newsletter, and video monitors in high traffic areas that cycle through safety information that personnel can consider while transiting throughout their facility. Personnel observed throughout this assessment demonstrated considerable dedication to increasing their knowledge of the hazards around them and the control measures to keep them safe.

CAS/Feedback and Improvement Conclusion

ORNL has effectively developed and implemented procedures, processes, and metrics that contribute to the improvement of WP&C processes, including scheduling and performing assessments that identify issues, categorizing identified issues, and resolving those issues. Feedback is solicited from workers, and lessons learned are incorporated into work packages and research notes. Metrics are effective in tracking the relevant safety and health issues encountered at ORNL, and communication flows well between all segments of management and personnel with specific SBMS roles within the organization.

6.0 FINDINGS

EA did not identify any 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 two 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 suggestions 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 offered to assist site management in implementing best practices or potential solutions to issues identified during the assessment.

All OFIs pertain to UT-Battelle.

- **OFI-MU-1:** Consider more stringently defining the requirements for Grade 4 work and establishing a list of specific routine jobs that can be accomplished as Grade 4 work. Activity screening and binning based upon scope of work complexity, consequences, and frequency can help determine the appropriate activity level work control document.

- **OFI-CSD-1:** Consider developing "control banding" techniques and including them in the QEA process to address hazards and controls for the laboratories and researchers who routinely work with a wide variety of chemical hazards. Control banding uses approaches that

SMEs have developed previously to control occupational chemical exposures based on a range or “band” of hazards (e.g., skin/eye irritant, very toxic, carcinogenic) and exposures (small, medium, large). Control banding techniques have been developed by the American Industrial Hygiene Association and the National Institute for Occupational Safety and Health.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: January 14-18 and 28-31, 2019

Office of Enterprise Assessments (EA) Management

Nathan H. Martin, Director, Office of Enterprise Assessments
John S. Boulden III, Acting Deputy Director, Office of Enterprise Assessments
Thomas R. Staker, Director, Office of Environment, Safety and Health Assessments
C.E. (Gene) Carpenter, Jr., Director, Office of Nuclear Safety and Environmental Assessments
Kevin G. Kilp, Director, Office of Worker Safety and Health Assessments
Gerald M. McAteer, Director, Office of Emergency Management Assessments

Quality Review Board

John S. Boulden III
Steven C. Simonson
Kevin L. Dressman
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EA Site Lead for ORNL

Jeff Snook

EA Assessors

Charles C. Kreager, Lead
Kevin G. Kilp, Senior Advisor
James R. Lockridge
Dennis K. Neitzel
Terry B. Olberding
Mario A. Vigliani

Appendix B
Key Documents Reviewed, Interviews, and Observations

Documents Reviewed

- CSD Injury & Illness Data and Occurrence Reports (2013 to present)
- CSD research safety summaries, qualitative exposure assessments, activity level hazard analysis documents, standard operating procedures and analytical methods, and other applicable supporting references (e.g., oxygen deficiency calculations) associated with the five experiments identified under "Observations".
- CSD Training Program Plan Procedure, and Selected CSD Researcher Training Records
- F&O Customer Survey Summary – Directorate, 1/30/19
- IDPTBD, *Oak Ridge National Laboratory Internal Dosimetry Program Technical Basis Document*
- MWP051933, *7920 and 7930 Modification of the Fire and Trouble Alarm Signals*, R0, 1/15/19
- NMP-AC-01 *Separation of Radium and Actinium from Thorium Solutions*
- NMP-PF-013 *Electrodeposition Operations*
- NMP-PFAB-001 *NpO2 Pellet Fabrication*
- NNFD-004, *Work Control*, R9, 4/1/16
- NNFD-018, *Pre-Job Briefs and Post-Job Reviews,* R4, 4/1/16
- NNFD-7920-OP-132, *Transfer of Radioactive Material via SRP-25T Cask*, R0, 6/21/06
- NNFD-FRM-058, *REDC Work Package Index*, R9, 1/11/17
- NNFD-REDC-001, *Glove Box Operations*
- NRPD TPP-6024, *Glove Box Operations Radiological Monitoring at the Radiochemical Engineering Development Center (REDC), Buildings 7920 and 7930*
- NRPD-IOP-2002 *Work Control for RPO Operations*
- NRPD-IOP-2003 *Radiological Posting, Labeling and Marking*
- NRPD-IOP-2004 *Monitoring for Airborne Radioactivity*
- NRPD-IOP-2005 *Air Sampler Monitor Placement*
- NRPD-IOP-2006 *Radiological Respiratory Protection*
- NRPD-IOP-2007 *Radiation Shielding and Radiological Material Containment*
- NRPD-IOP-2102 *Radiological Event Reporting*
- NRPD-IOP-2109 *Communicating Radiological Conditions*
- NRPD-IOP-2201 *Analyzing for the Presence of Airborne Radioactivity*
- NRPD-IOP-2202 *Survey Techniques for Radioactive Contamination*
- NRPD-IOP-2203 *Radiation Surveys*
- NRPD-IOP-2401 *Radiological Work Permits*
- NRPD-IOP-2801 *Response to Unanticipated Alarms*
- NRPD-IOP-2803 *Handling Radiologically Contaminated Personnel*
- NRPD-TBD-2100, *Oak Ridge National Laboratory Technical Basis for Radiological Air Monitoring at the Oak Ridge National Laboratory*
- Pre-Approved Work Plan for the Steam Production System
- PSD Guide *Examples of Activity-Based Hazard Analysis (ABHA)*
- QEA Assessment Reports for 2017 & 2018
- Radiological Application and Documentation System (RADS), *Guidance for Creating Radiological Work Permits (RWPs*)
- REDC Radiological Facility Surveillance Plan
- REDC Radiological Survey, REDC 503544
- RHACS Hazards Evaluation Questions Report

- RSS 11316.7 and bag out, Lab 109, RWP REDC-21899-12
- RSS 2486.19 bag out, Lab 209, RWP REDC-22302-8
- RSS 2497.17, Lab 211, RWP REDC-22528-4
- RSS 4191.12, RMAL Lab 225, RWP 4501-24351-0
- RSS 4710.14, Lab 201, RWP REDC-20968-14
- RSS 590.18, TAL Lab 208, RWP REDC-20973-11
- RSS 919.19, 7930 Room 212, RWP REDC-22755-5
- RWP REDC-21618-7, *Irradiated Targets Transfers with the Q-Ball Carrier (SRP-25T Cask)*, R7, 12/11/18
- SBMS Subject Area Documents with respect to Work Control, Chemical Safety, Medical Program, Occupational Hazard Controls (Working with Cryogens), Unbound Engineered Nanomaterials, Worker Safety & Health (ISMS Program Description & Worker Safety and Health Program).
- SMWP033934, *Ordinary and Critical Lifts at 7920*, R2, 3/20/18
- SMWP045523, *REDC Minor Maintenance Work Plan*, R1, 12/13/18
- Standards Based Management System Subject Area*, Implement Work Control for Operations, Maintenance and Services*
- Standards Based Management System Subject Area, *Radiological Work*
- Standards Based Management System Subject Area, *Welding Burning Hot Work*
- Standards Based Management System Subject Area, *Work Control*
- Standards Based Management System Subject Area*, Electrical Safety*
- Training Records (16)
- UT-T-MECH-004, *Operation of the ORNL Steam Distribution System (Served by the Central and Melton Valley Steam Plants),* R5, 1/4/18
- UT-T-MECH-039, *Sewage Treatment Plant Operation*, R4, 05/07/18
- WO 3593522, *Install Fiber Optic Cable in 7920 and 7930 Fire Panel*, 1/15/19
- WO3593250, *BLR-2719007, Rentech Boiler "D" #7*, R0, 1/17/19
- WO3593546, *HEATGENS/Heat Generating Systems, Steam Production G4 Work,* 1/15/19
- WO3601865, *Check Phase orientation and rotate as necessary on a RF Generator Supply*, 1/25/19
- WO3602078, *FLTR-2519001/Reverse Osmosis (RO) Water Filtration*, R0, 1/28/19
- Institutional Integrated Assessment Schedule FY 2016-18
- Institutional Integrated Assessment Schedule FY 2019
- Lessons Learned/Operation Experience Program
- Staff Concerns Program
- Safety Toolbox examples
- Performance Monday newsletter examples
- Examples of metrics used for trending WPC in the Comprehensive Performance System (COMPASS)
- FY 2018 Physical Science Directorate Integrated Safety Management/Safety Culture Assessment (ACTS 19432)
- WO 3593477, Sewage Treatment Plant Water Line Supply Installation Work Package, 1/14/19
- WO 3316770, Tie-in CHX Line to East DA Work Package, 1/31/19

Interviews

- Director, Facilities and Operations
- Director, Integrated Operations Support and Management System Owner for OM&S Work/Project Planning and Control
- Director, Facilities Management
- Director, Utilities

- Director, Office of Integrated Performance Management
- Performance Analysis & Quality (PAQ) Division Director
- PAQ Organizational Learning Group Leader
- Lessons Learned/Operating Experience Program Manager
- Continuous Improvement Program Manager
- PAQ Quality Manager
- PAQ Quality Representatives
- NMC&A Team Leader
- Nuclear Science and Engineering Directorate Training Manager
- Training Manager, Office of Technical Training
- NNFD Division Training Manager
- Utilities Division Training Manager
- F&O Directorate Technical Training Administrator
- Group Leader, Organizational Reliability
- Org & Process Improvement Communicator
- Operations Information Specialist
- Staff Concerns Coordinator
- Manager, Mechanical Utilities Complex
- Utilities Work Center/Operations Managers (3)
- Utilities Operations Maintenance Coordinator
- Central Complex Manager
- NNFD Division Director
- NRPD Division Director
- IFCTP Division Director
- NRPD RPO Group Leader for NNFD and Balance of Plant
- NRPD RPO Group Leader for NSF
- NRPD Group Leader, Nuclear and Radiological Support Services
- NRPD NRNF Radiological Engineer
- NRPD REDC/NNFD RPO Manager/RCT Supervisor
- NRPD REDC/NNFD RCTs
- NNFD Nuclear Research Operations Manager
- REDC Facility Manager
- REDC Facility Supervisor
- REDC Maintenance Supervisor
- REDC electricians (2) and HVAC mechanic
- CSD Research Support Staff (CSD RSS Point of Contract, Facility Operations Manager)
- CSD Research Support Group Leader who also serves as the Management System Owner for R&D Work Planning and Control
- CSD Qualified Safety & Health Professional who also serves as CSD Division Safety Officer,
- CSD Division Director, also the Division Work Authority
- CSD Training Officer
- CSD Group Leaders, Principal Investigators, Researchers and Laboratory Space Managers for the observed experiments
- ORNL Safety Services Division Director and Subject Matter Experts
- ORNL Medical Services Director
- QEA Subject Matter Expert
- Building 4100 Facility Operations Manager
- Building 4100 Facility Engineer

- Integrated Research Operations Division Technical Support Group Leader

Observations

NNFD/REDC Work Observations

- Work Observation for RSS 11316.7 and bag out, Lab 109, RWP REDC-21899-12
- Work Observation for RSS 4710.14, Lab 201 and bag out, RWP REDC-20968-14
- Work Observation for RSS 2497.17, Lab 211 and bag out, RWP REDC-22528-4
- Work Observation for RSS 590.18, TAL Lab 208, RWP REDC-20973-11
- Work Observation for RSS 2486.19 bag out, Lab 209, RWP REDC-22302-8
- Work Observation for RSS 919.19, 7930 Room 212, RWP REDC-22755-5
- Work Observation for RSS 4191.12, RMAL Lab 225, RWP 4501-24351-0

CSD/Chemical and Materials Sciences Building Work Observations

Each of the following research experiments and/or observations, including preparation and setup is typically multifaceted and often performed over several days or longer, only limited hands-on experimental activities were observed with the remainder of the experiment being simulated or explained by the research staff.

- A rare earth separations chemistry experiment within the CSD Chemical Separations Group (RSS No. 9603.8)
- A nanomaterial dispersion experiment using the new Sono-Tek Exactacoat Ultrasonic Spray Coating System within the CSD Materials Chemistry Group (RSS 9605.7)
- Spectroscopic research of thermal transport processes in various materials using a Class 4 laser system within the CSD Mass Spectrometry and Laser Spectroscopy Group (RSS No. 9331.6)
- Sparging of molten salt experiment to remove traces of water and oxides performed within the CSD Nanomaterials Chemistry Group (RSS No. 9329.7)
- Analyzing strontium in sewage water outfall samples being performed within the Radioactive Materials Analytical Laboratory (RMAL) within the CSD Nuclear Analytical Chemistry and Isotopics Laboratory Group (RSS No. 4191.12)
- A HAZOP review process for a new higher risk CSD research activity currently in the planning stages

Maintenance Work Observations

- Seven pre-job briefings, three at REDC and four at Utilities Mechanical
- Multiple REDC Plan of the Day meetings
- REDC post-job review for Q-ball job (critical lift transfer of radioactive material via SRP-25T)
- One REDC project planning meeting for PU238 loadout and package process
- Two Utilities Mechanical Plan of the Day meetings
- Utilities Shift Superintendent Turnover
- Work Observation for REDC modification to the Fire Alarm system fiber optic cables (pulling cables)
- Work observation for REDC 7920 and 7930 modification of the fire and trouble alarm signals (observed 7920 work)
- Work Observation for REDC Q-ball job (critical lift transfer of radioactive material via SRP-25T)

- Work Observation for Utilities WO 3602078 corrective maintenance to the reverse osmosis water filtration unit
- Work Observation for Utilities WO 3593250 installation of the continuous blowdown flowmeter
- Work Observation for Utilities WO 3593546 electrical troubleshooting and repair
- Work Observation for Utilities WO 3593477, Sewage Treatment Plant Water Line Supply Installation
- Work Observation for Utilities WO 3316770, Tie-in CHX Line to East DA Work Package
- Work Observation for Building 4100 WO 3601865 corrective maintenance for RF Generator Supply phase orientation
- Demonstration of the Work Plan System and the Facility Service Center

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.

Nonreactor Nuclear Facilities Division/Radiochemical Engineering Development Center WP&C Program and Implementation

- For observed work at REDC, NRPD did not ensure existing requirements for job coverage air sampling and breathing zone air sampling contained in technical procedure NRPD-IOP-2004, *Monitoring for Airborne Radioactivity*, Appendix 7 were followed as written, and consistent with alternate practices authorized by a separate technical position paper, contrary to conduct of operations procedure adherence requirements.

Facilities and Operations Directorate/Maintenance WP&C Program and Implementation

- Required hazard identification, analysis, and/or controls were not identified and/or properly implemented during several observed work activities, as required by the UT-Battelle SBMS procedure, Implement Work Control for Operations, Maintenance and Services.
    - Unidentified or unanalyzed hazards included personnel standing unnecessarily close to an excavator during a trenching activity; a worker connecting a pump to a Kubota battery while the unguarded engine was running; and a potential ergonomic issue.
    - Missing controls included point source ventilation for carbon steel welding and appropriate gloves for insulation work;
    - One pipefitter and an insulator were either not trained on or included in the hearing conservation program, even though their work would routinely involve proximity to loud equipment.