Pressure Safety Assessment at the Pacific Northwest National Laboratory

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Office of Enterprise Assessments
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Acronyms

BMI	Battelle Memorial Institute, Pacific Northwest Division
CAS	Contractor Assurance System
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
HDI	How Do I
MHTLS	Modular Hydrothermal Liquefaction System
OFI	Opportunity for Improvement
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
SME	Subject Matter Expert
SOP	Standard Operating Procedure
WSH	Worker Safety and Health

Pressure Safety Assessment
at the Pacific Northwest National Laboratory
December 2-6, 2019

Summary

Scope

This assessment evaluated the pressure safety program for research work at the Pacific Northwest National Laboratory (PNNL), which is managed by Battelle Memorial Institute, Pacific Northwest Division (BMI). In addition, the oversight provided by the Pacific Northwest Site Office (PNSO) related to pressure safety was assessed. For this report, research work relates to those small-scale bench top pressure systems used for research and larger pilot-scale pressure systems used to research viability of commercial systems; pressure systems used for facility utilities such as gas, water, and steam were not evaluated. This assessment was requested by PNSO after three events that were peripherally related to the pressure safety program between August 2018 and March 2019.

Significant Results for Key Areas of Interest

Overall, BMI has established and implemented a satisfactory pressure safety program for research-related pressure systems as required by 10 CFR 851, *Worker Safety and Health Program*.

Pressure Safety Program
BMI has established a satisfactory technical basis for how to address pressure risks of PNNL research work. The BMI pressure safety program and implementing procedures comprehensively address the equipment and pressure ranges at PNNL. The pressure safety program appropriately establishes requirements for the design, fabrication, testing, inspection, and operation of research-related pressure systems. Pressure safety training is extensive, and personnel qualifications are sufficiently rigorous to ensure that personnel understand how to implement the program.

Pressure Safety Program Implementation
The implementation of the BMI pressure safety program effectively ensures the safe design and operation of pressure systems used in research work. A review of nine pressure systems, including laboratory-scale and pilot-scale systems, found that implementation of the BMI pressure safety program is satisfactory. The system maintenance and test process and documentation of the results for the active pilot-scale pressure system demonstrated that this system was operated through a formal, deliberate process. There was a weakness in the documentation of laboratory-scale test and inspection results.

Pressure Safety Feedback and Improvement
BMI's self-assessments of the pressure safety program and event critiques have resulted in the identification and implementation of effective improvements in the pressure safety program.

Federal Oversight
PNSO provides satisfactory oversight of the BMI pressure safety program as it relates to research work. PNSO includes pressure safety in its risk matrix used to target its oversight resources.

Best Practices and Findings
There were no best practices or findings identified as part of this assessment.

Follow-up Actions

No follow-up actions are planned.

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at the Pacific Northwest National Laboratory

1.0 INTRODUCTION

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 worker safety and health (WSH) pressure safety program at the Pacific Northwest National Laboratory (PNNL), which is managed by Battelle Memorial Institute, Pacific Northwest Division (BMI). This assessment, which was conducted on December 2-6, 2019, evaluated the effectiveness of the implementation of the pressure safety program for pressure systems used in research work. The assessment also evaluated the oversight provided by the DOE Pacific Northwest Site Office (PNSO) related to pressure safety. This assessment was requested by PNSO.

In accordance with the *Plan for the Pressure Safety Assessment at the Pacific Northwest National Laboratory, December 2019*, this assessment included BMI work activities within PNNL facilities located in Richland, Washington. The assessment team observed selected work activities involving pressure systems used for research and larger pilot-scale pressure systems used to research viability of commercial systems. Pressure systems used for facility utilities such as gas, water and steam were not evaluated. Although not identified in the assessment plan, this assessment also observed some elements of work planning and control for activity-level research work activities involving pressure systems.

2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which is implemented 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 DOE Order 227.1A.

As identified in the assessment plan, this assessment considered requirements related to DOE pressure safety. Criteria guiding this assessment are based on objectives and criteria from Criteria and Review Approach Document (CRAD) EA-32-08, Revision 0, *Pressure Safety*. The assessment team also used elements of CRAD 45-21, Revision 1, *Feedback and Continuous Improvement Assessment Criteria and Approach – DOE Field Element*, to collect and analyze data on PNSO oversight activities related to pressure safety.

The assessment team examined key documents, such as DOE's contract with BMI, system descriptions, pressure technical basis documents, pressure safety permits, owners' inspection documents, work packages, hazard analyses, standard operating procedures (SOPs), policies, and training and qualification records. The assessment team also interviewed key personnel responsible for developing and executing the associated programs, and walked down selected research-related pressure systems. Appendix A lists the members of the assessment team, the Quality Review Board, and management responsible for this assessment.

There were no items for follow-up during this assessment.

3.0 RESULTS

The objective of this assessment was to verify that BMI has established and implemented a pressure safety program for research-related pressure systems in accordance with 10 CFR 851, *Worker Safety and Health Program*, section 1(a) and Appendix A.4, *Pressure Safety*, and DOE Contract Number DE-AC05-76RL01830, and that PNSO effectively oversees this program.

Overall, BMI has established and implemented a satisfactory pressure safety program for research-related pressure systems, as required by 10 CFR 851.

3.1 Pressure Safety Program

The objective of this portion of the assessment was to evaluate the BMI pressure safety program to determine whether it satisfactorily implements DOE requirements for pressure safety related to research work.

Technical Basis

To determine how to control pressure hazards based on risk and potential consequences of a pressure system failure, BMI established a technical basis document, *Technical Basis for Pressure Safety*, which satisfactorily establishes risk-based criteria for methods of evaluating and controlling pressure safety hazards in research-related work. BMI's evaluation and rationale adequately support its approach to pressure systems used in research work, particularly for laboratory-scale systems. In addition, the technical basis documents the evaluation of pressure hazards and determines when and how various pieces of equipment can be safely used in research at PNNL.

Program Description and Procedures

The *Pressure Safety Program Description* satisfactorily addresses 10 CFR 851, Appendix A.4 requirements. Based on the potential stored energy of a pressure system, the program establishes two primary types of pressure systems: "Action Required" and "Minimal Action." The action-required pressure systems are designed, assembled, and fabricated by BMI and operate over the technical basis threshold of 1,000 foot-pounds (ft-lbs) of stored energy. These pressure systems are required to have a pressure safety permit approved by the BMI-designated pressure safety subject matter expert (SME). Minimal-action systems must meet the same program requirements; however, formal review and approval of pressure permits by the PNNL pressure safety SME is not required.

The BMI pressure safety program comprehensively addresses the equipment and pressure ranges at PNNL. The program description adequately establishes how both types of pressure systems for research are to be designed, fabricated, tested, inspected, and operated by trained and qualified personnel in accordance with sound engineering principles, and in accordance with DOE, state, local, and national consensus codes, when applicable. BMI implements these program requirements through three "How Do I" (HDI) work control procedures that have specific instructions on establishing pressure system permits and conducting formal SME reviews. These three HDI work control documents, *Pressure and Vacuum Systems*, *Cryogenic Material and Systems*, and *Compressed Gas Supply Systems*, sufficiently cover the types of systems used at PNNL.

PNSO has formally delegated authority to BMI to serve as the "owner" and "owner's inspector" in accordance with American Society of Mechanical Engineers (ASME) B31, *Code for Process Piping*. Both the *Technical Basis for Pressure Safety* and *Pressure Safety Program Description* adequately

establish the roles and responsibilities for the ASME B31 owner and owner's inspector. The owner role is delegated to the PNNL Facilities and Operations Chief Engineer, and the owner's inspector role is delegated to the primary laboratory-wide BMI pressure safety SME. To avoid a conflict of interest, when the primary laboratory-wide BMI pressure safety SME is fulfilling the owner's inspector role on a pressure system, another qualified pressure safety engineer is assigned the role of pressure safety SME and approver of the pressure safety permit for the system. For example, on the Modular Hydrothermal Liquefaction System (MHTLS) where the primary laboratory-wide BMI pressure safety SME serves as the owner's inspector, the backup qualified BMI pressure safety SME supports the MHTLS pilot-scale pressure system as the permitting official. The assessment team reviewed two recent changes to the MHTLS pressure safety permit and found that the backup pressure safety SME appropriately signed the permit as the reviewer/approver.

When research projects with pressure systems take substantial resources to fulfill the ASME B31 owner's inspection role, BMI assigns an individual who is qualified as an owner's inspector or an independent engineering contractor to inspect and report on the pressure system. For example, the assessment team reviewed the final inspection report, *Owner's Inspector's Inspection of the Arctic Raven Pressure Vessel System for the Pacific Northwest National Laboratory at Premier Technologies*, and found that the report adequately documented that the owner's inspector was sufficiently qualified and had documented a satisfactory inspection of the pressure system.

Training and Qualification Requirements

BMI appropriately establishes clear requirements for training and qualification for individuals responsible for pressure system design, fabrication, testing, inspection, maintenance, and operation in the *Pressure Safety Program Description* and HDI work control procedures.

All researchers involved with the design, fabrication, testing, inspection, and operation of research-related pressure systems are required to take training course number 2390, *Pressure Systems Safety Training*. This course is comprehensive and satisfactorily addresses the safety information needed to fulfill assigned functional roles associated with pressure systems.

WSH-ADMIN-04, *WS&H Staff Training and Qualification Plan*, and its Exhibit 9, *Pressure Safety Engineer or Delegate*, provide a robust set of training and qualification requirements for the role of primary laboratory-wide pressure safety SME or delegate. The assessment team reviewed the current qualification cards for the assigned primary and backup pressure safety SMEs. Both individuals are professional engineers, are trained in DOE/PNNL pressure safety requirements, and meet the qualification standards established in WSH-ADMIN-04. Moreover, both SMEs are widely known and respected by the researchers working on the pressure systems walked down by the assessment team (see Section 3.2).

Pressure Safety Program Conclusions

Overall, BMI has established a satisfactory pressure safety program that includes establishment of a technical basis for how BMI implements the pressure safety requirements related to research work and three work control processes for ensuring pressure safety for research work. Training and qualification requirements for pressure system design, fabrication, testing, inspection, and operation are formally documented and robust, and assigned SMEs meet those requirements.

3.2 Pressure Safety Program Implementation

The objective of this portion of the assessment was to verify that BMI has satisfactorily implemented the pressure safety program for research-related pressure systems.

Pressure System Walkdowns

The assessment team walked down nine pressure systems. One system was in "cold lay-up" status (i.e., a system that is maintained but not currently operational), one was still under development, six were active laboratory-scale systems, and one was an active pilot-scale system (i.e., MHTLS).

Each pressure system was constructed with "off the shelf" pressure system components that were code compliant and BMI-technical-basis compliant, such as Parr® reactors and Swagelok® piping, fittings, and pressure relief valves. Pressure system permits for each of the seven active pressure systems were adequate in scope and provided accurate pictures, drawings, and sketches. The BMI pressure safety SME reviewed and approved each permit. Pressure safety hazard analysis and development of hazard controls is adequately integrated into work planning and control processes.

The assessment team interviewed research staff members and pressure safety SMEs. The SMEs exhibited a strong working relationship with the research staff. BMI SMEs are involved in initial pressure system development and implementation of any changes to the pressure systems, thereby ensuring that the systems remain in compliance with applicable codes and the BMI technical basis.

The assessment team reviewed 14 SOPs, maintenance instructions, and 20 completed forms documenting operating pressure relief valve tests (*Relief Valve Test for Research Equipment* form found in HDI work control procedure *Pressure and Vacuum Systems*) for the MHTLS. The maintenance and test documentation for the MHTLS indicates that pressure safety systems are maintained in a formal, deliberate fashion consistent with the SOPs that are in place. The assessment team walked down 30 pressure relief valves and pressure disks indicated on the MHTLS piping and instrumentation diagrams (P&IDs) and found each one installed and the pressure set as identified on the P&IDs.

Documentation, traceability, and accountability for inspection and testing (i.e., recording pressure relief valve tests, pressure system leak/pressure tests, and rupture disk inspections/replacements) of some laboratory-scale pressure systems did not consistently meet the requirements of 10 CFR 851, Appendix A.4. (See **Deficiency D-BMI-1.**) Two laboratory-scale systems for the High-Pressure Electrochemical Cell and Homogeneous Catalysis Reactor) in the Physical Science Laboratory (PSL) had no documentation of required leak tests, rupture disk inspections, or visual inspections. Research personnel in the PSL indicated that documentation may have been performed in laboratory notebooks, but the notebooks could not be located.

One laboratory-scale system in the Applied Process Engineering Laboratory had a locally designed "Pressure System Maintenance Log" used to document rupture disk inspections. One laboratory-scale system in the Bioproducts, Sciences, and Engineering Laboratory had documentation available in laboratory notebooks. Two laboratory-scale systems (one in the Process Development Laboratory East and one in the Environmental Molecular Sciences Laboratory) had formal documentation of tests and inspections on forms (i.e., *Leak/Pressure Test Form* and *Form: Relief Valve Test for Research Equipment*) found in HDI work control procedure *Pressure and Vacuum Systems*. The lack of availability and inconsistency of documentation for inspection and testing requirements make it difficult for BMI and PNSO to verify that required inspection and testing are being done for laboratory-scale pressure systems. (See **OFI-BMI-1.)**

The work planning and control documents for the pressure systems walked down by the assessment team identified the authorized researchers and indicated that all had completed required training course number 2390. Additionally, researchers operating the MHTLS had completed a robust personal training qualification program that specifically described the necessary important safety (including pressure safety) information for the larger, more complex operational and safety controls.

Pressure Safety Program Implementation Conclusions

BMI has satisfactorily implemented its pressure safety program for research-related pressure systems. The reviewed pressure systems were designed, fabricated, tested, operated, and inspected per the BMI pressure safety program. The system maintenance and test process documentation of the results demonstrated that the active pilot-scale pressure system was operated through a formal, deliberate process, but a weakness was identified in the consistency and lack of documentation of laboratory-scale test and inspection results.

3.3 Pressure Safety Program Feedback and Improvement

The objective of this portion of the assessment was to verify that BMI systematically identifies issues and concerns resulting in improvements in the pressure safety program.

The assessment team reviewed recent pressure safety self-assessments, annual analyses (referred to as "heat maps"), and other WSH performance assurance documentation. BMI effectively evaluates pressure safety program performance and identifies areas for improvement. Lessons learned applicable to PNNL were included in pressure safety HDI work control procedures and in training course number 2390.

Self-assessments of the pressure safety program and event critiques have resulted in the identification and implementation of effective improvements in the pressure safety program, including:

- Requiring approval from the fire protection SME to store gas cylinders in fume hoods
- Adding a new exhibit to the Pressure and Vacuum Systems HDI work control procedure to provide specific engineering controls for systems designed to use hazardous gases
- Adding clear direction to the Chemical General HDI work control procedure to address the chemical hazards of a compressed gas in addition to the pressure hazards.

Pressure Safety Program Feedback and Improvement Conclusions

BMI's use of self-assessments and periodic analyses is effective in identifying opportunities to improve pressure safety for research work. Specifically, pressure safety training and work control procedures have been altered to continuously improve performance.

3.4 DOE Site Office Oversight

The objective of this portion of the assessment was to assess PNSO's implementation of oversight processes to oversee and evaluate the BMI pressure safety program. These oversight processes include:

- Using WSH SMEs to oversee the review and approval of the BMI WSH program (required by 10 CFR 851), which includes pressure safety.
- Assigning a PNSO SME to oversee implementation of the BMI pressure safety program and monitor pressure safety performance through the BMI contractor assurance system (CAS).
- Conducting day-to-day operational awareness activities of research operations by three qualified Facility Representatives.

- Using an annual analysis of safety performance of various functional areas, including pressure safety, to determine the level of oversight needed.

The BMI CAS feedback indicated that pressure safety was being satisfactorily implemented based on laboratory performance and the results of two BMI pressure safety self-assessments conducted by a well-qualified pressure safety SME/engineer in fiscal years 2017 and 2019. Although PNSO had confidence in the BMI pressure safety program and its implementation, there were three events that were peripherally related to the pressure safety program between August 2018 and March 2019 (e.g., fire in a Physical Sciences Laboratory fume hood, a light-weight plastic capsule propelled from a disconnected coupling on a pressurized transfer line, and the rupture of a pressurized tube resulting in the spill of 50 ml of hot radiator fluid). These events, along with the PNSO SME's recommendation to conduct an independent assessment of the pressure safety program, prompted the PNSO Operations Division Director to ask EA to conduct this assessment of pressure safety to provide "additional confidence" that the BMI pressure safety program satisfactorily implemented 10 CFR 851, Appendix A.4 requirements for research-related pressure systems.

DOE Site Office Oversight Conclusions

PNSO's oversight processes are effective in overseeing BMI pressure safety for research work. PNSO personnel monitor pressure safety program elements and research operations in order to continuously improve performance.

4.0 BEST PRACTICES

There were no best practices identified as part of this assessment.

5.0 FINDINGS

There were no findings identified as part of this assessment.

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.

Battelle Memorial Institute, Pacific Northwest Division

Deficiency D-BMI-1: BMI has not ensured that documentation, traceability, and accountability for inspection and testing for laboratory-scale systems meet the requirements of 10 CFR 851, Appendix A.4. Two laboratory-scale systems (pressure permits for the High-Pressure Electrochemical Cell and Homogeneous Catalysis Reactor) in the Physical Science Laboratory (PSL) had no documentation of required leak tests, rupture disk inspections, or visual inspections. Research personnel in the PSL indicated that documentation may have been performed in laboratory notebooks, but the notebooks could not be located.

7.0 OPPORTUNITIES FOR IMPROVEMENT

The assessment team identified one OFI 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.

Battelle Memorial Institute, Pacific Northwest Division

OFI-BMI-1: Consider developing, and requiring the use of, a consistent and straightforward institutional process and format for formally documenting and retrieving required tests and inspections of laboratory-scale pressure systems. This process will provide better evidence of compliance with 10 CFR 851, Appendix A.4 and improve oversight by PNNL and PNSO personnel.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: December 2-6, 2019

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