Independent Assessment of the Chemical Safety Management Program at the Hanford Site Waste Treatment and Immobilization Plant

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Office of Enterprise Assessments
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Acronyms

AMR	Ammonia Reagent System
ANSI	American National Standards Institute
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CFR	Code of Federal Regulations
CM	Corrective Maintenance
CS	Chemical Safety
CSMP	Chemical Safety Management Program
CSMPD	Chemical Safety Management Program Description
DFLAW	Direct-Feed Low Activity Waste
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
EPDT	Environmental Performance Demonstration Test
FR	Facility Representative
LAW	Low-Activity Waste
LEL	Lower Explosive Limit
MAR	Material at Risk
MOC	Management of Change
NSD	ORP Nuclear Safety Division
OFI	Opportunity for Improvement
OOD	ORP Operations Oversight Division
ORP	Office of River Protection
PHA	Process Hazards Analysis
PM	Preventive Maintenance
PSM	Process Safety Management
RL	Richland Operations Office
SCR	Selective Catalytic Reduction
SHD	RL Safety & Health Division
SSCs	Structures, Systems, and Components
TSR	Technical Safety Requirement
WTCC	Waste Treatment Completion Company LLC
WTP	Waste Treatment and Immobilization Plant

INDEPENDENT ASSESSMENT OF THE CHEMICAL SAFETY MANAGEMENT PROGRAM AT THE HANFORD SITE WASTE TREATMENT AND IMMOBILIZATION PLANT

Executive Summary

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted an independent assessment of the effectiveness of the chemical safety management program (CSMP) implemented by Bechtel National Inc. (BNI) and its subcontractor, Waste Treatment Completion Company LLC (WTCC) at the Hanford Site Waste Treatment and Immobilization Plant (WTP). The development and implementation of the CSMP at WTP was the first Departmental use of the methodology of DOE-STD-1228-2019, *Preparation of Documented Safety Analysis for Hazard Category 3 DOE Nuclear Facilities*, which moved many chemical safety controls out of the documented safety analysis. EA conducted the onsite portion of this assessment on June 12-15, 2023. The assessment also evaluated the effectiveness of Office of River Protection and Richland Operations Office (together "DOE Hanford") oversight of CSMP development and initial implementation.

EA identified the following strengths:

- Chemical safety controls were identified for chemical hazards through several process hazards analyses and were appropriately integrated with worker safety and health requirements for standard industrial hazards.
- Strong communication and collaboration among the various DOE Hanford divisions that provide oversight of WTP's CSMP contribute to Federal oversight effectiveness.

EA also identified several areas of concern, including two findings, as summarized below:

- Implementing documents for the CSMP management of change process are not consistent with the DOE-approved criteria for application of the process. (Finding)
- Not all potential safety consequences of increasing water content in the anhydrous ammonia storage vessels were considered. (Finding)
- Several potential upset conditions for process anhydrous ammonia have not been analyzed, and safe upper and lower limits on some process parameters have not been established.
- Impairments of CSMP-affecting fire barriers were not adequately controlled. This is a recurrence of an issue previously identified by EA.
- Weaknesses in operator aid control and hazard information signage at the ammonia fill and storage location could increase the likelihood of an upset condition or frustrate mitigation efforts.

In summary, BNI/WTCC has established a generally adequate CSMP, with generally strong oversight from DOE Hanford. However, concerns were identified in the CSMP management of change process, fully analyzing and controlling the hazards associated with the anhydrous ammonia storage vessels and process equipment, reliably managing impairments to fire barriers, and controlling operator aids. Until the concerns identified in this report are addressed or effective mitigations are put in place to improve operational proficiency and compliance with programs and procedures, risk will be elevated as the facilities transition to operations.

INDEPENDENT ASSESSMENT OF THE CHEMICAL SAFETY MANAGEMENT PROGRAM AT THE HANFORD SITE WASTE TREATMENT AND IMMOBILIZATION PLANT

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the chemical safety management program (CSMP) being implemented by Bechtel National, Inc. (BNI) and its subcontractor Waste Treatment Completion Company LLC (WTCC) (collectively "BNI/WTCC") at the Hanford Site Waste Treatment and Immobilization Plant (WTP). EA conducted the onsite portion of this assessment on June 12-15, 2023.

At the time of this assessment, the WTP Low-Activity Waste (LAW) facility had completed startup testing and was undergoing commissioning in preparation for direct-feed low activity waste (DFLAW) operations expected to begin in 2024. In January 2020, DOE's Office of River Protection (ORP) approved Revision 3 of 24590-LAW-DSA-NS-18-0001, *Documented Safety Analysis* [DSA] *for the Low-Activity Waste Facility*. This revision to the LAW DSA was the first Departmental use of the methodology of DOE-STD-1228-2019, *Preparation of Documented Safety Analysis for Hazard Category 3 DOE Nuclear Facilities*, which DOE considers an acceptable successor document to DOE-STD-3009-94 Change Notice No. 1, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, for the purposes of developing DSAs for hazard category 3 nuclear facilities.

Implementation of the streamlined DSA methodology described in DOE-STD-1228-2019 included porting many chemical hazard controls from the previous DSA revision to a new CSMP, which was credited as a safety management program (SMP) in chapter 18 of the revised DSA. Chapter 5 of the DSA identified two key elements implemented by the SMP: an ORP-approved chemical safety management program description (CSMPD) document and an ORP-approved management of change (MOC) procedure.

Chemical hazards and associated hazard controls screened from further evaluation in the DSA in accordance with DOE-STD-1228-2019 are managed under the CSMP. Safety functions and requirements for hazard controls are identified in appendix A of 24590-WTP-PD-RAWS-SS-0003, *Chemical Safety Management Program Description*. The CSMP identifies "Chemical Safety" (CS) controls and the approval authority structure applicable to changes. The CSMP integrates the programs that support maintaining the mechanical integrity of structures, systems, and components (SSCs) for chemical hazard controls and provides the MOC procedure.

The porting of these CS controls from the DSA to the CSMP, and the adequacy of their descriptions in the DOE-approved CSMPD, was previously reviewed by EA in *Safety Basis Assessment at the Hanford Site Waste Treatment and Immobilization Plant Low-Activity Waste Facility – May 2020*. After EA's previous assessment, BNI performed additional process hazards analyses (PHAs) and revised the CSMPD to include new CS controls specific to the balance of facilities (BOF) ammonia reagent system (AMR) (appendix B of the CSMPD) and the environmental performance demonstration test (EPDT) (appendix C of the CSMPD).

Consistent with the *Plan for the Independent Assessment of the Chemical Safety Management Program at the Hanford Site Waste Treatment and Immobilization Plant – June 2023*, this assessment evaluated the adequacy of CSMPD-implementing procedures and the MOC procedure and their implementation. This

assessment also reviewed the PHAs used in the development of Revision 1 of the CSMPD (applicable to appendices B and C) to verify that the facility hazards were properly identified and their associated accident scenarios were appropriately evaluated. Additionally, this assessment evaluated whether the controls that were developed and added for the AMR and EPDT were adequate to effectively prevent or mitigate accidents to provide adequate protection to the public, workers, and the environment. Furthermore, the implementation of worker safety and health requirements and process safety management (PSM) requirements applicable to the planned use of anhydrous ammonia at WTP was evaluated. Because of the pre-operational status of the treatment process, the scope of the PSM evaluation was limited to installed equipment and infrastructure that supports the future use of anhydrous ammonia, hazard analyses conducted in support of that usage, and programmatic procedures established to conform with applicable requirements. Finally, this assessment evaluated the effectiveness of ORP and Richland Operations Office (RL) (together "DOE Hanford")[1] oversight of BNI/WTCC's development and initial implementation of the CSMP.

2.0 METHODOLOGY

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

As identified in the assessment plan, this assessment considered requirements related to the development and implementation of the CSMP. Criteria to guide this assessment were based on selected objectives and criteria from EA Criteria and Review Approach Document (CRAD) 30-11, Revision 0, *Safety Systems Management Review*, as these objectives and criteria apply to key chemical defense in depth SSCs maintained and monitored in accordance with the CSMPD, table A-2, items 7 and 8. Additional PSM objectives and lines of inquiry not covered by EA CRAD 30-11 are listed in appendix B of the assessment plan and were informed by applicable portions of EA CRAD 32-05, Revision 0, *Chemical Hazard*, and EA CRAD 32-03, Revision 1, *Industrial Hygiene Program*. EA also used elements of EA CRAD 30-07, Revision 0, *Federal Line Management Oversight Processes*, to collect and analyze data on DOE field office oversight activities related to the CSMP.

EA examined key documents, such as system descriptions, work packages, procedures, manuals, analyses, policies, and training and qualification records. EA also interviewed key personnel responsible for developing and executing the associated programs; observed a CSMP-affecting surveillance; and walked down significant portions of WTP chemical systems, focusing on CSMP-related SSCs. The members of the assessment team, the Quality Review Board, and the management responsible for this assessment are listed in appendix A.

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

[1] Some sitewide oversight functions are consolidated to a single group within ORP or RL. The organizations conducting CSMP oversight include the Safety & Health Division, which is part of RL, the Nuclear Safety Division, which is part of ORP, and the ORP Operations Oversight Division. Both RL and ORP provide programmatic oversight for projects managed by both offices.

3.0 RESULTS

3.1 Development and Implementation of Safety Controls

This portion of the assessment evaluated BNI/WTCC's implementation of safety management processes and controls, including process hazards analysis, change control, configuration management, and chemical safety control implementing procedures.

3.1.1 Process Hazards Analysis

BNI/WTCC has developed technically adequate PHAs that identify facility hazards, evaluate their accident potential, and develop effective preventive and mitigative chemical safety controls to provide adequate protection to the public, workers, and the environment. The reviewed hazard events associated with the BOF AMR and EPDT were appropriately completed using the PHA methodology in 24590-WTP-GPP-RAWS-SS-0001, *Process Hazard Analysis for Chemical Safety and Process Safety Management*, which is similar to the methodology used in the preparation of the LAW DSA. Hazards associated with plant operation (normal, abnormal, and accident conditions), external events, and natural phenomena hazards were appropriately included and adequately evaluated in the PHAs. The PHAs appropriately used bounding inventory values (material at risk, or MAR) for the hazardous material being evaluated and appropriately included worker safety hazards when they could be accident initiators or exacerbate the consequences of an accident.

Available credited chemical safety controls (preventive and mitigative) were properly identified for each hazard requiring mitigation to provide adequate protection to the workers and public. Each potential accident scenario was appropriately and accurately evaluated for its unmitigated likelihood of occurrence and consequence to facility workers, co-located workers, and to the public (maximally exposed offsite individual). The required mitigated analyses were accurately performed and confirmed the adequacy of chemical safety controls when mitigation was required.

While these controls are adequate for normal operations, the lack of engineered controls to supplement or replace some administrative controls may lessen protection during upset conditions. For example, controls to ensure that process cells remain unoccupied during melter operations when nitrous oxides could be present are limited to a door lock with an administratively controlled key. No indication is provided to alert operators if a process cell door is inadvertently opened. Additionally, access to the ammonia dilution skid room administratively requires personnel to verify negative pressure and no alarming conditions prior to entering. However, the monitors are remote from the door accessing the room, and no lock or other physical barrier is in place to prevent entry. (See **OFI-BNI/WTCC-1**.)

3.1.2 Change Control (Management of Change for Process Chemical Safety)

BNI/WTCC has a generally effective change control program that was approved by DOE Hanford and is performed by qualified individuals. DOE approved the current revision of 24590-WTP-GPP-RAWS-SS-0003, *Management of Change for Process Chemical Safety*, on May 16, 2023. The MOC procedure appropriately requires that the contractor review changes that can affect process chemical hazards and that they be evaluated and approved prior to implementation. The MOC procedure adequately describes its purpose and scope, the roles and responsibilities of those who use the procedure, personnel requiring training, and records requirements. A review of training records confirmed that personnel involved with the MOC process are properly trained and qualified in its performance and application. Consistent with the DSA and technical safety requirements (TSRs), the MOC procedure appropriately requires that a change be reviewed and evaluated to determine whether it requires DOE approval when it could introduce one of the following:

- An increase in the probability of the occurrence or the consequences of an accident or the malfunction of equipment important to chemical safety previously evaluated in the safety analysis
- The possibility of an accident or malfunction of a different type than evaluated previously in the safety analysis
- A decrease in the margin of safety of a chemical safety control already evaluated in the safety analysis.

The MOC procedure appropriately applies to both proposed changes and discovery of changes that have not been previously evaluated in the safety analysis. BNI/WTCC has developed additional forms and procedures used by technical authority reviewers to screen such changes for MOC applicability. However, contrary to the DOE-approved applicability criteria in 24590-WTP-GPP-RAWS-SS-0003, which is identified as a key element in the DSA and required to be implemented by TSR 5.6.2.m, BNI/WTCC altered the applicability screening questions in its web-based *Plant Engineering Technical Authority Review* (TAR) form used to determine whether the MOC process needs to be applied to changes potentially affecting process chemical safety. (See **Finding F-BNI/WTCC-1**.) Deviations from the applicability criteria include the following:

- One applicability criterion in the MOC procedure states that it applies when "A change impacts items designated Chemical Safety (CS) or chemical Defense in Depth (DiD)." Question 2 of the TAR form asks, "Does the change being reviewed *remove or alter* a CS item or chemical DiD equipment *as defined in CSMPD 24590-WTP-PD-RAWS-SS-0003 Appendix A*?" (emphasis added). The change from "impact[]" to "remove or alter" may affect a user's interpretation of whether the criterion applies. Further, while CSMPD appendix A lists the CS classification of CS controls and identifies "Chemical Key Defense in Depth (DiD) SSCs," neither "CS item" nor "chemical DiD equipment" is a defined term.
- One applicability criterion states that it applies when "A process chemical hazard has not been evaluated or the hazard evaluation may not be adequate in an existing process hazard analysis (PHA)." Question 3 of the TAR form asks, "Does the change have the potential to introduce a new process chemical hazard or increase the severity of an existing hazard as per 24590-LAW-ES-NS-17-004, Process Hazards Analysis?" The question as written does not apply the same criteria, and limits "an existing PHA" to only the initial PHA performed in support of the DSA, prior to CS controls being ported to the CSMP, which it incorrectly cites.
- One applicability criterion states that it applies when "Changes to Process Safety Management (PSM) designated items (when there is a PHA that establishes CSMP controls and associated safety functions and functional requirements.)" Question 5 of the TAR form asks, "Does the change have the potential to impact Process Safety Management (PSM) designated items *as defined in* the Process Safety Management Program Description (PSMPD) 24590-WTP-PD-RAWS-SS-0001?" (emphasis added). The PSMPD does not define "PSM designated items."

Inconsistencies in criteria for screening changes, including incorrect references to definitions of terms or language inconsistent with the DOE-approved applicability criteria, could result in the misapplication of the MOC procedure.

3.1.3 Configuration Management

BNI/WTCC has a configuration management process in place to ensure that safety controls continue to meet safety basis requirements. According to 24590-WTP-PD-RACM-CM-0002, *As-Built Program Description*, "during the Engineering, Procurement, and Construction (EPC) phases of the project, the as-built configuration is represented by the design and associated design change control documents." This

includes a "Field Change Notice" (FCN) program that combines the design drawings and affected design change control documents together to represent the as-built condition. The reviewed FCN procedure methodology (described in 24590-WTP-GPP-CON3103, *Field Changes and Request for Information*) and a sample of four isometric drawings affected by two FCNs were adequate. The FCN procedure methodology is adequate for ensuring that as-built status is recorded and proposed changes are appropriately evaluated for compliance with applicable codes and standards before their implementation. Additionally, a limited walkthrough of four chemical safety controls confirmed that chemical safety control components, configuration, and labeling were consistent with the respective piping and instrumentation diagrams.

According to 24590-WTP-PD-RACM-CM-0002, "during the Commissioning and Operation (CO) phases of the project, design change control documents need to be incorporated into selected design documents to support plant operation and response to abnormal operating conditions without delay." Despite being in the commissioning phase of the project, EA was not provided any implementation procedures applicable to the as-built program for the CO phase. All design changes reviewed by EA were documented using the FCN methodology, without having been incorporated into the associated design documents.

3.1.4 Chemical Safety Control Implementing Procedures

Reviewed chemical safety control implementing procedures were generally adequate and appropriately performed by qualified individuals. Personnel required to perform or review maintenance and surveillance activities associated with the chemical safety controls receive adequate training on their use. The training includes adequate requisite knowledge of the chemical safety control and is appropriately part of the qualification process for maintenance technicians, operating personnel, and supervisors. Training also appropriately includes and confirms by testing that affected personnel have adequate knowledge of required actions when a procedure action cannot be met. However, contrary to 10 CFR 830.122(d)(1) three of the six reviewed chemical safety control implementing procedures contained errors associated with torque requirements. (See **Deficiency D-BNI/WTCC-1**.) Specifically:

- 24950-LAW-LOP-SUR-003-01-000, *CSMP 17 – Inspection of Melter 1 Special Relief Device MLTR 1 STBY FCLR SPECIAL RLF DEVICE (LOP-SP-00003)*, contained multiple errors in the units to describe torque requirements (i.e., ft/lb was used instead of ft-lb).
- 24950-LAW-LOP-SUR-003-04-000, *CSMP 17 – Replacement of Melter 2 Special Relief Device MLTR 2 STBY FCLR SPECIAL RLF DEVICE (LOP-SP-00008)*, contained multiple errors in the units to describe torque requirements (i.e., ft/lb was used instead of ft-lb).
- 24950-LAW-CHW-SUR-0001-08-000, *CSMP 7 – REMOVAL AND REPLACEMENT OF MLTR 2 SBS CLG JKT RLF B (LOP-PSV-2150)*, contained an error in torque wrench requirements (i.e., 45 ft-lb torque wrench was listed as required, but some procedure steps required 60 ft-lb of torque).

Implementing procedures that contain errors could result in workers misinterpreting those procedures and safety controls not being restored to their proper configuration to perform their safety function.

During observations in the LAW facility, an impairment to a CSMP-credited fire door did not have a required fire watch posted as a compensatory measure. The previous fire watch left at the end of the mid shift and was not replaced by day shift; therefore, the fire watch was not being implemented as required by DOE-STD-1066-2016, *Fire Protection*, section 5.1.5, *Fire Protection System Impairments*. (See **Deficiency D-BNI/WTCC-2**.) With no one in place to support the necessary actions to restore the fire barrier in case of a fire, the fire door would remain open, thereby increasing the risk of a fire penetrating a credited fire separation. BNI/WTCC responded to this observation by immediately restoring the

compensatory measure. This is a recurrence of an issue documented in a previous EA assessment that has not been adequately corrected.

During a weekly fire door surveillance observed by EA, performed to 24590-WTP-COWP-WC-23-03718, *Weekly LAW Fire Rated Personnel Door Inspection*, 13 of 32 observed fire doors were determined to be unsatisfactory, including 11 of 17 that protected CSMP-related SSCs. One door that was determined and documented to be unsatisfactory was appropriately repaired by a carpenter who accompanied the maintenance personnel performing the surveillance. The carpenter was qualified to perform the repair work but was not signed on to the surveillance work package and was not qualified to perform the inspection under training curriculum 13081, *Perform Inspection and Testing of Fire Door Assemblies*. Following repairs, the carpenter verbally told the maintenance personnel, who were no longer in the vicinity of the repaired door, that the door now performed satisfactorily. The maintenance personnel then inappropriately changed the record-copy work package without verification to indicate that the door was satisfactory. The performance of work by unqualified personnel and the alteration of record documents without the verification of SSC condition are contrary to 10 CFR 830.122(e)(1) requirements that work be performed consistent with technical standards and administrative controls using approved instructions and procedures. (See **Deficiency D-BNI/WTCC-3**.) Performance of procedure steps by personnel not authorized to perform them and altering record documentation without verification of the condition being documented could lead to degraded SSCs not being appropriately evaluated and restored, and configuration management not being appropriately maintained.

Additionally, contrary to DOE Order 422.1, *Conduct of Operations*, attachment 2, requirement 2.q, operator aids designed to assist first responders responding to a leak at the ammonia receipt and storage location were not adequately controlled. (See **Deficiency D-BNI/WTCC-4**.) Specifically, an appropriately controlled operator aid listing valves that would need to be manipulated by the Hanford Fire Department to stop an ammonia leak referred to large placards hanging near the valves. The placards were not controlled operator aids and were not firmly affixed. A lack of appropriate controls for operator aids could result in them being relocated to the incorrect components, resulting in improper valve manipulation during response to an upset condition.

Development and Implementation of Safety Controls Conclusions

Overall, BNI/WTCC has developed technically adequate PHAs and a generally effective change control program. BNI/WTCC also has an effective configuration management process. Reviewed chemical safety control implementing procedures were generally adequate. However, BNI/WTCC altered the DOE-approved applicability criteria in its web-based form used to determine whether the MOC process needs to be applied to changes potentially affecting process chemical safety. Further, some reviewed chemical safety control implementing procedures contained errors associated with torque wrench requirements, compensatory measures for a fire impairment were not maintained, an observed surveillance activity was not properly controlled, and operator aids were not always adequately controlled.

3.2 Integration of Worker Safety and Health Requirements

This portion of the assessment evaluated BNI/WTCC's programs, plans, and procedures that implement 10 CFR 851, *Worker Safety and Health Program*, requirements for chemical and applicable physical hazards (noise, welding hazards, etc.) associated with CSMP-bounded chemical operations.

3.2.1 Chemical Hazard Analysis

BNI/WTCC has adequately identified occupational hazards regulated by 10 CFR 851 that are associated with CSMP-bounded chemical operations. Specific chemical hazards are described in the CSMPD, section 2. Adequate procedures are in place for worker hazard analyses to capture the chemical and physical hazards associated with CSMP operations and CSMP-associated preventive maintenance (PM) and corrective maintenance (CM). These procedures are defined in 24590-WTP-PD-RAWS-IH-0001, *Worker Safety and Health Requirement Area – Industrial Hygiene Program Description*. Further, BNI/WTCC has adequately developed qualitative exposure analyses to document potential worker exposures to chemical and physical hazards associated with CSMP operations and CSMP-associated PM and CM. Adequate plans and procedures are in place for confirmative quantitative exposure monitoring and analysis once operations commence. Industrial Hygiene personnel are required to provide ongoing personnel exposure monitoring to ensure that safety controls are effective as directed by 24590-WTP-GPP-RAWS-IH-0001, *Industrial Hygiene Exposure Assessment and Control*.

3.2.2 Worker Exposure Controls

BNI/WTCC has adequately identified controls for potential worker exposures for 10 CFR 851 regulated hazards that are associated with CSMP-bounded chemical operations. Procedure 24590-WTP-GPP-RAWS-IH-0001 provides adequate direction for the establishment of exposure controls for 10 CFR 851 hazards associated with CSMP-bounded operations. These controls are documented on form 24590-RAWS-F00066, *Exposure Control Plan*, specific to each activity. Additionally, the exposure control plan adequately identifies training and medical program requirements for workers involved in the performance of CSMP activities. These requirements are communicated to the BNI/WTCC training department for inclusion in individual worker training plans and to the occupational medicine support contractor. The established medical program appropriately requires workers to have a respiratory medical clearance and participate in silica medical surveillance and the hearing conservation program.

3.2.3 Flowdown of Safety Requirements to Subcontractor

BNI/WTCC has adequately flowed down CSMP worker safety and health requirements to the subcontracted supplier of ammonia to the site. Subcontractor operating procedures are appropriately reviewed and approved by BNI/WTCC personnel. Based on reviewed training plans, subcontractor personnel are trained appropriately on the exposure controls for ammonia hazards associated with the ammonia filling operations. Ammonia supplier delivery personnel are incorporated into the BNI/WTCC respiratory protection program, appropriate aspects of the medical surveillance program, and training.

3.2.4 Industrial Hygiene Procedure Change Control

BNI/WTCC has established an adequate change control process for Industrial Hygiene procedures. Proposed Industrial Hygiene document changes are appropriately submitted to Systems Engineering in accordance with 24590-WTP-MGDR-RAWS-SS-0002, *Applicability of Chemical Safety Management Program (CSMP) Management of Change (MOC) Process to Technical Processes*. An initial review determines whether the change is subject to a technical authority review through the MOC process. If an MOC review is not required, Industrial Hygiene management appropriately ensures that the change is compliant with 10 CFR 851 requirements and processes the document for publication.

Integration of Worker Safety and Health Requirements Conclusions

Overall, BNI/WTCC's programs, plans, and procedures adequately implement 10 CFR 851 requirements for chemical and applicable physical hazards associated with CSMP-bounded chemical operations.

BNI/WTCC has adequately identified 10 CFR 851 hazards and controls. Also, BNI/WTCC has adequately flowed down CSMP worker safety and health requirements to the subcontracted supplier of ammonia to the site. Finally, BNI/WTCC has established an adequate change control process for Industrial Hygiene procedures.

3.3 Process Safety Management

This portion of the assessment evaluated BNI/WTTC's programs, plans, and procedures to implement PSM requirements applicable to the planned use of anhydrous ammonia at WTP that demonstrate meeting the requirements of 29 CFR 1910.111, *Storage and handling of anhydrous ammonia*, 29 CFR 1910.119, *Process safety management of highly hazardous chemicals*, and the DSA to provide adequate protection to the public, workers, and the environment from chemical release/exposure hazards.

3.3.1 Employee Participation

BNI/WTCC has developed an adequate written plan of action to ensure the consultation and participation of workers on the hazards, processes, and procedures related to the use of anhydrous ammonia. 24590-WTP-PL-RAWS-SS-0003, *Process Safety Management Program Employee Participation Plan of Action*, addresses worker involvement in PHA, the development of work procedures, and training. However, the plan of action does not identify how BNI/WTCC will engage employee representatives (i.e., the bargaining unit) for consultation and participation on PSM elements in accordance with 29 CFR 1910.119. (See **OFI-BNI/WTCC-2**.)

3.3.2 Process Safety Information

BNI/WTCC has compiled generally adequate written process safety information to enable personnel involved in operating the process to identify and understand the hazards posed by anhydrous ammonia. Documentation on the fabrication and installation of the storage vessels is compiled in 24590-WTP-SRR-PROC-0032998, *Certificate of Compliance – American Fabrication, Inc*. In addition, BNI/WTCC documented conformance with the American National Standards Institute (ANSI) K61.1:1999, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*, and 29 CFR 1910.111 requirements as a completed action item under 24590-WTP-GCA-MGT-21-00910, *Pre-Startup Safety Review for Anhydrous Ammonia - F-ENG-01, Confirmation of K61.1 1999 (and 29 CFR 1910.111) requirements still needed*.

Despite generally adequate process safety information, contrary to 29 CFR 1910.119(d)(2)(i)(D), BNI/WTCC has not documented an operational safe lower limit for outside ambient temperature. (See **Deficiency D-BNI/WTCC-5**.) The lack of an operational safe lower limit for outside ambient temperature could impact the safe use of anhydrous ammonia gas at the LAW facility. Anhydrous ammonia gas is transported through piping from storage vessels. Approximately 1,200 feet of the piping is buried; this piping exits the ground at the outside wall of the LAW facility, runs vertically to the roof, and enters the dilution skid inside the facility. At a design delivery pressure of 21 pounds per square inch gauge (psig), condensation of the ammonia would begin to occur at 7 degrees Fahrenheit (°F). Over the past 20 years, annual low temperatures in the Richland, WA, area have been below 7 °F during 15 of those years, and below 0 °F during 9 of those years. With a liquid to gas expansion ratio of approximately 850, introduction of a small volume of condensed ammonia into the dilution skid, or a gas surge if subsequently re-vaporized within the piping, could raise the ammonia concentration above the lower explosive limit (LEL). CCN296656, *Process Hazard Analysis Principles Baseline – Rules of the Road* (Rules of the Road), states that "For events involving ammonia releases and potential ammonia explosions … [i]gnition in the SCO/SCR is Anticipated." Similarly, 24590-LAW-PL-NS-16-0002, *Safety Strategy Summary Document – Ammonia*, notes that "There are many events that could potentially lead to

a confinement breach and a subsequent release of ammonia. Some of the possible causes include: high ammonia flow to the selective catalytic reduction (SCR) unit, resulting in the deflagration of ammonia/air mixtures in the offgas system." The potential for introducing liquid anhydrous ammonia into the dilution skid under cold outside ambient conditions, or surge in flow if the liquid anhydrous ammonia subsequently volatilizes, is an unanalyzed scenario.

3.3.3 Process Hazards Analysis

BNI/WTCC has performed and documented a PHA on processes involving anhydrous ammonia that is appropriate to the complexity of the processes and generally adequate to identify, evaluate, and control the hazards. The BOF PHA (24590-WTP-RPT-ESH-20-001, *Process Hazards Analysis for Balance of Facilities Ammonia Reagent System*) covers activities and infrastructure from receipt of ammonia stock to piping of ammonia gas up to the boundary valve at the LAW facility, with the remainder of ammonia-related processes covered under the LAW PHA (24590-LAW-ES-NS-17-004, *Process Hazards Analysis in Support of the LAW DSA*). The PHA teams used appropriate methodologies to determine and evaluate the hazards of the covered process(es) and adequately addressed most process hazards, applicable controls and consequences of failure, early detection methodologies, siting, and human factors. However, contrary to 29 CFR 1910.119(e)(3)(i), two scenarios involving the potential for developing explosive conditions within the process were not fully evaluated, and several other scenarios did not account for the entire MAR quantities in documenting the potential public impact consequences. (See **Deficiency D-BNI/WTCC-6**.) Specifically:

- The LAW PHA did not evaluate potential chemical interactions between mercury and ammonia. 24590-WTP-LIST-RAMA-SS-0003, *Process Safety Management 29 CFR 1910.119(d) Process Safety Information for Anhydrous Ammonia System*, identifies the potential for ammonia to react with mercury to form fulminate-like compounds, which are explosive. Scenarios that could bring ammonia into contact with varying amounts of mercury include:
  - Residual mercury in the melter off-gas stream that was not captured by the carbon adsorber during normal operations
  - Mercury that was released from the carbon adsorber during a mitigated carbon bed fire
  - Melter off-gas bypassing the carbon beds due to activation of an interlock (e.g., off-gas high efficiency particulate air [HEPA] preheater high temperature interlock).
- The LAW PHA did not evaluate the consequences of the possible introduction of hydrocarbon into the dilution skid resulting in an explosive mixture in the process stream. The BOF PHA evaluated the potential for receipt of the wrong chemical from a tanker delivery in *Scenario AMR-3-CS016* and the subsequent potential for loss of confinement. Based on the types of chemicals delivered to WTP and the configuration of the transport tankers and connection equipment, the site determined that incorrect delivery would be limited to chlorine, propane, or butane; only chlorine presented a chemical incompatibility/reactivity concern in the storage vessels, making that incorrect delivery self-evident. The LAW PHA further evaluated the potential for propane or butane in the downstream ammonia feed under two scenarios; however, neither scenario evaluates the potential for producing an air/gas mixture above the LEL within the dilution skid and directing that mixture to the SCR unit. The Rules of the Road states that "[f]or events involving ammonia releases and potential ammonia explosions … [i]gnition in the SCO/SCR is Anticipated." Although the dilution skid as designed produces an ammonia/air mixture of 6% to stay below the ammonia LEL of 16%, the potential introduction of propane (LEL=2.6%) or butane (LEL=1.6%) into the mixture represents an unanalyzed deflagration risk.

- The consequences for some scenarios outlined in the BOF PHA are not adequately documented. For example, the following PHA scenarios involving catastrophic events have a larger MAR quantity than is addressed in the potential public impact consequences; however, no justification is included for basing the potential public impact consequences on a lesser quantity:
  - *Scenario AMR-1-CS001 – Fire*. The MAR is identified as 13,000 gallons; however, the public consequences are based on 6,000 gallons.
  - *Scenario AMR-1-CS002 – Fire*. The MAR is identified as 8,000 gallons; however, the public consequences are based on 6,000 gallons.
  - *Scenario AMR-1-CS003 – Fire*. The MAR is identified as 12,000 gallons; however, the public consequences are based on 6,000 gallons.
  - *Scenario AMR-2-CS001 – Explosion*. The MAR is identified as 17,000 gallons; however, the public consequences are based on 6,000 gallons.

Observed signage on the anhydrous ammonia storage vessels met requirements but was less obvious than the fill points for other chemicals/fuels that are received into tanks on site. Vessel labels are visible on approach to, but not at, the delivery connection point. Also, helical markings on hoses have limited contrast with the background, which may not draw the attention of individuals with some types of color perception deficiencies. Other identifiers are either partially obscured by fencing or positioned in a manner that makes them difficult to notice. In addition, the BOF PHA recommends that anhydrous ammonia be delivered after the end of normal work hours, when the site population is significantly reduced; the readability of existing signage for deliveries after sunset may be further reduced. (See **OFI-BNI/WTCC-3**.)

3.3.4 Training

BNI/WTCC has developed adequate training related to the safe use of anhydrous ammonia. Course 24590-LAW-G-0007-LP-001, *DFLAW DSA/TSR/CSMP/HAR for Shift Operations Managers and System Engineers*, provides training on the physical and administrative controls for the process, change management, defense in depth, facility operations, safety and health hazards, and overview of emergency operations including shutdown. In addition, course 24590-WTP-CBT-RAEP-EP-008, *Ammonia Safety*, provides training to site employees and subcontractor personnel on the hazards of anhydrous ammonia and emergency response actions to take in the event of a release. The training content for both courses is sufficiently comprehensive for the respective roles of the intended audiences.

3.3.5 Pre-Startup Safety Review

BNI/WTCC has effectively performed a variety of safety reviews and assessments to ensure that the anhydrous ammonia storage facility has been constructed in accordance with design standards and specifications, and that adequate procedural documents are in place. As noted in section 3.3.2 of this report, BNI/WTCC documented conformance of the constructed storage vessels with ANSI K61.1:1999 and 29 CFR 1910.111 as part of a pre-startup safety review that was completed in advance of receiving anhydrous ammonia. In addition, five reviewed self-assessments conducted over the past year were comprehensive. Five recommendations from one of those assessments were selected for review of follow-up actions, and all had the appropriate actions assigned or completed.

3.3.6 Mechanical Integrity

BNI/WTCC has generally adequately designed, properly located, constructed, installed, and established procedures for the safe operation of anhydrous ammonia systems. However, contrary to the mechanical

integrity requirements of 29 CFR 1910.119(j)(1)(i) and 29 CFR 1910.119(j)(1)(iii), after the vessels and related equipment were installed, a self-identified issue related to increasing water content in the storage vessels was not fully analyzed for potential internal corrosion implications. (See **Finding F-BNI/WTCC-2**.) Not fully analyzing the potential for internal corrosion could result in unanticipated equipment failure, including the storage vessels as well as safety-related devices that may be impacted due to dislodged corrosion products.

BNI/WTCC completed a post-construction evaluation of corrosion potential in the storage vessels as documented in 24590-BOF-N1D-AMR-00001, *CORROSION EVALUATION: Anhydrous Ammonia Storage Vessels*, which was updated in 2015. This evaluation stated that "water could eventually build up in the tanks due to the evaporation of very pure ammonia [but this] is not a concern from a corrosion point of view since the minimal increase in ammonium hydroxide (NH4OH) will not have a significant effect on corrosion rates" (emphasis added). The evaluation also states that "[d]efinitive corrosion data is difficult to find for carbon steel and stainless steels in ammonia solutions."

Further, in 2021, BNI/WTCC identified a question related to anhydrous ammonia procurement quality in 24590-WTP-RPT-ESH-21-002, *Pre-Startup Safety Review in Support of Receipt of Anhydrous Ammonia*. A follow-up action, documented in 24590-WTP-GRN-MGT-21-00837, *Procurement quality review for water or oil content*, reviewed the ammonia procurement specification to determine whether the minimum amount of water allowed in the anhydrous ammonia and the concentration of oil or other contaminants allowed are identified. As part of this effort, BNI/WTCC evaluated the potential for increasing water content in the vessels over multiple fill cycles as anhydrous ammonia gas is removed to support the DFLAW process. Because water accumulation will depress the ammonia vapor pressure, increasing accumulation would affect the ability to maintain minimum necessary pressure in the vessels. The action was closed on November 28, 2021, with a final determination that up to 46% water could accumulate without compromising sufficient anhydrous ammonia gas for DFLAW. However, the potential impact of the high-water content in the liquid phase on potential vessel corrosion was not re-evaluated.

In addition, a second pathway for water-induced corrosion in the head space of the vessels has not been self-identified or evaluated. When the ambient temperature is too low to maintain adequate gas pressure in the storage vessels, liquid is piped from the vessels through one or two 50-kilowatt vaporizers and returned to the vessels as a gas. Unlike the ambient temperature-driven volatilization of ammonia, the vaporizers will return a gas stream with a higher level of water vapor. Once returned to the vessels, water will condense on the head space walls at a disproportionally higher rate than ammonia due to differing vapor pressures, likely exceeding the water concentration in the source liquid drawn from the vessels. This condensate may further accelerate corrosion of the vessels in the head space. In addition, dislodged corrosion products may impact safety-related devices, such as interfering with the proper seating of excess flow control valves, if activated.

3.3.7 Management of Change

BNI/WTCC has established its MOC procedure to manage changes to process chemicals, technology, equipment, and procedures and changes to facilities that affect processes involving anhydrous ammonia. The procedure is "applied when it has been identified that a change request impacts process chemical safety (including items covered under process safety management), requires a change to a CSMP [safety function] or CSMP [functional requirement], removed chemical [defense in depth], or is a new process chemical hazard." If applied, the procedure would generally ensure that the technical basis of proposed changes, the safety impacts, implementation timeframes, and authorization requirements of the proposed changes have been considered. However, contrary to 29 CFR 1910.119(l)(2)(ii), BNI/WTCC did not consider all potential safety consequences of increasing water content in the anhydrous ammonia storage vessels. (See **Finding F-BNI/WTCC-2**.) The change in composition of the vessel contents could affect

the rate of internal corrosion, which could impact the operation of safety devices and structural integrity of the system. For example, the issue of increasing water content in the anhydrous ammonia storage vessels (discussed in section 3.3.6 above) was identified in 2021 but determined by BNI/WTCC to not be in scope of the MOC process due to the ammonia/water mixture being a reduced chemical hazard that did not present a new or increased worker exposure hazard. This limited focus on the direct chemical exposure hazard of the mixture excluded consideration of broader potential safety impacts within the process, such as the consequences of increased internal corrosion of the anhydrous ammonia storage vessels. As a result, the potential impact on system components and safety features of the anhydrous ammonia storage system has not been further evaluated.

3.3.8 Emergency Planning and Response

BNI/WTCC has established an emergency action plan for WTP, including procedures and equipment for detecting and responding to small releases of anhydrous ammonia. The necessary alarms for promptly detecting anhydrous ammonia releases are in place but not yet fully operational. The emergency action plan includes procedures for reporting emergencies and emergency evacuation. Suitable respiratory protection is in a readily accessible location near the anhydrous ammonia storage vessels.

Process Safety Management Conclusions

Overall, BNI/WTCC has developed programs, plans, and procedures to implement PSM requirements applicable to the planned use of anhydrous ammonia at WTP that are generally adequate for protection of the public, the workers, and the environment from chemical release/exposure hazards. However, some hazards and operating conditions have not been fully analyzed, including one that was excluded from additional analysis due to a narrow application of MOC criteria.

3.4 DOE Field Element Oversight

This portion of the assessment evaluated the adequacy of DOE Hanford's oversight of BNI/WTCC's development and implementation of the WTP CSMP, including program and field oversight of CSMP-related activities.

All DOE Hanford oversight is performed using DOE-PRO-PAI-50085, *Integrated Oversight*. Facility Representatives (FRs) in the ORP Operations Oversight Division (OOD) provide oversight of WTP facility operations. FR oversight is performed in accordance with DOE-PPD-PAI-51864, *Facility Representative Program*. Current WTP facility-specific FR qualification plans are written to a version of the DSA prior to the porting of CS controls from the DSA to the CSMP, but interviewed qualified FRs stated that they had received training on the CSMP and that the qualification plans are in the process of being revised to include CSMP-specific criteria. (See **OFI-DOE Hanford-1**.)

Programmatic oversight functions are provided by appropriate organizations in both ORP and RL for projects managed by both offices. WTP CSMP oversight is performed by the RL Safety & Health Division (SHD). The chemical safety program manager position, DOE Hanford's CS subject matter expert (SME) with responsibility for programmatic oversight of the CSMP, was recently moved to SHD from the ORP Nuclear Safety Division (NSD) to align with WTP CS controls being ported from the DSA to the CSMP. SHD leadership stated that a qualification plan is currently being developed for this SME position. The previous chemical safety program manager stated that he was qualified as a Nuclear Safety Specialist per DOE-STD-1183-2004, *Nuclear Safety Specialist Functional Area Qualification Standard*, and was pursuing qualification to DOE-STD-1176-2004, *Chemical Processing Functional Area Qualification Standard*, prior to the position being moved out of NSD. The SHD CS SME position is currently vacant, but the previous CS SME is the FR team lead for OOD's WTP Facility Operations

Team and is providing support to SHD oversight until the chemical safety program manager position is filled and the incumbent is qualified.

Teamwork and collaboration between OOD, SHD, and NSD for CSMP oversight were evident, and strengthen oversight effectiveness. During interviews, leadership from OOD and SHD described collaborative processes for ensuring that oversight of BNI/WTCC's implementation of the CSMP and its MOC process are coordinated among stakeholders in different DOE Hanford divisions. This CSMP oversight is appropriately performed using AMSQ-PRO-SH-51911, *Chemical Safety Management Program Review*, which is currently being revised to reflect the changes in program oversight discussed above.

FR staffing remains significantly below full staffing levels, but substantial progress is being made toward achieving full staffing. EA reviewed the 2022 staffing analysis for OOD, which was appropriately performed in November 2022 in accordance with DOE-STD-1063-2021, *Facility Representatives*. At the time of the analysis, OOD—which provides operational oversight of Tank Farms as well as WTP—was staffed at 50% of the analyzed staffing requirements (8 FRs onboard with 15.82 full-time equivalents needed). At the time of this assessment, OOD was staffed with four of seven FRs required for WTP, with two fully qualified and one with an interim qualification, plus a fully qualified team lead whose position is not counted toward FR staffing in the staffing analysis. Additionally, the WTP Federal FRs are supported by four government service support contract staff to ensure adequate oversight of WTP facility operations. In interviews, OOD leadership described plans in place to bring additional FRs on board. Over approximately the past year, DOE Hanford leadership has instituted multiple FR hiring and retention initiatives. Based on interviews with current OOD staff and leadership and review of several years of historical staffing, these initiatives have been effective both for recruiting and for improving job satisfaction of incumbent FRs and have contributed to a positive trend in FR staffing.

DOE Field Element Oversight Conclusions

DOE Hanford generally provides effective oversight of BNI/WTCC's CSMP development and implementation. Strong teamwork and communication among various groups responsible for oversight throughout DOE Hanford is evident, contributing to effective oversight. Continued attention to staffing and qualification of oversight personnel is warranted, particularly for operations oversight as WTP facilities approach operations.

4.0 BEST PRACTICES

No best practices were identified during this assessment.

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.

BNI/WTCC

Finding F-BNI/WTCC-1: BNI/WTCC altered the DOE-approved applicability criteria in its web-based *Plant Engineering Technical Authority Review* form used to determine whether the MOC process needs to be applied to changes potentially affecting DOE-controlled portions of the CSMP. (24590-WTP-GPP-RAWS-SS-0003 and TSR 5.6.2.m)

Finding F-BNI/WTCC-2: BNI/WTCC did not consider all potential safety consequences of increasing water content in the anhydrous ammonia storage vessels. (29 CFR 1910.119(j)(1)(i), 29 CFR 1910.119(j)(1)(iii), and 29 CFR 1910.119(l)(2)(ii))

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.

BNI/WTCC

Deficiency D-BNI/WTCC-1: Some BNI/WTCC chemical safety control implementing procedures contained errors associated with torque requirements. (10 CFR 830.122(d)(1))

Deficiency D-BNI/WTCC-2: BNI/WTCC did not maintain compensatory measures for a fire impairment. (DOE-STD-1066-2016, sec. 5.1.5)

Deficiency D-BNI/WTCC-3: BNI/WTCC did not ensure that fire door inspections were performed by qualified personnel in accordance with procedures and that the results of the inspections were accurately documented. (10 CFR 830.122(e)(1))

Deficiency D-BNI/WTCC-4: BNI/WTCC did not adequately control operator aids at the ammonia receipt and storage location. (DOE Order 422.1, att. 2, requirement 2.q)

Deficiency D-BNI/WTCC-5: BNI/WTCC has not documented an operational safe lower limit for outside ambient temperature. (29 CFR 1910.119(d)(2)(i)(D))

Deficiency D-BNI/WTCC-6: BNI/WTCC has not documented a hazard analysis of the possible formation of mercury fulminate or consequences of hydrocarbon introduction into the dilution skid, nor fully documented the potential public impacts in various scenarios. (29 CFR 1910.119(e)(3)(i))

7.0 OPPORTUNITIES FOR IMPROVEMENT

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

BNI/WTCC

OFI-BNI/WTCC-1: Consider strengthening access controls to areas where hazards may be present, such as providing status indication for process cell doors and physical access controls (e.g., a lock) for the ammonia dilution skid room.

OFI-BNI/WTCC-2: Consider updating *Process Safety Management Program Employee Participation Plan of Action* to identify how BNI/WTCC will engage employee representatives (i.e., the bargaining unit) for consultation and participation on PSM elements.

OFI-BNI/WTCC-3: Consider signage improvements at the anhydrous ammonia fill location. Options to consider include adding additional signage, either on the fence or directly on the paved surface, that identifies that the location is for delivery of anhydrous ammonia only and is visible to the delivery vendor at the connection point under all anticipated lighting conditions.

DOE Hanford

OFI-DOE Hanford-1: Consider including a CSMP-specific continuing-training requirement or other documentation of CSMP knowledge in qualification records for WTP FRs qualified to versions of qualification standards prior to the inclusion of CSMP-specific knowledge requirements.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: June 12-15, 2023

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