OAK RIDGE
NATIONAL LABORATORY
MANAGED BY UT-BATTELLE
FOR THE DEPARTMENT OF ENERGY

ORNL/TM-2012/599

Pressure Safety Program Implementation at ORNL

January 2013

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UT-BATTELLE
ORNL-27 (4-00)

ORNL/TM-2012/599

Facilities and Operations Directorate

PRESSURE SAFETY PROGRAM IMPLEMENTATION AT ORNL

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January 2013

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managed by
UT-BATTELLE, LLC
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

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ACRONYMS

ACTS	Assessment and Commitment Tracking System
ASME	American Society of Mechanical Engineers
DOE	US Department of Energy
DOM	directorate operations manager
F&O	Facilities and Operations Directorate
FHRD	Fabrication, Hoisting, and Rigging Division
FIA	Federal Inspection Agency (National Board of Boiler and Pressure Vessel Inspectors designation)
NBIC	National Board (of Boiler and Pressure Vessel Inspectors) Inspection Code
NTS	Noncompliance Tracking System
ORNL	Oak Ridge National Laboratory
PRI	pressure retaining item
PRV	pressure release valve
QA	quality assurance
SBMS	Standards Based Management System
SME	subject matter expert
SPRS	Steam Pressure-Reducing Station
WSHPD	Worker Safety and Health Program Description
WSS	Work Smart Standards

EXECUTIVE SUMMARY

The Oak Ridge National Laboratory (ORNL) is a US Department of Energy (DOE) facility that is managed by UT-Battelle, LLC. In February 2006, DOE promulgated worker safety and health regulations to govern contractor activities at DOE sites. These regulations, which are provided in 10 CFR 851, *Worker Safety and Health Program*, establish requirements for worker safety and health program that reduce or prevent occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. The regulations state that contractors must achieve compliance no later than May 25, 2007.

According to 10 CFR 851, Subpart C, *Specific Program Requirements*, contractors must have a structured approach to their worker safety and health programs that at a minimum includes provisions for pressure safety. In implementing the structured approach for pressure safety, contractors must establish safety policies and procedures to ensure that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained, qualified personnel in accordance with applicable sound engineering principles. In addition, contractors must ensure that all pressure vessels, boilers, air receivers, and supporting piping systems conform to (1) applicable American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (2004) Sections I through XII, including applicable code cases; (2) applicable ASME B31 piping codes; and (3) the strictest applicable state and local codes. When national consensus codes are not applicable because of pressure range, vessel geometry, use of special materials, etc., contractors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local codes.

This report documents the work performed to address legacy pressure vessel deficiencies and comply with pressure safety requirements in 10 CFR 851. It also describes actions taken to develop and implement ORNL's Pressure Safety Program.

E.1 LEGACY PRESSURE VESSELS AT ORNL

When UT-Battelle assumed operational responsibility for ORNL on April 1, 2000, only ASME *Boiler and Pressure Vessel Code* Section VIII was included in its prime contract, and the Tennessee state law on pressure vessels did not apply because it exempts pressure vessels under federal control. Consequently, a comprehensive pressure vessel safety program for the hundreds of legacy pressure vessels in use at that time by researchers and support staff did not exist. In December 2003, DOE revised UT-Battelle's prime contract to include the ASME *Boiler and Pressure Vessel Code*, Sections I, II, IV, V, VI, VII, VIII, IX, and X; ASME B31.1, *Power Piping*; ASME B31.5, *Refrigeration Piping*; ASME B31.8, *Gas Transmission and Distribution Piping Systems*; and the National Board (of Boiler and Pressure Vessel Inspectors) Inspection Code (NBIC). Development of the ORNL Pressure Safety Program began in 2004 with the creation of the *Implementation Plan for Legacy Pressure Vessels*. This plan outlined activities for achieving full compliance with applicable portions of the ASME *Boiler and Pressure Vessel Code*.

After DOE promulgated 10 CFR 851, *Worker Safety and Health Program*, in February 2006, UT-Battelle formed a working group within ORNL to guide and assist laboratory management in implementing the rule. The working group comprised a cross section of employees, including safety and health subject matter experts (SMEs), research staff, operations personnel, management, and union representatives. Based on working group considerations of ORNL legacy pressure vessels and potential noncompliance issues, UT-Battelle requested a temporary variance from specific pressure safety requirements in 10 CFR 851 in a letter dated February 26, 2007.

The working group based its review of legacy pressure vessel issues on preliminary results from the 2004 *Implementation Plan for Legacy Pressure Vessels*. To achieve full compliance with applicable portions of the ASME *Boiler and Pressure Vessel Code*, the plan proposed identifying legacy pressure vessels and placing each of them into an inspection program. Due to the large number of pressure vessels requiring inspection and the limited availability of qualified technical resources, the projected completion date for the work scope defined in the implementation plan was fiscal year 2012. Based on this projected completion schedule, the variance request included a commitment by UT-Battelle to achieve full compliance with applicable pressure safety in 10 CFR 851 by September 30, 2012.

E.2 PRESSURE SAFETY PROGRAM AT ORNL

The principle objective of ORNL's Pressure Safety Program is to prevent unwanted releases of toxic chemicals and hazardous energy from pressure systems, especially into locations that could adversely affect the human and natural environments, through compliance with the pressure safety standards in 10 CFR 851, *Worker Safety and Health Program*. This objective is being realized at ORNL through application of the various elements of the Pressure Safety Program. Key elements of the Pressure Safety Program include (1) the inspection plan for legacy pressure vessels, (2) Standards Based Management System (SBMS) Engineering Management subject areas, (3) ASME and National Board of Boiler and Pressure Vessel Inspectors (National Board) Certifications, (4) audits and assessments, and (5) documents and publications.

E.2.1 Inspection Plan For Legacy Pressure Vessels

On May 8, 2008, the Surveillance group within ORNL's Fabrication, Hoisting, and Rigging Division (FHRD) opened Assessment and Commitment Tracking System (ACTS) Assessment Number 11044, Inspection Plan for Legacy Pressure Vessels, to track the identified deficiencies and corrective actions taken to resolve them as a result of internal and ultrasonic inspections of boilers and pressure vessels in accordance with NBIC requirements, as applicable. The objectives of corrective actions performed by Surveillance staff to achieve satisfactory closure of all ACTS 11044 action items involved (1) identifying and inspecting legacy pressure vessels with potential 10 CFR 851 compliance issues, (2) resolving all deficiencies, and (3) ensuring that satisfactory closeout documentation was entered into ACTS by September 30, 2012. Surveillance staff also developed monthly and quarterly status reports to document progress in achieving a goal of resolving and closing at least 25 ACTS 11044 action items per quarter beginning June 1, 2010.

Inspections and mechanical integrity assessments were prioritized and scheduled based on the level of hazard posed by the pressure vessel as determined during the initial assessment. The most common deficiency involved pressure relief devices, such as rupture disks and pressure relief valves, that must be installed on pressure vessels in a manner that provides adequate overpressure protection in the event of an abnormal or emergency event. An overpressure event can result in a catastrophic release of toxic chemicals or hazardous energy that could injure workers, destroy property, and adversely affect the environment.

The final monthly report summarizes the inspection activities and related tasks that were conducted by the Surveillance staff between May 2010 and September 2012 and documents closure of all 216 ACTS 11044 action items. In finalizing closure of ACTS 11044, Quality Assurance and Surveillance staff reviewed closure evidence for each action item and determined that the closure documentation for each action item was satisfactory.

E.2.2 Standards Based Management System Engineering Management Subject Areas

Two separate but related SBMS Engineering Management System subject areas were developed to implement the Pressure Safety Program at ORNL. Brief descriptions of the two subject areas follow.

The Pressure Vessels and Related Components subject area was initially developed and issued in 2004 under Action Item 2 of the Implementation Plan for Legacy Pressure Vessels. It was updated on September 28, 2011, with references to the procedures in the Pressure System Safety subject area. The nine procedures in the Pressure Vessels and Related Components subject area describe processes for designing, acquiring, installing, operating, maintaining, repairing, and decommissioning ASME-certified pressure vessels and components. They also include suggested guidelines for noncertified pressure vessels. To comply with 10 CFR 851 pressure safety requirements, all ASME-certified pressure vessels must comply with requirements in a specific section of the ASME code and be stamped with the ASME code stamp of that section. In addition, all ASME vessels must be registered with the National Board.

The Pressure System Safety subject area identifies requirements and describes methods for conducting activities involving new or existing pressure systems at ORNL. The term "pressure system" means all pressure vessels and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems because of their potential for catastrophic failure due to backfill pressurization. Associated hardware (e.g., gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system. This definition of pressure system, which is all encompassing and provides no exclusions, means that any leak-tight pressure boundary is within the scope of DOE's 10 CFR 851, *Worker Safety and Health Program*. The Pressure System Safety subject area was issued on August 17, 2011, with six procedures for achieving the pressure safety objectives in 10 CFR 851.

E.2.3 ASME and National Board Certifications

Fabrication shops capable of performing construction, maintenance, and repair activities for the ORNL complex are managed by FHRD. These capabilities include authorization from ASME for construction of new pressure vessels and the National Board for repair of pressure retaining items (PRIs).

On February 23, 2010, ASME reauthorized UT-Battelle, LLC, use of the "U" certification mark, which ORNL initially acquired in the 1980s. The terms and conditions of the certificate state that "Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME *Boiler and Pressure Vessel Code*," specifically Section VIII, Division 1. The scope of the certificate covers "Manufacture of pressure vessels at the above location and field sites controlled by the above location." Also on this date, UT-Battelle received a Certificate of Authorization from ASME reauthorizing the use of the "U2" certification mark, which ORNL initially acquired in 2004. The terms and conditions of the certificate state that "Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME *Boiler and Pressure Vessel Code*," specifically Section VIII, Division 2. The scope of the certificate covers "Manufacture of pressure vessels at the above location and field sites controlled by the above location."

On March 11, 2010, the National Board issued a Certificate of Authorization to UT-Battelle, LLC, to apply the "R" symbol stamp for repairs and alterations of PRIs performed in accordance with NBIC provisions. The scope of this reauthorization of a previous certificate is limited to metallic repairs and/or alterations at the above location and extended for field repairs and/or alterations controlled by this location.

On March 30, 2010, the National Board issued a Certificate of Authorization to UT-Battelle, LLC, to apply the "NB" mark to boilers, pressure vessels, or other PRIs that are registered with the National Board in accordance with its provisions. The scope of this reauthorization of a previous certificate is limited to items manufactured in accordance with ASME "U" and "U2" certification marks.

These National Board Certificates of Authorization are an important element of ORNL's Pressure Safety Program because they allow FHRD to register boilers, pressure vessels, or other PRIs with the National Board and perform repairs and alterations to PRIs without involving procurement of subcontractor facilities or manpower.

On November 1, 2011, the National Board issued a Certificate of Accreditation to certify that UT-Battelle, LLC, is accredited as a Federal Inspection Agency (FIA) capable of performing in-service and repair inspection activities in accordance with the requirements of National Board publication NB-390. This Certificate of Accreditation is the first FIA accreditation ever issued by the National Board to a federal government facility.

As the prime management contractor for operation of a DOE site, UT-Battelle, LLC, is responsible for compliance with 10 CFR 851 at ORNL. The accreditation of UT-Battelle, LLC, as an FIA demonstrates that the ORNL in-service inspection program effectively meets the objective standards of the National Board for carrying out inspections of installed and operating pressure equipment.

E.2.4 Audits and Assessments

The effectiveness of the Pressure Safety Program in complying with pressure safety requirements in 10 CFR 851 was assessed in 2010 and 2012 by two different teams.

The Audit and Oversight Directorate's Independent Oversight Services organization performed an assessment of the UT-Battelle, LLC, corrective actions outlined in a variance request submitted to DOE in March 2007. Phase II of the assessment occurred on March 15–19, 2010, and addressed legacy pressure vessels. The assessment was limited to reviewing the progress UT-Battelle had made on the corrective actions outlined in the variance request that was designed to bring UT-Battelle managed facilities into compliance with 10 CFR 851. Assessment results noted two potential vulnerabilities in complying with 10 CFR 851 requirements by September 30, 2012. These vulnerabilities were successfully addressed and monitored by Surveillance staff through implementation of the Inspection Plan for Legacy Pressure Vessels using ACTS 11044.

On June 12–14, 2012, ORNL hosted Community of Practices for Pressure Safety meetings. During the meetings, SMEs from Pacific Northwest National Laboratory, Lawrence Livermore National Laboratory, and Idaho National Laboratory reviewed ORNL's Pressure Safety Program and evaluated overall compliance with pressure safety requirements in 10 CFR 851. Review activities focused on overview presentations, discussions with FHRD staff, tours of ORNL fabrication shops and facilities with active pressure systems, and evaluation of the SBMS Pressure System Safety and Pressure Vessels and Related Components subject areas. After the review, the SMEs determined that FHRD personnel and capabilities were exceptional and that ORNL has sufficient policies and procedures in place to comply with the pressure safety requirements in 10 CFR 851.

E.2.5 Documents and Publications

The following technical reports, FHRD documents, pressure system integrity descriptions, and status reports were developed and used to successfully implement the Pressure Safety Program at ORNL. They

also serve as the technical foundation for ensuring continued compliance with the pressure safety requirements in 10 CFR 851.

Two technical reports, *Steam Pressure-Reducing Station Safety and Energy Efficiency Improvement Project*, ORNL/TM-2010/284, October 2010, and *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*, January 2012, were prepared to document safety enhancements and cost savings resulting from implementation of the Pressure Safety Program.

The procedure *Inspection and Testing of Pressure Retaining Items*, FHRD-T-SSI 1006, Rev. 2, September 20, 2011, was revised by FHRD to provide guidance and requirements for conducting in-service inspection and testing of PRIs. The procedure *Inspection and Testing of Pressure Relieving Devices*, FHRD-T-SSI 2002, Rev. 2, October 20, 2011, was revised by FHRD to establish a uniform method for inspecting and testing pressure relieving devices.

On November 18, 2011, UT-Battelle, LLC, issued the *Controlled Manufacturing Manual* for shop and field fabrication of pressure vessels in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, and Section VIII, Division 2, and PRIs in accordance with NBIC and jurisdictional (DOE) requirements. The *Controlled Manufacturing Manual* is integral to ASME Certificates of Authorization and provides rules for repair of PRIs.

On November 18, 2011, FHRD issued the *Inservice Inspection Quality Control Program Manual.* This manual includes quality requirements for the performance of in-service inspections of ORNL PRIs in accordance with NBIC and National Board document NB-390 under the FIA Certificate of Accreditation. The in-service inspection program described by this manual applies to PRIs, including boilers and pressure vessels constructed and certified as compliant with Sections I, IV, VIII, Division 1 and VIII, Division 2 of the ASME *Boiler and Pressure Vessel Code* or the ASME B31 piping codes, and noncode PRIs installed and operating at ORNL. The manual also defines the organizational structure, functional responsibilities, levels of authority, lines of communication, and duties for carrying out the In-Service Inspection Program.

Surveillance staff maintains an ORNL website for assisting pressure system owners in complying with the pressure safety requirements in 10 CFR 851. The website includes a series of documents that describe the pressure system integrity programs managed by Surveillance and the capabilities and expertise within the Surveillance group. The website also includes hazard assessments prepared by Surveillance staff in accordance with SBMS Pressure System Safety subject area requirements for the pressure systems owned by FHRD. These hazard assessments satisfy the hazard identification and assessment and hazard prevention and abatement requirements in 10 CFR 851.

In May 2010, a study revealed that the remaining open action items in ACTS 11044 were a vulnerability to UT-Battelle's ability to meet its variance commitments. The study also revealed a second vulnerability involving implementation of guidance in SBMS for complying with the pressure safety requirements in 10 CFR 851. To achieve closure of all ACTS 11044 action items by September 30, 2012, Surveillance staff established a goal of resolving at least 25 ACTS 11044 action items per quarter and submitting monthly and quarterly status reports to document progress toward addressing the two vulnerabilities and achieving this goal. These reports provide a record of the activities taken to successfully close all 216 ACTS 11044 action items by September 30, 2012.

1. INTRODUCTION

The Oak Ridge National Laboratory (ORNL) is a US Department of Energy (DOE) facility managed by UT-Battelle, LLC (UT-Battelle), under contract DE-AC05-00OR22725. In February 2006, DOE promulgated worker safety and health regulations to govern contractor activities at DOE sites. The final rule, 10 CFR 851, *Worker Safety and Health Program* (Ref. 1), codified the department's Worker Protection Program requirements, established in DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, including requirements for worker safety and health programs that reduce or prevent occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. The regulation also stated that contractors must achieve compliance through their approved worker safety and health programs no later than May 25, 2007.

1.1 SPECIFIC PROGRAM REQUIREMENTS UNDER 10 CFR 851

According to 10 CFR 851, Subpart C, *Specific Program Requirements*, contractors must have a structured approach to their worker safety and health programs that at a minimum includes provisions for pressure safety. In implementing the structured approach for pressure safety, contractors must establish safety policies and procedures to ensure that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable sound engineering principles. In addition, contractors must ensure that all pressure vessels, boilers, air receivers, and supporting piping systems conform to (1) applicable parts of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (2004), Sections I through XII, including applicable code cases; (2) applicable ASME B31 piping codes; and (3) the strictest applicable state and local codes. When national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials, etc.), contractors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local codes.

1.2 TEMPORARY VARIANCE REQUEST

After DOE promulgated 10 CFR 851, *Worker Safety and Health Program* in February 2006, UT-Battelle formed a working group within ORNL to guide and assist laboratory management in implementing the rule. The working group comprised a cross section of employees, including safety and health subject matter experts (SMEs), research staff, operations personnel, management, and union representatives. Based on working group consideration of ORNL legacy pressure vessels and potential noncompliance issues, UT-Battelle requested a temporary variance from specific pressure safety requirements in 10 CFR 851 in a letter dated February 26, 2007 (Ref. 2).

The variance request was submitted to DOE consistent with the variance process prescribed in 10 CFR 851, Subpart D. Details of the variance request concerning legacy pressure vessel compliance are described in Enclosure 4 to the letter dated February 26, 2007. The technical basis for the variance request, which concerns specific program requirements in 10 CFR 851, Subpart C, and pressure safety requirements in Appendix A, Part 4, follows.

> *The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code does not have an "equivalency" process as established and recognized in many of the National Fire Protection Association (NFPA) standards. Unlike the NFPA, the ASME Boiler and Pressure Vessel Code does not provide the implementation flexibility that permits the use of alternative methods where alternative methods provide equivalent*

protection. Therefore, UT-Battelle, LLC (UT-Battelle) is seeking a temporary variance from the following section of 10 C.F.R. § 851:

10 CFR 851.27(b)(7)—ASME Boiler and Pressure Vessel Code (2004)

10 CFR 851 Appendix A (4)(b)(1)—ASME Boiler and Pressure Vessel Code (2004)

Before submission of the variance request, an announcement was published in *ORNL Today*, UT-Battelle's web-based electronic newsletter, regarding the temporary variance request. A letter was also sent to all ORNL division directors informing them that UT-Battelle would be seeking a temporary variance to the rule for pressure vessels. The division directors were requested to share this information with their employees. In addition, a letter was sent to the bargaining unit safety and health representatives notifying them that UT-Battelle would be seeking a temporary variance from the rule for pressure vessels. An announcement of the temporary variance request was posted on bulletin boards and break rooms throughout the laboratory.

1.3 WORKING GROUP CONSIDERATIONS

The working group based its review of legacy pressure vessel issues on preliminary results in the *Implementation Plan for Legacy Pressure Vessels*. The primary goal of this plan was to identify legacy pressure vessels and place each of them into an inspection program. The plan covered boilers and pressure vessels located within the ORNL complex that (1) fell within the scope of the ASME *Boiler and Pressure Vessel Code* and (2) were installed, repaired, altered, or reactivated before May 20, 2004. The plan included five milestones and nine actions for achieving full compliance with applicable portions of the ASME *Boiler and Pressure Vessel Code* prescribed in 10 CFR 851. These milestones and actions were tracked in the ORNL Assessment and Commitment Tracking System (ACTS) as Assessment Number 7479. Development of the *Implementation Plan for Legacy Pressure Vessels* included participation by all line organizations at ORNL.

Because of the large number of pressure vessels requiring inspection and the limited availability of qualified technical resources, the projected completion date for the work scope defined in the *Implementation Plan for Legacy Pressure Vessels* was fiscal year 2012. Therefore, the variance request included a commitment by UT-Battelle to achieve full compliance with applicable pressure safety requirements in 10 CFR 851 by September 30, 2012.

1.4 SCOPE AND OBJECTIVES

Worker health and safety requirements that govern the conduct of contractor activities at DOE sites are provided in 10 CFR 851, *Worker Safety and Health Program*, which establishes requirements for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. The principle objective of ORNL's Pressure Safety Program is to prevent unwanted releases of toxic chemicals and hazardous energy from pressure systems, especially into locations that could adversely affect the human and natural environments, through compliance with the pressure safety standards in 10 CFR 851, *Worker Safety and Health Program*.

This objective is being realized at ORNL through application of the various elements of the Pressure Safety Program that were developed and implemented at ORNL. Key elements of the Pressure Safety Program involve the following areas that are the focus of discussions in this report.

- Implementation Plan for Legacy Pressure Vessels
- Inspection Plan for Legacy Pressure Vessels
- Standards Based Management System (SBMS) Engineering Management System subject areas
  - Pressure System Safety
  - Pressure Vessels and Related Components
- Certifications
  - ASME
    - U symbol
    - U2 symbol
  - National Board of Boiler and Pressure Vessel Inspectors (National Board)
    - Federal Inspection Agency (FIA)
    - NB mark
    - R mark
- Audits and assessments
- Documents and publications
  - Technical reports
    - Steam-Pressure-Reducing Station (SPRS) Safety and Energy Efficiency Improvement Project
    - Liquid Nitrogen Storage and Distribution Continuous Improvement Project
  - Fabrication, Hoisting, and Rigging Division (FHRD) inspection and testing procedures
  - Controlled Manufacturing Manual [for ASME "U" and "U2" construction and National Board Inspection Code (NBIC) "R" repairs]
  - Inservice Inspection Quality Control Program Manual (for FIA certification)
  - Pressure system integrity program descriptions
  - Monthly and quarterly status reports

Actions taken to achieve compliance with pressure safety requirements in 10 CFR 851 were reported and monitored in ACTS using the following assessment numbers.

Assessment Number 7479—*Implementation Plan for Legacy Pressure Vessels*
Assessment Number 9575—Noncompliance Tracking System (NTS) *Report – Legacy Vessels Subject to the Boiler and Pressure Vessel Code*
Assessment Number 11044—*Inspection Plan for Legacy Pressure Vessels*

This report only describes activities related to development of the Pressure Safety Program performed between April 1, 2000, when UT-Battelle began managing ORNL, and September 30, 2012, when ORNL achieved compliance with the pressure safety requirements in 10 CFR 851. Table 1 presents a timeline with key activities for this period.

Table 1. Key Activity Timeline

Date	Activity
April 1, 2000	UT-Battelle initiates contract management at Oak Ridge National Laboratory (ORNL) under Contract DE-AC05-00OR22725
January, 2001	UT-Battelle is reauthorized by the American Society of Mechanical Engineers (ASME) to use the "U" certification mark and the National Board of Boiler and Pressure Vessel Inspectors (National Board) to use the "R" symbol stamp and the "NB" mark for another 3-year period
2002	Internal assessment identifies need for improved pressure vessel program
2003	ORNL DOE Site Office and UT-Battelle form Work Smart Standards team to identify hazards created by pressure vessels and to address pressure safety
2003	The ASME *Boiler and Pressure Vessel Code*, Sections I, II, IV, V, VI, VII, VIII, IX, and X; ASME B31.1, *Power Piping*; ASME B31.5, *Refrigeration Piping*; ASME B31.8, *Gas Transmission and Distribution Piping Systems*; and the National Board Inspection Code (NBIC) are added to UT-Battelle's prime contract
2003	The Standards Based Management System (SBMS) program office initiates the Engineering Management System
January, 2004	UT-Battelle is reauthorized by ASME to use the "U" certification mark and the National Board to use the "R symbol stamp and the "NB" mark for another 3-year period. UT-Battelle also obtains authorization for the "U2" certification mark for a 3-year period
2004	ORNL develops *Implementation Plan for Legacy Pressure Vessels*
2004	The SBMS program office publishes the Pressure Vessel subject area
February 21, 2005	ORNL opens Assessment and Commitment Tracking System (ACTS) Assessment Number 7479 *Implementation Plan for Legacy Pressure Vessels*
February 9, 2006	DOE issues 10 CFR 851, *Worker Safety and Health Program*
January, 2007	UT-Battelle is reauthorized by ASME to use the "U" and "U2" certification marks and the National Board to use the "R" symbol stamp and the "NB" mark for another 3-year period
January 23, 2007	ORNL opens Assessment and Commitment Tracking System (ACTS) Assessment Number 9575 *NTS Report—Legacy Vessels Subject to the Boiler and Pressure Vessel Code*
February 9, 2007	DOE establishes compliance date for 10 CFR 851, *Worker Safety and Health Program*
February 26, 2007	UT-Battelle submits ORNL variance request for 10 CFR. 851, *Worker Safety and Health Program* to DOE
May 25, 2007	DOE establishes date for compliance by all DOE contractors with 10 CFR 851, *Worker Safety and Health Program*
May 8, 2008	ORNL opens ACTS Assessment Number 11044, *Inspection Plan for Legacy Pressure Vessels*, to track the identified deficiencies and corrective actions taken to resolve them as a result of internal and ultrasonic inspections of boilers and pressure vessels in accordance with National Board Inspection Code requirements as applicable
December 18, 2009	UT-Battelle submits first draft of the *Inservice Inspection Quality Control Program Manual* to the National Board to become accredited as a Federal Inspection Agency (FIA)
February 9, 2010	UT-Battelle is reauthorized by ASME to use the "U" and "U2" certification marks and the National Board to use the "R" symbol stamp and the "NB" mark for another 3-year period
March 15–19, 2010	UT-Battelle conducts Independent Oversight Services Phase II assessment for legacy pressure vessels

Table 1. (continued)

Date	Activity
May 2010	UT-Battelle issues *Independent Oversight Services Assessment of Laboratory Corrective Actions for the 10 C.F.R. 851 Rule Variance Request for Phase I—Fire Barrier/Chemical Management and Phase II—Legacy Pressure Vessels*, Project Number IO-2010-8
June 1, 2010	Surveillance staff begins reporting the status of legacy pressure vessel inspection activities to the director of the Facilities and Operations Directorate
June 30, 2010	SBMS program office publishes the Pressure Vessel and Related Components subject area that included revision and expansion of the Pressure Vessel subject area procedures initially issued in 2004 and updated in 2007
June 30, 2010	Surveillance staff issues first monthly report for Assessment Number 11044
August 31, 2010	Surveillance staff issues first quarterly report for Assessment Number 11044
October 30, 2010	*Steam Pressure-Reducing Station Safety and Energy Efficiency Improvement Project*, ORNL/TM-2010/284, published
November 2, 2010	National Board grants UT-Battelle a Provisional Certificate of Accreditation as an FIA
December 9, 2010	ORNL chief engineer receives authorization from the ORNL Engineering Council and the directorate operations managers to develop the SBMS subject area for Pressure System Safety based on flowcharts developed by the SBMS Pressure System Safety Development Team
August 12, 2011	Link to Pressure System Integrity Program for Power and Process Piping description document added to the Fabrication, Hoisting, and Rigging Division (FHRD) Surveillance website
August 17, 2011	SBMS program office publishes the Pressure System Safety subject area
August 18, 2011	FHRD begins developing hazard analyses for pressure systems at ORNL
August 31, 2011	Link to Pressure System Integrity Program for Pressure Vessels description document added to the FHRD Surveillance website
August 31, 2011	Link to Pressure System Integrity Program for Hazard Analysis and Hazard Mitigation description document added to the FHRD Surveillance website
September 6, 2011	Link to Pressure System Integrity Program for Overpressure Protection description document added to the FHRD Surveillance website
September 6, 2011	Link to Pressure System Integrity Program for Power and Heating Boilers description document added to the FHRD Surveillance website
September 20, 2011	FHRD publishes procedure titled *Inspection and Testing of Pressure Relieving Devices*, FHRD-T-SSI 2002 Rev 2
September 28, 2011	SBMS program office publishes changes to the Pressure Vessel and Related Components subject area including reference to the Pressure System Safety subject area
October 16, 2011	Date set for all ORNL divisions to either comply with SBMS Pressure System Safety procedures or have an approved implementation plan in place
October 20, 2011	FHRD publishes procedure titled *Inspection and Testing of Pressure Retaining Items*, FHRD-T-SSI 1006 Rev 2
November 1, 2011	National Board grants UT-Battelle a Certificate of Accreditation as an FIA
November 18, 2011	FHRD issues FIA *Inservice Inspection Quality Control Program Manual*, Ed. 2 Rev. 2
November 18, 2011	FHRD issues *Controlled Manufacturing Manual*, Ed. 13, Rev. 1
December 16, 2011	FHRD issues *Worker Safety and Health Program (10 CFR 851) Compliance Assessment for Pressure System Safety*

Table 1. (continued)

Date	Activity
January 2012	ORNL lean team issues a report titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*
January 27, 2012	Surveillance staff presents a briefing to the Facilities and Operations director on the closure status of ACTS 11044 action items
June 12–14, 2012	ORNL hosts Community of Practice for Pressure Safety at ORNL
June 27, 2012	The ORNL Site Office approves a major change to the ORNL Worker Safety and Health Program Description (WSHPD) dated May 2012 stating ORNL will follow the current versions of the ASME *Boiler and Pressure Vessel Code* and the B31 piping codes. DOE issues a letter stating the ORNL WSHPD was evaluated for compliance with the referenced requirements and found acceptable
September 21, 2012	The deficient liquid nitrogen storage tank on the west side of Building 4500S is removed from service and the last ACTS 11044 action item is closed satisfactorily
September 28, 2012	Surveillance issues the report titled *Assessment and Commitment Tracking System Final Monthly Report for Assessment Number: 11044*
November 27, 2012	UT-Battelle is reauthorized by ASME to use the “U” and “U2” certification marks and the National Board to use the “R” symbol stamp and the “NB” mark for another 3-year period

2. LEGACY PRESSURE VESSELS AT ORNL

The variance request addressed more than 1,300 legacy pressure vessels used at ORNL for research and support services. Many of these pressure vessels were placed in service before DOE promulgated 10 CFR 851, *Worker Safety and Health Program*, in February 2006. Those fabricated before 2004 do not comply with 10 CFR 851 pressure safety requirements because they do not conform to construction rules in the 2004 edition of the ASME *Boiler and Pressure Vessel Code*.

When UT-Battelle assumed operational responsibility for ORNL on April 1, 2000, only ASME *Boiler and Pressure Vessel Code* Section VIII was included in its prime contract with DOE, and the portion of DOE O 440.1A on pressure safety was not included in the ORNL prime contract at that time. Tennessee state law on pressure vessels also does not apply because it exempts pressure vessels under federal control (Tenn. Code Ann. § 68-122-101 et seq.) In addition, a comprehensive pressure vessel safety program did not exist at ORNL. For these reasons, UT-Battelle recognized the need for a comprehensive pressure vessel inspection and integrity assessment program, identified this deficiency, and began the process to create a pressure vessel safety program.

The ORNL DOE Site Office and UT-Battelle formed a Work Smart Standards (WSS) team in 2003 to identify hazards created by pressure vessels and standards to address pressure safety. In December 2003, the ASME *Boiler and Pressure Vessel Code*, Sections I, II, IV, V, VI, VII, VIII, IX, and X; ASME B31.1, *Power Piping*; ASME B31.5, *Refrigeration Piping*; ASME B31.8, *Gas Transmission and Distribution Piping Systems*; and NBIC were added to UT-Battelle's prime contract through DEAR 970.5204-2 *Laws, Regulations, and DOE Directives* (Dec. 2000) (Deviation).

The ORNL Site Office reviewed the updated ORNL Worker Safety and Health Program Description (WSHPD) dated May 2012 and issued a letter to UT-Battelle (Ref. 3) stating that DOE evaluated the ORNL WSHPD for compliance with applicable requirements and determined it to be acceptable. The letter included the following statement.

> *10 CFR 851.27(a)(7) and (8) incorporates specific Pressure Piping, Boilers, and Pressure Vessel Code references from 2004, which have been updated since 851 was issued. Since new pressure vessels cannot be purchased or fabricated to the older obsolete codes, this WSHPD revision ensures your adherence to the current versions of these incorporated Pressure Piping, Boilers, and Pressure Vessel Code references.*

2.1 IMPLEMENTATION PLAN FOR LEGACY PRESSURE VESSELS

Development of the ORNL Pressure Safety Program began in 2004 with the creation of the *Implementation Plan for Legacy Pressure Vessels*. This plan, which was used as the basis for UT-Battelle's variance request, included five milestones and nine action items for achieving full compliance with applicable portions of the ASME *Boiler and Pressure Vessel Code*. These milestones and actions were monitored under ACTS Assessment Number 7479. A description of each milestone and action follows.

Milestone 1 Staff should identify all vessels currently on site. This milestone (Action Item 7479.1) was closed on November 10, 2005 when each division completed pressure vessel identification. Applies to boilers and pressure vessels operated within ORNL that have been installed, repaired, altered, or reactivated before May 20, 2004 that fall within the scope of the ASME Boiler and Pressure Vessel Code.

Milestone 2 Of the division directors owning pressure vessels, the owner/user of the pressure vessels shall supply vessel design and operating information to the subject matter expert (SME) of the Pressure Vessels and Related Components subject area. This milestone (Action Item 7479.2) was closed on May 10, 2006 when all pressure vessel owners supplied design and operating information.

Milestone 3 Form Vessel Review Committee to determine hazard classification/priority of vessels. This milestone (Action Item 7479.3) was closed on May 10, 2006 when a vessel review committee was commissioned to determine hazard classification and priority of pressure vessels. The charter states that "A risk assessment will be performed of ORNL's legacy pressure vessels to ensure that safe equipment and work practices and effective management systems are being used. The assessment will include prioritizing inspections performed in accordance with the Department of Energy (DOE) requirements contained in the UT-Battelle Work Smart Standards (WSS), the *Pressure Vessel Implementation Plan* as outlined in the *Pressure Vessels and Related Components Subject Area*, as well as implementation of best practices."

Milestone 4 Inspections for determining fit for service of existing identified vessels should be scheduled in order to identify upcoming outages and program requirements. This milestone (Action Item 7479.4) was closed on September 30, 2012, when all legacy pressure vessel inspections were completed. The records related to the scheduled inspections are contained in the "Pressure Vessel Inventory" maintained in the FH&R Division SharePoint site.

Milestone 5 Pressure vessel inspections should be performed, as scheduled, to determine fit for service and remaining life. This milestone (Action Item 7479.5) was closed on September 30, 2012, when all legacy pressure vessel inspections were completed. Table 2 shows the timeline for pressure vessel inspection activities.

Table 2. Pressure Vessel Inspection Timeline

Activity	Target Completion Date	Completion Status
Risk rank pressure vessels	June 2007	Stored energy was calculated and used as the basis for risk ranking more than 1,000 legacy pressure vessels at ORNL within the scope of 10 CFR 851
Categorize risk ranking of pressure vessels	June 2007	Risk ranking of pressure vessels was completed in June 2007 with about 50% categorized as "High" risk
Inspect external surfaces of 50% of highest risk pressure vessels	September 2008	External inspections for more than 50% of the "High" risk pressure vessels were completed by September 30, 2008
Inspect external surfaces and measure wall thicknesses of 90% of highest risk pressure vessels	September 2009	External inspections and wall thickness measurements for more than 90% of the "High" risk pressure vessels were completed by September 30, 2009. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service
Inspect external surfaces and measure wall thicknesses of 50% of limited risk pressure vessels	September 2010	External inspections for all of the "High" and "Limited" risk pressure vessels were completed by September 30, 2010. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service

Table 2 (continued)

Activity	Target Completion Date	Completion Status
Inspect internal surfaces of 25% of highest risk pressure vessels	September 2010	Internal inspections were completed for more than 25% of the "High" risk pressure vessels with unacceptable wall thinning by September 30, 2010. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service
Inspect internal surfaces of 90% of highest risk pressure vessels	September 2011	Internal inspections were completed for 93% of the "High" risk pressure vessels with unacceptable wall thinning by August 31, 2011. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service
Complete inspection of 100% of pressure vessels	September 2012	All required inspections of pressure vessels at ORNL were completed

Action 1 Identify appropriate pressure vessels standards to be included in UT-Battelle's prime contract with DOE and serve as the foundation for the Pressure Vessel Safety Program. This action was established prior to the issuance of 10 CFR 851 which identified the ASME B&PV Code as the principal standard for pressure safety. Other applicable codes from 10 CFR 851 are:(1) The applicable American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (2004); sections I through section XII including applicable Code Cases (incorporated by reference, see § 851.27) (2) The applicable ASME B31 (Code for pressure piping) standards as indicated below; and or as indicated in paragraph (b)(3) of this section: (i) B31.1—2001—*Power Piping*, and B31.1a—2002—*Addenda to ASME B31.1*— 2001 (incorporated by reference, see § 851.27); (ii) B31.2—1968—*Fuel Gas Piping* (incorporated by reference, see § 851.27); (iii) B31.3—2002—*Process Piping* (incorporated by reference, see § 851.27); (iv) B31.4—2002—*Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids* (incorporated by reference, see § 851.27); (v) B31.5—2001—*Refrigeration Piping and Heat Transfer Components*, and B31.5a— 2004, *Addenda to ASME B31.5*—2001 (incorporated by reference, see § 851.27); (vi) B31.8—2003—*Gas Transmission and Distribution Piping Systems* (incorporated by reference, see § 851.27); (vii) B31.8S—2001—*Managing System Integrity of Gas Pipelines* (incorporated by reference, see § 851.27); (viii) B31.9—1996—*Building Services Piping* (incorporated by reference, see § 851.27); (ix) B31.11—2002—*Slurry Transportation Piping Systems* (incorporated by reference, see § 851.27); and (x) B31G—1991—*Manual for Determining Remaining Strength of Corroded Pipelines* (incorporated by reference, see § 851.27). Additional codes and standards adopted by UT-Battelle were: National Board Inspection Code (NBIC).This action (Action Item 7479.6.1) was closed on June 30, 2010 when applicable standards were identified.

Action 2 Developed Laboratory procedures on pressure vessels that addresses the following areas:

- Designing a pressure vessel
- Acquiring a pressure a vessel
- Installing a pressure vessel
- Operating and maintaining a pressure vessel
- Inspecting a pressure vessel
- Taking a pressure vessel out of service or reactivating a pressure vessel

- Repairing a pressure vessel
- Maintaining a legacy pressure vessel

This action (Action Item 7479.6.2) was closed on June 30, 2010 when the SBMS program office published the Pressure Vessel and Related Components Subject Area that included nine procedures that cover these topics.

Action 3 Established a Pressure Vessel Review Committee. This action (Action Item 7479.6.3) was closed on June 30, 2010 when the committee established a process to evaluate the conditions of existing pressure vessels and determine inspection priorities. The following elements were considered by the committee in determining whether a pressure vessel can continue in operation: potential stored energy of each vessel; type of service; and barriers, administrative controls, current status, operational procedures, and management practices. By prioritizing pressure vessel inspection and evaluation activities, ORNL reduced cumulative risk over a four-year period as the timeline in Fig. 1 shows.

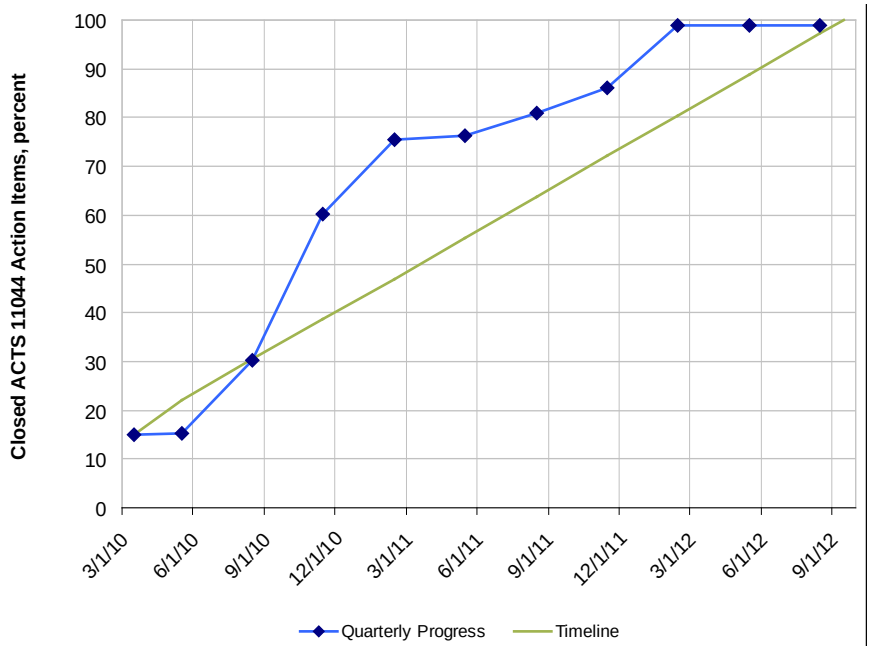


Fig. 1. Closure status of legacy pressure vessel action items in ACTS 11044 for quarter ending August 31, 2012.

Action 4 Established procedure for the inspection and testing of pressure retaining items. This action (Action Item 7479.6.4) was closed on June 30, 2010 with the development of a procedure that establishes requirements for conducting in-service inspection and testing of pressure-retaining items.

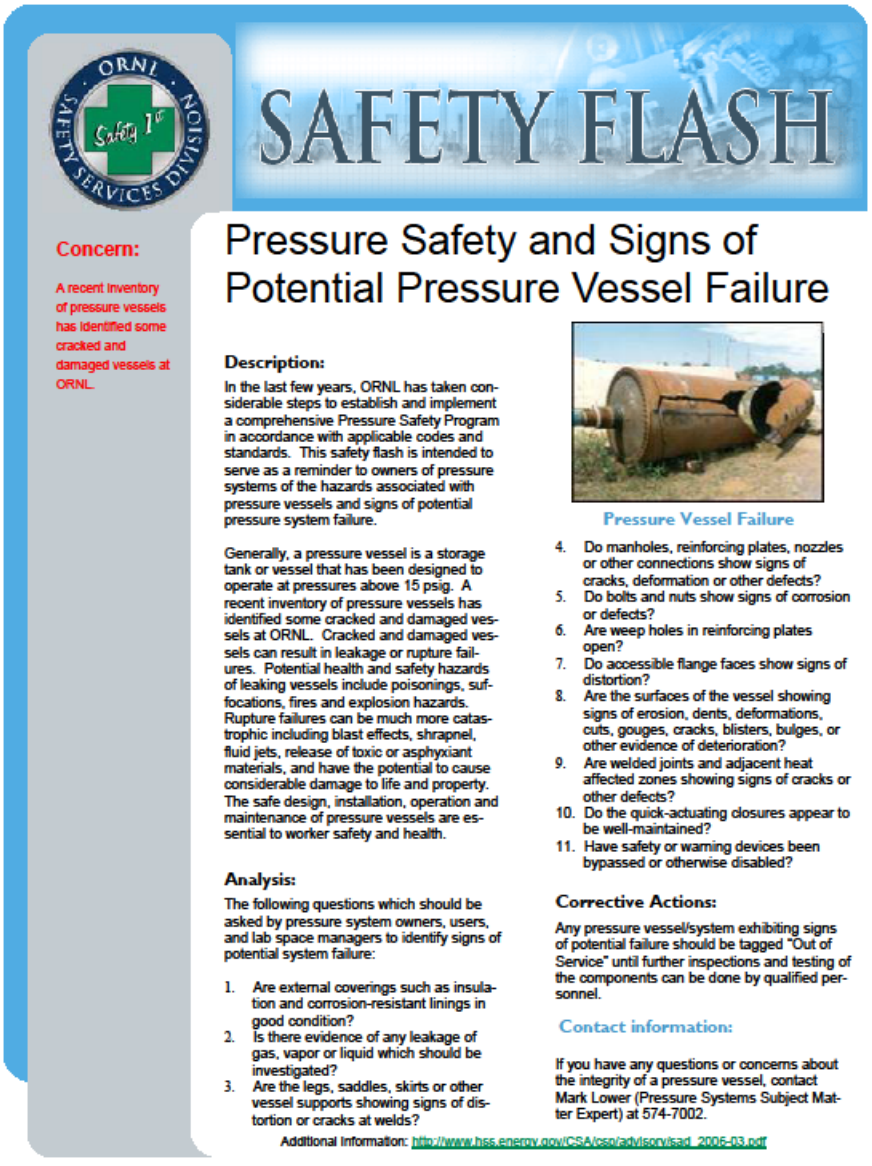
Action 5 Conducted a comprehensive Laboratory-wide survey to identify all pressure vessels in service at ORNL. This action (Action Item 7479.6.5) was closed on June 30, 2010 when the survey was completed.

Action 6 Collect pressure vessel design information from vessel owners. This action (Action Item 7479.6.6) was closed on June 30, 2010 when all pressure vessel design information was collected.

Action 7 Procure equipment and training necessary for conducting pressure vessel inspections. This action (Action Item 7479.6.7) was closed on July 23, 2010 when training was completed and equipment was purchased.

Action 8 Develop and maintain inspection schedule for in-service pressure vessels. This action (Action Item 7479.6.8) was closed on June 30, 2010 with the development of an inspection schedule. This information is tracked by Surveillance staff in the Fabrication, Hoisting and Rigging Division through the ORNL Pressure Vessels and Pressure Safety Members SharePoint site.

Action 9 Distribute *Safety Flash* to Laboratory population on pressure vessel safety and signs of potential vessel failure. This action (Action Item 7479.6.9) was closed on June 30, 2010 when the *Safety Flash* shown in Fig. 2 was distributed.



SAFETY FLASH

Concern:

A recent inventory of pressure vessels has identified some cracked and damaged vessels at ORNL.

Pressure Safety and Signs of Potential Pressure Vessel Failure

Description:

In the last few years, ORNL has taken considerable steps to establish and implement a comprehensive Pressure Safety Program in accordance with applicable codes and standards. This safety flash is intended to serve as a reminder to owners of pressure systems of the hazards associated with pressure vessels and signs of potential pressure system failure.

Generally, a pressure vessel is a storage tank or vessel that has been designed to operate at pressures above 15 psig. A recent inventory of pressure vessels has identified some cracked and damaged vessels at ORNL. Cracked and damaged vessels can result in leakage or rupture failures. Potential health and safety hazards of leaking vessels include poisonings, suffocations, fires and explosion hazards. Rupture failures can be much more catastrophic including blast effects, shrapnel, fluid jets, release of toxic or asphyxiant materials, and have the potential to cause considerable damage to life and property. The safe design, installation, operation and maintenance of pressure vessels are essential to worker safety and health.

Analysis:

The following questions which should be asked by pressure system owners, users, and lab space managers to identify signs of potential system failure:

1. Are external coverings such as insulation and corrosion-resistant linings in good condition?
2. Is there evidence of any leakage of gas, vapor or liquid which should be investigated?
3. Are the legs, saddles, skirts or other vessel supports showing signs of distortion or cracks at welds?

Pressure Vessel Failure

4. Do manholes, reinforcing plates, nozzles or other connections show signs of cracks, deformation or other defects?
5. Do bolts and nuts show signs of corrosion or defects?
6. Are weep holes in reinforcing plates open?
7. Do accessible flange faces show signs of distortion?
8. Are the surfaces of the vessel showing signs of erosion, dents, deformations, cuts, gouges, cracks, blisters, bulges, or other evidence of deterioration?
9. Are welded joints and adjacent heat affected zones showing signs of cracks or other defects?
10. Do the quick-actuating closures appear to be well-maintained?
11. Have safety or warning devices been bypassed or otherwise disabled?

Corrective Actions:

Any pressure vessel/system exhibiting signs of potential failure should be tagged "Out of Service" until further inspections and testing of the components can be done by qualified personnel.

Contact information:

If you have any questions or concerns about the integrity of a pressure vessel, contact Mark Lower (Pressure Systems Subject Matter Expert) at 574-7002.

Additional Information: http://www.hss.energy.gov/CSA/csp/advisory/sad_2005-03.pdf

Fig. 2. *Safety Flash* for pressure safety.

2.2 INSPECTION PLAN FOR LEGACY PRESSURE VESSELS

On May 8, 2008, the Surveillance group within FHRD opened ACTS Assessment Number 11044, *Inspection Plan for Legacy Pressure Vessels*, to track the identified deficiencies and corrective actions taken to resolve them as a result of internal and ultrasonic inspections of boilers and pressure vessels in accordance with NBIC requirements as applicable. The objectives of corrective actions performed by the Surveillance staff to achieve satisfactory closure of all ACTS 11044 Action Items were to (1) identify and inspect legacy pressure vessels with potential 10 CFR 851 compliance issues, (2) resolve all deficiencies, and (3) ensure that satisfactory closeout documentation was entered into ACTS by September 30, 2012. To achieve this objective, Surveillance committed to a goal of resolving and closing at least 25 ACTS 11044 action items per quarter beginning June 1, 2010.

On May 15, 2010, ACTS 11044 included 193 action items (Ref. 4). Of this total, 29 were action items that had been closed satisfactorily, 57 were action items that had been accepted by the owners, and 107 were action items that had not yet been accepted by the owners. On September 28, 2012, ACTS 11044 included 216 action items. The total number of ACTS 11044 action items increased from 193 to 216 because additional legacy pressure vessel deficiencies were identified by the Surveillance staff as they focused on addressing the following issues.

- Assisting owners in developing action plans for resolving deficiencies reported in ACTS 11044.
- Compiling pressure vessel nameplate information, manufacturers' data reports, and other types of historical documentation if available.
- Compiling pressure relief device specifications, inspection records, and historical repair and replacement data.
- Continuing initial inspections of legacy pressure vessels to meet variance request milestones and entering deficiencies into ACTS 11044 as appropriate.
- Reviewing inspection reports to identify legacy pressure vessels with deficiencies that needed to be entered into ACTS 11044.
- Implementing a process for identifying and notifying owners of deficient pressure vessels, working with the owners to resolve the deficiencies, and entering deficiencies not resolved within 90 days into ACTS 11044.
- Verifying closure documentation for accuracy and completeness, modifying the existing text to provide sufficient and satisfactory closure evidence, and submitting the closure evidence to Quality Assurance (QA) personnel for review and validation.

The 216 legacy pressure vessels tracked under ACTS Action Number 11044 were categorized based on the following deficiencies.

- Exterior corrosion; awaiting disposition
- Inaccessible
- Insulated; wall thickness cannot be determined
- Isolation valve before pressure relief device
- No pressure relief device could be located within system

- Incorrect rupture disk setting
- Verification of remaining life calculation needed

The 216 legacy pressure vessels with identified deficiencies were distributed among the ORNL directorates as indicated in Table 3.

Table 3. Distribution of ORNL Legacy Pressure Vessels with Identified Deficiencies

Directorate	Legacy Pressure Vessels with Deficiencies
Facilities and Operations	104
Physical Sciences	45
Energy and Engineering Sciences	2
Nuclear Operations	22
Neutron Sciences	43
Total	**216**

Inspections and mechanical integrity assessments were prioritized and scheduled based on the level of hazard posed by the pressure vessels as determined during the initial assessments. The most common deficiency involved pressure relief devices such as rupture disks and pressure relief valves (PRVs) that must be installed on pressure vessels in a manner that provides adequate overpressure protection in the event of an abnormal or emergency event. An overpressure event can result in a catastrophic release of toxic chemicals or hazardous energy that could injure workers, destroy property, and adversely affect the environment.

The final monthly and quarterly reports that document the inspection activities and related tasks that were conducted by the Surveillance staff between May 2010 and September 2012 are discussed in Sect. 6.5. Progress realized in closing the 216 action items in ACTS 11044 is shown graphically in Fig. 3.

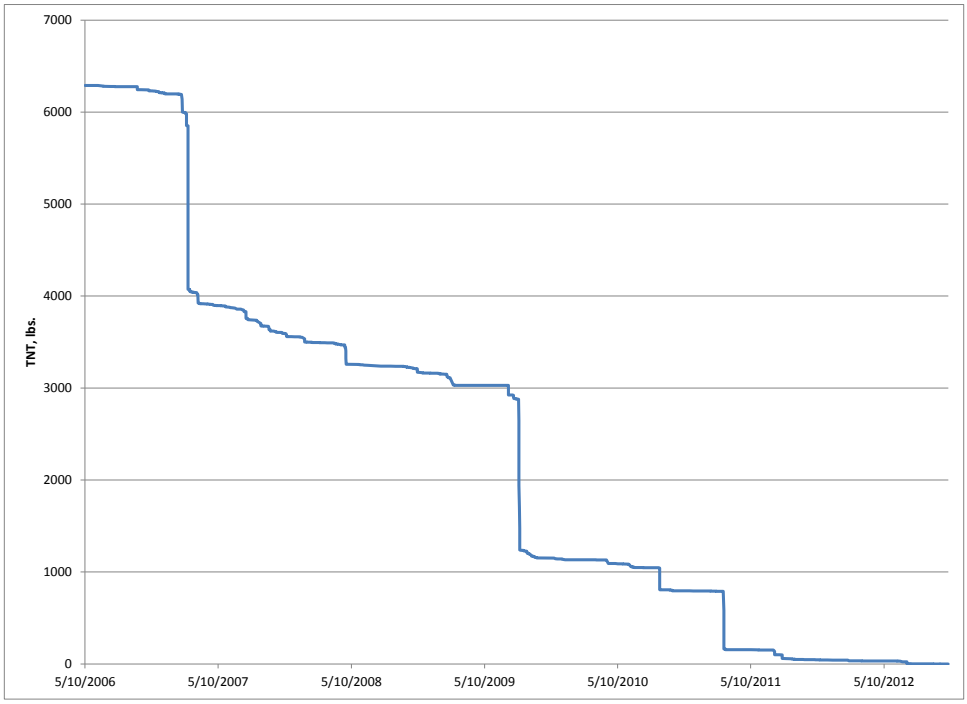


Fig. 3. Timeline for reducing cumulative pressure vessel risk.

Based on review of closure documentation for selected ACTS 11044 action items, a QA representative began identifying weaknesses in closure documentation on December 12, 2010. Soon after, a QA representative began conducting the following activities.

- Reviewing each ACTS 11044 action item to ensure that the closure documentation reflected "tangible and objective evidence" as justification for closure.
- Performing a role as "super-delegate," which permits editing ACTS 11044 records if necessary.
- Working with the ACTS coordinator to reopen closed action items that required revision to include additional closure evidence.
- Meeting with pressure vessel inspectors and Surveillance staff to discuss closure issues and identify proper closure evidence.
- Participating in field reviews with pressure vessel inspectors and Surveillance staff to obtain photographic records that could be used to supplement other closure evidence.
- Reviewing issues and closure evidences in "ORNL Pressure Vessel and Pressure Safety" files for ACTS 11044 action items.
- Reviewing closed action items with Surveillance staff to determine whether any action items needed to be reopened so additional corrective actions could be performed and used as further justification for closure.
- Meeting with owners to obtain additional closure evidence.
- Reviewing engineering evaluations on closed action items with Surveillance staff for accuracy and completeness.

In finalizing closure of ACTS 11044, QA and Surveillance staff reviewed closure evidence for each action item and determined that the closure documentation for each action item was satisfactory.

In a related activity, Surveillance staff completed development of the Access formatted Inspection Database in July 2011. The Inspection Database includes up-to-date information compiled for all of the identified PRIs at ORNL. This database was an enhancement to an earlier Excel database that was reformatted using more appropriate software in anticipation of the National Board review for the FIA designation.

2.3 NTS REPORT—LEGACY VESSELS SUBJECT TO THE BOILER AND PRESSURE VESSEL CODE

The Facilities and Operations Directorate (F&O) opened ACTS Assessment Number 9575, *NTS Report—Legacy Vessels Subject to the Boiler and Pressure Vessel Code,* on January 23, 2007, to track the NTS report separately from the implementation plan for legacy pressure vessels in ACTS 7479. Individual action items entered into ACTS 9575 corresponded to the two vulnerabilities (Action Items 9575.2.1 and 9575.2.2) and six recommendations (Action Items 9575.2.3 to 9575.2.8) identified in the report titled *Independent Oversight Services Assessment of Laboratory Corrective Actions for the 10 C.F.R. 851 Rule Variance Request for Phase I—Fire Barrier/Chemical Management—and Phase II—Legacy Pressure Vessels*—Project Number IO-2010-8, May 2010 (Ref. 4), discussed in Sect. 5.1. The other action item (Action Item 9575.1.1) tracked disposition of the variance request.

Action Items 9575.2.1 to 9575.2.8 were closed by September 28, 2012, when the final monthly status report was issued documenting that all ACTS 11044 action items were closed satisfactorily. This status report is discussed in Sect. 6.5.1.

3. STANDARDS BASED MANAGEMENT SYSTEM SUBJECT AREAS

Two separate but related SBMS Engineering Management System subject areas were developed to implement the Pressure Safety Program at ORNL. Summaries of the Pressure Vessels and Related Components subject area and the Pressure System Safety subject area follow.

3.1 PRESSURE VESSELS AND RELATED COMPONENTS

The Pressure Vessels and Related Components subject area was initially developed and issued in 2004 under Action 2 of the *Implementation Plan for Legacy Pressure Vessels*. It was later updated on September 28, 2011, with references to the procedures in the Pressure System Safety subject area.

The nine procedures in the Pressure Vessels and Related Components subject area describe processes for designing, acquiring, installing, operating, maintaining, repairing, and decommissioning ASME-certified pressure vessels and components. They also include suggested guidelines for noncertified pressure vessels. To comply with 10 CFR 851 pressure safety requirements, all ASME-certified pressure vessels must comply with requirements in a specific section of the ASME code and be stamped with the ASME code stamp of that section. In addition, all ASME vessels must be registered with the National Board.

Procedure: Designing a Pressure Vessel—applies to staff members who are designing ASME-certified pressure vessels but does not apply to procured designs of pressure vessels. This five-step procedure is intended to ensure that pressure vessels are designed to meet applicable design criteria and code requirements.

Procedure: Acquiring an Off-Site-Manufactured Pressure Vessel—applies to staff acquiring ASME-certified pressure vessels and components from an off-site vendor or manufacturer but does not apply to regular catalogue items (other than pressure vessels) used for their intended purposes. This four-step procedure is intended to ensure compliance with design documentation and applicable QA requirements.

Procedure: Acquiring an On-Site-Fabricated Pressure Vessel—applies to ASME-certified pressure vessels and components fabricated by the ORNL Fabrication Division. This three-step procedure is intended to ensure compliance with design documentation and applicable QA requirements.

Procedure: Installing a Pressure Vessel—applies to staff installing or reinstalling an ASME-certified pressure vessel but does not apply to regular catalogue items (other than pressure vessels) used for their intended purpose. This six-step procedure is intended to ensure that the pressure vessel is installed and inspected in compliance with design documentation and applicable QA and code requirements.

Procedure: Inspecting a Pressure Vessel—applies to staff responsible for ASME-certified pressure vessels (owners). This two-step procedure is intended to ensure that ASME-certified vessels and attached PRVs undergo scheduled inspections. The testing and inspection of some vessels, such as those used with hazardous, toxic, or expensive contents, are special cases. The SME or inspector should be contacted for information and assistance. Another special case is a PRV that cannot be manually tested such as a PRV without a lever.

Procedure: Taking a Pressure Vessel out of Service—applies to staff responsible for taking pressure vessels out of service. This three-step procedure is intended to ensure that pressure vessels are taken out of service in a way that protects human health, the environment, and the equipment. Owners taking a vessel out of service should consider following the manufacturer's instructions for taking vessels out of service, suspending scheduled inspections and maintenance, protecting the vessel from damage, labeling

equipment with the owner's name and organization, and maintaining documentation and records (e.g., operating and maintenance history and manufacturer's instructions).

Procedure: Reactivating a Pressure Vessel—applies to staff responsible for reactivating an out of service ASME-certified pressure vessel. This three-step procedure is intended to ensure that pressure vessels that have been taken out of service are reactivated appropriately.

Procedure: Repairing or Altering a Pressure Vessel—applies to staff responsible for repairs or alterations of ASME-certified pressure vessels in service. This five-step procedure is intended to ensure that repairs and alterations to pressure vessels comply with design and repair documentation and meet applicable QA requirements. ASME-certified pressure vessels must be repaired or altered by an ASME-certified "R" symbol stamp holder. All repairs, other than those defined as routine by NBIC, and alterations must be registered with the National Board.

Procedure: Maintaining Legacy Pressure Vessel—applies to staff operating, inspecting, repairing, or reactivating a legacy pressure vessel. Legacy vessels include existing pressure vessels (in use before May 20, 2004) that fall within the scope of the ASME *Boiler and Pressure Vessel Code*. This two-step procedure is intended to ensure that repairs and alterations to legacy pressure vessels comply with design and repair documentation and meet applicable QA requirements.

The Pressure Vessels and Related Components subject area also includes deployment tools that provide guidance related to the following topics.

- Exhibit: Type of Pressure Vessel
- Exhibit: Pressure Vessel Inspection Frequency Table for Inspection Intervals and Inspection of Pressure Relief Valves
- Form: Pressure Test Report
- Form: Pressure Test Documentation

3.2 PRESSURE SYSTEM SAFETY

The Pressure System Safety subject area identifies requirements and describes methods for conducting activities involving new or existing pressure systems at ORNL. The term "pressure system" means all pressure vessels, piping components, and pressure sources including cryogenic, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems because of their potential for catastrophic failure as a result of backfill pressurization. Associated hardware (e.g., gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system. This definition of pressure system, which is all encompassing and provides no exclusions, means that any leak-tight pressure boundary is within the scope of 10 CFR 851, *Worker Safety and Health Program*.

Effective pressure system safety management involves a systematic approach to evaluating the pressure system as a whole rather than ensuring that only individual PRIs are designed, constructed, and operated safely. The primary function of a pressure system is to safely confine solid, liquid, or gaseous material or maintain a vacuum within a leak-tight pressure boundary consisting of interconnected pressure equipment such as pressure vessels, tanks, pipes, valves, fittings, and pressure relief devices. The objective of pressure system safety is to identify, evaluate, and mitigate consequences of unwanted releases that could occur as a result of failures in processes, procedures, or equipment. Pressure systems should be designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable sound engineering principles.

The Pressure System Safety subject area was issued on August 17, 2011. It includes six procedures for achieving the pressure safety objectives in 10 CFR 851. Appendix A presents the Pressure System Safety Program Description, which discusses the safety basis and approach used to develop these procedures.

Procedure: Identify Pressure System—applies to ORNL staff that work with new or existing pressure systems. This includes pressure systems owned or operated by DOE or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off-site. This four-step procedure is intended to ensure that pressure systems are identified by a team of SMEs and workers that are knowledgeable in the applicable technologies, hazards, and safety issues.

Procedure: Gather System Information—applies to ORNL staff that need to gather pressure system safety information for new and existing pressure systems. This includes pressure systems owned or operated by DOE or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off-site. This two-step procedure is intended to ensure that the system evaluation team gathers information about pressure system hazards, pressure system technologies, and pressure system equipment.

Pressure system safety information is used to identify pressure system hazards, establish the design basis for a pressure system, and support hazard communication requirements. It is also needed by personnel developing training programs and operating procedures, subcontractors whose employees work with the pressure system, teams conducting pre-start-up reviews, and local emergency preparedness planners. Accurate, written, and complete pressure system safety information is essential to an effective hazard assessment. To be useful, it should comprise both process and mechanical design information including a description of the system and all the documentation necessary to establish its design basis. Another very important piece of pressure system safety information that should be documented involves identification of applicable codes and standards used to establish good engineering practice. Although pressure system safety information may exist in many forms, reference to important documents should be provided. Without complete pressure system safety information, it may be difficult or impossible to perform an effective hazards analysis or determine whether process changes or pressure system equipment modifications increase the risk of an uncontrolled release.

Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies—applies to ORNL staff that need to perform a hazard analysis and identify mitigation strategies for new or existing pressure systems. This includes pressure systems owned or operated by DOE or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off-site. This seven-step procedure is intended to ensure that a pressure system hazard analysis is an organized and systematic effort to identify, evaluate, and control the hazards involved in maintaining a pressure boundary and preventing unwanted or unplanned releases from a pressure system.

The objective of a pressure system hazard analysis is to identify existing and potential workplace hazards and assess the risk of associated worker injury or illness and determine areas of excessive risk where preventative and mitigative measures may be warranted to better control the hazards. It also provides a means for identifying accident scenarios that could lead to worker injuries or fatalities, property damage, public exposure to chemicals, environmental impacts, or other adverse consequences. A pressure system hazard analysis must be performed initially to obtain baseline information and as often thereafter as necessary to ensure continued worker safety and health. The frequency for performing a pressure system hazard analysis, including the schedule for the first time an activity or facility is assessed, should be established using a graded approach that reflects the degree of potential hazards, includes consideration of

the uncertainties surrounding the hazard analysis, and supports a continual improvement process for minimizing hazards.

Procedure: Complete/Verify Pre-Start-Up Activities—applies to ORNL staff that need to complete/verify pre-start-up activities for new or existing pressure systems. This includes pressure systems owned or operated by DOE or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off-site. This four-step procedure is intended to ensure that hazard mitigation strategies are implemented before operating a new or existing pressure system.

Procedure: Operate Pressure System—applies to ORNL staff that operate new or existing pressure systems including pressure systems owned or operated by DOE or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off-site. This eight-step procedure covers accidents, operational and design changes, and routing maintenance and inspection activities.

Procedure: Manage Change and Nonroutine Work—applies to ORNL staff that identify and manage changes related to new or existing pressure systems. This includes pressure systems owned or operated by DOE or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ ORNL procedures, whether the work is conducted at ORNL or off-site. This five-step procedure is intended to ensure that the management of change process is used to control all modifications to pressure systems that could adversely affect the leak-tight integrity or structural capacity of a pressure system or result in an uncontrolled release.

The Pressure System Safety subject area also includes deployment tools that provide guidance related to the following topics.

- Exhibit: Pressure System Applicability
- Guidelines: Pressure Safety Information
- Guidelines: Pressure System Hazard Assessment Guideline
- Guidelines: Hazard Analysis Report Template
- Guidelines: DOE-HDBK-1100-2004, *Chemical Process Hazards Analysis* (2004)
- Guidelines: DOE G 440.1-8, *Implementation Guide for Use with 10 CFR Part 851, Worker Safety and Health Programs* (Dec. 27, 2006)

A compliance assessment for the SBMS Pressure System Safety subject area was conducted by FHRD in December 2011. The assessment results are included in *Worker Safety and Health Program (10 CFR 851) Compliance Assessment for Pressure System Safety*, which is included in Appendix A.

4. CERTIFICATIONS

FHRD manages fabrication shops capable of performing construction, maintenance, and repair activities for the ORNL complex. These capabilities include authorization from ASME for construction of new pressure vessels and the National Board for repair of PRIs.

4.1 AMERICAN SOCIETY OF MECHANICAL ENGINEERS

On February 23, 2010, UT-Battelle received a Certificate of Authorization from ASME (Certificate Number 34,450) reauthorizing the use of the "U" certification mark that ORNL initially acquired in the 1980s. The terms and conditions of the certificate state that "Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME *Boiler and Pressure Vessel Code*," specifically Section VIII, Division 1. The scope of the certificate covers "Manufacture of pressure vessels at the above location and field sites controlled by the above location." The U Certificate of Authorization expires on March 30, 2013.

Also on this date, UT-Battelle received a Certificate of Authorization from ASME (Certificate Number 34,772) reauthorizing the use of the "U2" certification mark that ORNL initially acquired in 2004. The terms and conditions of the certificate state that "Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME *Boiler and Pressure Vessel Code*," specifically Section VIII, Division 2. The scope of the certificate covers "Manufacture of pressure vessels at the above location and field sites controlled by the above location." The U2 Certificate of Authorization also expires on March 30, 2013.

These ASME Certificates of Authorization are an important element of ORNL's Pressure Safety Program because they allow FHRD to manufacture nonfired pressure vessels without involving procurement of subcontractor facilities or manpower. They are also supported by a quality control system that is documented in the *Controlled Manufacturing Manual* that is maintained by FHRD consistent with ASME code requirements in Section VIII, Division 1, Mandatory Appendix 10 Quality Control System. Additional information about this manual is presented in Sect. 6.2.2.

On November 26 and 27, 2012, a team representing the State of Tennessee, Department of Labor, and the Hartford Steam Boiler organization in Connecticut conducted a qualification review of the FHRD QA control program including the *Controlled Manufacturing Manual*. The objective of the review was to evaluate the various quality system elements in the manual and implementation of these elements within FHRD. The reviewers identified no unsatisfactory findings or deficiencies and recommended reauthorization of the ASME "U" and "U2" certification marks.

4.2 NATIONAL BOARD

The National Board is an organization of the chief boiler and pressure vessel inspectors in the states of the United States, the provinces of Canada, and some municipalities having populations exceeding one million persons and is recognized as being technically competent in the field of pressure equipment by federal, state, and municipal authorities. It exists to facilitate public safety by administering boiler and pressure vessel inspector training and certification programs, by ensuring the safe operation of boilers and pressure vessels by promoting the establishment of laws (boiler laws) among the member jurisdictions, and by striving to achieve uniformity of those laws between the member jurisdictions. These boiler laws require

1. construction and certification of boilers and pressure vessels in compliance with the ASME *Boiler and Pressure Vessel Code* when these items are to be installed and operated within the jurisdiction;

2. regular, periodic inspections of boilers and pressure vessels to verify they remain in acceptable condition for continued operations based on specified inspection and acceptance criteria; and

3. application of NBIC requirements for repairs and alterations of pressure equipment.

In most states, provinces, and municipalities either a state inspector or a "special" inspector (one employed by an insurance company) performs the required periodic inspections.

The codes and standards published by the National Board meet the requirements of the American National Standards Institute (ANSI/NB23) for consensus standards. This means the standards have been prepared and approved by consensus committees consisting of stakeholders representing a balanced makeup in their areas of interest to ensure impartiality. These codes and standards address the requirements for inspector training and certification, accreditation of inspection and repair organizations, and established practices for repairing or altering PRIs.

As a DOE facility, ORNL is specifically exempted from complying with the laws of the State of Tennessee as they pertain to boilers and pressure vessels. However, federal regulations exist for ensuring personnel safety under 10 CFR 851, Appendix A, Part 4; which requires contractors at DOE sites to implement a Pressure Safety Program. Each program must ensure pressure equipment is safe for operation through effective implementation of procedures for procurement, inspection, engineering, hazard assessments, and ongoing maintenance. These programs must comply with nationally recognized standards such as the ASME *Boiler and Pressure Vessel Code* for the procurement of new pressure equipment and NBIC for inspection and repair of operating pressure equipment. Pressure equipment installed before implementation of these requirements (legacy equipment) must be evaluated for safety compliance. When pressure equipment is not certifiable as compliant with the ASME *Boiler and Pressure Vessel Code*, the pressure equipment must be afforded an equivalent level of safety as if these requirements had been applied.

On March 30, 2010, the National Board issued a Certificate of Authorization (Certificate R-2727) to UT-Battelle to apply the "NB" mark to boilers, pressure vessels, or other PRIs that are registered with the National Board in accordance with its provisions. The scope of this reauthorization of a previous certificate is limited to items manufactured in accordance with ASME "U" and "U2"certification marks. This current Certificate of Authorization expires on March 30, 2013.

On March 11, 2010, the National Board issued a Certificate of Authorization to UT-Battelle to apply the "R" symbol stamp for repairs and alterations of PRIs performed in accordance with NBIC provisions. The scope of this reauthorization of a previous certificate is limited to metallic repairs and/or alterations at the above location and extended for field repairs and/or alterations controlled by this location. This current Certificate of Authorization also expires on March 30, 2013.

These National Board Certificates of Authorization are an important element of ORNL's Pressure Safety Program because they allow FHRD to register boilers, pressure vessels, or other PRIs with the National Board and perform repairs and alterations to PRIs without involving procurement of subcontractor facilities or manpower.

On November 1, 2011, the National Board issued a Certificate of Accreditation to certify that UT-Battelle is accredited as an FIA capable of performing in-service and repair inspection activities in accordance with the requirements of National Board publication NB-390. This Certificate of Accreditation, which is the first FIA accreditation issued by the National Board to a federal government facility, expires on March 30, 2013. On November 18, 2011, FHRD issued the *Inservice Inspection Quality Control Program*

Manual, which includes quality requirements for the performance of in-service inspections at ORNL as the FIA. Additional information about this manual is presented in Sect. 6.2.3.

As the prime management contractor for operation of a DOE site, UT-Battelle is responsible for compliance with 10 CFR 851 at ORNL. The accreditation of UT-Battelle as an FIA demonstrates that ORNL has developed and implemented an in-service inspection program directing technically competent and qualified inspection staff to effectively apply the objective standards of the National Board for carrying out the inspections of installed and operating pressure equipment.

5. AUDITS AND ASSESSMENTS

The effectiveness of the Pressure Safety Program in complying with the pressure safety requirements in 10 CFR 851 was assessed in 2010 and 2012 by two different teams.

5.1 INDEPENDENT OVERSIGHT SERVICES

The Audit and Oversight Directorate's Independent Oversight Services organization performed an assessment of UT-Battelle's corrective actions outlined in a variance request submitted to DOE in March 2007. Phase II of the assessment occurred on March 15–19, 2010, and addressed legacy pressure vessels. The assessment was limited to reviewing the progress UT-Battelle had made on the corrective actions outlined in the variance request that was designed to bring UT-Battelle managed facilities into compliance with 10 CFR 851. UT-Battelle committed to DOE in the variance request to complete the corrective actions by September 30, 2012. Results of the assessment are documented in a reported titled *Independent Oversight Services Assessment of Laboratory Corrective Actions for the 10 C.F.R. 851 Rule Variance Request for Phase I, Fire Barrier/Chemical Management, and Phase II, Legacy Pressure Vessels*, Project Number IO-2010-8, May 2010 (Ref. 4). Assessment results noted two potential vulnerabilities in complying with 10 CFR 851 requirements by September 30, 2012.

The corrective actions schedule compression was noted as a potential vulnerability because the large number of incomplete, open, and unaccepted corrective actions in ACTS 11044 could jeopardize UT-Battelle's ability to meet its variance request commitments. Beginning in June 2010, this vulnerability was addressed as follows. The corrective actions in ACTS 11044 were tracked by various assigned division managers supported by QA division staff, and a new Pressure Vessel Inspection Program project manager began tracking these actions and working with the legacy pressure vessel owners to develop and augment effective closure documentation. The status of these actions was reported in monthly and quarterly status reports that were used to communicate with ORNL directorate and division staff about the status of ACTS 11044 action items for legacy pressure vessels within their organizations. Additional information about the scope and contents of the monthly and quarterly status reports is presented in Sect. 6.5.

The second potential vulnerability noted that users of the ASME *Boiler and Pressure Vessel Code* do not have the knowledge or experience to interpret the code. This potential vulnerability was addressed through changes to the SBMS Pressure Vessels and Related Components subject area discussed in Sect. 3.1 and development of the Pressure System Safety subject area discussed in Sect. 3.2. The Pressure System Safety Program Description in Appendix B describes the technical basis and rationale used to develop the Pressure System Safety subject area.

5.2 COMMUNITY OF PRACTICE

On June 12–14, 2012, ORNL hosted Community of Practices for Pressure Safety meetings. During the meetings, SMEs from Pacific Northwest National Laboratory, Lawrence Livermore National Laboratory, and Idaho National Laboratory reviewed ORNL's Pressure Safety Program and evaluated overall compliance with pressure safety requirements in 10 CFR 851. Review activities focused on overview presentations, discussions with FHRD staff, tours of ORNL fabrication shops and facilities with active pressure systems, and evaluation of the SBMS Pressure System Safety and Pressure Vessels and Related Components subject areas. The scope and objective of SME review activities focused on consideration of the following questions.

- Are ORNL policies consistent with 10 CFR 851, Appendix A, Part 4?
- Are adequate processes in place to identify, assess, prevent, and abate hazards?
- Do the capabilities and expertise at ORNL provide sufficient support to comply with ORNL policies and DOE requirements?
- Are FHRD processes and procedures adequate to meet the objectives of ORNL and DOE requirements?
- Are there gaps, weaknesses, or areas for improvement in the ORNL SBMS subject areas or FHRD processes?

After the review, the SMEs determined that FHRD personnel and capabilities are exceptional, and ORNL has sufficient policies and procedures in place to comply with the pressure safety requirements in 10 CFR 851.

6. PRESSURE SAFETY PROGRAM BASELINE DOCUMENTS AND PUBLICATIONS

The following documents and publications were prepared as part of the Pressure Safety Program development process. Although many of these documents and publications were discussed in a historical context in previous sections, they are categorized and summarized in this section because they are the resources and technical basis that establish the baseline for achieving compliance with pressure safety requirements in 10 CFR 851 by September 30, 2012.

Because code rules, inspection technology, fabrication techniques, and DOE regulations change over time, revisions to these document and publication versions will likely be required as the Pressure Safety Program evolves to reflect changing research needs and unforeseen DOE mission objectives. Consequently, the versions of the documents and publications discussed in this section establish the baseline for ORNL's Pressure Safety Program on December 31, 2012.

6.1 TECHNICAL REPORTS

F&O sponsors a continuous process improvement program. Its purpose is to stimulate, promote, and sustain a culture of improvement throughout all levels of the organization. Strategic objectives of the continuous process improvement program include achieving excellence in laboratory operations in the areas of safety, health, and the environment. The SPRS Safety and Energy Efficiency Improvement Project and the Liquid Nitrogen Storage and Distribution Improvement Project were conducted to address specific 10 CFR 851 pressure safety compliance issues.

6.1.1 Steam-Pressure-Reducing Station Safety and Energy Efficiency Improvement Project

Steam is used at ORNL for a variety of process heating applications including space heating and conditioning. The steam is produced by a fuel-fired boiler at the ORNL steam plant and distributed throughout the main campus by a complex steam-pipe network. At any given time, the amount of steam produced by the steam plant is primarily a function of building steam demand and thermal energy losses from the steam pipe network. Because fuel is the dominant cost in steam generation, reducing boiler fuel consumption by improving the energy efficiency of the steam system is key to lowering ORNL's overall utility costs. Reducing fuel consumption also decreases air emissions, including carbon monoxide, carbon dioxide, particulate matter, and oxides of nitrogen.

Although steam is an effective energy transfer medium, there are potential safety hazards associated with its distribution and use. These hazards include effects of uncontrolled steam releases and exposure to heated surfaces. At ORNL, these hazards are controlled by constructing and maintaining a leak-tight steam confinement boundary and limiting access and exposure to heated surfaces by installing and using physical barriers such as heat shields, thermal insulation, and personal protective equipment. Avoiding uncontrolled steam releases and installing thermal insulation on heated surfaces also helps ORNL reduce boiler fuel consumption by increasing the thermal efficiency of the steam system.

The SPRS Safety and Energy Efficiency Improvement Project was initiated by F&O with the following key objectives.

- Comply with DOE's worker health and safety program requirements for pressure safety by constructing and maintaining a leak-tight steam confinement boundary.

- Decrease energy consumption and lower utility operating costs by eliminating steam leaks and reducing thermal energy losses.

Activities focused on maintaining and upgrading SPRSs that are part of the ORNL steam distribution network to comply with applicable ASME rules for piping.

The SPRS Safety and Energy Efficiency Improvement Project being performed by F&O is helping ORNL continue to improve both energy efficiency and worker safety by modifying, maintaining, and repairing SPRSs. Since work began in 2006, numerous energy-wasting steam leaks have been eliminated, heat losses from uninsulated steam pipe surfaces have been reduced, and deficient pressure equipment has been replaced. These improvements helped ORNL reduce its overall utility costs by decreasing the amount of fuel used to generate steam. Reduced fuel consumption also decreased air emissions. These improvements also helped lower the risk of burn injuries to workers and helped prevent shrapnel injuries resulting from missiles produced by pressurized component failures. In most cases, the economic benefit and cost effectiveness of the SPRS Safety and Energy Efficiency Improvement Project is reflected in payback periods of 1 year or less.

A description of the SPRS Safety and Energy Efficiency Improvement Project is presented in an ORNL technical report, *Steam-Pressure-Reducing Station Safety and Energy Efficiency Improvement Project*, ORNL/TM-2010/284, October 2010 (Ref. 5), which presents additional information about the safety and economic benefits realized from this project.

6.1.2 Liquid Nitrogen Storage and Distribution Improvement Project

On December 21, 2010, F&O authorized the formation of an ORNL lean team to identify options for effectively and safely storing and distributing liquid nitrogen at ORNL. The initial lean team meeting was held in April 2011. Members of the lean team include staff from the Logistical Services and Fabrication, Hoisting, and Rigging Divisions.

The lean team published a report in January 2012 titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project* (Ref. 6). This report establishes the basis for proposed action plans for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL. These deficiencies represent noncompliance with pressure safety requirements in 10 CFR 851. This report described the strengths and weaknesses of the options considered and suggested a proposed action for storing and distributing liquid nitrogen at ORNL.

The proposed action involves replacing the existing liquid nitrogen delivery vehicle with a new vehicle that includes a 2,000 gal. liquid nitrogen storage tank and complies with applicable US Department of Transportation regulations. The cost for the replacement vehicle is $288,000. The proposed action also involves removing from service liquid nitrogen storage tanks located in the yard area of Building 7010 and the west end of Building 4500S and replacing them with larger capacity leased liquid nitrogen storage tanks that are refilled by a vendor. The site preparation costs for these two liquid nitrogen storage tanks is $130,000, and the cost to lease these two liquid nitrogen storage tanks is $16,800 per year.

Beginning in January 2012, the Procurement Division solicited proposals from vendors to supply two leased liquid nitrogen storage tanks and a liquid nitrogen delivery vehicle to replace the vehicle currently being used to deliver liquid nitrogen to various locations throughout the ORNL complex. After reviewing the technical and cost proposals, the Procurement Division began negotiating a subcontract with a vendor to supply leased storage tanks for installation at Buildings 7010 and 4500S. The Procurement Division also negotiated the terms and conditions of a subcontract with a liquid nitrogen delivery vehicle vendor. The delivery vehicle arrived at ORNL in December 2012. As a parallel action, F&O completed construction of reinforced concrete slabs near Buildings 7010 and 4500S in August 2012. These slabs are foundations and work surfaces for the leased storage tanks. The deficient liquid nitrogen storage tank on the west side of Building 4500S was removed from service and the ACTS 11044 action item for this

legacy pressure vessel was closed on September 21, 2012. Until the leased storage tank for Building 4500S is installed and operational, dewars will be used temporarily by researchers in Building 4500S.

6.2 FABRICATION, HOISTING, AND RIGGING DIVISION DOCUMENTS

6.2.1 Inspection and Testing Procedures

The procedure titled *Inspection and Testing of Pressure Retaining Items*, FHRD-T-SSI 1006, Rev. 2, September 20, 2011, was revised by FHRD to provide guidance and requirements for conducting in-service inspection and testing of PRIs. This procedure applies to all FHRD personnel performing in-service inspection and testing of PRIs for ORNL and associated DOE sites.

The procedure titled *Inspection and Testing of Pressure Relieving Devices*, FHRD-T-SSI 2002, Rev. 2, October 20, 2011, was revised by FHRD to establish a uniform method for inspecting and testing pressure relieving devices. This procedure applies to all FHRD Surveillance inspection personnel performing inspection and testing of safety valves, safety relief valves, relief valves, and rupture disks.

The procedures, which are accessible from the FHRD Surveillance website, are implemented under the SBMS Engineering Management System, Pressure System Safety subject area discussed in Sect. 3.2 and are an important element of ORNL's Pressure Safety Program.

6.2.2 Controlled Manufacturing Manual

On November 18, 2011, UT-Battelle issued the *Controlled Manufacturing Manual*, Edition 13, Rev. 1, for shop and field fabrication of pressure vessels in compliance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1 and Section VIII, Division 2, and PRIs in accordance with NBIC and jurisdictional (DOE) requirements

The *Controlled Manufacturing Manual* is integral to ASME accreditation, discussed in Sect. 4.1. It also provides rules for repair of PRIs.

6.2.3 *Inservice Inspection Quality Control Program Manual*

On November 18, 2011, FHRD issued edition 2, Rev. 1, of the *Inservice Inspection Quality Control Program Manual.* This manual includes quality requirements for the performance of in-service and repair inspections of ORNL PRIs in accordance with NBIC and National Board document NB-390 under the FIA Certificate of Accreditation issued to UT-Battelle by the National Board on November 1, 2011. (Additional information about the FIA Certificate of Accreditation is discussed in Sect. 4.2.)

The In-Service Inspection Program described by this manual complies with the requirements of the most recently published revision of NB-390. The manual states that UT-Battelle shall comply with the requirements of NB-23, NBIC, and the manual itself while performing the following in-service inspection activities as the FIA at ORNL.

- Fitness for continued service verification inspection activities on DOE-owned boilers, pressure vessels, and piping and privately owned boilers, pressure vessels, and piping under DOE's regulatory control.

- Necessary inspections to facilitate shop and field repairs and alterations to PRIs.

The in-service inspection program described by this manual applies to PRIs, including boilers and pressure vessels constructed and certified as compliant with Sections I, IV, and VIII, Divisions 1 and VIII, Division 2 of the ASME *Boiler and Pressure Vessel Code* or the ASME B31 series piping codes and standards, and noncode PRIs installed at ORNL.

The manual also defines the organizational structure, functional responsibilities, levels of authority, lines of communication, and duties for carrying out the In-Service Inspection Program.

6.3 PRESSURE SYSTEM INTEGRITY PROGRAM DESCRIPTIONS

Surveillance staff maintains a website that is accessible to all divisions at ORNL. The website includes a series of documents (listed below) that describe the pressure system integrity programs managed by Surveillance and the capabilities and expertise within the Surveillance group for assisting pressure system owners in complying with the pressure safety requirements in 10 CFR 851.

- Pressure System Integrity Program for Overpressure Protection, September 6, 2011
- Pressure System Integrity Program for Pressure Vessels, August 31, 2011
- Pressure System Integrity Program for Power and Process Piping, August 12, 2011
- Pressure System Integrity Program for Hazard Analysis and Hazard Mitigation, August 31, 2011
- Pressure System Integrity Program for Power and Heating Boilers, September 6, 2011

These five documents are included in Appendix C.

In addition, Surveillance staff prepared a PowerPoint presentation that describes the roles and responsibilities of division staff for complying with procedures in the Pressure System Safety subject area.

These documents and the presentation are available on the FHRD Surveillance website for use by pressure system owners.

6.4 HAZARD ASSESSMENTS

Surveillance staff prepared hazard assessments in accordance with the SBMS Pressure System Safety subject area requirements for the pressure systems owned by FHRD. Example hazard analyses are available on the FHRD Surveillance website. Surveillance staff also assisted owners of other pressure systems within F&O prepare hazard assessments.

These hazard assessments satisfy hazard identification and assessment and hazard prevention and abatement requirements in the following 10 CFR 851 paragraphs.

§851.21 Hazard identification and assessment
§851.22 Hazard prevention and abatement

6.5 STATUS REPORTS FOR ACTS 11044

In May 2010, an assessment revealed that the remaining open action items in ACTS 11044 were a vulnerability to UT-Battelle's ability to meet its variance commitments (Ref. 4). The assessment, which is discussed in more detail in Sect. 5.1, also revealed a second vulnerability involving implementation of guidance in SBMS for complying with pressure safety requirements in 10 CFR 851. To achieve closure of all ACTS 11044 action items by September 30, 2012, Surveillance staff established a goal of resolving at

least 25 ACTS 11044 action items per quarter and submitting monthly and quarterly status reports to document progress toward addressing the two vulnerabilities and achieving this goal.

6.5.1 Monthly Status Reports

On May 15, 2010, ACTS 11044 included 193 action items (Ref. 4). Of this total, 29 action items were closed satisfactorily, 57 were accepted by the owner, and 107 were not yet accepted by the owner. On September 28, 2012, ACTS 11044 included 216 action items with satisfactory closure documentation. The total number of ACTS 11044 action items increased from 193 to 216 because additional legacy pressure vessel deficiencies were identified by the Surveillance staff as they focused on addressing the following issues.

- Assisting owners in developing action plans for resolving deficiencies reported in ACTS 11044.
- Compiling pressure vessel nameplate information; manufacturers' data reports; and other types of historical documentation, if available.
- Compiling pressure relief device specifications, inspection records, and historical repair and replacement data.
- Continuing initial inspections of legacy pressure vessels to meet variance request milestones and entering deficiencies into ACTS 11044 as appropriate.
- Reviewing inspection reports to identify legacy pressure vessels with deficiencies that needed to be entered into ACTS 11044.
- Implementing a process for identifying and notifying owners of deficient pressure vessels, working with the owners to resolve the deficiencies, and entering the deficiencies not resolved within 90 days into ACTS 11044.
- Verifying closure documentation for accuracy and completeness and modifying the existing text to provide sufficient and satisfactory closure evidence.

Status reports for ACTS 11044 were submitted each month from June 2010 to September 2012 to document the progress made in addressing legacy pressure vessel issues. A summary of the information that was included in these status reports follows.

Surveillance staff completed a comprehensive review of the 1,240 PRIs at ORNL and determined that 215 had deficiencies that required evaluation to identify appropriate corrective actions. Some, but not all, of the deficient PRIs had ACTS 11044 action item numbers. Based on review results, Surveillance staff took the following corrective actions to address the PRI deficiencies.

1. About 45% of the 215 deficient PRIs had pressure relief device installation, testing, or inspection issues or potential pressure safety concerns involving installation of isolation valves upstream of the pressure relief devices. Surveillance staff assessed PRIs with pressure relief device installation issues to justify continued operation based on results of a hazard analysis or an engineering evaluation of the PRI and the various components in the pressure system. Surveillance staff also worked with owners to establish administrative controls for ensuring that the isolation valves remain fully open when the PRI is operating.

2. Many PRIs had insulation that restricted access for nameplate verification and thickness measurements. Access for performing thickness checking is easily obtained by removing small areas of insulation and installing inspection ports at strategic locations. Surveillance staff prioritized PRIs

that required inspection ports or insulation removal so that ORNL insulator craft resources could be used effectively.

3. In some cases PRIs had heavy corrosion, but the metal loss was within an acceptable limit. However, prompt action by the owner was considered necessary to prevent further deterioration. These actions often involved eliminating connection leaks or implementing corrosion mitigation measures.

4. Four pressure vessels required rerating. Surveillance staff prepared engineering calculations or written justifications as the basis for closure documentation for these pressure vessels, and in March 2011, Surveillance staff obtained acceptance from the authorized inspector to rerate these pressure vessels. By May 30, 2011, a nameplate with the revised rating was installed on each of these pressure vessels, and the ACTS 11044 action items for these pressure vessels were closed satisfactorily.

Item 2 above focuses on the need for insulation removal and further emphasizes the potential vulnerability (Vulnerability 1) caused by limited availability of insulator craft support. Additional information about this vulnerability is discussed in Sect. 5.1.

The potential vulnerability (Vulnerability 2) in implementing SBMS guidance for pressure safety focused on alerting staff about the information in the Pressure System Safety subject area and emphasizing the need for complying with 10 CFR 851 pressure safety requirements. On December 9, 2010, the directorate operations managers (DOMs) were asked to review flowcharts that addressed the following areas.

- Identify Pressure System
- Gather System Information
- Perform Hazard Analysis and Identify Mitigation Strategies
- Complete/Validate Pre-Start-Up Activities
- Operate Pressure System
- Manage Change and Nonroutine Work

These flowcharts were developed by the SBMS Pressure System Safety Development Team to implement the SBMS subject area for Pressure System Safety and were used as the basis for development of SBMS Pressure System Safety procedures. After discussion, the DOMs authorized the SBMS Pressure System Safety Development Team to proceed with procedure development.

On August 17, 2011, the SBMS program office published the Pressure System Safety documents for this subject area. The six Pressure System Safety procedures in this subject area are discussed in Sect. 3.2. Following publication, divisions were required to either comply with these procedures or have an approved implementation plan in place by October 16, 2011.

Based on a review of identified potential vulnerabilities affecting UT-Battelle's ability to meet its legacy pressure vessel variance commitments by September 30, 2012, Surveillance staff recognized that the problem areas described in Table 4 could not be addressed effectively without direct intervention by ORNL directorate and division management and staff.

Table 4. Legacy Pressure Vessel Problem Areas

Problem Area	Problem Area Description
1	Surveillance staff needs an action plan for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL.
2	Surveillance staff and action item owners are unable to reallocate insulator craft resources needed to characterize and quantify legacy pressure vessel deficiencies.
3	Surveillance staff is unable to reallocate the services of Quality Assurance personnel to verify the accuracy and completeness of closure documentation.

The following actions were taken to address each of these problem areas.

In December 2010, F&O authorized an ORNL lean team to identify options for effectively and safely storing and distributing liquid nitrogen at ORNL. The lean team published a report in January 2012 titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*. This report establishes the basis for proposed action plans for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL. These deficiencies represent non-compliance with pressure safety requirements in DOE's worker safety and health rules in 10 CFR 851.

Beginning in January 2012, the Procurement Division solicited proposals from vendors to supply two leased liquid nitrogen storage tanks and a liquid nitrogen delivery vehicle to replace the vehicle being used to deliver liquid nitrogen to various locations throughout the ORNL complex. After reviewing the technical and cost proposals, the Procurement Division began negotiating a subcontract with a vendor to supply leased storage tanks for installation at Buildings 7010 and 4500S. The Procurement Division also negotiated the terms and conditions of a subcontract with a liquid nitrogen delivery vehicle vendor. The delivery vehicle arrived at ORNL in December 2012. As a parallel action, F&O completed construction of reinforced concrete slabs near Buildings 7010 and 4500S in August 2012. These slabs are foundations and work surfaces for the leased storage tanks. The deficient liquid nitrogen storage tank on the west side of Building 4500S was removed from service, and the ACTS 11044 action item for this legacy pressure vessel was closed on September 21, 2012. Until the leased storage tank for Building 4500S is installed in early 2013 and operational, dewars will be used temporarily by researchers in Building 4500S.

Surveillance staff addressed Problem Area 2 by identifying pressure vessels with insulation that required removal to allow wall thickness measurements or provide access to nameplate data and by working with owners and insulators to coordinate insulation removal and implement applicable corrective actions. Insulation removal activities for all affected pressure vessels were completed in December 2011.

A QA representative addressed Problem Area 3 by evaluating closure documentation and reviewing each ACTS 11044 action item to ensure that the closure documentation reflected "tangible and objective evidence" as justification for closure. Duties performed by the QA representative included the following.

- Acting as a super-delegate and editing ACTS 11044 records, as necessary.
- Working with the ACTS coordinator and reopening closed action items that required revision to include additional closure evidence.
- Meeting with pressure vessel inspectors and Surveillance staff to discuss closure issues and identify proper closure evidence.

- Participating in field reviews with pressure vessel inspectors and Surveillance staff to obtain photographic records that could be used to supplement other closure evidence.

- Reviewing issues and closure evidence in "ORNL Pressure Vessel and Pressure Safety" files for ACTS 11044 action items.

- Reviewing closed action items with Surveillance staff to determine whether any action items needed to be reopened so additional corrective actions could be performed and used as further justification for closure.

- Meeting with owners to obtain additional closure evidence.

- Reviewing engineering evaluations on closed action items with Surveillance staff for accuracy and completeness.

After completing these activities, QA and Surveillance staff completed reviewing closure evidence for all closed ACTS 11044 action items and determined that the closure documentation for each action item was satisfactory.

The final monthly report that covers the period from September 1, 2012, to September 31, 2012, is included as Appendix D.

6.5.2 Quarterly Status Reports

Status reports for ACTS 11044 were submitted each quarter from August 2010 to August 2012. Each quarterly status report updated the closure status of ACTS 11044 action items. A plot of closure status progress is shown in Fig. 1. The quarterly report for ACTS 11044, that covers the period from June 1, 2012, to August 31, 2012, is included as Appendix E.

7. SUMMARY AND CONCLUSIONS

Worker health and safety requirements that govern the conduct of contractor activities at DOE sites are provided in 10 CFR 851, *Worker Safety and Health Program* (Ref. 1). This regulation establishes requirements for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. The regulation also requires contractors to comply with pressure safety requirements in Subpart C, *Specific Program Requirements,* by May 25, 2007.

After DOE promulgated 10 CFR 851, *Worker Safety and Health Program*, in February 2006, UT-Battelle formed a working group within ORNL to guide and assist laboratory management in implementing the rule. Based on working group considerations of ORNL legacy pressure vessels and potential noncompliance issues, UT-Battelle requested a temporary variance from specific pressure safety requirements in 10 CFR 851 in a letter dated February 26, 2007 (Ref. 2). The variance request included a commitment by UT-Battelle to achieve full compliance with applicable pressure safety requirements in 10 CFR 851 by September 30, 2012, and was considered necessary due to the large number of pressure vessels requiring inspection and the limited availability of qualified technical resources. The working group based its review of legacy pressure vessel issues on preliminary results of an assessment titled *Implementation Plan for Legacy Pressure Vessels* that began in 2004. Development of the ORNL Pressure Safety Program began with the creation of this plan.

The principle objective of ORNL's Pressure Safety Program is to prevent unwanted releases of toxic chemicals and hazardous energy from pressure systems, especially into locations that could adversely affect the human and natural environments, through compliance with the pressure safety standards in 10 CFR 851. This objective is being realized at ORNL through implementation of the following Pressure Safety Program elements.

- SBMS Pressure Vessels and Related Components and Pressure System Safety procedures
- ASME and National Board certifications
- FHRD documents

The nine procedures in the Pressure Vessels and Related Components subject area describe processes for designing, acquiring, installing, operating, maintaining, repairing, and decommissioning ASME-certified pressure vessels and components. They also include suggested guidelines for noncertified pressure vessels. The Pressure System Safety subject area identifies requirements and describes methods for conducting activities involving new or existing pressure systems at ORNL. Effective pressure system safety management involves a systematic approach to evaluating the pressure system as a whole rather than ensuring that only individual PRIs are designed, constructed, and operated safely. All ORNL divisions were required to either comply with SBMS Pressure System Safety procedures or have an approved implementation plan in place by October 16, 2011.

FHRD manages fabrication shops capable of performing construction, maintenance, and repair activities for the ORNL complex. These capabilities include authorization from ASME and the National Board to fabricate and repair pressure vessels. The ASME Certificates of Authorization are an important element of ORNL's Pressure Safety Program because they allow FHRD to manufacture pressure vessels without involving procurement of subcontractor facilities or manpower. The National Board Certificates of Authorization are another important element of ORNL's Pressure Safety Program because they allow FHRD to register boilers, pressure vessels, or other PRIs with the National Board and perform repairs and alterations to PRIs without involving procurement of subcontractor facilities or manpower. UT-Battelle also received accreditation as an FIA performing in-service inspection activities in accordance with the

requirements of National Board publication NB-390. This Certificate of Accreditation is the first FIA accreditation issued to a federal government facility by the National Board.

FHRD developed two procedures, *Inspection and Testing of Pressure Retaining Items* and *Inspection and Testing of Pressure Relieving Devices,* to allow division personnel to perform in-service inspection and testing of PRIs and inspection and testing of safety valves, safety relief valves, relief valves, and rupture disks. FHRD maintains the *Controlled Manufacturing Manual* for shop and field fabrication of pressure vessels in compliance with ASME *Boiler and Pressure Vessel Code* Section VIII, Division 1, and Section VIII, Division 2, and PRIs in accordance with NBIC and jurisdictional (DOE) requirements. The *Controlled Manufacturing Manual* is integral to ASME accreditation and provides rules for repair of PRIs. FHRD also developed and issued an additional document, the *Inservice Inspection Quality Control Program Manual,* which includes quality requirements for the performance of in-service inspections of ORNL PRIs. This manual is integral to FIA accreditation by the National Board. Surveillance staff also prepared a series of hazard assessments in accordance with SBMS Pressure System Safety subject area requirements. These hazard analyses were prepared specifically for pressure systems owned by FHRD and are consistent with the hazard identification and hazard mitigation rules in 10 CFR 851.

On May 8, 2008, ORNL opened ACTS 11044 to track inspections of boilers and pressure vessels as part of *Implementation Plan for Legacy Pressure Vessels* commitments. To achieve closure of all ACTS 11044 action items by September 30, 2012, Surveillance staff established a goal of resolving at least 25 ACTS 11044 action items per quarter and submitting monthly and quarterly status reports to F&O to document progress toward addressing two identified vulnerabilities and achieving this goal. After all inspection activities were completed and all legacy pressure vessel compliance issues were resolved, ACTS 11044 was closed satisfactorily on September 28, 2012.

8. REFERENCES

1. *Worker Safety and Health Program*, Title 10, Code of Federal Regulations, Part 851, US Department of Energy, Washington, DC.
2. Letter dated February 26, 2007, from UT-Battelle to DOE, Subject: Contract DE-AC05-00OR22725, ORNL Variance Requests from 10 C.F.R. § 851, *Worker Safety and Health Program*.
3. Letter dated June 27, 2012, from DOE to UT-Battelle, Subject: Contract DE-AC05-00OR22725, Oak Ridge National Laboratory (ORNL), Worker Safety and Health Program Description (WSHPD) Annual Review Required by 10 CFR 851, *Worker Safety and Health Program*.
4. *Assessment of Laboratory Corrective Actions for the 10 C.F.R § 851 Rule Variance Request for Phase I—Fire Barrier/Chemical Management and Phase II—Legacy Pressure Vessels*, Project Number IO-201-8, Oak Ridge National Laboratory, May 2010.
5. *Steam Pressure-Reducing Station Safety and Energy Efficiency Improvement Project*, Facilities and Operations Directorate, Oak Ridge National Laboratory, ORNL/TM-2010/284, January 2011.
6. *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*, Facilities and Operations Directorate, Oak Ridge National Laboratory, January 2012.

APPENDIX A. WORKER SAFETY AND HEALTH PROGRAM (10 CFR 851) COMPLIANCE ASSESSMENT FOR PRESSURE SYSTEM SAFETY

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WORKER SAFETY AND HEALTH PROGRAM (10 CFR 851) COMPLIANCE ASSESSMENT FOR PRESSURE SYSTEM SAFETY DECEMBER 16, 2011

A.1 INTRODUCTION

Worker health and safety requirements that govern the conduct of contractor activities at DOE sites are provided in 10 CFR 851, *Worker Safety and Health Program*. This regulation establishes requirements for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites.

According to 10 CFR 851, Subpart Subpart C – *Specific Program Requirements*, contractors must have a structured approach to their worker safety and health program which at a minimum includes provisions for pressure safety. In implementing the structured approach for pressure safety, contractors must establish safety policies and procedures to ensure that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. In addition, contractors must ensure that all pressure vessels, boilers, air receivers, and supporting piping systems conform to (1) applicable American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (2004); sections I through section XII including applicable Code Cases; (2) applicable ASME B31 (Code for Pressure Piping) standards; and (3) the strictest applicable state and local codes. When national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials, etc.), contractors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local codes.

The term pressure system means all pressure vessels, and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems due to their potential for catastrophic failure due to backfill pressurization. Associated hardware (*e.g.*, gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system. This definition of pressure system, which is all encompassing and provides no exclusions, means that any leak tight pressure boundary is within the scope of DOE's 10 CFR 851, *Worker Safety and Health Program*.

The primary function of a pressure system is to safely confine solid, liquid, or gaseous material or maintain a vacuum within a leak-tight pressure boundary consisting of interconnected pressure-retaining components such as pressure vessels, tanks, pipes, valves, fittings, and pressure relief devices. Effective pressure system safety management involves a systematic approach to evaluating the pressure system as a whole rather than assuring that individual pressure-retaining items are designed, constructed, and operated safely.

A.2 PRESSURE SYSTEM SAFETY

Pressure system safety requirements at the Oak Ridge National Laboratory (ORNL) are defined in the Pressure System Safety Subject Area in the ORNL Standards Based Management System (SBMS). The purpose of the Pressure System Safety Subject Area is to meet pressure safety requirements in DOE's *Worker Safety and Health Program*, 10 CFR 851, by proving procedures for preventing unwanted

releases of toxic chemicals and hazardous energy from pressure systems. This regulation establishes the framework for an effective worker safety and health program that provides DOE contractor workers with a safe and healthful workplace in which workplace hazards are abated, controlled, or otherwise mitigated in a manner that provides reasonable assurance that workers are adequately protected from identified hazards.

The Pressure System Safety Subject Area establishes safety policies and procedures for ensuing that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. These principles are defined in pressure vessel and piping codes adopted by ASME and in applicable state and local codes. For pressure systems and related components that are not covered by these codes, measures for ensuring a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local codes should be implemented.

The Pressure System Safety Subject Area includes the following procedures for identifying, evaluating, and mitigating consequences of unwanted releases from a pressure system that could occur as a result of failures in process, procedures, or equipment.

- Identify Pressure System
- Gather System Information
- Perform Hazard Analysis and Identify Mitigation Strategies
- Complete/Validate Pre-Startup Activities
- Operate Pressure System
- Manage Change and Non-Routine Work

A.3 COMPLIANCE MATRIX

The specific program requirements in 10 CFR 851, Subpart C reflect what DOE considers the essential elements of a successful worker safety and health program. These requirements are subdivided into the following categories.

- Management responsibilities and worker rights (§851.20)
- Hazard identification and assessment (§851.21)
- Hazard prevention and abatement (§851.22)
- Safety and health standards (§851.23)
- Functional areas (§851.24)
- Training and information (§851.25)
- Recordkeeping and reporting (§851.26)

Mandatory requirements for implementing pressure safety are provided in 10 CFR 851, Appendix A.

Requirements in 10 CFR 851 that specifically apply to pressure systems at ORNL are identified in the following table along with the corresponding procedures and methods in the Pressure System Safety Subject Area for complying with each requirement. Requirements in 10 CFR 851 that do not specifically apply to pressure systems at ORNL or general requirements in 10 CFR 851 that are addressed in other SBMS Subject Areas are not included in the table. The program description in SBMS that provides additional information about the Pressure System Safety and Pressure Vessels and Related Components subject areas is included in Attachment 1.

Compliance Matrix for Pressure System Safety

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.3 Definitions *Pressure systems* means all pressure vessels, and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems should be considered pressure systems due to their potential for catastrophic failure due to backfill pressurization. Associated hardware (*e.g.*, gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system.	**Procedure: Identify Pressure System** This procedure applies to Oak Ridge National Laboratory (ORNL) staffs who work with new or existing **pressure systems**. This includes pressure systems owned or operated by the Department of Energy (DOE) or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off site. **Pressure Systems** - Consists of all pressure vessels and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems due to their potential for catastrophic failure due to backfill pressurization. Associated hardware (e.g., gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system.
§851.10 General requirements (b) The written worker safety and health program must describe how the contractor complies with the: (1) Requirements set forth in Subpart C of this part that are applicable to the hazards associated with the contractor's scope of work; and	**Program Description: Pressure System Safety** See Attachment 1, Sect. 4.
§851.11 Development and approval of the worker safety and health program (a) *Preparation and submission of worker safety and health program.* By February 26, 2007, contractors must submit to the appropriate Head of DOE Field Element for approval a written worker safety and health program that provides the methods for implementing the requirements of Subpart C of this part. (2) If more than one contractor is responsible for covered workplaces, each contractor must: (ii) Coordinate with the other contractors responsible for work at the covered workplaces to ensure that there are clear roles, responsibilities and procedures to ensure the safety and health of workers at multi-contractor workplaces.	Procedure: Gather System Information Pressure system safety information is used to identify pressure system hazards, establish the design basis for a pressure system, and support hazard communication requirements. It is also needed by personnel developing training programs and operating procedures, subcontractors whose employees work with the pressure system, teams conducting pre-startup reviews, and local emergency preparedness planners.

Compliance Matrix for Pressure System Safety

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.11 Development and approval of the worker safety and health program (a) *Preparation and submission of worker safety and health program.* By February 26, 2007, contractors must submit to the appropriate Head of DOE Field Element for approval a written worker safety and health program that provides the methods for implementing the requirements of Subpart C of this part. (3) The worker safety and health program must describe how the contractor will: (i) Comply with the requirements set forth in Subpart C of this part that are applicable to the covered workplace, including the methods for implementing those requirements; and	**Program Description: Pressure System Safety** See Attachment 1, Sect. 4.
§851.11 Development and approval of the worker safety and health program (a) *Preparation and submission of worker safety and health program.* By February 26, 2007, contractors must submit to the appropriate Head of DOE Field Element for approval a written worker safety and health program that provides the methods for implementing the requirements of Subpart C of this part. (3) The worker safety and health program must describe how the contractor will: (ii) Integrate the requirements set forth in Subpart C of this part that are applicable to a covered workplace with other related site-specific worker protection activities and with the integrated safety management system.	**4.0 References** Section 4 for each Pressure System Safety procedure identifies SBMS subject areas that provide other related site-specific worker protection activities that are consistent with the integrated safety management system.
§851.20 Management responsibilities and worker rights and responsibilities (a) *Management responsibilities.* Contractors are responsible for the safety and health of their workforce and must ensure that contractor management at a covered workplace: (2) Use qualified worker safety and health staff (*e.g.*, a certified industrial hygienist, or safety professional) to direct and manage the program;	**Subject Matter Expert:** Mark Lower **Management System Owner:** Tom Etheridge

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.20 Management responsibilities and worker rights and responsibilities (a) *Management responsibilities.* Contractors are responsible for the safety and health of their workforce and must ensure that contractor management at a covered workplace: (4) Provide mechanisms to involve workers and their elected representatives in the development of the worker safety and health program goals, objectives, and performance measures and in the identification and control of hazards in the workplace;	Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies **2.0 Required Procedure** Step 2. The System POC selects individuals for the hazard analysis team. Note: This team is responsible for conducting the hazard analysis for a pressure system and for identifying potential pressure system hazards that require mitigation. A pressure system hazard analysis is best performed by a team with varied operational and technical backgrounds. The team leader needs to be knowledgeable in the selected hazard analysis methodology and remain impartial throughout the evaluation. At least one team member should be familiar with the physical features and performance requirements for the pressure system. An ideal team consists of individuals that have knowledge of the standards, codes, specifications, and regulations applicable to the pressure system.
§851.20 Management responsibilities and worker rights and responsibilities (a) *Management responsibilities.* Contractors are responsible for the safety and health of their workforce and must ensure that contractor management at a covered workplace: (6) Establish procedures for workers to report without reprisal job-related fatalities, injuries, illnesses, incidents, and hazards and make recommendations about appropriate ways to control those hazards; (7) Provide for prompt response to such reports and recommendations;	Procedure: Operate Pressure System **4.0 References** Stop Work subject area

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.21 Hazard identification and assessment (a) Contractors must establish procedures to identify existing and potential workplace hazards and assess the risk of associated workers injury and illness. Procedures must include methods to: (1) Assess worker exposure to chemical, physical, biological, or safety workplace hazards through appropriate workplace monitoring; (2) Document assessment for chemical, physical, biological, and safety workplace hazards using recognized exposure assessment and testing methodologies and using of accredited and certified laboratories; (3) Record observations, testing and monitoring results; (4) Analyze designs of new facilities and modifications to existing facilities and equipment for potential workplace hazards; (5) Evaluate operations, procedures, and facilities to identify workplace hazards; (6) Perform routine job activity-level hazard analyses; (7) Review site safety and health experience information; and (8) Consider interaction between workplace hazards and other hazards such as radiological hazards. (c) Contractors must perform the activities identified in paragraph (a) of this section, initially to obtain baseline information and as often thereafter as necessary to ensure compliance with the requirements in this Subpart.	Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies **2.0 Required Procedure** Step 3. The team conducts a hazard analysis of the pressure system based on available pressure system information. When the original technical information for a pressure system no longer exists, the pressure system information must be developed in sufficient detail to support a pressure system **hazard analysis**. The hazard analysis must include methods for addressing the following areas (at a minimum) that are applicable to the pressure system: 1. For pressure vessel systems that contain or will contain chemical agents or inert gases, conduct and document modeling for a worst case scenario and/or plausible accident scenario. Note: Contact a Health and Safety field support representative for assistance to conduct modeling. 2. Analyze designs of new facilities and modifications to existing facilities and equipment for potential workplace hazards. See the Design subject area. 3. Evaluate operations, procedures, and facilities to identify workplace hazards. 4. Perform routine job activity-level hazard analyses. Refer to the Work Control subject area. 5. Review site safety and health experience information. 6. Consider interaction between workplace hazards and other hazards such as radiological hazards. 7. Consider potential public and environmental impacts. Note: Refer to the Pressure System Hazard Assessment Guideline, Emergency Preparedness and Response subject area, and guidance in DOE G 440.1 8, “Implementation Guide for use with 10 CFR 851 Worker Safety and Health Program,” Section 3.3.2 - Hazard Identification and Assessment. Contact the Pressure System Safety subject matter expert with questions. **Hazard Analysis** - A term used broadly to discuss all aspects of hazards identification and analysis, safety and accident analyses, and associated documentation.

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.21 Hazard identification and assessment (c) Contractors must perform the activities identified in paragraph (a) of this section, initially to obtain baseline information and as often thereafter as necessary to ensure compliance with the requirements in this Subpart.	Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies **1.0 Applicability** A pressure system hazard analysis must be performed initially to obtain baseline information and as often thereafter as necessary to ensure continued worker safety and health. The frequency for performing a pressure system hazard analysis, including the schedule for the first time an activity or facility is assessed should be established using a graded approach that reflects the degree of potential hazards, includes consideration of the uncertainties surrounding the hazard analysis, and supports a continual improvement process for minimizing hazards.
§851.22 Hazard prevention and abatement (a) Contractors must establish and implement a hazard prevention and abatement process to ensure that all identified and potential hazards are prevented or abated in a timely manner. (1) For hazards identified either in the facility design or during the development of procedures, controls must be incorporated in the appropriate facility design or procedure. (2) For existing hazards identified in the workplace, contractors must: (i) Prioritize and implement abatement actions according to the risk to workers; (ii) Implement interim protective measures pending final abatement; and (iii) Protect workers from dangerous safety and health conditions;	Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies **1.0 Applicability** A pressure system hazard analysis is an organized and systematic effort to identify, evaluate, and control the hazards involved in maintaining a **pressure boundary** and preventing unwanted or unplanned releases from a pressure system. The objective of a pressure system hazard analysis is to identify existing and potential workplace hazards and assess the risk of associated worker injury or illness and determine areas of excessive risk where preventative and mitigative measures may be warranted to better control the hazards. It also provides a means for identifying accident scenarios that could lead to worker injuries or fatalities, property damage, public exposure to chemicals, environmental impacts, or other adverse consequences. **Pressure Boundary** - A closed system of physical barriers intended for containing pressure or vacuum

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.22 Hazard prevention and abatement (b) Contractors must select hazard controls based on the following hierarchy: (1) Elimination or substitution of the hazards where feasible and appropriate; (2) Engineering controls where feasible and appropriate; (3) Work practices and administrative controls that limit worker exposures; and (4) Personal protective equipment.	Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies **2.0 Required Procedure** Step 5. This procedure applies to Oak Ridge National Laboratory (ORNL) staff that needs to perform a **hazard analysis** and identify mitigation strategies for new or existing **pressure systems**. This includes pressure systems owned or operated by the Department of Energy (DOE) or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off site. For hazards identified either in the facility design or during the development of operating procedures, the team helps establish controls for identified pressure system hazards so the controls can be incorporated into the facility design or procedures. For existing hazards identified in the workplace, abatement actions must be prioritized according to risk to the worker. Abatement actions must be promptly implemented and interim protective measures must be implemented pending final abatement of the hazards. Workers must be protected immediately from dangerous safety and health conditions. Hazards must be systematically managed and documented through final abatement or control. Select hazard controls based on the following hierarchy. 1. Elimination or substitution of the hazards where feasible and appropriate 2. Engineering controls where feasible and appropriate 3. Work practices and administrative controls that limit worker exposures 4. Personal protective equipment Note: When elimination or substitution of the hazard is not feasible and appropriate or does not reduce the associated risk to acceptable levels, these controls may be supplemented with engineering controls. Where engineering controls are not feasible and appropriate or do not reduce the associated risk to acceptable levels, these controls may be supplemented with work practices and administrative controls. Where necessary, these controls may be further supplemented with the use of appropriate PPE. Other potential strategies for hazard prevention or abatement should be considered when applicable including training, assessments, Fabrication and Manufacturing Quality Assurance Plans, and configuration control.

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.22 Hazard prevention and abatement (c) Contractors must address hazards when selecting or purchasing equipment, products, and services.	Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies **2.0 Required Procedure** Step 7. Staff addresses identified hazards and implements mitigation strategies, including selecting or purchasing equipment, products, and services.
§851.24 Functional areas (a) Contractors must have a structured approach to their worker safety and health program which at a minimum, include provisions for the following applicable functional areas in their worker safety and health program: construction safety; fire protection; firearms safety; explosives safety; pressure safety; electrical safety; industrial hygiene; occupational medicine; biological safety; and motor vehicle safety. (b) In implementing the structured approach required by paragraph (a) of this section, contractors must comply with the applicable standards and provisions in Appendix A of this part, entitled "Worker Safety and Health Functional Areas."	**Subject Area: Pressure System Safety** **1.0 Introduction** This subject area identifies requirements and describes methods for conducting activities involving new or existing **pressure systems** at the Oak Ridge National Laboratory (ORNL). Effective pressure system safety management involves a systematic approach to evaluating the pressure system as a whole rather than assuring that only individual pressure-retaining items are designed, constructed, and operated safely. The primary function of a pressure system is to safely confine solid, liquid, or gaseous material or maintain a vacuum within a leak-tight pressure boundary consisting of interconnected pressure-retaining components such as pressure vessels, tanks, pipes, valves, fittings, and pressure relief devices. The objective of pressure system safety is to identify, evaluate, and mitigate consequences of unwanted releases that could occur as a result of failures in process, procedures, or equipment. Pressure systems should be designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. The Pressure System Applicability exhibit* addresses the pressure systems and components that must comply with the system safety requirements in this subject area. Also refer to the Pressure Vessels and Related Components subject area and Pressure System Safety Program Description for further information. The Pressure System Safety subject area includes the following procedures for identifying, evaluating, and mitigating consequences of unwanted releases from a pressure system that could occur as a result of failures in process, procedures, or equipment: • Identify Pressure System • Gather System Information • Perform Hazard Analysis and Identify/Implement Mitigation Strategies • Complete/Verify Pre-Startup Activities • Operate Pressure System • Manage Change and Non-Routine Work *The Pressure System Applicability exhibit is included in Attachment 2.

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.25 Training and information (a) Contractors must develop and implement a worker safety and health training and information program to ensure that all workers exposed or potentially exposed to hazards are provided with the training and information on that hazard in order to perform their duties in a safe and healthful manner. (b) The contractor must provide: (1) Training and information for new workers, before or at the time of initial assignment to a job involving exposure to a hazard; (2) Periodic training as often as necessary to ensure that workers are adequately trained and informed; and (3) Additional training when safety and health information or a change in workplace conditions indicates that a new or increased hazard exists. (c) Contractors must provide training and information to workers who have worker safety and health program responsibilities that is necessary for them to carry out those responsibilities.	Procedure: Complete/Verify Pre-Startup Activities Step 2. Pre-startup review team identifies and documents acceptance criteria to complete/verify pre-startup activities for a pressure system. Note: The team review should consider the following: • Equipment • Procedures • Training • Hazard analysis (if new or modified) • Quality assurance • Design/construction Program Description: Pressure System Safety 4.6 Training and Information Training is an important aspect of DOE's Worker Safety and Health Program and is therefore a key element of the Pressure System Safety subject area. Program requirements for training and information are defined in §851.25. Compliance with these requirements involves developing and implementing a worker safety and health training and information program for ensuring that all workers exposed or potentially exposed to hazards are provided with the training and information on that hazard in order to perform their duties in a safe and healthful manner. In this context, the term worker includes both ORNL and subcontractor employees who are involved in activities that could be affected by a pressure system release. Pressure system safety training is also required to comply with management responsibilities defined in §851.20(a)(5) for providing workers with access to relevant program information. The Complete/Verify Pre-Startup Activities includes a requirement to review and verify that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. Although the levels of training needed to comply with this requirement vary from one pressure system to another, two types of worker training should be considered.

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
	General pressure system safety training provides workers with an overview of the health and safety issues associated with building, operating, testing, maintaining, altering, and repairing pressure systems. This training focuses on awareness of the types of pressure retaining items that may be part of a pressure system, potential hazards to the human and natural environment associated with the stored energy, and the possible consequences of an uncontrolled or unplanned release. Awareness training should be given to new workers either before or at the time of initial assignment to a job involving exposure to a pressure system hazard as required by §851.25(b)(1). Customized pressure system safety training provides workers with pressure system safety information, hazard analysis results, and hazard controls that are specific to a particular pressure system. Periodic or additional training may be required if changes to the pressure system introduce new hazards or increase existing hazards as required by §851.25(b)(2) and §851.25(b)(3).
§851.26 Recordkeeping and reporting	Program Description: Pressure System Safety
(a) *Recordkeeping.* Contractors must:	4.7 Recordkeeping and Reporting
(1) Establish and maintain complete and accurate records of all hazard inventory information, hazard assessments, exposure measurements, and exposure controls.	Maintenance and retrieval of accurate and complete pressure system safety information including hazard inventory information, results of hazard analyses, exposure measurements, and exposure controls is critical to the long-term viability of an effective worker safety and health program for pressure systems as required in §851.26(a)(1). Whenever possible, this information should be recorded and stored in an electronic format for convenient retrieval. A hazard analysis report template in the Perform Hazard Analysis and Identify/Implement Mitigation Strategies procedure includes guidelines for documenting pressure system safety information. Procedure: Perform Hazard Analysis and Identify/Implement Mitigation Strategies Step 6. The team documents the hazard analysis and mitigation strategies.

Compliance Matrix for Pressure System Safety

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
§851.26 Recordkeeping and reporting (b) *Reporting and investigation.* Contractors must: (1) Report and investigate accidents, injuries and illness;	Program Description: Pressure System Safety 4.7 Recordkeeping and Reporting In an effort to provide continuous improvement in the worker safety and health program for pressure safety, pressure system incidents should be investigated and reported as required in §851.26(b)(1). Requirements for investigating pressure system incidents are included in the Operate Pressure System procedure. Procedure: Operate Pressure System Step 3. Staff refers to the Critiques and Investigations subject area and Manage Change and Non-Routine Work procedure as needed.
§851.27 Reference sources (b) *List of standards incorporated by reference.* (7) American Society of Mechanical Engineers (ASME) Boilers and Pressure Vessel Code, sections I through XII including applicable Code Cases, (2004). (8) ASME B31 (ASME Code for Pressure Piping) as follows: (i) B31.1-2001-Power Piping, and B31.1a-2002-Addenda to ASME B31.1-2001; (ii) B31.2-1968-Fuel Gas Piping; (iii) B31.3-2002-Process Piping; (iv) B31.4-2002-Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; (v) B31.5-2001-Refrigeration Piping and Heat Transfer Components, and B31.5a- 2004, Addenda to ASME B31.5-2001; (vi) B31.8-2003-Gas Transmission and Distribution Piping Systems; (vii) B31.8S-2001-Managing System Integrity of Gas Pipelines; (viii) B31.9-1996-Building Services Piping; (ix) B31.11-2002-Slurry Transportation Piping Systems; and (x) B31G-1991-Manual for Determining Remaining Strength of Corroded Pipelines.	Program Description: Pressure System Safety 2.0 Purpose The Pressure System Safety subject area establishes safety policies and procedures for ensuing that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. These principles are defined in pressure vessel and piping codes adopted by the American Society of Mechanical Engineers (ASME) and adopted by applicable state and local jurisdictional laws. For pressure systems and related components that are not covered by these codes, measures for ensuring a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local jurisdictional laws should be implemented.

Compliance Matrix for Pressure System Safety

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
Appendix A **4 Pressure Safety** (a) Contractors must establish safety policies and procedures to ensure that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles.	Program Description: Pressure System Safety 2.0 Purpose The Pressure System Safety subject area establishes safety policies and procedures for ensuing that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. These principles are defined in pressure vessel and piping codes adopted by the American Society of Mechanical Engineers (ASME) and adopted by applicable state and local jurisdictional laws. For pressure systems and related components that are not covered by these codes, measures for ensuring a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local jurisdictional laws should be implemented.

Compliance Matrix for Pressure System Safety

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
Appendix A **4 Pressure Safety** (b) Contractors must ensure that all pressure vessels, boilers, air receivers, and supporting piping systems conform to: (1) The applicable American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (2004); sections I through section XII including applicable Code Cases (incorporated by reference, see §851.27) (2) The applicable ASME B31 (Code for Pressure Piping) standards as indicated below; and or as indicated in paragraph (b)(3) of this section: (i) B31.1-2001-Power Piping, and B31.1a-2002-Addenda to ASME B31.1-2001 (incorporated by reference, see §851.27); (ii) B31.2-1968-Fuel Gas Piping (incorporated by reference, see §851.27); (iii) B31.3-2002-Process Piping (incorporated by reference, see §851.27); (iv) B31.4-2002-Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids (incorporated by reference, see §851.27); (v) B31.5-2001-Refrigeration Piping and Heat Transfer Components, and B31.5a-2004, Addenda to ASME B31.5-2001 (incorporated by reference, see §851.27); (vi) B31.8-2003-Gas Transmission and Distribution Piping Systems (incorporated by reference, see §851.27); (vii) B31.8S-2001-Managing System Integrity of Gas Pipelines (incorporated by reference, see §851.27); (viii) B31.9-1996-Building Services Piping (incorporated by reference, see §851.27); (ix) B31.11-2002-Slurry Transportation Piping Systems (incorporated by reference, see §851.27); and (x) B31G-1991-Manual for Determining Remaining Strength of Corroded Pipelines (incorporated by reference, see §851.27). (3) The strictest applicable state and local codes.	Program Description: Pressure System Safety 1.0 Introduction Pressure safety requirements are covered in two subject areas within the Standards-Based Management System (SBMS), the Pressure System Safety subject area and the Pressure Vessels and Related Components subject area. The Pressure Vessels and Related Components subject area describes the process for designing, acquiring and installing ASME-certified pressure vessels and components. It also includes suggested guidelines for non-certified pressure vessels. The Pressure System Safety subject area identifies requirements and describes methods for conducting activities involving new or existing **pressure systems** at the Oak Ridge National Laboratory (ORNL).

Compliance Matrix for Pressure System Safety

Requirement in 10 CFR 851 Applicable to Pressure Safety	Compliance Action
(c) When national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials, etc.), contractors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local code. Measures must include the following:	
(1) Design drawings, sketches, and calculations must be reviewed and approved by a qualified independent design professional (*i.e.*, professional engineer). Documented organizational peer review is acceptable.	
(2) Qualified personnel must be used to perform examinations and inspections of materials, in-process fabrications, non-destructive tests, and acceptance test.	
(3) Documentation, traceability, and accountability must be maintained for each unique pressure vessel or system, including descriptions of design, pressure conditions, testing, inspection, operation, repair, and maintenance.	

ATTACHMENT 1 – PROGRAM DESCRIPTION FOR PRESSURE SYSTEM SAFETY

The text for Appendix B, Attachment 1 is presented as Appendix C.

ATTACHMENT 2 – EXHIBIT: PRESSURE SYSTEM APPLICABILITY

The pressure system safety requirements are applicable to all pressure systems and components, except when the system:

1. is continuously vented to atmosphere through a flow path providing sufficient capacity to preclude overpressurization, or

2. has a volumetric capacity not exceeding 5.0 ft^3 (0.14 m^3) and the product of pressure (P) times volume (V) does not exceed 73 psi-ft^3 (14 kPa-m^3); where "P" is the maximum allowable working pressure (MAWP) or differential pressure in psig (kPa), and "V" is the volumetric capacity in ft^3 (m^3).

3. has a system volume which exceeds the limitations given in (2) above, but whose maximum stored energy potential does not exceed 10,000 joules in all credible scenarios, or

4. is limited to portable containers having a capacity not greater than 5 gallons (19 L) and is primarily used for the convenient storage, transport, or use of:

    - edible or potable substances which are intended for personal consumption (i.e., beverage, food, or medicine containers or packaging)

    - personal hygiene substances (shampoo, deodorant, toothpaste, perfume, etc.)

    - consumer or industrial substances addressed by other subject areas or established procedures and guidelines (paints, solvents, adhesives, cleaning agents, and other substances; whether inert or hazardous)

5. comprises a self-contained, portable assembly whose functional design and pressure safety considerations comply with nationally recognized standards for such devices. Examples of these systems include refrigerators, window air conditioners, water fountains, small food preparation and housekeeping appliances, personal hygiene devices, and similar mechanisms.

6. items covered by other subject areas, including but not limited to, compressed gas cylinders.

Note: Examples of atmospheric pressure systems may include, but are not limited to: sanitary and storm drains; heating, ventilation, and air conditioning (HVAC) air handling and ventilation distribution systems and components; etc. Technical assistance in determining the applicability of any pressure system for compliance to or exemption from these requirements may be obtained from the subject matter expert.

When systems are functionally interdependent, the boundaries for each system are determined by the type of interface occurring between the systems. The interface types and applicable boundaries are defined as follows:

1. Communicating (co-mingled flow paths between systems) - the boundary must be at the sealing surface of the first mechanical joint or the weld edge preparation for the first circumferential weld joint where system interface connections are made (e.g., a boiler drum attachment point where both feed water and steam systems attach).

2. Indirectly Communicating (separate flow paths, but functionally interdependent, where thermal or pressure interactions occur between systems) - the boundary of each system is shared by the common element(s) across which the thermal or pressure interactions take place, but separate flow paths of the interfacing systems are maintained (e.g., tube and tube sheets of a heat exchanger).

3. Non-Communicating - multiple system inputs which converge in a common component, but maintain distinctly separate flow paths. The various systems have essentially no interconnection or common elements, and have no functional interaction (e.g., a single instrumentation or control module with multiple independent pressure sensing connections from pressure systems).

APPENDIX B. PRESSURE SYSTEM SAFETY PROGRAM DESCRIPTION

APPENDIX B. PRESSURE SYSTEM SAFETY PROGRAM DESCRIPTION

B.1 INTRODUCTION

Pressure safety requirements are covered in two subject areas within the Standards-Based Management System (SBMS), the Pressure System Safety subject area and the Pressure Vessels and Related Components subject area.

The Pressure Vessels and Related Components subject area describes the process for designing, acquiring and installing ASME-certified pressure vessels and components. It also includes suggested guidelines for non-certified pressure vessels. For legacy pressure vessels, see the Implementation Plan for Legacy Pressure Vessels and the procedure Maintaining Legacy Pressure Vessels. Information on flexible hose assemblies can also be found in the Guide on the Selection and Use of Flexible Hose Assemblies. The Pressure Vessels and Related Components subject area includes the following procedures for designing, acquiring and installing pressure vessels and related components:

- Designing a Pressure Vessel
- Acquiring an Offsite-Manufactured Pressure Vessel
- Acquiring an Onsite-Fabricated Pressure Vessel
- Installing a Pressure Vessel
- Inspecting a Pressure Vessel
- Taking a Pressure Vessel Out of Service
- Reactivating a Pressure Vessel
- Repairing or Altering a Pressure Vessel
- Maintaining Legacy Pressure Vessels

The Pressure System Safety subject area identifies requirements and describes methods for conducting activities involving new or existing pressure systems at the Oak Ridge National Laboratory (ORNL). This includes pressure systems owned or operated by the Department of Energy (DOE) or UT-Battelle, as well as others if contracted work requirements require following UT-Battelle/ORNL procedures, whether the work is conducted at ORNL or off site. A pressure system consists of all pressure vessels and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems due to their potential for catastrophic failure due to overpressurization. Associated hardware (e.g., gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system.

The primary function of a pressure system is to safely confine solid, liquid, or gaseous material or maintain a vacuum within a leak-tight pressure boundary consisting of interconnected pressure-retaining components such as pressure vessels, tanks, pipes, valves, fittings, and pressure relief devices. Effective pressure system safety management involves a systematic approach to evaluating the pressure system as a whole rather than assuring that individual pressure-retaining items are designed, constructed, and operated safely.

The Pressure System Safety subject area includes the following procedures for identifying, evaluating, and mitigating consequences of unwanted releases from a pressure system that could occur as a result of failures in process, procedures, or equipment:

- Identify Pressure System
- Gather System Information
- Perform Hazard Analysis and Identify/Implement Mitigation Strategies

- Complete/Verify Pre-Startup Activities
- Operate Pressure System
- Manage Change and Non-Routine Work

B.2 PURPOSE

The purpose of the Pressure System Safety subject area is to achieve compliance with pressure safety requirements in DOE's Worker Safety and Health Program, 10 CFR 851, by providing procedures for preventing uncontrolled releases of toxic chemicals and hazardous energy from pressure systems. This regulation establishes the framework for an effective worker safety and health program that provides DOE contractor workers with a safe and healthful workplace in which workplace hazards are abated, controlled, or otherwise mitigated in a manner that provides reasonable assurance that workers are adequately protected from identified hazards.

The Pressure System Safety subject area establishes safety policies and procedures for ensuing that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. These principles are defined in pressure vessel and piping codes adopted by the American Society of Mechanical Engineers (ASME) and adopted by applicable state and local jurisdictional laws. For pressure systems and related components that are not covered by these codes, measures for ensuring a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local jurisdictional laws should be implemented.

B.3 RESPONSIBILITIES

The Division Director or his/her designee is responsible for assigning a point of contact (POC) for the pressure system. The System POC is responsible for identifying team members to support pressure system evaluation. The team members are responsible for identifying equipment intended to contain a medium above or below atmospheric pressure under any foreseeable operating or upset condition and for determining if the medium (gas, liquid, solid, or vacuum) is confined by a pressure boundary. The **system evaluation team** members are responsible for gathering pressure system information, characterizing hazards, and determining if the pressure system is within the scope of the Pressure System Safety subject area. The team members should include subject matter experts and workers that are knowledgeable in the applicable technologies, hazards, and safety issues.

For pressure systems that are within the scope of the Pressure System Safety subject area, the System POC is responsible for establishing a pressure system identifier that uniquely distinguishes one pressure system from another and for selecting individuals for the **hazard analysis team.** This team is responsible for conducting the hazard analysis for a pressure system, identifying potential pressure system hazards that require mitigation, developing appropriate mitigation strategies, and documenting the hazard analysis and mitigation strategies.

A pressure system hazard analysis is best performed by a team with varied operational and technical backgrounds. The team leader needs to be knowledgeable in the selected hazard analysis methodology and remain impartial throughout the evaluation. At least one team member should be familiar with the physical features and performance requirements for the pressure system. An ideal team consists of individuals who collectively possess knowledge of the standards, codes, specifications, and regulations applicable to the pressure system.

The system POC is responsible for selecting team members to conduct/verify pre-startup activities for a pressure system. This **pre-startup review team** is responsible for verifying that hazard mitigation

strategies have been developed and implemented in accordance with applicable Pressure System Safety procedures, identifying and documenting acceptance criteria to complete/verify pre-startup activities for a pressure system, and reviewing and verifying that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. The pre-startup review team is also responsible for verifying that the system is ready to operate. An ideal pre-startup review team should have knowledge of the standards, codes, specifications, and regulations applicable to the pressure system and include worker representation.

Staff is responsible for developing a management of change (MOC) process for a pressure system. The purpose of the MOC process is to control all modifications to a pressure system that could adversely affect the leak tight integrity or structural capacity of a pressure system or result in an uncontrolled release. Staff are also responsible for identifying and reviewing each proposed change; documenting the basis for a change; revising pressure system safety information, pressure system hazard analysis, pressure system training, and pressure system operating procedures to reflect the change, as appropriate; conducting a pre-startup review, if necessary; following the implementation of a change; and maintaining MOC documentation in accordance with the MOC process.

B.4 PROGRAM ELEMENTS AND IMPLEMENTATION METHODS

The specific program requirements in 10 CFR 851, Subpart C reflect what DOE considers the essential elements of a successful worker safety and health program. These requirements are subdivided into the following categories:

- Management responsibilities and worker rights (§851.20)
- Hazard identification and assessment (§851.21)
- Hazard prevention and abatement (§851.22)
- Safety and health standards (§851.23)
- Functional areas (§851.24)
- Training and information (§851.25)
- Recordkeeping and reporting (§851.26)

Mandatory requirements for implementing pressure safety are provided in 10 CFR 851, Appendix A. Decisions concerning implementation of worker protection measures should be based on a graded approach to ensure that available resources are used most efficiently.

B.4.1 Management Responsibilities and Worker Rights and Responsibilities

Procedures in the Pressure System Safety subject area represent a structured approach for complying with DOE's Worker Safety and Health Program requirements for pressure safety including management responsibilities and worker rights and responsibilities requirements defined in §851.20. Methods for determining whether or not a pressure system exists and if it is within the scope of the Pressure System Safety subject area are provided in the Identify Pressure System procedure.

B.4.2 Hazard Identification and Assessment

Requirements for identifying and assessing pressure system hazards are defined in §851.21(a), (b), and (c). Compliance with these requirements involves the collection of information about the pressure system followed by a thorough, orderly, and systematic approach to identifying, evaluating, and controlling existing and potential workplace hazards associated with a release.

B.4.2.1 Pressure System Safety Information

Accurate, written, and complete pressure system safety information is essential to an effective hazard assessment required by §851.21(a). To be useful, it should include documentation that addresses pressure system hazards, technologies, and equipment. A procedure for Gathering System Information is included in the Pressure System Safety subject area. This procedure includes instructions for determining pressure system applicability and guidelines for identifying and compiling pressure system safety information.

Although pressure system safety information may exist in many forms, reference to important documents should be provided whenever the applicable information is not readily accessible. If original information about pressure system hazards, technologies, or equipment does not exist or is not available, it must be created. Without complete pressure system safety information, it may be difficult or impossible to perform an effective hazards analysis or determine if process changes or pressure system equipment modifications increase the risk of an uncontrolled release.

B.4.2.2 Hazard Analysis

Hazard analysis is a term used broadly to discuss all aspects of hazards identification and analysis, safety and accident analyses, and associated documentation. A pressure system safety hazard analysis is an organized and systematic effort to identify and analyze the significance of potential hazards associated with a pressure system including the technology employed to safely contain its contents. It also helps workers make decisions for improving safety and reducing the consequences of unwanted or unplanned releases. The primary objective of a hazard analysis is to identify potential causes and consequences of fires, explosions, releases of toxic or flammable chemicals, and major spills of hazardous chemicals by focusing on pressure system equipment, instrumentation, utilities, routine and non-routine human actions, and external factors that might adversely impact worker safety and health.

To be effective, the hazard identification and assessment activities should be performed by a team of people with varied operational and technical backgrounds. The team leader needs to be fully knowledgeable in the proper implementation of the analysis methodology that is used and should be impartial in the evaluation. The other full-time or part-time team members need to provide the team with expertise in areas such as process chemistry, pressure system technology and design, operating procedures and practices, including how the work is actually performed, alarms, emergency procedures, instrumentation, maintenance procedures, both routine and non-routine tasks, including how the tasks are authorized, procurement of parts and supplies, safety and health, and any other relevant subject as the need dictates. Participation by workers and their elected representatives as members of the team as required by §851.20(a)(4) may provide the team with a more complete understanding of the hazards and assistance in identifying measures to mitigate the potential consequences of a release. At least one team member must be familiar with the physical features and performance requirements for the process. An ideal team consists of individuals that have knowledge of the standards, codes, specifications, and regulations applicable to the pressure system.

To help assure that all hazards are identified and evaluated, the hazard analysis team must use methods that consider the existing and potential workplace hazards and risks associated with the eight areas defined in §851.21(a), as applicable. Analyzing designs of new facilities and modifications to existing facilities and equipment for potential workplace hazards is required by §851.21(a)(4). This analysis must be performed initially to obtain baseline information and as often thereafter as necessary to ensure compliance with the requirements in §851.21(c). Use of pressure system safety information is an essential part of an effective hazard analysis.

The Perform Hazard Analysis and Identify/Implement Mitigation Strategies procedure in the Pressure System Safety subject area includes steps for conducting a pressure system safety hazard analysis, guidelines for selecting an appropriate hazard analysis method, and a hazard analysis report template. Although the hazard analysis methodology selected must be appropriate for the type and complexity of the pressure system being assessed, use of a combination of methods may provide complementary findings that may be useful to the team in validating the results.

The initial hazard analysis for a pressure system must be documented and recorded as required by §851.26(a)(1). It should also be included as part of the pressure system safety information. Any modifications or updates to the hazard analysis must also be documented so the hazard analysis remains current.

B.4.3 Hazard Prevention and Abatement

To comply with §851.22(a) requirements, all identified pressure system hazards must be prevented or abated through a hazard prevention or abatement process. For hazards identified during design or development, controls must be incorporated in the facility design or procedure. For existing hazards, controls must be based on the following hierarchy which is specified in §851.22(b):

(1) Elimination or substitution of the hazards where feasible and appropriate;
(2) Engineering controls where feasible and appropriate;
(3) Work practices and administrative controls that limit worker exposures; and
(4) Personal protective equipment.

Hazards must also be a consideration in selecting or purchasing equipment, products, or services as described in §851.22(c).

The Perform Hazard Analysis and Identify/Implement Mitigation Strategies procedure includes a hazard analysis report template that can be used to document the hazard analysis findings and mitigation strategies to comply with requirements in §851.26(a)(1).

B.4.4 Safety and Health Standards

The Occupational Safety and Health Administration (OSHA) standard on Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119, is the only safety and health standard listed in §851.23 that applies specifically to pressure systems. However, it only applies to processes that contain specific types and quantities of chemicals listed in 29 CFR 1910.119, Appendix A. The OSHA requirements in 29 CFR 1910.119 do not typically apply at ORNL because the amounts of these chemicals that are processed or stored are generally much less than the threshold quantities.

Although this standard only applies to facilities where the listed chemicals are processed or stored in large quantities, the Process Safety Management (PSM) approach used by OSHA to formulate this standard is based on technology developed at the Center for Chemical Process Safety (CCPS) by the American Society of Chemical Engineers (AIChE). This technology was developed in the 1980s as part of an effort to evaluate existing methods to design pressure relief systems for runaway reactions and to develop additional process-safety technologies.

Because DOE contractors may manage facilities and processes covered by the OSHA rule for Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119, DOE's Office of Health (EH-5) developed two handbooks that provide guidance in complying with these rules. The purpose of the two handbooks, Process Safety Management for Highly Hazardous Chemicals, DOE-HDBK-1101-2004 and

Chemical Process Hazards Analysis, DOE-HDBK-1100-2004 is to facilitate implementation of the provisions of the rule within the DOE.

The approach used to develop the pressure system safety management procedures in the Pressure System Safety subject area is consistent with the information in the DOE handbooks and the technology developed at the CCPS.

B.4.5 Functional Areas

Rules in §851.24(a) for pressure safety and pressure system safety standards and provisions defined in Appendix A require the development of policies and procedures for ensuring that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. To achieve this objective, all pressure vessels, boilers, air receivers, and supporting piping system must conform to:

- The applicable American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (2004); Sections I through Section XII including applicable Code Cases as indicated in §851.27(b)(7).
- The applicable ASME B31 (Code for Pressure Piping) standards as indicated in §851.27(b)(8)
- The strictest applicable state and local codes.

However, when national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials, etc.) these pressure retaining items must comply with alternative requirements defined in Appendix A, §4(c). These requirements indicate that the following three measures must be implemented to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local code.

- Design drawings, sketches, and calculations must be reviewed and approved by a qualified independent design professional (i.e., professional engineer). Documented organizational peer review is acceptable.
- Qualified personnel must be used to perform examinations and inspections of materials, in-process fabrications, non-destructive tests, and acceptance test.
- Documentation, traceability, and accountability must be maintained for each unique pressure vessel or system, including descriptions of design, pressure conditions, testing, inspection, operation, repair, and maintenance.

State and local codes are included in this list because they often incorporate requirements contained in other national codes and consensus standards such as the International Building Code and the International Fire Code. At ORNL, state and local codes apply to some, but not all, facilities. Code interpretations and issues are resolved in concert with the ORNL Code Authority and relevant subject matter experts as delineated in the SBMS Engineering Management System. However, DOE is the final code authority for DOE facilities on the ORNL site.

The Pressure System Safety subject area includes three additional procedures for meeting pressure safety requirements in 10 CFR 851. The Complete/Verify Pre-Startup Activities procedure includes steps for establishing acceptance criteria for verifying that a pressure system is ready to operate. A key requirement in this procedure involves verification that hazard mitigation strategies are implemented. The Operate Pressure System procedure includes steps for addressing accidents and events, assessing impacts of

operational or design changes, performing routine maintenance and inspections, and determining if the pressure system is to be placed in standby or decommissioned. The Manage Change and Non-Routine Work procedure includes steps for establishing a management of change (MOC) process for controlling all modifications to a pressure system that can adversely affect worker safety and health.

B.4.6 Training and Information

Training is an important aspect of DOE's Worker Safety and Health Program and is therefore a key element of the Pressure System Safety subject area. Program requirements for training and information are defined in §851.25. Compliance with these requirements involves developing and implementing a worker safety and health training and information program for ensuring that all workers exposed or potentially exposed to hazards are provided with the training and information on that hazard in order to perform their duties in a safe and healthful manner. In this context, the term worker includes both ORNL and subcontractor employees who are involved in activities that could be affected by a pressure system release.

Pressure system safety training is also required to comply with management responsibilities defined in §851.20(a)(5) for providing workers with access to relevant program information. The Complete/Verify Pre-Startup Activities includes a requirement to review and verify that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. Although the levels of training needed to comply with this requirement vary from one pressure system to another, two types of worker training should be considered.

General pressure system safety training provides workers with an overview of the health and safety issues associated with building, operating, testing, maintaining, altering, and repairing pressure systems. This training focuses on awareness of the types of pressure retaining items that may be part of a pressure system, potential hazards to the human and natural environment associated with the stored energy, and the possible consequences of an uncontrolled or unplanned release. Awareness training should be given to new workers either before or at the time of initial assignment to a job involving exposure to a pressure system hazard as required by §851.25(b)(1). Customized pressure system safety training provides workers with pressure system safety information, hazard analysis results, and hazard controls that are specific to a particular pressure system. Periodic or additional training may be required if changes to the pressure system introduce new hazards or increase existing hazards as required by §851.25(b)(2) and §851.25(b)(3).

B.4.7 Recordkeeping and Reporting

Maintenance and retrieval of accurate and complete pressure system safety information including hazard inventory information, results of hazard analyses, exposure measurements, and exposure controls is critical to the long-term viability of an effective worker safety and health program for pressure systems as required in §851.26(a)(1). Whenever possible, this information should be recorded and stored in an electronic format for convenient retrieval. A hazard analysis report template in the Perform Hazard Analysis and Identify/Implement Mitigation Strategies procedure includes guidelines for documenting pressure system safety information.

In an effort to provide continuous improvement in the worker safety and health program for pressure safety, pressure system incidents should be investigated and reported as required in §851.26(b)(1). Requirements for investigating pressure system incidents are included in the Operate Pressure System procedure.

B.5 SBMS DOCUMENTS SUPPORTING THIS PROGRAM DESCRIPTION

The Pressure System Safety subject area establishes safety policies and procedures for ensuing that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. External requirements for the Pressure System Safety subject area are included in DOE's Worker Safety and Health Program, 10 CFR 851. The specific program requirements in 10 CFR 851, Subpart C reflect what DOE considers the essential elements of a successful worker safety and health program. Mandatory requirements for implementing pressure safety are provided in 10 CFR 851, Appendix A.

APPENDIX C. PRESSURE SYSTEM INTEGRITY PROGRAM DESCRIPTIONS

APPENDIX C. PRESSURE SYSTEM INTEGRITY PROGRAM DESCRIPTIONS

PRESSURE SYSTEM INTEGRITY PROGRAM FOR OVERPRESSURE PROTECTION SEPTEMBER 6, 2011

C.1. INTRODUCTION

C.1.1 Scope

C.1.1.1 The Pressure System Integrity Program for Overpressure Protection represents capabilities and expertise within ORNL's Fabrication, Hoisting, and Rigging (FHRD) for

1. determining overpressure protection requirements for pressure-retaining items and pressure systems, and

2. ensuring that pressure-retaining items and pressure systems are protected from all credible overpressure events.

Pressure systems means all pressure vessels, and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems due to their potential for catastrophic failure due to backfill pressurization. Associated hardware (*e.g.*, gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system. The term pressure-retaining item refers to pressure vessels, boilers, tanks, piping, valves, associated hardware, and other types of components with a leak tight pressure boundary and sufficient structural capacity for preventing an uncontrolled release.

The program scope includes the following elements.

- overpressure protection by system design
- pressure relief device sizing and effluent handling system design
- pressure relief system specifications and procurement
- pressure relief device receiving inspection and acceptance
- pressure relief device inservice inspection and testing

The FHRD Surveillance manages the Pressure System Integrity Program for Overpressure Protection.

C.1.1.2 The Pressure System Integrity Program for Overpressure Protection is applicable to pressure-retaining items and pressure systems that are

1. located on government property and owned by DOE or UT-Battelle, and
2. operate above or below atmospheric pressure.

C.1.1.3 Pressure-retaining items and pressure systems that are leased by DOE or UT-Battelle are excluded from the scope of the Pressure System Integrity Program for Overpressure Protection.

C.1.2 Objective

C.1.2.1 The Pressure System Integrity Program for Overpressure Protection communicates methods used by FHRD staff to assist owners of pressure-retaining items and pressure systems comply with pressure safety requirements in Appendix A of DOE's *Worker Safety and Health Program*, 10 CFR 851.

C.1.2.2 Compliance involves establishing safety policies and procedures for ensuring that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. Specifically, owners must ensure that all pressure-retaining items and pressure systems are capable of protecting workers from workplace hazards including physical, chemical, biological, or safety hazards with any potential to cause illness, injury, or death to a person.

C.1.3 Responsibilities

C.1.3.1 The ORNL Standards Based Management System (SBMS) Subject Area: Pressure System Safety defines staff responsibilities for complying with pressure safety requirements in DOE's *Worker Safety and Health Program*, 10 CFR 851. According to procedures in this Subject Area, the Division Director appoints a Point of Contact (POC) who is responsible for selecting team members to conduct a hazard analysis for each pressure system. This hazard analysis team is responsible for conducting the hazard analysis for the pressure system, identifying potential pressure system hazards that require mitigation, and documenting the hazard analysis and mitigation strategies. For pressure systems that include different types of pressure-retaining items, an ideal team consists of staff that own and operate the system and other individuals that have knowledge of the standards, codes, specifications, inspection, testing, repair, and regulations applicable to the system and its various pressure-retaining items.

C.1.3.2 The Pressure System Safety Subject Matter Expert (SME) is responsible for communicating with the POC about the scope and objective of hazard analysis and for identifying appropriate FHRD staff and other knowledgeable personnel to serve as members of the hazard analysis team. The SME is also responsible for providing the hazard analysis team with information about the potential consequences of an uncontrolled release from a pressure system or pressure-retaining item and assisting the team develop hazard prevention and abatement strategies for protecting workers.

C.1.3.3 The SME and FHRD staffs are responsible for assisting the hazard analysis team identify and gather pressure system safety information applicable to the pressure-retaining items in the pressure system.

C.1.3.3 The SME and FHRD staffs are responsible for assisting the owners of a pressure systems implement the hazard prevention and abatement strategies identified in the hazard analysis. Hazard prevention and abatement strategies for avoiding overpressure events generally involve a pressure relief system based on overpressure protection by system design or installation of at least one appropriately sized pressure relief device.

All possible overpressure scenarios that constitute a hazard under the prevailing conditions must be identified as part of the hazard analysis process before selecting a pressure relief system for the application. Overpressure can occur because of a single failure or multiple events, and each scenario may involve the release from one or more pressure relief devices. The probability of occurrence for each event should be determined to help identify credible overpressure scenarios.

After a list of credible overpressure scenarios is established, each scenario is evaluated in terms of pressure generated and the rates at which material must be relieved. These results along with process flow diagrams, material balance data, process chemistry, piping and instrumentation diagrams, equipment specification sheets, and the overall performance and safety objectives of the facility are used to establish the design basis for the pressure relief system. Selection and sizing of pressure relief devices that satisfy the design basis are the responsibility of the owner with assistance from individuals knowledgeable in pressure relief system design and technology. Users are responsible for ensuring that the specified pressure relief devices are properly installed prior to initial operation.

C.1.3.3 The SME and FHRD staffs are responsible for assisting the owner of a pressure system evaluate various options for protecting pressure-retaining items from exceeding allowable pressure limits. Overpressure protection can be provided by installing pressure relief devices on each pressure-retaining item or by system design. The choice depends on applicable code rules and the potential consequences of an unplanned release.

C.2 OVERPRESSURE PROTECTION BY SYSTEM DESIGN

C.2.1 Surveillance staff can assist owners of pressure systems identify overpressure scenarios and determine whether overpressure protection by system design in lieu of pressure relief devices is a viable hazard prevention strategy. Rules for overpressure protection by system design are provided in the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UG-140 (2007 Edition, 2009 Addenda).

C.2.2. Viability is assessed by verifying that the maximum allowable working pressure of the pressure-retaining items is greater than the highest pressure that can reasonably be expected for the pressure system under all credible operating scenarios and upset conditions, including equipment and instrumentation malfunctions. Surveillance staff can also assist owners of pressure systems document the overpressure protection by system design assessment and establish the design basis for the various pressure-retaining items in the pressure system consistent with the assessment results.

C.3 PRESSURE RELIEF DEVICE SIZING AND EFFLUENT HANDLING SYSTEM DESIGN

C.3.1 Surveillance staff can assist owners of pressure systems select the appropriate types of pressure relief devices for a pressure system and determine the pressure relieving capacity needed to protect the pressure system from all credible operating scenarios and upset conditions. In addition, Surveillance staff can assist the owner size inlet and outlet piping connected to pressure relief devices so that excessive pressure loss in either the inlet or outlet manifolds do not restrict flow through the pressure relief device and result in insufficient pressure relief capacity. Results of these technical determinations establish the design basis for the pressure relief system.

C.3.2 A pressure relief device is an integral part of a pressure relief system. It automatically opens at a predetermined or set pressure level and thereby provides a venting path for the contained material. Pressure relief devices should only function during abnormal events or emergency situations. They should not be used to control pressure during normal operations including startup and shutdown. Temperature-actuated devices can have distinct advantages over pressure-actuated styles, but these devices are typically intended for control purposes and are usually not certified for pressure relief applications.

Selection of the proper type and size pressure relief device for a particular application is critically important. If the flow capacity of the pressure relief device is insufficient, the pressure can continue to rise when the volumetric flow rate through the device is less than the rate of volume increase of the confined material. In a properly designed pressure relief system, a volumetric balance will be struck before the pressure rises above an acceptable pressure limit. Volume increases typically result from:

- excess material inflow,
- gas generation from chemical reactions,
- thermal expansion, or
- vaporization due to heat input from external sources or internal exothermic processes.

C.3.3 Pressure relief devices are subdivided into two categories – reclosing and non-reclosing pressure relief devices.

C.3.3.1 Reclosing pressure relief devices are designed to open to relieve excess pressure and to reclose when normal conditions are restored. Although the spring loaded pressure relief valve is the most widely used reclosing pressure relief device, there are many other types. Safety, relief, safety-relief, pilot-operated, power-actuated, and temperature-actuated pressure relief valves are terms commonly used to refer to reclosing pressure relief devices. A vacuum relief valve is also a reclosing type pressure relief device because it is designed to reclose and prevent further flow of fluid after normal conditions are restored.

Pressure relief valves open under excessive static pressure to allow the contents to flow until normal pressure has been restored. Their operation is characterized by rapid opening pop action or by opening generally proportional to the increase in pressure over the opening pressure. Once the system pressure has decreased to a certain value less that the set pressure, normal conditions have been restored and the valve closes to prevent further escape of the contents. Pressure relief valves can be used for either gas or liquid service.

Pressure relief devices are also used to vent excessive vacuum from pressure vessels that are not designed for full vacuum service. Venting may be required as material is removed from a closed pressure vessel or the temperature of the contents is reduced. Without proper venting, excessive vacuum can cause the heads to collapse or the wall to buckle thereby resulting in structural failure. Pressure and vacuum vent valves are actuated either by excessive pressure or vacuum. The three major types of pressure and vacuum vent valves include weight-loaded pallet vent valves, pilot-operated vent valves, and spring- or weight-loaded vent valves.

C.3.3.2 Non-reclosing pressure relief devices automatically open at a set pressure and remain open until they are manually reset or replaced. Rupture disk devices are a very common type of non-reclosing pressure relief device. Other types include breaking pin, buckling pin, fusible plug, shear pin, and blow-off manhole cover devices.

A rupture disk device consists of a solid, relatively thin piece of material that is generally installed between a pair of specially designed flanges. The flanges have machined hold-down seats that hold the disk in place and prevent it from slipping. Rupture disks may be designed in several configurations such as flat, domed (prebulged), or reverse acting. A conventional domed rupture disk is a prebulged solid metal disk designed to burst when the concave side is acted upon by excessive pressure. Correct installation is essential for this type of disk to function as intended during an overpressure event.

Rupture disks are often used instead of pressure relief valves in situations that involve:

- rapid pressure rise,
- toxic fluids where no leakage past a reclosing pressure relief device is permitted,
- corrosive fluids that may cause progressive deterioration of a reclosing pressure relief device, and
- fluids that deposit solids or gums that could interfere with the operation of a reclosing pressure relief device (Parry 1992).

Use of a rupture disk device in series with a reclosing pressure relief device such as a pressure relief valve is sometimes necessary. This configuration can be effective in minimizing the loss of valuable or hazardous materials by leakage through the pressure relief valve and can be used in situations where a rupture disk alone or a rupture disk located on the inlet side of a pressure relief valve is impracticable. This combination can also be used to prevent corrosive gases from reaching the vulnerable internals of a pressure relief valve. Whenever a rupture disk device is used in combination with a pressure relief valve, the combination should be carefully evaluated to ensure that the media being handled and the valve operational characteristics will result in opening of the valve coincident with the bursting of the rupture disk.

Although use of a rupture disk device and a reclosing pressure relief device in series is permitted, inservice problems can arise that can affect performance during an emergency. A rupture disk will not burst at its prescribed pressure if back pressure builds up in the space between the disk and the pressure relief valve. This situation can occur when leakage develops in the rupture disk due to corrosion or other causes. Users should be cautioned that many common styles of pressure relief valves will not open at the prescribed set pressure if back pressure builds up in the space between the valve and rupture disk. For this situation, a specially designed valve is required such as a diaphragm valve or a valve equipped with a bellows above the disk.

C.3.4 Equipment for proper effluent handling is usually influenced by the size and types of pressure relief devices that are present in the system, the flow rates and quantities of materials that could be discharged, and the expected relief scenarios. In properly designed effluent handling systems, the process technologies and equipment selected meet the requirements of all credible release scenarios. In addition to pressure vessels and piping components, other equipment that may be part of a properly designed effluent handling system includes:

- Absorbers
- Cyclone separators
- Dump (blowdown) tanks
- Flame arrestors
- Flares
- Gravity separators (horizontal and vertical)
- Incinerators
- Quench pools or tanks
- Scrubbers
- Spray towers
- Stacks

- Vane impingement separators
- Vapor-liquid separators

To ensure that effluent handling systems operate as intended during an emergency, periodic inspection and regular maintenance of the equipment may be necessary.

C.4 PRESSURE RELIEF SYSTEM SPECIFICATIONS AND PROCUREMENT

C.4.1 Surveillance staff can assist owners of pressure systems develop technical specifications for procuring pressure relief devices and effluent handling system components. The specifications need to reflect applicable design criteria and performance requirements consistent with the design basis for the pressure relief system.

Surveillance staff can also assist owners of pressure systems identify candidate vendors for the pressure relief devices and effluent handling system components and compile budgetary cost estimates for the vendors. In addition, Surveillance staff can develop criteria for evaluating the Offeror's technical proposals for greatest value, lowest price procurements.

C.5 PRESSURE RELIEF DEVICE RECEIVING INSPECTION AND ACCEPTANCE

C.5.1 FHRD staff can assist owners of pressure systems by examining pressure relief devices when they arrive at the ORNL receiving department and verifying that the pressure relief devices meet the technical specifications. FHRD staff will reject pressure relief devices that do not meet the applicable acceptance criteria.

C.5.2 FHRD staff can also assist owners of pressure systems by conducting acceptance testing of pressure relief devices. The test methods and acceptance criteria are described in the FHRD procedure titled "Inspection and Test of Pressure Relieving Devices" (Ref. C.7.1). FHRD staff will document the inspection and test results and provide the results to the pressure system owner.

C.5.3 Surveillance staff will enter the pressure relief devices in the inspection database so that inservice inspections can be conducted by the FHRD staff at prescribed intervals. Surveillance staff is also capable of assisting ORNL personnel install pressure relief devices and verify their operational readiness.

C.6 PRESSURE RELIEF DEVICE INSERVICE INSPECTION AND TESTING

C.6.1 FHRD staff is capable of assisting owners of pressure systems by conducting inservice inspections and testing of pressure relief devices in accordance with requirements in the FHRD procedure titled "Inspection and Test of Pressure Relieving Devices" (Ref. C.7.1). FHRD staff will document the inspection and test results and provide the results to the pressure system owner.

C.6.2 The "Inservice Inspection Manual" (Ref. C.7.2) defines the organizational structure, functional responsibilities, levels of authority, lines of communication and assignment of responsibilities for inservice inspections. This manual also documents the program policies; describes the processes for implementing the requirements of the NBIC (Ref. C.7.3); and outlines the management approach for planning, controlling, and accomplishing inservice inspection activities at ORNL.

C.7 REFERENCES

C.7.1 “Inspection and Test of Pressure Relieving Devices,” FD-T-SSI 2002 Rev 1, Fabrication Hoisting and Rigging Division, October 20, 2006

C.7.2 “Inservice Inspection Manual,” Fabrication Hoisting and Rigging Division, 2011

C.7.3 “National Board Inspection Code,” NB-23, National Board of Boiler and Pressure Vessel Inspectors, 2010

PRESSURE SYSTEM INTEGRITY PROGRAM
FOR
PRESSURE VESSELS
AUGUST 31, 2011

C.8 INTRODUCTION

C.8.1 Scope

C.8.1.1 The Pressure System Integrity Program for Pressure Vessels represents capabilities and expertise within ORNL's Fabrication, Hoisting, and Rigging (FHRD) for

1. periodically examining pressure vessels to verify system safety, and

2. evaluating the pressure-retaining capacity and structural integrity of pressure vessels for continued service.

The program scope includes the following elements.

- inspection and testing
- fitness-for-service assessments
- repairs and replacements
- design and procurement

The Pressure System Integrity Program for Pressure Vessels is managed by staff of the FHRD Surveillance Group.

C.8.1.2 The Pressure System Integrity Program for Pressure Vessels is applicable to pressure vessels that are

1. within the scope of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Divisions 1, 2, and 3, and

2. operated by UT-Battelle staff provided the pressure vessels are located on government property and owned by DOE or UT-Battelle.

C.8.1.2 Pressure vessels that are leased by DOE or UT-Battelle are excluded from the scope of the Pressure System Integrity Program for Pressure Vessels.

C.8.2 Objective

C.8.2.1 The Pressure System Integrity Program for Pressure Vessels communicates methods used by FHRD staff to assist owners of pressure vessels comply with pressure safety requirements in Appendix A of DOE's *Worker Safety and Health Program*, 10 CFR 851.

C.8.2.2 Compliance involves establishing safety policies and procedures for ensuring that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles.

Specifically, owners must ensure that all pressure vessels conform to requirements in the following sections of the 2004 edition of the ASME Boiler and Pressure Vessel Code, as applicable.

- Section VIII, Rules for Construction of Pressure Vessels, Division 1
- Section VIII, Rules for Construction of Pressure Vessels, Division 2-Alternative Rules
- Section VIII, Rules for Construction of Pressure Vessels, Division 3-Alternative Rules for Construction of High Pressure Vessels

C.8.3 Responsibilities

C.8.3.1 The ORNL Standards Based Management System (SBMS) Subject Area: Pressure System Safety defines staff responsibilities for complying with pressure safety requirements in DOE's *Worker Safety and Health Program*, 10 CFR 851. According to procedures in this Subject Area, the Division Director appoints a Point of Contact (POC) who is responsible for selecting team members to conduct a hazard analysis for the pressure system that includes the pressure vessel. This hazard analysis team is responsible for conducting the hazard analysis for the pressure system, identifying potential pressure system hazards that require mitigation, and documenting the hazard analysis and mitigation strategies. For pressure systems that include pressure vessels, an ideal team consists of staff that own and operate the system and other individuals that have knowledge of the standards, codes, specifications, inspection, testing, repair, and regulations applicable to the system.

C.8.3.2 The Pressure System Safety Subject Matter Expert (SME) is responsible for communicating with the POC about the scope and objective of hazard analysis and for identifying appropriate FHRD staff and other knowledgeable personnel to serve as members of the hazard analysis team. The SME is also responsible for providing the hazard analysis team with access to the documents listed in Sect. 5 for consideration in developing hazard prevention and abatement strategies.

C.8.3.3 The SME and FHRD staff is responsible for assisting the hazard analysis team identify and gather safety information applicable to pressure vessels in the pressure system.

C.8.3.4 The SME and FHRD staff is responsible for assisting the owner of a pressure system implement the hazard prevention and abatement strategies identified in the hazard analysis. Hazard prevention and abatement strategies for verifying the integrity of pressure vessels and ensuring that they are safe to operate involve periodic external and internal inspections, fitness-for-service assessments, repairs, and replacements.

C.9 INSPECTION AND TESTING

C.9.1 Inspection and testing of pressure-retaining items including pressure vessels are conducted by FHRD staff in accordance with guidelines and requirements in Ref. C.13.1. These guidelines and requirements are consistent with Part 2, Section 2 of the National Board Inspection Code (NBIC) (Ref. C.13.2).

C.9.2 Inspections of pressure vessels are only performed by FHRD staff that have demonstrated competency by passing the National Board Commission Examination and have six months of

on-the-job experience. These Inspectors are certified by the National Board of Boiler and Pressure Vessel Inspectors and have a National Board Inservice Inspector Commission.

C.9.3 Nondestructive examinations of pressure vessel are only performed by FHRD staffs that are certified in accordance with requirements in Ref. C.13.3.

C.9.4 Inspection of pressure relief devices for pressure vessels are conducted in accordance with requirements in Ref. C.13.4.

C.9.5 The "Inservice Inspection Manual" (Ref. C.13.5) defines the organizational structure, functional responsibilities, levels of authority, lines of communication and assignment of responsibilities for inservice inspections. This manual also documents the program policies; describes the processes for implementing the requirements of the NBIC (Ref. C.13.2); and outlines the management approach for planning, controlling, and accomplishing inservice inspection activities at ORNL.

C.10 FITNESS-FOR-SERVICE ASSESSMENTS

C.10.1 Fitness-for-service (FFS) assessments for pressure vessels that have degraded while in service are conducted by Surveillance staff in accordance with standardized procedures and methods defined in Ref. C.13.6.

C.10.2 The procedures and methods defined in Ref. C.13.6 were developed to evaluate the pressure boundaries of pressure vessels, boiler components, and piping with a flaw resulting from single or multiple damage mechanisms. A general fitness-for-service assessment involves the following eight steps.

Step	Description
1	Flaw and Damage Mechanism Identification
2	Applicability and Limitations of the FFS Assessment Procedures
3	Data Requirements
4	Assessment Techniques and Acceptance Criteria
5	Remaining Life Evaluation
6	Remediation
7	In-Service Monitoring
8	Documentation

C.11 REPAIRS AND REPLACEMENTS

C.11.1 The "Inservice Inspection Manual" (Ref. C.13.5) describes the Inservice Inspection Program for ORNL for complying with NBIC (Ref. C.13.2) requirements including inspection activities for continued service of boilers, pressure vessels and piping and necessary inspections to facilitate shop and field repairs to pressure-retaining items.

C.11.2 The FHRD Director has full responsibility and authority over the implementation of the Inservice Inspection Program.

C.11.3 The Inservice Inspection Program is managed and implemented by a team of individuals within the FHRD with the following titles: Division Director, Surveillance Program Manager, Mechanical Engineer, and Inspector.

C.12 DESIGN AND PROCUREMENT

C.12.1 Surveillance staff is capable of assisting ORNL personnel develop designs for pressure vessels including

- Determining ASME Code rules that apply to pressure vessel
- Establishing design criteria
- Collecting and filing documentation

C.12.2 Surveillance staff is capable of assisting ORNL personnel acquire onsite fabricated pressure vessels and procure offsite manufactured pressure vessels by performing the following activities.

- Determine quality assurance, fabrication, and procurement requirements
- Perform receiving inspections
- Collect and file documentation

C.12.3 Surveillance staff is capable of assisting ORNL personnel install and inspect pressure vessels and pressure relief devices and place pressure vessels and pressure relief devices on an inservice inspection schedule.

C.12.4 Surveillance staff is capable of assisting ORNL personnel remove pressure vessels from service and return pressure vessels to active service.

C.13 REFERENCES

C.13.1 “Inspection and Testing of Pressure-Retaining Items,” FHRD-T-SSI 1006 Rev 1, Fabrication Hoisting and Rigging Division, July 11, 2009

C.13.2 “National Board Inspection Code,” NB-23, National Board of Boiler and Pressure Vessel Inspectors, 2010

C.13.3 “Qualification/Certification Requirements for NDE Examiners,” FHRD-ADM-ACP-11 Rev. 2, October 9, 2009

C.13.4 “Inspection and Test of Pressure Relieving Devices,” FD-T-SSI 2002 Rev. 1, Fabrication Hoisting and Rigging Division, October 20, 2006

C.13.5 “Inservice Inspection Manual,” Fabrication Hoisting and Rigging Division, 2011

C.13.6 “Fitness-For-Service,” API 579/ASME FFS-1, American Petroleum Institute and American Society of Mechanical Engineers, June 5, 2007

PRESSURE SYSTEM INTEGRITY PROGRAM
FOR
HAZARD ANALYSIS AND HAZARD MITIGATION
AUGUST 31, 2011

C.14 INTRODUCTION

C.14.1 Scope

C.14.1.1 The Pressure System Integrity Program for Hazard Analysis and Hazard Mitigation represents capabilities and expertise within ORNL's Fabrication, Hoisting, and Rigging Division (FHRD) for assisting pressure system owners

1. conduct hazard analyses and
2. identify hazard mitigation strategies for protecting workers from pressure system hazards.

The program scope includes the following elements.

- hazard identification and assessment
- hazard prevention and abatement

The Pressure System Integrity Program for Hazard Analysis and Hazard Mitigation is managed by the FHRD Surveillance Group.

C.14.1.2 The Pressure System Integrity Program for Hazard Analysis and Hazard Mitigation is applicable to pressure systems as defined in 10 CFR 851.3 – Definitions and restated below.

> *Pressure systems* means all pressure vessels, and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems should be considered pressure systems due to their potential for catastrophic failure due to backfill pressurization. Associated hardware (*e.g.*, gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system.

C.14.2 Objective

C.14.2.1 The Pressure System Integrity Program for Hazard Analysis and Hazard Mitigation describes capabilities within the Surveillance Group for assisting pressure system owners comply with the following DOE's *Worker Safety and Health Program*, 10 CFR 851, Subpart C – Specific Program Requirements.

- §851.21 Hazard identification and assessment
- §851.22 Hazard prevention and abatement

C.14.2.2 Compliance involves identify existing and potential workplace hazards and establishing and implementing a hazard prevention and abatement process to ensure that all identified and potential hazards are prevented or abated in a timely manner. The term workplace hazard is defined in 10 CFR 851.3 – Definitions to mean a physical, chemical, biological, or safety hazard with any potential to cause illness, injury, or death to a person.

C.14.3 Responsibilities

C.14.3.1 The ORNL Standards Based Management System (SBMS) Subject Area: Pressure System Safety defines staff responsibilities for complying with pressure safety requirements in DOE's *Worker Safety and Health Program*, 10 CFR 851. According to procedures in this Subject Area, the Division Director appoints a Point of Contact (POC) who is responsible for selecting team members to conduct a hazard analysis for a pressure system. This hazard analysis team is responsible for conducting the hazard analysis for the pressure system, identifying potential pressure system hazards that require mitigation, and documenting the hazard analysis and mitigation strategies. For pressure systems that include pressure vessels, an ideal team consists of staff that own and operate the system and other individuals that have knowledge of the standards, codes, specifications, inspection, testing, repair, and regulations applicable to the system.

C.14.3.2 The Pressure System Safety Subject Matter Expert (SME) is responsible for communicating with the POC about the scope and objective of hazard analysis and for identifying appropriate FHRD staff and other knowledgeable personnel to serve as members of the hazard analysis team. The SME is also responsible for providing the hazard analysis team with access to the documents discussed in Sect. 2 for consideration in developing hazard prevention and abatement strategies.

C.14.3.3 The SME and FHRD staffs are responsible for assisting the hazard analysis team identify and gather safety information applicable to the various pressure-retaining components in the pressure system as the need dictates.

C.14.3.4 The SME and FHRD staffs are responsible for assisting the owner of a pressure system implement the hazard prevention and abatement strategies identified in the hazard analysis.

C.15 HAZARD IDENTIFICATION AND ASSESSMENT

Surveillance staff is capable of assisting pressure system owners compile pressure system safety information and conduct hazard analyses in accordance with pressure safety requirements in 10 CFR 851.21. The staff is also capable of understanding and interpreting the requirements in the health and safety standards listed in 10 CFR 851.23(a) and the reference sources in 10 CFR 851.27(b). In addition, Surveillance staff manages a database of pressure system safety information for legacy pressure-retaining items within the ORNL complex.

Pressure System Safety Information

Accurate, written, and complete pressure system safety information is essential to an effective hazard assessment required by 10 CFR 851.21(a). To be useful, it should include documentation that addresses pressure system hazards, technologies, and equipment. A procedure for Gathering System Information is included in the Pressure System Safety Subject Area. This procedure includes instructions for determining pressure system applicability and guidelines for identifying and compiling pressure system safety information.

Although pressure system safety information may exist in many forms, reference to important documents should be provided whenever the applicable information is not readily accessible. If original information about pressure system hazards, technologies, or equipment does not exist or is not available, it must be created. Without complete pressure system safety information, it may be difficult or impossible to perform an effective hazards analysis or determine if process

changes or pressure system equipment modifications increase the risk of an uncontrolled release.

Hazard Analysis

Hazard analysis is a term used broadly to discuss all aspects of hazards identification and analysis, safety and accident analyses, and associated documentation. A pressure system safety hazard analysis is an organized and systematic effort to identify and analyze the significance of potential hazards associated with a pressure system including the technology employed to safely contain its contents. It also helps workers make decisions for improving safety and reducing the consequences of unwanted or unplanned releases. The primary objective of a hazard analysis is to identify potential causes and consequences of fires, explosions, releases of toxic or flammable chemicals, and major spills of hazardous chemicals by focusing on pressure system equipment, instrumentation, utilities, routine and non-routine human actions, and external factors that might adversely impact worker safety and health.

To be effective, the hazard identification and assessment activities should be performed by a team of people with varied operational and technical backgrounds. The team leader needs to be fully knowledgeable in the proper implementation of the analysis methodology that is used and should be impartial in the evaluation. The other full-time or part-time team members need to provide the team with expertise in areas such as process chemistry, pressure system technology and design, operating procedures and practices, including how the work is actually performed, alarms, emergency procedures, instrumentation, maintenance procedures, both routine and non-routine tasks, including how the tasks are authorized, procurement of parts and supplies, safety and health, and any other relevant subjects as the need dictates. Participation by workers and their elected representatives as members of the team as required by 10 CFR 851.20(a)(4) may provide the team with a more complete understanding of the hazards and assistance in identifying measures to mitigate the potential consequences of a release. At least one team member must be familiar with the physical features and performance requirements for the process. An ideal team consists of individuals that have knowledge of the standards, codes, specifications, and regulations applicable to the pressure system.

To help assure that all hazards are identified and evaluated, the hazard analysis team must use methods that consider the existing and potential workplace hazards and risks associated with the eight areas defined in 10 CFR 851.21(a), as applicable. Analyzing designs of new facilities and modifications to existing facilities and equipment for potential workplace hazards is required by 10 CFR 851.21(a)(4). This analysis must be performed initially to obtain baseline information and as often thereafter as necessary to ensure compliance with the requirements in 10 CFR 851.21(c). Use of pressure system safety information is an essential part of an effective hazard analysis.

The Perform Hazard Analysis and Identify/Implement Mitigation Strategies procedure in the Pressure System Safety Subject Area includes steps for conducting a pressure system safety hazard analysis, guidelines for selecting an appropriate hazard analysis method, and a hazard analysis report template. Although the hazard analysis methodology selected must be appropriate for the type and complexity of the pressure system being assessed, use of a combination of methods may provide complementary findings that may be useful to the team in validating the results.

Surveillance staff is also capable of assisting pressure system owners document and record the initial hazard analysis for a pressure system as required by §851.26(a)(1) and ensure that the

hazard analysis is included as part of the pressure system safety information. Any modifications or updates to the hazard analysis must also be documented so the hazard analysis remains current.

C.16 HAZARD PREVENTION AND ABATEMENT

Surveillance staff is capable of assisting pressure system owners develop hazard mitigation strategies in accordance with pressure safety requirements in 10 CFR 851.22. To comply with 10 CFR 851.22(a) requirements, all identified pressure system hazards must be prevented or abated through a hazard prevention or abatement process. For hazards identified during design or development, controls must be incorporated in the facility design or procedure. For existing hazards, controls must be based on the following hierarchy which is specified in 10 CFR 851.22(b).

(1) Elimination or substitution of the hazards where feasible and appropriate
(2) Engineering controls where feasible and appropriate
(3) Work practices and administrative controls that limit worker exposures
(4) Personal protective equipment

Surveillance staff is also capable of assisting pressure system owners ensure that hazards are considered in selecting or purchasing equipment, products, or services as described in §851.22(c).

PRESSURE SYSTEM INTEGRITY PROGRAM
FOR
POWER AND HEATING BOILERS
SEPTEMBER 6, 2011

C.17 INTRODUCTION

C.17.1 Scope

C.17.1.1 The Pressure System Integrity Program for Power and Heating Boilers represents capabilities and expertise within ORNL's Fabrication, Hoisting, and Rigging (FHRD) for

1. periodically examining power and heating boilers to verify their safety, and

2. evaluating the pressure-retaining capacity and structural integrity of power and heating boilers for continued service.

The program scope includes the following elements.

- inspection and testing
- fitness-for-service assessments
- repairs and replacements

The Pressure System Integrity Program for Power and Heating Boilers is managed by staff of the FHRD Surveillance Group.

C.17.1.2 The Pressure System Integrity Program for Power and Heating Boilers is applicable to boilers that are

1. identified either in American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section I, Part PG or Section IV, Part HG, and

2. operated by UT-Battelle staff provided these boilers are located on government property and owned by DOE or UT-Battelle.

C.17.1.3 Boilers that are leased by DOE or UT-Battelle are excluded from the scope of the Pressure System Integrity Program for Power and Heating Boilers.

C.17.2 Objective

C.17.2.1 The Pressure System Integrity Program for Power and Heating Boilers communicates methods used by FHRD staff to assist owners of a steam or hot water pressure system that includes either a power or heating boiler comply with requirements in DOE's *Worker Safety and Health Program*, 10 CFR 851, Appendix A for pressure safety.

C.17.2.2 Compliance involves establishing safety policies and procedures for ensuring that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles. Specifically, owners must ensure that all boilers conform to requirements in ASME Boiler and Pressure Vessel Code, Sections I and IV including applicable Code Cases, (2004).

C.17.3 Responsibilities

C.17.3.1 The ORNL Standards Based Management System (SBMS) Subject Area: Pressure System Safety defines staff responsibilities for complying with pressure safety requirements in DOE's *Worker Safety and Health Program*, 10 CFR 851. According to procedures in this Subject Area, the Division Director appoints a Point of Contact (POC) who is responsible for selecting team members to conduct a hazard analysis for the steam or hot water pressure system. This hazard analysis team is responsible for conducting the hazard analysis for the pressure system, identifying potential pressure system hazards that require mitigation, and documenting the hazard analysis and mitigation strategies. For a steam or hot water pressure system, an ideal team consists of staff that own and operate the system and other individuals that have knowledge of the standards, codes, specifications, inspection, testing, repair, and regulations applicable to the system.

C.17.3.2 The Pressure System Safety Subject Matter Expert (SME) is responsible for communicating with the POC about the scope and objective of hazard analysis and for identifying appropriate FHRD staff and other knowledgeable personnel to serve as members of the hazard analysis team. The SME is also responsible for providing the hazard analysis team with access to the documents listed in Sect. 5 for consideration in developing hazard prevention and abatement strategies.

C.17.3.3 The SME and FHRD staff is responsible for assisting the hazard analysis team identify and gather safety information applicable to the steam or hot water pressure system.

C.1.3.4 The SME and FHRD staff is responsible for assisting the owner of a steam or hot water pressure system implement the hazard prevention and abatement strategies identified in the hazard analysis. Hazard prevention and abatement strategies for verifying the integrity of power and heating boilers and ensuring that they are safe to operate involve periodic external and internal inspections, fitness-for-service assessments, repairs, and replacements.

C.18 INSPECTION AND TESTING

C.18.1 Inspection and testing of pressure-retaining items including power and heating boilers are conducted by FHRD staff in accordance with guidelines and requirements in Ref. C.21.1. These guidelines and requirements are consistent with Part 2, Section 2 of the National Board Inspection Code (NBIC) (Ref. C.21.2). Inspections are only performed by FHRD staff that have demonstrated competency by passing the National Board Commission Examination and have six months of on-the-job experience. These Inspectors are certified by the National Board of Boiler and Pressure Vessel Inspectors and have a National Board Inservice Inspector Commission.

C.18.2 Inspections of power and heating boiler are only performed by FHRD staff that have demonstrated competency by passing the National Board Commission Examination and have six months of on-the-job experience.

C.18.3 Nondestructive examinations of power and heating boiler components are only performed by FHRD staff that is certified in accordance with requirements in Ref. C.21.3.

C.18.4 Inspection of pressure relief devices for power and heating boilers are conducted in accordance with requirements in Ref. C.21.4.

C.18.5 The "Inservice Inspection Manual" (Ref. C.21.5) defines the organizational structure, functional responsibilities, levels of authority, lines of communication and assignment of responsibilities for inservice inspections. This manual also documents the program policies; describes the processes for implementing the requirements of the NBIC (Ref. C.21.2); and outlines the management approach for planning, controlling, and accomplishing inservice inspection activities at ORNL.

C.19 FITNESS-FOR-SERVICE ASSESSMENTS

C.19.1 Fitness-for-service (FFS) assessments for power and heating boilers that have degraded while in service are conducted by Surveillance staff in accordance with standardized procedures and methods defined in Ref. C.21.6.

C.19.2 The procedures and methods defined in Ref. C.21.6 were developed to evaluate the pressure boundaries of pressure vessels, boiler components, and piping with a flaw resulting from single or multiple damage mechanisms. A general fitness-for-service assessment involves the following eight steps.

Step	Description
1	Flaw and Damage Mechanism Identification
2	Applicability and Limitations of the FFS Assessment Procedures
3	Data Requirements
4	Assessment Techniques and Acceptance Criteria
5	Remaining Life Evaluation
6	Remediation
7	In-Service Monitoring
8	Documentation

C.20 REPAIRS AND REPLACEMENTS

C.20.1 The "Inservice Inspection Manual" (Ref. C.21.5) describes the Inservice Inspection Program for ORNL for complying with NBIC (Ref. C.21.2) requirements including inspection activities for continued service of boilers, pressure vessels and piping and necessary inspections to facilitate shop and field repairs to pressure-retaining items.

C.20.2 The FHRD Director has full responsibility and authority over the implementation of the Inservice Inspection Program.

C.20.3 The Inservice Inspection Program is managed and implemented by a team of individuals within the FHRD with the following titles: Division Director, Surveillance Program Manager, Mechanical Engineer, and Inspector.

C.21 REFERENCES

C.21.1 "Inspection and Testing of Pressure-Retaining Items," FHRD-T-SSI 1006 Rev 1, Fabrication Hoisting and Rigging Division, July 11, 2009

C.21.2 "National Board Inspection Code," NB-23, National Board of Boiler and Pressure Vessel Inspectors, 2010

C.21.3 “Qualification/Certification Requirements for NDE Examiners,” FHRD-ADM-ACP-11 Rev. 2, October 9, 2009

C.21.4 “Inspection and Test of Pressure Relieving Devices,” FD-T-SSI 2002 Rev. 1, Fabrication Hoisting and Rigging Division, October 20, 2006

C.21.5 “Inservice Inspection Manual,” Fabrication Hoisting and Rigging Division, 2011

C.21.6 “Fitness-For-Service,” API 579/ASME FFS-1, American Petroleum Institute and American Society of Mechanical Engineers, June 5, 2007

APPENDIX D. MONTHLY STATUS REPORT FOR SEPTEMBER 28, 2012

APPENDIX D. MONTHLY STATUES REPORT FOR SEPTEMBER 28, 2012

ASSESSMENT AND COMMITMENT TRACKING SYSTEM
FINAL MONTHLY REPORT FOR ASSESSMENT NUMBER: 11044

Assessment Type: Internal Assessment; Safety Assessment
Assessment Owner: Mark Lower
Assessment Title: Inspection Plan for Legacy Vessels
Assessment Description: Perform internal and ultrasonic inspection of boilers and pressure vessels in accordance with NBIC requirements, as applicable and as stated in Milestone #5 of the Implementation Plan for Legacy Pressure Vessels and item 7(b)10 of the Variance Request for 10 CFR 851, Worker Safety and Health Program Inspection of Pressure Vessels per ASME Boiler and Pressure Vessel Code.
Owning Organization: Surveillance (50206885)

Barry Oland
September 28, 2012

D.1 INTRODUCTION

The U.S. Department of Energy (DOE) promulgated worker safety and health regulations to govern contractor activities at DOE sites in February 2006. The final rule codified the department's Worker Protection Program requirements established in DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*. Worker health and safety requirements that govern the conduct of contractor activities at DOE sites are provided in 10 CFR 851, *Worker Safety and Health Program* (Ref. 1). This regulation establishes requirements for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. The regulation also states that contractors must achieve compliance with all the requirements of Subpart C – *Specific Program Requirements*, and their approved worker safety and health program no later than May 25, 2007.

On June 27, 2012, the ORNL Site Office of DOE reviewed the updated ORNL Worker Safety and Health Program Description (WSHPD) dated May 2012 and issued a letter stating that DOE evaluated the ORNL WSHPD for compliance with applicable requirements and determined it to be acceptable (Ref. 2). The letter included the following statement.

> 10 CFR 851.27(a)(7) and (8) incorporates specific Pressure Piping, Boilers, and Pressure Vessel Code references from2004, which have been updated since 851 was issued. Since new pressure vessels cannot be purchased or fabricated to the older obsolete codes, this WSHPD revision ensures your adherence to the current versions of these incorporated Pressure Piping, Boilers, and Pressure Vessel Code references.

D.1.1 Pressure Safety Requirements

According to 10 CFR 851, Subpart C – *Specific Program Requirements*, contractors must have a structured approach to their worker safety and health program which at a minimum includes provisions for pressure safety. In implementing the structured approach for pressure safety, contractors must establish safety policies and procedures to ensure that pressure systems are designed, fabricated, tested, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with

applicable and sound engineering principles. In addition, contractors must ensure that all pressure vessels, boilers, air receivers, and supporting piping systems conform to (1) applicable American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (2004); sections I through section XII including applicable Code Cases; (2) applicable ASME B31 (Code for Pressure Piping) standards; and (3) the strictest applicable state and local codes. When national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials, etc.), contractors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local codes.

The term pressure system means all pressure vessels, and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems should be considered pressure systems due to their potential for catastrophic failure due to backfill pressurization. Associated hardware (*e.g.*, gauges and regulators), fittings, piping, pumps, and pressure relief devices are also integral parts of the pressure system. This definition of pressure system, which is all encompassing and provides no exclusions, means that any leak tight pressure boundary is within the scope of DOE's 10 CFR 851, *Worker Safety and Health Program*.

Consequences for non-compliance with DOE's 10 CFR 851, *Worker Safety and Health Program* requirements are illustrated and explicitly stated in the "Preliminary Notice of Violation," WEA-2010-02 that was issued by the U.S. Department of Energy, National Nuclear Security Administration on June 1, 2010 (Ref. 3) for an explosives safety incident that occurred at the Sandia National Laboratory. The violations center on non-compliance with two key rules in 10 CFR 851, Subpart C – *Specific Program Requirements* involving hazard identification and assessments (§851.21) and hazard prevention and abatement (§851.22). Although the violation involved an explosives safety incident, the hazard identification and prevention rules in 10 CFR 851, Subpart C – *Specific Program Requirements* apply equally to pressure safety.

D.1.2 10 CFR 851 Variance Request for Legacy Pressure Vessels

The rule, codified as 10 CFR 851, established a variance process that provides contractors with an exception to compliance with some part or the entire rule with DOE approval. In February 2007 (Ref. 4), UT-Battelle filed a temporary variance with DOE from 10 CFR 851 requirements related to legacy pressure vessels (LPVs). This variance addresses approximately 1154 legacy pressure vessels used on site for research and support services. The target variance completion date is September 30, 2012. The temporary variance was requested because the necessary construction and alteration of the facility could not be completed by the prescribed date of May 25, 2007. In May 2012, the variance completion date was extended to December 31, 2012 to allow sufficient time to finalize closure documentation.

D.1.3 10 CFR 851 Variance Corrective Actions

Variance corrective actions for legacy pressure vessel are tracked under ORNL's Assessment and Commitment Tracking System (ACTS) Number 11044 which is owned by the Surveillance organization within ORNL's Fabrication, Hoisting and Rigging Division (FHRD). The objectives of corrective actions being performed by the Surveillance staff to achieve satisfactory closure of all ACTS 11044 Action Items are to (1) identify and inspect legacy pressure vessels, (2) resolve all deficiencies, and (3) ensure that satisfactory close-out documentation is entered into ACTS by September 30, 2012. To achieve this goal, Surveillance committed to resolve at least 25 ACTS 11044 Action Items per quarter beginning June 1, 2010.

On May 15, 2010, ACTS 11044 included 193 Action Items (Ref. 5). This total included 29 Action Items that were closed satisfactorily, 57 Action Items that were accepted by the owner, and 107 Action Items

that were not yet accepted by the owner. On September 28, 2012, ACTS 11044 included 216 Action Items. The total number of ACTS 11044 Action Items increased from 193 to 216 because additional legacy pressure vessel deficiencies were identified by the Surveillance staff as they focused on addressing the following issues.

- Assisting owners develop action plans for resolving deficiencies reported in ACTS 11044.
- Compiling pressure vessel nameplate information, Manufacturer's Data Reports, and other types of historical documentation, if available.
- Compiling pressure relief device specifications, inspection records, and historical repair and replacement data.
- Continuing initial inspections of legacy pressure vessels to meet variance request milestones and entering deficiencies into ACTS 11044 as appropriate.
- Reviewing inspection reports to identify legacy pressure vessels with deficiencies that need to be entered into ACTS 11044.
- Implementing a process for identifying and notifying owners of deficient pressure vessels, working with the owners to resolve the deficiency, and entering the deficiency into ACTS 11044 if the deficiency is not resolved within 90 days.
- Verifying closure documentation for accuracy and completeness and modifying the existing text to provide sufficient and satisfactory closure evidence.

A summary of legacy pressure vessel variance issues related to ACTS 11044 Action Items is presented in Sect. 2.

Surveillance staff completed development of the Access formatted "Inspection Database" in July 2011. The "Inspection Database" includes up-to-date information compiled for the 1312 currently identified pressure retaining items at ORNL. Based on a review of the information in this database, inspections for all pressure vessels have been completed. Surveillance staff is also continuing to obtain shell thickness measurement results and other specific types of data needed to maintain and update the database.

Surveillance staff also continues to maintain and improve an ORNL website that describes capabilities within the Surveillance Group for assisting divisions comply with pressure safety requirements in 10 CFR 851. In addition, Surveillance staff is continuing to prepare hazard analyses for new pressure systems and posting them on the website to assist other ORNL divisions comply with the hazard analysis procedure in the SBMS Pressure Safety Subject Area. Surveillance staff is also working with the Facilities Management Division to ensure compliance with the SBMS Pressure Safety Subject Area. The types of documents included on the website are described in Sect. 3.2.

On September 21, 2012, the final open ACTS 11044 Action Item was closed completing all of the variance corrective actions for legacy pressure vessels at ORNL.

D.1.4 Potential Vulnerabilities

In May 2010, a study revealed that the remaining open Action Items in ACTS 11044 are a vulnerability to UT-Battelle's ability to meet its variance commitments (Ref. 5). The study concluded that to correct the deficiencies, craft resources will be necessary, and line management will need to identify funding. With a

significant number of corrective actions to complete, craft resources to make the necessary repairs may be stretched. If the Action Item owners continue to delay implementing corrective actions, there may not be sufficient time or funding available to complete the actions on schedule. The study also revealed that a second vulnerability involves implementation of guidance in SBMS for complying with pressure safety requirements in 10 CFR 851.

Actions taken to address these potential vulnerabilities and related problem areas are discussed in Sect. 3.

D.1.5 Contributions and Accomplishments

A summary of major contributions and accomplishments completed to date by the Surveillance Group follows.

- Published SBMS Pressure System Safety Subject Area in August 2011
- Revised SBMS Pressure Vessel and Related Components Subject Area in May 2012
- Closed 100% of ACTS 11044 Action Items
- Published *Steam Pressure-Reducing Station Safety and Energy Efficiency Improvement Project,* ORNL/TM-2010/284, January 2011
- Realized $1,000,000 in cost savings by improving steam system safety and energy efficiency
- Published Federal Inspection Agency (FIA) Manual, and obtained accreditation as a Federal Inspection Agency from The National Board of Boiler and Pressure Vessel Inspectors – a first for any branch of the US government
- Revised ORNL inspection procedures for pressure system components and pressure-retaining items to more fully assess the safety of pressure vessel and establish more consistent and accurate documentation of these assessments.
- Developed Surveillance Group website that contains useful information for owners of pressure systems at ORNL including:
  - ✓ hazard analyses for oxygen, acetylene, argon, and compressed air pressure systems
  - ✓ pressure system integrity programs for boilers, piping, pressure vessels, pressure relief devices, and hazard analysis and hazard mitigation
  - ✓ PowerPoint presentation describing roles and responsibilities for achieving compliance with pressure system safety requirements in 10 CFR 851
- Completed inspections for 100% of high-risk legacy pressure vessels at ORNL
- Participated in Lean Team meetings to identify options for safely and efficiently storing and distributing liquid nitrogen at ORNL and issued a report in January 2012 describing proposed actions and alternatives identified by the Lean Team
- Addressed problem areas involving inspection of insulated legacy pressure vessels by:
  - ✓ working with insulators to prioritize insulation abate activities
  - ✓ identifying locations for installation of inspection ports
- Completed verification of closure documentation for 215 Action Items.

- Rerated 8 pressure vessels to extend their useful service life and reduce the number of required inspections.

- Completed closure of all ACTS 11044 Action Items.

On November 1, 2011, the Fabrication, Hoisting and Rigging Division of the Facilities and Operations Directorate of UT-Battelle, LLC set a historic precedent by being the very first organization to obtain accreditation as a Federal Inspection Agency from the National Board of Boiler and Pressure Vessel Inspectors ("The National Board"). The National Board is an organization of the Chief Boiler and Pressure Vessel Inspectors in the States of the United States, the Provinces of Canada, and some municipalities having populations exceeding 1 million persons; and is recognized as being technically competent in the field of pressure equipment by Federal, State, and Municipal authorities.

The National Board exists to facilitate public safety by administering Boiler and Pressure Vessel Inspector training and certification programs, ensuring the safe operation of boilers and pressure vessels by promoting the establishment of laws ("boiler laws") among the member jurisdictions, and striving to achieve uniformity of those laws between their member jurisdictions. These boiler laws require:

1. construction and certification of boilers and pressure vessels in compliance with the ASME Boiler and Pressure Vessel Code ("the Code") when these items are to be installed and operated within the jurisdiction;

2. regular, periodic inspections of boilers and pressure vessels to verify their condition remains acceptable for continued operations; and

3. application of the National Board Inspection Code (NBIC) requirements for repairs and alterations of pressure equipment.

In most states, provinces, and municipalities either a state inspector or a "special" inspector (one employed by an insurance company) performs the required periodic inspections.

The codes and standards published by the National Board meet the requirements of the American National Standards Institute (ANSI) for consensus standards. This means the standards have been prepared and approved by consensus committees consisting of stakeholders representing a balanced makeup in their areas of interest to ensure impartiality. These codes and standards address the requirements for inspector training and certification, accreditation of inspection and repair organizations, and established practices for repairing or altering pressure retaining items.

As a US Government reservation, ORNL is specifically exempted from complying with the Laws of the State of Tennessee as they pertain to boilers and pressure vessels. However, federal regulations exist for ensuring personnel safety under 10 CFR 851, Appendix A, Part 4; which requires contractors at DOE sites to implement a Pressure Safety Program. Each program must ensure pressure equipment is safe for operation through effective implementation of procedures for procurement, inspection, engineering, hazard assessments, and ongoing maintenance. These programs must comply with nationally recognized standards such as the ASME Code for the procurement of new pressure equipment, and the NBIC for inspection and repairs of operating pressure equipment. Pressure equipment installed prior to the implementation of these requirements ("legacy equipment") must be evaluated for safety compliance. When pressure equipment is not certifiable as compliant with the Code, the pressure equipment must be afforded an equivalent level of safety as if these requirements had been applied.

As the prime management contractor for operation of a DOE site, UT-Battelle, LLC is responsible for compliance with 10 CFR 851 at ORNL. The accreditation of UT-Battelle, LLC as a Federal Inspection Agency demonstrates the ORNL inservice inspection program has effectively applied the objective standards of the National Board for carrying out the inspections of installed and operating pressure equipment.

In December 2011, Surveillance staff began performing the following activities in preparation for the upcoming Community of Practices meeting that will focus on pressure system safety at ORNL.

- Identifying potential pressure safety topics and compliance issues that could be discussed during the meeting.

- Preparing appropriate responses to potential questions from a multidisciplinary team of meeting participants.

- Developing hazard analyses for pressure systems in the Fabrication, Hoisting and Rigging Division for consistency with 10 CFR 851, Subpart C – *Specific Program Requirements*.

Community of Practices for Pressure Safety meetings was held the week of June 12-14, 2012. During the meetings, subject matter experts from Pacific Northwest National Laboratory (PNNL), Lawrence Livermore National Laboratory (LLNL), and Idaho National Laboratory (INL) reviewed ORNL's pressure safety program and evaluated overall compliance with pressure safety requirements in 10 CFR 851. Review activities focused on overview presentations by Tom Etheridge and Mark Lower, discussions with FHRD staff, tours of ORNL fabrication shops and facilities with active pressure systems, and evaluation of SBMS Pressure System Safety and Pressure Vessels and Related Components Subject Areas. .After the review, the subject matter experts determined that FHRD personnel and capabilities are exceptional and ORNL has sufficient policies and procedures in place to comply with pressure safety requirements in 10 CFR 851.

On January 27, 2012, Surveillance staff presented a briefing to the Facilities and Operations Director, Jimmy Stone, the Chief Engineer, Tom Etheridge, and the Fabrication, Hoisting and Rigging Division Director, Claude Robison on the closure status of ACTS 11044 Action Items. Topics of discussion during the meeting focused on plans for closing all remaining Action Items by September 30, 2012 (Vulnerability 1) and the approach being taken by Surveillance staff to implement the SBMS Pressure System Safety Subject Area that was published in August 2011 (Vulnerability 2). The status of the three problem areas identified in Sect. 3.3 was also discussed. Problem Area 1 involves liquid nitrogen storage tank deficiencies and alternatives for addressing the deficiencies described in the Lean Team report that was published in January 2012 titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*. Problem Area 2 involves removal of insulation on the outer surfaces of pressure vessels to provide access for wall thickness measurements. This problem area was addressed by completing insulation removal activities in December 2011. Problem Area 3 involves review of closure evidence by Quality Assurance personnel. These reviews were completed in February 2012 for the 215 ACTS 11044 Action Items that are closed.

D.2 SUMMARY OF VARIANCE ISSUES FOR LEGACY PRESSURE VESSELS

Owners of the 216 Action Items in ACTS 11044 involving legacy pressure vessels are assigned to five different ORNL Directorates. The current status of these Action Items is summarized in Table D.1. The various types of deficiencies represented by the 216 Action Items in ACTS 11044 are subdivided into the variance issue categories defined in Table D.2.

The monthly progress for closing ACTS 11044 legacy pressure vessel Action Items is characterized in Fig. D.1.

Table D.1. Summary of Action Items in ACTS 11044*

Directorate/Division	Number of Action Items			
	Closed	**Accepted**	**Unaccepted**	**Total**
Facilities and Operations Directorate	104	0	0	104
Fabrication, hoisting, and Rigging Division	2	0	0	2
Facility Management	68	0	0	68
Laboratory Protection	1	0	0	1
Utilities Division	33	0	0	33
Physical Sciences Directorate	45	0	0	45
Energy and Engineering Sciences Directorate	2	0	0	2
Nuclear Operations Directorate	22	0	0	22
Neutron Sciences Directorate	43	0	0	43
Total	**216**	**0**	**0**	**216**

*The effective date is September 28, 2012.

Table D.2. Types of Legacy Pressure Vessel Variance Issues

Number of Action Items	Variance Issue Description
216	Closed
0	Exterior corrosion; awaiting disposition
0	Inaccessible
0	Insulated, wall thickness cannot be determined
0	Isolation valve before pressure relief device
0	No pressure relief device could be located within system
0	Incorrect rupture disk setting
0	Verify remaining life calculation
216	**Total**

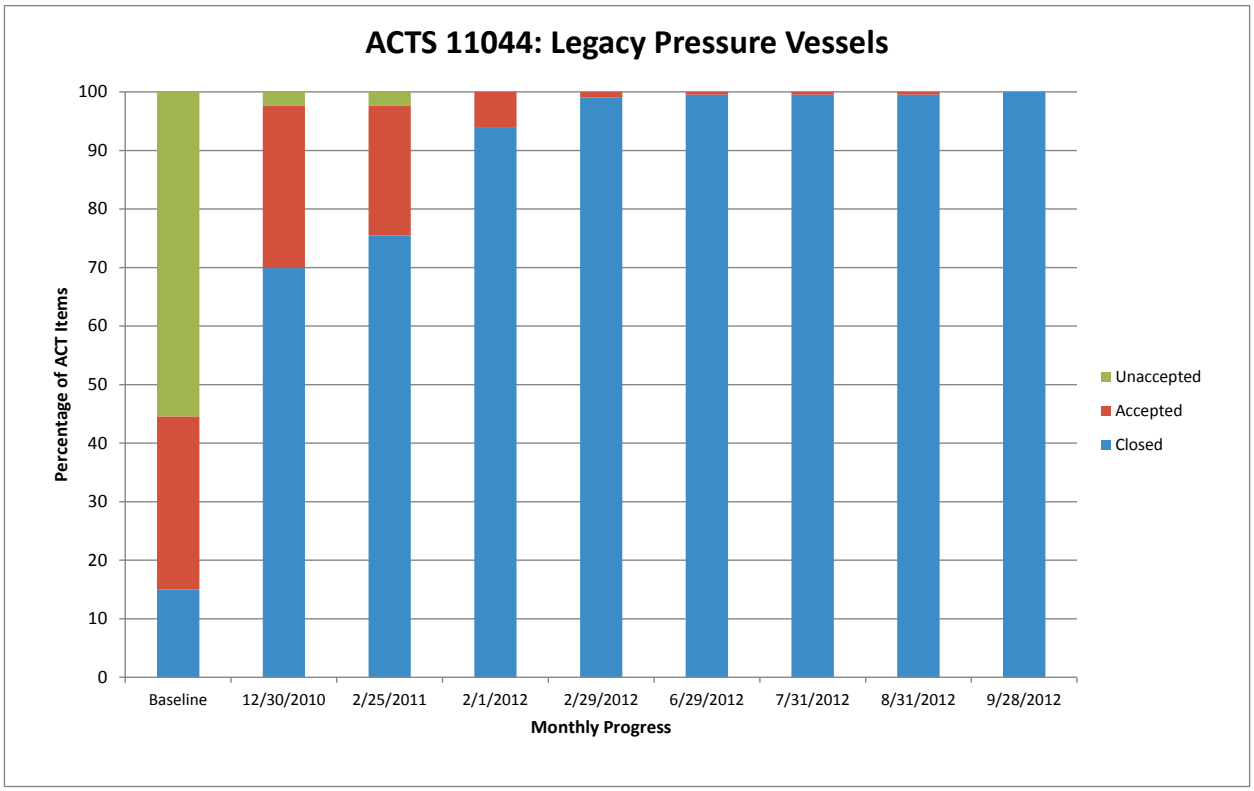

Fig. D.1. Closure Status of Legacy Pressure Vessel Action Items in ACTS 11044.

D.3 POTENTIAL VULNERABILITY STATUS

Corrective actions were taken to address the two potential vulnerabilities affecting UT-Battelle's ability to meet its legacy pressure vessel variance commitments as defined in the Variance Request for 10 C.F.R. § 851, Worker Safety and Health Program Inspection of Pressure Vessels per ASME Boiler and Pressure Vessel Code. These vulnerabilities are identified and discussed in Sect. 1.4.

Vulnerability 1 involves delays in implementing corrective actions due to unavailability of craft support. Vulnerability 2 involves development and implementation of guidance in SBMS for complying with pressure safety requirements in 10 CFR 851.

D.3.1 Vulnerability 1

Beginning in June 2010, corrective actions in ACTS 11044 are being tracked by various assigned Division Management supported by Quality Assurance Division staff. Also, a new Pressure Vessel Inspection Program Project Manager is tracking these actions and working with the legacy pressure vessel owners to develop and augment effective closure documentation. This monthly report was prepared for use in communicating with ORNL Directorate and Division staff about the status of ACTS 11044 Action Items for legacy pressure vessels within their organizations.

Surveillance staff completed a comprehensive review of the 1240 pressure-retaining items (PRIs) at ORNL and determined that 215 have deficiencies that require evaluation to identify appropriate corrective actions. Some, but not all, of the deficient PRIs have ACTS 11044 Action Item numbers. Based on review results, Surveillance staff has taken the following corrective actions to address the PRI deficiencies.

1. Approximately 45% of the 215 deficient PRIs have pressure relief device installation, testing, or inspection issues or potential pressure safety concerns involving installation of isolation valves upstream of the pressure relief devices. Surveillance staff is assessing PRIs with pressure relief device installation issues to justify continued operation based on results of a hazard analysis or an engineering evaluation of the PRI and the various components in the pressure system. Surveillance staff is also working with owners to establish administrative controls for ensuring that the isolation valves remain fully open when the PRI is operating.

2. Many PRIs have insulation that restricts access for nameplate verification and thickness measurements. Access for performing thickness checking is easily obtained by removing small areas of insulation and installing UT Ports at strategic locations. These UT ports provide data needed to evaluate the structural integrity of the PRI. However, an insulation obstructed nameplate is generally not accessible until the insulation is removed. The nameplates provide additional data about the physical characteristics of the PRI including its pressure and temperature ratings and the materials of construction. Access to nameplate data is not necessarily required provided the integrity of the PRI can be determined from thickness measurement results. Surveillance staff is prioritizing PRIs that require UT ports or insulation removal so that ORNL insulator craft resources are employed effectively.

3. In some cases PRIs have heavy corrosion, but the metal loss is within an acceptable limit. However, prompt action by the owner may be considered necessary to prevent further deterioration. These actions may involve eliminating connection leaks or implementing corrosion mitigation measures.

4. Four vessels require rerating. Surveillance staff has prepared engineering calculations or written justification as the basis for closure documentation for these vessels. In March 2011, Surveillance staff obtained acceptance from the Authorized Inspector to rerate these vessels. To complete the closure process, rerating nameplates require attachment to the vessel. By May 30, 2011, a name plate with the revised rating was installed on each of these pressure vessels and the ACTS 11044 Action Items for these vessels are now closed satisfactorily.

Item 2 above focuses on the need for insulation removal and further emphasizes the potential vulnerability caused by limited availability of insulator craft support. Surveillance staff and Action Owners recognize this vulnerability but are unable to reallocate the needed resources. Therefore, resolving the legacy pressure vessel issues for these Action Items by September 30, 2012 is potentially problematic.

Following a meeting on December 21, 2010 in which Tom Etheridge and Mark Lower met with ORNL management to discuss the status of the ORNL pressure vessel and pressure system safety program, the Facilities and Operations Directorate authorized the formation of an ORNL Lean Team to identify options for effectively and safely storing and distributing liquid nitrogen at ORNL. The initial Lean Team meeting was held in April 2011. Members of the Lean Team include staff from the Logistical Services and the Fabrication, Hoisting, and Rigging Divisions.

D.3.2 Vulnerability 2

The potential vulnerability in implementing SBMS guidance for pressure safety focuses on alerting staff about the information in the Pressure System Safety Subject Area and emphasizing the need for complying with 10 CFR 851 pressure safety requirements. Work being performed by the Pressure System Safety Development Team to prepare a Subject Area in SBMS is a first step in addressing this potential vulnerability. A summary of Development Team activities performed to date follows.

On December 9, 2010, Tom Etheridge presented the following flowcharts to the DOMs for consideration.

- Identify Pressure System
- Gather System Information
- Perform Hazard Analysis and Identify Mitigation Strategies
- Complete/Validate Pre-Startup Activities
- Operate Pressure System
- Manage Change and Non-Routine Work

These flowcharts were developed by the SBMS Pressure System Safety Development Team to implement the SBMS Subject Area for Pressure System Safety and were used as the basis for development of SBMS Pressure System Safety procedures. After discussion, the DOMs authorized the SBMS Pressure System Safety Development Team to proceed with procedure development.

On August 17, 2011, the SBMS program office published the Pressure System Safety documents for this subject area. Following publication, divisions are required to either comply with these procedures or have an approved implementation plan by October 16, 2011.

Surveillance staff began preparing hazard assessments for pressure systems in the Fabrication, Hoisting, and Rigging Division. Surveillance staff also published a series of documents that describe the Pressure System Integrity Programs managed by the Surveillance Group. These documents describe the capabilities and expertise within the Surveillance Group for assisting pressure system owners comply with pressure safety requirements in 10 CFR 851. In addition, Surveillance staff prepared a PowerPoint presentation that describes the roles and responsibilities of Division staff for complying with procedures in the Pressure System Safety Subject Area. Surveillance staff published each of these documents on the Surveillance Group website for use by pressure system owners.

Surveillance staff completed its review of comments and concerns pertaining to the Pressure Vessels and Related Components Subject Area. Suggested changes to the procedures in this subject area were reviewed for consistency with requirements in the Pressure System Safety Subject Area and other SBMS Subject Areas referenced by these procedures. On April 30, 2012, the SBMS Program Office issued a Notice of Pending Release of Subject Area for the Pressure Vessels and Related Components Subject Area. In May 2012, the SBMS program office published the revised Pressure Vessels and Related Components documents for this subject area.

D.3.3 Problem Areas

Based on a review of identified potential vulnerabilities that are affecting UT-Battelle's ability to meet its legacy pressure vessel variance commitments by September 30, 2012, Surveillance staff recognizes that the problem areas described in Table D.3 cannot be addressed effectively without direct intervention by ORNL Directorate and Division management and staff.

Table D.3. Problem Areas that Require ORNL Directorate and Division Intervention

Problem Area	Problem Area Description
1	Surveillance staff needs an action plan for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL.
2	Surveillance staff and Action Item Owners are unable to reallocate insulator craft resources needed to characterize and quantify legacy pressure vessel deficiencies.
3	Surveillance staff is unable to reallocate the services of Quality Assurance personnel to verify the accuracy and completeness of closure documentation.

The following actions were taken to address each of these problem areas.

As discussed in Sect. 3.1, the Facilities and Operations Directorate authorized an ORNL Lean Team to identify options for effectively and safely storing and distributing liquid nitrogen at ORNL. The Lean Team published a report in January 2012 titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*. This report establishes the basis for proposed action plans for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL. These deficiencies represent non-compliance with pressure safety requirements in DOE's worker safety and health rules in 10 CFR 851.

Beginning in January 2012, the Procurement Division solicited proposals from vendors to supply two leased liquid nitrogen storage tanks and a liquid nitrogen delivery vehicle to replace the vehicle currently being used to deliver liquid nitrogen to various locations throughout the ORNL complex. After reviewing the technical and cost proposals, the Procurement Division began negotiating a subcontract with a vendor to supply leased storage tanks for installation at Bldgs. 7010 and 4500S. The Procurement Division also negotiated the terms and conditions of a subcontract with a liquid nitrogen delivery vehicle vendor. The delivery vehicle is currently scheduled to arrive at ORNL in October 2010. As a parallel action, the Facilities and Operations Directorate completed construction of reinforced concrete slabs near Bldgs. 7010 and 4500S in August 2012. These slabs are foundations and work surfaces for the leased storage tanks. The deficient liquid nitrogen storage tank on the west side of Bldg. 4500S was removed from service and the ACTS 11044 action item for this legacy pressure vessel was closed on September 21, 2012. Until the leased storage tank for Bldg. 4500S is installed and operational, dewars will be used temporarily by researchers in Bldg. 4500S.

Surveillance staff began addressing Problem Area 2 by identifying pressure vessels with insulation that needs to be removed to allow wall thickness measurements or provide access to nameplate data. In addition, Surveillance staff is developing strategies for assessing pressure safety hazards and identifying hazard mitigation measures that reduce or eliminate the need for removing insulation. Surveillance staff is also prioritizing the insulated pressure vessels and beginning to work with owners and insulators to coordinate insulation removal and implement applicable corrective actions. Information in the "Inspection Database" provides a structured approach for identifying pressure vessels that require inspection and prioritizing inspection activities. Based on a review of the information in the "Inspection Database", Surveillance staff is working with insulators to prioritize insulation removal activities and install surveillance ports needed to measure the wall thickness of legacy pressure vessels so that Surveillance staff can complete visual examinations and wall thickness measurements of these pressure vessels. Insulation removal activities for all affected pressure vessels were completed in December 2011.

Based on review of closure documentation for selected ACTS 11044 Action Items, a Quality Assurance representative began identifying weaknesses in closure documentation on December 12, 2010. Funding

for the services of the Quality Assurance representative is being provided by the Fabrication, Hoisting, and Rigging Division to address Problem Area 3 by conducting the following activities.

- Reviewing each ACTS 11044 Action Item to ensure that the closure documentation reflects "tangible and objective evidence" as justification for closure.
- Performing a role as "Super-Delegate" which permits editing ACTS 11044 records, if necessary.
- Working with the ACTS coordinator to reopen closed Action Items that require revision to include additional closure evidence.
- Meeting with pressure vessel inspectors and Surveillance staff to discuss closure issues and identify proper closure evidence.
- Participating in field reviews with pressure vessel inspectors and Surveillance staff to obtain photographic records that can be used to supplement other closure evidence.
- Reviewing issues and closure evidences in "ORNL Pressure Vessel and Pressure Safety" files for ACTS 11044 Action Items.
- Reviewing closed Action Items with Surveillance staff to determine if the Action Item needs to be reopened so additional corrective actions can be performed and used as further justification for closure.
- Meeting with owners to obtain additional closure evidence.
- Reviewing engineering evaluations on closed Action Items with Surveillance staff for accuracy and completeness.

Quality Assurance and Surveillance staff completed reviewing closure evidence for all closed ACTS 11044 Action Items and determined that the closure documentation for each Action Item is satisfactory.

D.4 SUMMARY AND CONCLUSIONS

Five ORNL Directorates are responsible for the 216 legacy pressure vessel Action Items in ACTS 11044. To date, all 216 Action Items have been accepted by the owners and closed satisfactorily.

In May 2010, a study identified two potential vulnerabilities that are affecting UT-Battelle's ability to meet its legacy pressure vessel variance commitments (Ref. 5). Vulnerability 1 involves delays in implementing corrective actions due to unavailability of specific personnel resources. Vulnerability 2 involves development and implementation of guidance in SBMS for complying with pressure safety requirements in 10 CFR 851. The following actions were taken to address these vulnerabilities.

Vulnerability 1 was addressed by developing action plans for resolving cryogenic liquid nitrogen storage vessel deficiencies (Problem Area 1), employing insulator craft to remove insulation from legacy pressure vessels to allow wall thickness measurements (Problem Area 2), and allocating the services of Quality Assurance personnel to verify the accuracy and completeness of ACTS 11044 closure documentation (Problem Area 3).

Issues related to Problem Area 1 are addressed in an ORNL Lean Team report titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project* that was published in January 2012. This

report establishes the basis for proposed action plans for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL. The Procurement Division negotiated terms and conditions with vendors to supply leased liquid nitrogen storage tanks and to purchase a replacement liquid nitrogen delivery vehicle Staff of the FHRD are implementing actions necessary to construct foundations for the leased storage tanks. Installation of leased liquid nitrogen storage tanks will resolve the legacy pressure vessel compliance issues associated with cryogenic liquid nitrogen storage vessels. In September 2012, the deficient liquid nitrogen storage tank on the west side of Bldg. 4500S was removed from service. Dewars will be used temporarily by researchers in Bldg. 4500S until the leased liquid nitrogen storage tank is installed and placed in service.

Surveillance staff addressed Problem Area 2 by identifying pressure vessels with insulation that needs to be removed to allow wall thickness measurements or provide access to nameplate data and working with owners and insulators to coordinate insulation removal. Problem Area 2 was resolved in December 2011 when insulator craft completed removal of insulation from all pressure vessels that require wall thickness measurements.

A Quality Assurance representative addressed Problem Area 3 by completing review all ACTS 11044 Action Items, assessing the accuracy and completeness of the closure documentation, and identifying weaknesses in closure documentation. Problem Area 3 was resolved in February 2012 when Quality Assurance and Surveillance staff completed review of closure evidence for all closed ACTS 11044 Action Items and determined that the closure documentation for each Action Item was satisfactory.

Vulnerability 2 was resolved by implementing guidance in SBMS for complying with pressure safety requirements in 10 CFR 851. The SBMS program office addressed this vulnerability on August 17, 2011 by publishing the Pressure System Safety Subject Area. Following publication, divisions are required to comply with the procedures in this Subject Area by October 16, 2011.

In conclusion, the two potential vulnerabilities identified in the Assessment of Laboratory Corrective Actions for the 10 C.F.R § 851 Rule Variance Request for Phase II – Legacy Pressure Vessels (Ref. 5) have been addressed and satisfactory close-out documentation has been entered into ACTS 11044 for the 216 Action Items before the required completion date of September 30, 2012.

Now that all ACTS 110444 Action Items are closed, a final report will be prepared to document the work performed to address the variance request for legacy pressure vessels and serve as the basis for closing ACTS 9575 – NTS Report - Legacy Vessels Subject to the Boiler and Pressure Vessel Code.

D.5 REFERENCES

1. *Worker Safety and Health Program*, Title 10, Code of Federal Regulations, Part 851, U.S. Department of Energy, Washington, DC.
2. Letter dated June 27, 2012 from DOE to UT-Battelle, Subject: Contract DE-AC05-00OR22725, Oak Ridge National Laboratory (ORNL), Worker Safety and Health Program Description (WSHPD) Annual Review Required by 10 CFR 851, *Worker Safety and Health Program*.
3. *Preliminary Notice of Violation*, Sandia Corporation, Sandia National Laboratories, WEA-2010-02, U.S. Department of energy, National Nuclear Security Administration, Washington, DC, June 1, 2010.
4. Letter dated February 26, 2007 from UT-Battelle to DOE, Subject: Contract DE-AC05-00OR22725, ORNL Variance Requests from 10 C.F.R. § 851, *Worker Safety and Health Program*.
5. *Assessment of Laboratory Corrective Actions for the 10 C.F.R § 851 Rule Variance Request for Phase I – Fire Barrier/Chemical Management and Phase II – Legacy Pressure Vessels*, Project Number IO-201-8, Oak Ridge National Laboratory, May 2010.

APPENDIX E. QUARTERLY STATUS REPORT FOR AUGUST 31, 2012

APPENDIX E. QUARTERLY STATUES REPORT FOR AUGUST 31, 2012

ASSESSMENT AND COMMITMENT TRACKING SYSTEM QUARTERLY REPORT FOR ASSESSMENT NUMBER: 11044

Assessment Type: Internal Assessment; Safety Assessment
Assessment Owner: Mark Lower
Assessment Title: Inspection Plan for Legacy Vessels
Assessment Description: Perform internal and ultrasonic inspection of boilers and pressure vessels in accordance with NBIC requirements, as applicable and as stated in Milestone #5 of the Implementation Plan for Legacy Pressure Vessels and item 7(b)10 of the Variance Request for 10 CFR 851, Worker Safety and Health Program Inspection of Pressure Vessels per ASME Boiler and Pressure Vessel Code.
Owning Organization: Surveillance (50206885)

Barry Oland
August 31, 2012

E.1 INTRODUCTION

The quarterly report for Assessment and Commitment Tracking System (ACTS) Number 11044, titled Inspection Plan for Legacy Vessels covers the period from June 1, 2012 to August 31, 2012. Legacy pressure vessel deficiencies that are described in ACTS 11044 reflect potential non-compliance with pressure system safety requirements in DOE's "Worker Safety and Health Program," 10 CFR 851 (Ref. 1). The objective of activities being performed by the Surveillance staff is to identify and inspect legacy pressure vessels, address all ACTS 11044 Action Items, assist legacy pressure vessel owners resolve all deficiencies, and enter satisfactory close-out documentation in ACTS by September 30, 2012.

E.2 BASELINE

On March 15, 2010, ACTS 11044 included 193 Action Items (Ref. 2). This baseline total included 29 Action Items that were closed satisfactorily, 57 Action Items that were accepted by the owner, and 107 Action Items that were not yet accepted by the owner. By the end of May 2010 ACTS 11044 included 30 closed Action Items, 117 accepted Action Items, and 49 Action Items that were not yet accepted by the owners.

E.3 ACCOMPLISHMENTS

On June 1, 2010, Surveillance staff began addressing legacy pressure vessel deficiencies by performing the following activities.

- contacting owners of legacy pressure vessels to stress the importance of acknowledging acceptance of all assigned ACTS Action Item numbers within ACTS 11044
- identifying owners of pressure vessels that are no longer in service, abandoned, or used by more than one individual or group
- assisting owners develop action plans for resolving deficiencies

- identifying pressure vessels that cannot be inspected because they are insulated with asbestos, mineral fiber, or fiberglass; inaccessible for internal inspection; or located in a hazardous environment or inaccessible area

- continuing initial inspections of legacy pressure vessels to meet variance request milestones and entering deficiencies into ACTS 11044 as appropriate

- reviewing inspection reports to identify legacy pressure vessels with deficiencies that need to be entered into ACTS 11044

- clearing non-conformance issues for specific legacy pressure retaining items

- verifying closure documentation for accuracy and completeness

- participating in Pressure System Safety Development Team and Steering Committee meetings that focus on developing an SBMS Subject Area for Pressure System Safety

- participating in Lean Team meetings to identify options for safely storing and distributing liquid nitrogen within the ORNL complex

A summary of major contributions and accomplishments by Surveillance staff through August 31, 2012 follows.

- Published SBMS Pressure System Safety Subject Area in August 2011

- Revised SBMS Pressure Vessel and Related Components Subject Area in May 2012

- Closed 99.5% of ACTS 11044 Action Items by May 31, 2011

- Published *Steam Pressure-Reducing Station Safety and Energy Efficiency Improvement Project*, ORNL/TM-2010/284, January 2011

- Realized $1,000,000 in cost savings by improving steam system safety and energy efficiency

- Published Federal Inspection Agency (FIA) Manual, and obtained accreditation as a Federal Inspection Agency from The National Board of Boiler and Pressure Vessel Inspectors – a first for any branch of the US government

- Revised ORNL inspection procedures for pressure system components and pressure-retaining items to more fully assess the safety of pressure vessel and establish more consistent and accurate documentation of these assessments.

- Developed Surveillance Group website that contains useful information for owners of pressure systems at ORNL including:
  - ✓ hazard analyses for oxygen, acetylene, argon, and compressed air pressure systems
  - ✓ pressure system integrity programs for boilers, piping, pressure vessels, pressure relief devices, and hazard analysis and hazard mitigation
  - ✓ PowerPoint presentation describing roles and responsibilities for achieving compliance with pressure system safety requirements in 10 CFR 851

- Completed inspections for 100% of high-risk legacy pressure vessels at ORNL

- Participated in Lean Team meetings to identify options for safely and efficiently storing and distributing liquid nitrogen at ORNL and issued a report in January 2012 describing proposed actions and alternatives identified by the Lean Team

- Addressed problem areas involving inspection of insulated legacy pressure vessels by:
  - ✓ working with insulators to prioritize insulation abate activities
  - ✓ identifying locations for installation of inspection ports

- Completed verification of closure documentation for 215 Action Items.

On November 1, 2011, the Fabrication, Hoisting and Rigging Division of the Facilities and Operations Directorate of UT-Battelle, LLC set a historic precedent by being the very first organization to obtain accreditation as a Federal Inspection Agency from the National Board of Boiler and Pressure Vessel Inspectors ("The National Board"). The National Board is an organization of the Chief Boiler and Pressure Vessel Inspectors in the States of the United States, the Provinces of Canada, and some municipalities having populations exceeding 1 million persons; and is recognized as being technically competent in the field of pressure equipment by Federal, State, and Municipal authorities.

The National Board exists to facilitate public safety by administering Boiler and Pressure Vessel Inspector training and certification programs, ensuring the safe operation of boilers and pressure vessels by promoting the establishment of laws ("boiler laws") among the member jurisdictions, and striving to achieve uniformity of those laws between their member jurisdictions. These boiler laws require:

1. construction and certification of boilers and pressure vessels in compliance with the ASME Boiler and Pressure Vessel Code ("the Code") when these items are to be installed and operated within the jurisdiction;

2. regular, periodic inspections of boilers and pressure vessels to verify their condition remains acceptable for continued operations; and

3. application of the National Board Inspection Code (NBIC) requirements for repairs and alterations of pressure equipment.

In most states, provinces, and municipalities either a state inspector or a "special" inspector (one employed by an insurance company) performs the required periodic inspections.

The codes and standards published by the National Board meet the requirements of the American National Standards Institute (ANSI) for consensus standards. This means the standards have been prepared and approved by consensus committees consisting of stakeholders representing a balanced makeup in their areas of interest to ensure impartiality. These codes and standards address the requirements for inspector training and certification, accreditation of inspection and repair organizations, and established practices for repairing or altering pressure retaining items.

As a US Government reservation, ORNL is specifically exempted from complying with the Laws of the State of Tennessee as they pertain to boilers and pressure vessels. However, federal regulations exist for ensuring personnel safety under 10 CFR 851, Appendix A, Part 4; which requires contractors at DOE sites to implement a Pressure Safety Program. Each program must ensure pressure equipment is safe for operation through effective implementation of procedures for procurement, inspection, engineering, hazard assessments, and ongoing maintenance. These programs must comply with nationally recognized standards such as the ASME Code for the procurement of new pressure equipment, and the NBIC for inspection and repairs of operating pressure equipment. Pressure equipment installed prior to the

implementation of these requirements ("legacy equipment") must be evaluated for safety compliance. When pressure equipment is not certifiable as compliant with the Code, the pressure equipment must be afforded an equivalent level of safety as if these requirements had been applied.

As the prime management contractor for operation of a DOE site, UT-Battelle, LLC is responsible for compliance with 10 CFR 851 at ORNL. The accreditation of UT-Battelle, LLC as a Federal Inspection Agency demonstrates the ORNL inservice inspection program has effectively applied the objective standards of the National Board for carrying out the inspections of installed and operating pressure equipment.

On June 12-14, 2012, ORNL hosted Community of Practices for Pressure Safety meetings. During the meetings, subject matter experts from Pacific Northwest National Laboratory (PNNL), Lawrence Livermore National Laboratory (LLNL), and Idaho National Laboratory (INL) reviewed ORNL's pressure safety program and evaluated overall compliance with pressure safety requirements in 10 CFR 851. Review activities focused on overview presentations by Tom Etheridge and Mark Lower, discussions with FHRD staff, tours of ORNL fabrication shops and facilities with active pressure systems, and evaluation of SBMS Pressure System Safety and Pressure Vessels and Related Components Subject Areas. After the review, the subject matter experts determined that FHRD personnel and capabilities are exceptional and ORNL has sufficient policies and procedures in place to comply with pressure safety requirements in 10 CFR 851.

By August 31, 2012, ACTS 11044 included 216 Action Items. This total includes 215 Action Items that are closed satisfactorily (99%) and 1 Action Item that is being addressed. To date, all 216 Action Items have been accepted by the owners. Table E.1 summarizes the time-dependent changes in ACTS 11044 Action Item entries.

Table E.1. ACTS 11044 Action Item summary

Date	Closed	Accepted	Unaccepted	Total
March 15, 2010 (Baseline)	29	57	107	193
June 1, 2010 (Surveillance staff initiated involvement)	30	117	49	196
August 27, 2010	65	128	21	214
November 30, 2010	130	81	5	216
February 28, 2011	163	48	5	216
May 31, 2011	165	48	3	216
August 31, 2011	175	41	0	216
November 30, 2011	186	30	0	216
February 29, 2012	214	2	0	216
May 31, 2012	215	1	0	216
August 31, 2012	215	1	0	216

E.4 TIMELINE

To achieve closure of all ACTS 11044 Action Items by September 30, 2012, Surveillance staff committed to resolving at least 25 ACTS 11044 Action Items per quarter. Progress towards achieving this objective is shown graphically in Fig. E.1.

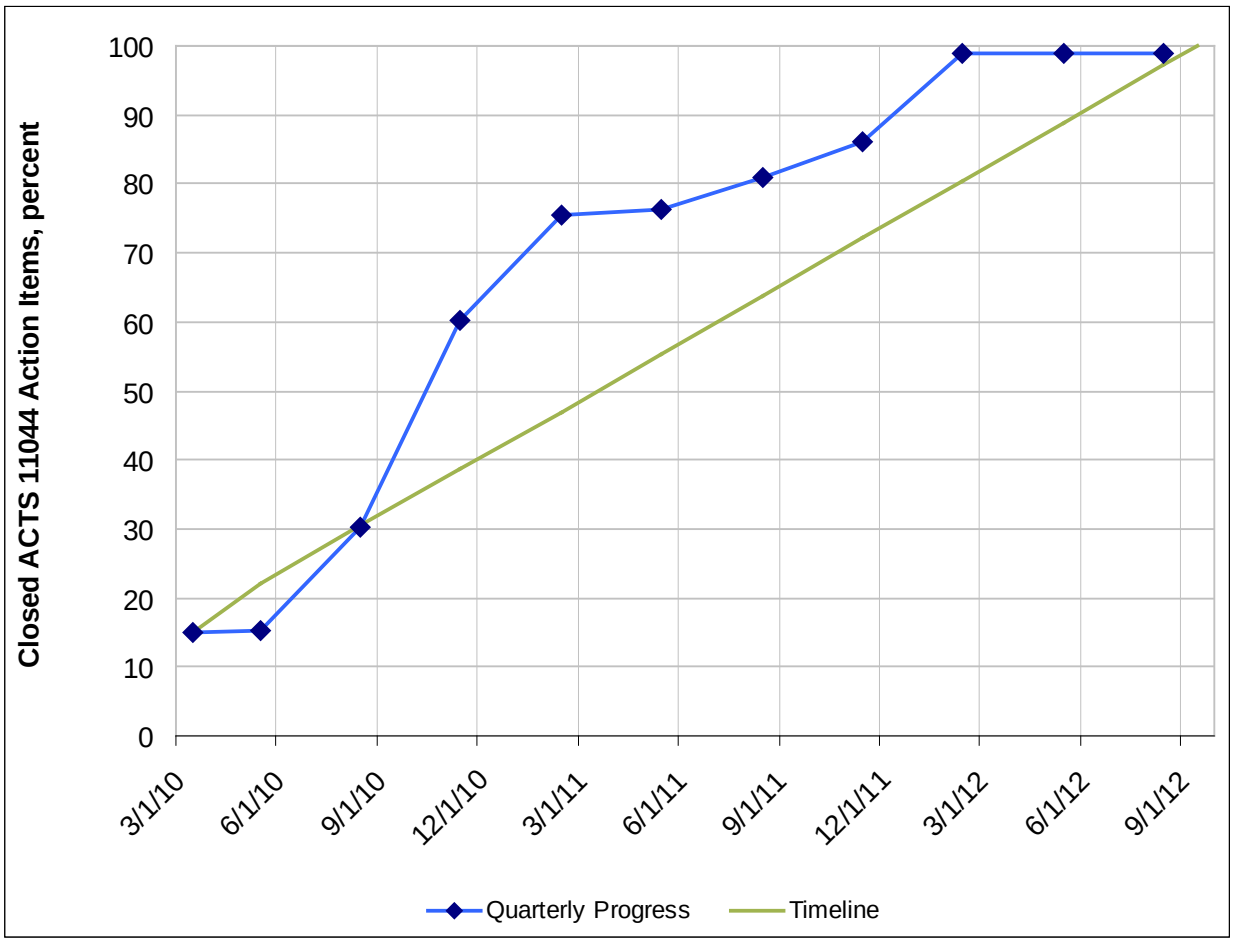

Fig. E.1. Closure status of Legacy Pressure Vessel Action Items in ACTS 11044.

E.5 STATUS OF VARIANCE REQUEST FOR INSPECTION OF PRESSURE VESSELS

On February 26, 2007, UT-Battelle submitted variance requests from 10 CFR 851 to DOE (Ref. 3). Enclosure 4 of this submittal describes the variance request for inspection of pressure vessels to verify compliance with ASME Boiler and Pressure Vessel Code. Section 7(b)10 of this enclosure establishes a plan and schedule for inspecting in-service pressure vessels to determine their fitness-for-service and remaining life. In May 2012, the variance completion date was extended from September 30, 2012 to December 31, 2012 to allow sufficient time to finalize closure documentation.

Data needed to make fitness-for-service and remaining life determinations for legacy pressure vessels are obtained by external and internal inspections. These inspections are performed by staff of the Fabrication, Hoisting, and Rigging Division in accordance with pressure vessel inspection requirements in the National Board Inspection Code (NBIC). The inspectors are currently using the 2011 edition of the NBIC (Ref. 4). Fitness-for-service and remaining life determinations are performed by Surveillance staff in

accordance with fitness-for-service engineering assessment procedures in API 579-1/ASME FFS-1 2007, *Fitness-For-Service* (Ref. 5). This standard is a compendium of consensus methods for reliable assessment of the structural integrity of equipment containing identified flaws or damage.

External inspection activities are performed by visually examining accessible exterior surfaces of pressure vessels to compile information regarding their design features and operating parameters and to characterize their general physical conditions. These inspections focus on identifying leakage, cracks, blisters, bulges, corrosion, erosion, and other evidence of deterioration. Pressure vessels with external coverings such as insulation and corrosion-resistant linings that are in good condition are not removed for inspection provided the inspector has no reason to suspect any unsafe condition behind these items.

Internal inspections are only required for pressure vessels that are susceptible to local pitting or uniform corrosion. To determine susceptibility, the inspector considers the service environment, operating conditions, and the types of materials used to construct the pressure vessels. The inspector also obtains ultrasonic wall thickness measurements and uses the results to quantify metal loss inside the pressure vessel. For insulated pressure vessels, insulation is removed at selected locations to provide access to the outer surface of the pressure vessel for ultrasonic wall thickness measurements. Severe corrosion is most often located at liquid level lines, the bottom, and the shell area adjacent to and opposite inlet nozzles.

Engineering analyses are performed for pressure vessels with unacceptable wall thinning to estimate the rate of metal loss and determine a maximum allowable operating pressure. Pressure vessels with unacceptable wall thinning that operate at pressures that exceed maximum allowable stress limits are either rerated for a reduced operating pressure or removed from service. The rate of metal loss is used to determine the remaining service life of the pressure vessel and to establish the next inspection interval.

To date, Surveillance staff has identified 1240 legacy pressure vessels at ORNL within the scope of 10 CFR 851. The “Inspection Database” that was developed by Surveillance staff includes up-to-date information compiled for the 1312 pressure retaining items at ORNL including the remaining open Action Items in ACTS 11044. Surveillance staff is continuing to obtain missing shell thickness measurement results and other specific types of data needed to complete safety assessments for these pressure vessels. Safety assessment results will serve as the basis for identifying corrective actions for those pressure-retaining items with deficiencies. Table E.2 summarizes the activities, target completion dates, and completion status for legacy pressure vessel inspections.

Table E.2. Pressure Vessel Inspection Status

Activity	Target Completion Date*	Completion Status
Risk rank pressure vessels	June 2007	Stored energy was calculated and used as the basis for risk ranking more than 1000 legacy pressure vessels at ORNL within the scope of 10 CFR 851.
Categorize risk ranking of pressure vessels	June 2007	Risk ranking of pressure vessels was completed in June 2007 with approximately 50% categorized as "High" risk.
Inspect external surfaces of 50% of highest risk pressure vessels	September 2008	External inspections for more than 50% of the "High" risk pressure vessels were completed by September 30, 2008.
Inspect external surfaces and measure wall thicknesses of 90% of highest risk pressure vessels	September 2009	External inspections and wall thickness measurements for more than 90% of the "High" risk pressure vessels were completed by September 30, 2009. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service.
Inspect external surfaces and measure wall thicknesses of 50% of limited risk pressure vessels	September 2010	External inspections for all of the "High" and "Limited" risk pressure vessels were completed by September 30, 2010. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service.
Inspect internal surfaces of 25% of highest risk pressure vessels	September 2010	Internal inspections for more than 25% of the "High" risk pressure vessels with unacceptable wall thinning were inspected by September 30, 2010. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service.
Inspect internal surfaces of 90% of highest risk pressure vessels	September 2011	Internal inspections were completed for 93% of the "High" risk pressure vessels with unacceptable wall thinning by August 31, 2011. Pressure vessels with unacceptable wall thinning were either rerated for a reduced operating pressure or removed from service.
Complete inspection of 100% of pressure vessels	September 2012	

*Milestones are defined in Ref. 3.

E.6 FUTURE ACTIVITIES

Future actions that will be taken during the next reporting period will focus on the following areas.

- Coordinating construction of reinforced concrete slabs that serve as foundations and work surfaces for the leased liquid nitrogen storage tanks located near Bldgs. 7010 and 4500S.
- Working with the Procurement Division to finalize and implement the lease agreement for installing liquid nitrogen storage tanks on these slabs.

Surveillance staff will continue to maintain and improve an ORNL website that describes capabilities within the Surveillance Group for assisting divisions comply with pressure safety requirements in

10 CFR 851. In addition, Surveillance staff is continuing to prepare hazard analyses for pressure systems and posting them on the website to assist other ORNL divisions comply with the hazard analysis procedure in the SBMS Pressure Safety Subject Area.

Surveillance staff is also working with the Facilities Management Division to ensure compliance with the SBMS Pressure Safety Subject Area.

E.7 PROBLEM AREAS

Based on a review of potential vulnerabilities identified in May 2010 (Ref. 2) that are affecting UT-Battelle's ability to meet its legacy pressure vessel variance commitments by September 30, 2012, Surveillance staff recognizes that the problem areas described in Table E.3 cannot be addressed effectively without direct intervention by ORNL Directorate and Division management and staff.

Table E.3. Problem Areas that Require ORNL Directorate and Division Intervention

Problem Area	Problem Area Description
1	Surveillance staff needs an action plan for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL.
2	Surveillance staff and Action Item Owners are unable to reallocate insulator craft resources needed to characterize and quantify legacy pressure vessel deficiencies.
3	Surveillance staff is unable to reallocate the services of quality assurance personnel to verify the accuracy and completeness of closure documentation.

In January 2012, an ORNL Lean Team issued a report titled *Liquid Nitrogen Storage and Distribution Continuous Improvement Project*. This report establishes the basis for proposed action plans for resolving legacy pressure vessel deficiencies associated with cryogenic liquid nitrogen storage vessels located throughout ORNL. Beginning in January 2012, the Procurement Division solicited proposals from vendors to supply two leased liquid nitrogen storage tanks and a liquid nitrogen delivery vehicle to replace the vehicle currently being used to deliver liquid nitrogen to various locations throughout the ORNL complex. After reviewing the technical and cost proposals, the Procurement Division began negotiating a subcontract with a vendor to supply leased storage tanks for installation at Bldgs. 7010 and 4500S. The Procurement Division also negotiated the terms and conditions of a subcontract with a liquid nitrogen delivery vehicle vendor. The delivery vehicle is currently scheduled to arrive at ORNL in October 2010. As a parallel action, the Facilities and Operations Directorate completed construction of reinforced concrete slabs near Bldgs. 7010 and 4500S in August 2012. These slabs are foundations and work surfaces for the leased storage tanks. After the leased storage tank for Bldg. 4500S is installed and operational, the deficient liquid nitrogen storage tank located on the west side of Bldg. 4500S will be removed from service and the ACTS 11044 action item for this legacy pressure vessel will be closed.

Surveillance staff addressed Problem Area 2 by identifying pressure vessels with insulation that needs to be removed to allow wall thickness measurements or provide access to nameplate data and working with owners and insulators to coordinate insulation removal. Problem Area 2 was resolved in December 2011 when insulator craft completed removal of insulation from all pressure vessels that required wall thickness measurements.

A quality assurance representative addressed Problem Area 3 by completing review all ACTS 11044 Action Items, assessing the accuracy and completeness of the closure documentation, and identifying

weaknesses in closure documentation. Problem Area 3 was resolved in February 2012 when quality assurance and Surveillance staff completed review of closure evidence for all closed ACTS 11044 Action Items and determined that the closure documentation for each Action Item was satisfactory.

E.8 REFERENCES

1. *Worker Safety and Health Program*, Title 10, Code of Federal Regulations, Part 851, U.S. Department of Energy, Washington, DC.
2. *Assessment of Laboratory Corrective Actions for the 10 C.F.R § 851 Rule Variance Request for Phase I – Fire Barrier/Chemical Management and Phase II – Legacy Pressure Vessels*, Project Number IO-201-8, Oak Ridge National Laboratory, May 2010.
3. Letter dated February 26, 2007 from UT-Battelle to DOE, Subject: Contract DE-AC05-00OR22725, ORNL Variance Requests from 10 C.F.R. § 851, *Worker Safety and Health Program*.
4. *National Board Inspection Code, Part 2 – Inspection*, National Board of Boiler and Pressure Vessel Inspectors, 2011.
5. *Fitness-For-Service*, API 579-1/ASME FFS-1, (API 579 Recommended Practice 579, Fitness-For-Service second edition) American Petroleum Institute's. June 5, 2007.