ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Quick Start Summary

Product ID: 543 | Revision ID: 2370 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureQuickstart.pdf

## 1 Who needs to know about these requirements

The requirements of Pressure Systems apply to pressure system owners, designers, custodians, mechanics, operators, inspectors, repair organizations, and anyone involved with pressure system design, procurement, construction, installation, testing, operation, inspection, maintenance, repair, and decommissioning.

## 2 Why

SLAC is committed to meeting Cal/OSHA regulations (8 CCR), applicable codes and standards, and sound engineering principles for pressure systems. Failure to meet them may result in an explosion, injury or death, and/or release of hazardous materials into the environment.

## 3 What do I need to know

The pressure systems program manager is involved in every stage of a pressure system's service life, from design/conception through decommissioning. System documentation must be complete and available at all times.

- At the design stage the pressure systems program manager must conduct a technical review.
- When a purchase requisition is completed for a system, components, or related services, the pressure systems program manager's approval must be on file.
- System documentation must be complete and available for construction/fabrication/registration.
- A new pressure system can only be authorized to operate by registering it with the pressure systems program manager; all legacy pressure systems must also be registered.
- Pressure systems must be inspected, maintained, and repaired by qualified persons, and a record of work completed must be kept on file and submitted to the pressure systems program manager.
- A pressure test is required for a new pressure system or an existing pressure system after repair or alteration.
- Pressure vessels no longer in use must be decommissioned according to an approved plan.

## 4 When

The requirements of this chapter take effect 26 October 2021.

## 5 Where do I find more information

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"

Or contact the program manager.

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14*

# Pressure Systems

Product ID: 56 | Revision ID: 1882 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/pdfs/ESHch14.pdf

## 1 Purpose

The purpose of this program is to ensure worker safety and that pressure systems comply with Cal/OSHA regulations (8 CCR), applicable codes and standards, and sound engineering principles. The program covers design, purchase, construction, installation, operation, inspection, maintenance, repair, and decommissioning of the following pressure system types and system components (such as pressure relief devices, piping, fittings, gauges, valves, and associated pressure-retaining hardware):

- Pressure vessels, boilers, and air receivers, and their supporting piping systems
- Cryogenic systems
- Vacuum systems that can be pressurized due to backfill
- *Conventional systems* used for utilities and facilities, and low conductivity water (LCW)
- *Scientific systems* such as cryomodules, superconducting magnets, experiment target vessels, and other experimental equipment (above 15 psig as well as under vacuum)
- Compressed gas systems
- Refrigeration systems

The requirements of this program apply to pressure system operators, custodians, owners, mechanics, inspectors, design engineers, project managers, line management, the Pressure Systems Working Group, and the pressure systems program manager.

### 1.1 Codes and Standards

Systems must be designed and built to comply with the appropriate regulatory requirements and applicable codes and standards. For example:

- Pressure vessels, boilers, and air receivers with pressure greater than 15 pounds per square inch gauge (psig) and cross-sections greater than 6 inches generally fall under the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code (BPVC).*
- Compressed gas systems generally fall under the federal Department of Transportation (DOT) and Compressed Gas Association (CGA) standards.
- Utilities in buildings generally fall under the *California Mechanical Code* and the *California Plumbing Code.*
- Refrigeration systems are generally designed following the ASME and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards.

- Pressure Systems: Alternate Pressure Systems Qualification Requirements provides options for evaluating systems designed to meet scientific program requirements. This document provides alternate methods for qualifying systems where it may not be possible or reasonable to satisfy the codes and standards recognized by this program.

Please contact the pressure systems program manager for assistance in identifying the applicable regulatory requirements, codes, and standards.

## 1.2 Excluded Pressure Systems and Activities

The requirements of this program (excluding Pressure Systems: Pressure Test Procedures) do not apply to the following:

- Systems designed and built to codes and standards specified in other chapters of this manual. For example: Fire systems (see Chapter 12, "Fire and Life Safety")
- Pressure containers that are integral parts or components of rotating or reciprocating mechanical devices of commercially available products, such as pumps, compressors, turbines, generators, engines, and hydraulic or pneumatic cylinders
- Pneumatic and hydraulic systems that are an integral part of a vehicle
- Storage tanks that are open to atmosphere at all times
- Cryogenic systems open to the atmosphere at all times (see Chapter 36, "Cryogenic and Oxygen Deficiency Hazard Safety")
- Welding, brazing, and soldering equipment

In all these cases applicable codes and standards still apply and pressure relief devices as needed must be incorporated to ensure safe use.

# 2 Roles and Responsibilities

Functional roles and general responsibilities for each under this program are listed below. More detailed responsibilities and when they apply are provided in the procedures and requirements.

The roles may be performed by one or more individuals and one individual may play more than one role, depending on the structure of the organizations involved. Responsibilities may be delegated.

## 2.1 Operator

- Follows operating procedures supplied by the manufacturer or system owner
- Keeps log sheet of operation, as applicable
- Operates pressure system(s) within approved design conditions

## 2.2 Custodian

- Follows documented procedures and assigned responsibilities to ensure safe operation and maintenance of pressure systems
- Notifies responsible authorities and gains approval before deviating from approved system design and procedures
- If applicable, recommends decommissioning and decommissioning plan

## 2.3 Owner

- Reviews and authorizes pressure system design and construction (and associated inspection and certification)
- Assigns qualified project managers
- Ensures that only qualified persons install, operate, modify, maintain, or repair pressure systems
- Authorizes decommissioning and ensures the decommissioning plan is submitted to the pressure systems program manager

## 2.4 Mechanic

- Follows documented procedures for assigned tasks, including installation, maintenance, repair and decommissioning
- Maintains systems according to applicable codes, standards, and the requirements of this chapter

## 2.5 Inspector

- Is designated by line management and trained and qualified by the pressure systems program manager to witness pressure tests for a specific pressure system (see Competent and Qualified Persons and Engineers). (For example, a pressure system inspector for tube trailers is designated as "Pressure System Inspector: Tube Trailers".)
- Follows inspection procedures
- Inspects systems according to applicable codes and standards and the requirements of this chapter

## 2.6 Design Engineer

- Designs systems according to applicable code (for example, ASME BPVC for qualifying pressure vessels)
- Uses a basic minimum design margin for any pressure system(s) unless a lower design margin can be justified by applicable codes or stress analysis or engineering calculations (see Pressure Systems: Design and Construction Requirements)

## 2.7 Project Manager

- Ensures that pressure systems meet applicable codes and standards and sound engineering principles

- Ensures that sufficient documentation for operation, inspection, maintenance, and repair is provided to the custodian and transfers responsibility to the custodian once the project is completed

## 2.8 Field Construction Manager (FCM)

- Is responsible for ensuring pressure test plans are submitted by subcontractors to the pressure system program manager for approval
- Ensures that the submitted test plans are filled out completely, with supporting documents
- Schedules pressure test with inspectors

## 2.9 Line Management

- Is responsible for overall safety of the pressure systems belonging to its directorate
- Designates an owner, custodian, and inspector for each pressure system

## 2.10 Pressure Systems Working Group

- Helps establish pressure system evaluation criteria based on Cal/OSHA (8 CCR), appropriate codes and standards, and sound engineering principles
- Determines systems to be evaluated
- Evaluates identified systems for risks and mitigations
- Participates in peer review of SLAC pressure systems
- Is chaired by a member of the working group
- Supports the pressure systems program manager for all technical aspects of the program
- Must be subject matter experts as designated by line management and approved by the chief safety officer
- Serves as primary point of contact and representative for their respective directorates for all matters concerning implementation of pressure system requirements

## 2.11 Pressure Systems Program Manager

- Develops, maintains, and manages the pressure systems program
- Advises management on applicable regulations and codes and standards
- Establishes procedures and policies for pressure systems and reviews and updates the program as required
- Is responsible for developing training and qualifying standards for pressure system operators, mechanics, inspectors, and design engineers
- Is responsible for training and qualifying pressure system operators, mechanics, inspectors, and design engineers

- Administers the pressure systems database
- Reviews purchase requisitions for pressure systems to ensure compliance
- Reviews decommissioning plans

# 3 Procedures, Processes, and Requirements

These documents describe the detailed requirements for this program and how to implement them:

- Pressure Systems: Design and Construction Requirements (SLAC-I-730-0A21S-047). Describes requirements for designing, constructing, and modifying pressure systems
- Pressure Systems: Alternate Pressure Systems Qualification Requirements (SLAC-I-730-0A21S-065). Describes process for evaluating and qualifying pressure system components that were not manufactured under the required national codes, require modifications not possible within the scope of the approved codes, or are to be used in a manner outside the applicability of the code under which they were designed or manufactured
- Pressure Systems: Procurement Procedure (SLAC-I-730-0A21C-030). Describes process for purchasing pressure systems, components, and services
- Pressure Systems: Registration Procedure (SLAC-I-730-0A21C-031). Describes process for registering new and legacy pressure systems
- Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements (SLAC-I-730-0A21S-053). Describes personnel qualifications, minimum inspection frequencies, maintenance types, and repair requirements
- Pressure Systems: Pressure Test Procedures (SLAC-I-730-0A21C-033). Describes process for testing new and existing pressure systems and components
- Pressure Systems: Decommissioning Procedure (SLAC-I-730-0A21C-032). Describes process for decommissioning pressure systems

These are the forms and tools for this program:

- Pressure Systems: New Pressure System Registration Form (SLAC-I-730-0A21J-040). Form for registering and approving new pressure systems; documents compliance with program requirements
- Pressure Systems: Legacy Pressure System Registration Form (SLAC-I-730-0A21J-041). Form for registering legacy pressure systems; documents system identification numbers, specifications, status, and risk level
- Pressure Systems: Inspection Report Form (SLAC-I-730-0A21J-043). Form for documenting inspections
- Pressure Systems: Maintenance and Repair Report Form (SLAC-I-730-0A21J-042). Form for documenting maintenance and repair work
- Pressure Systems: Pressure Test Plan Form (SLAC-I-730-0A21J-044). Form for documenting the test plan required for all pressure tests
- Pressure Systems: Pressure Test Record Form (SLAC-I-730-0A21J-045). Form for documenting the results of pressure tests
- Pressure Systems Database. Database of pressure systems

- Competent and Qualified Persons and Engineers. SharePoint site for approval and listing of competent and qualified personnel

These are other program documents and resources:

- Pressure Systems Safety Program (SharePoint)

# 4 Training

## 4.1 Operator

Workers who operate a pressure system must complete the following course before operating the system:

- ESH Course 122, Pressure System Operator (ESH Course 122) (every 60 months)

Workers who handle and use compressed gas cylinders or who attach pressure regulators to compressed gas cylinders must complete the following course:

- ESH Course 172, Compressed Gas Safety (ESH Course 172)

Workers who work with cryogenic liquids or use systems/equipment that involve cryogenic liquids must complete the following course:

- ESH Course 175, Cryogenic Liquids and Oxygen Deficiency Safety Training (ESH Course 175)

## 4.2 Custodian

No training required.

## 4.3 Owner

No training required.

## 4.4 Mechanic

Workers who install, maintain, or pressure test pressure systems must complete the following courses before performing work on the system:

- ESH Course 122, Pressure System Operator (ESH Course 122) (every 60 months)
- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (every 60 months)

## 4.5 Inspector

Qualified pressure system inspectors must complete the following:

- ESH Course 122, Pressure System Operator (ESH Course 122) (every 60 months)

- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (every 60 months)
- ESH Course 143, Pressure System Inspector (ESH Course 143) or (National Board of Boiler and Pressure Vessel Inspector Commission (in lieu of ESH Course 143)

## 4.6 Design Engineer

Design engineers must complete the following training:

- ASME Pressure Vessel Training Course or equivalent training course developed by the pressure systems program manager (and maintain qualification) if involved in the design of a new ASME pressure vessel

*Note* *Any training that is to be considered equivalent to the ASME course for certain pressure systems must be submitted to the pressure systems program manager for approval.*

- ESH Course 122, Pressure System Operator (ESH Course 122) (every 60 months)
- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (every 60 months)

## 4.7 Project Manager

No training required.

## 4.8 Line Management

No training required.

## 4.9 Pressure Systems Working Group

Members of the working group must complete the following courses:

- ESH Course 122, Pressure System Operator (ESH Course 122) (every 60 months)
- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (every 60 months)

And have at least five years of experience in either design, fabrication, operation, or inspection of pressure systems.

## 4.10 Pressure Systems Program Manager

The pressure system program manager must complete the following courses:

- ESH Course 122, Pressure System Operator (ESH Course 122) (every 60 months)
- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (every 60 months)

# 5 Definitions

*alteration.* Any change in the item described on the original manufacturer's data report that affects the pressure containing capability of the pressure-retaining item. Non-physical changes such as increase in the maximum allowable working pressure (internal or external), increase in design temperature, or a reduction in minimum temperature of a pressure retaining item must be considered an alteration[1]. Usually applies to pressure systems compliant with ASME code. Also referred to as *re-rating*.

*component*. An item within a pressure system connected to other items and make up a functioning process

*construction.* An all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, and certification at the time of manufacture

*cryogen.* A refrigerated liquefied gas having a boiling point colder than -90ºC (-130ºF or 183 K) at 14.7 pounds per square inch absolute (psia)

*cryomodule.* A type of pressure system used in accelerator systems. The function of a cryomodule is to support the dressed radio frequency cavities, efficiently maintain them at operating temperature of about 2 K, ensure proper alignment, and accommodate associated hardware.

*custodian.* A person who is responsible for a pressure system and ensures that it is properly maintained

*decommissioning.* Taking a pressure system off-line and rendering it unusable

*design engineer.* The person responsible for the design of a pressure system to ensure that it functions as required for its intended purpose

*design temperature.* The temperature determined by the designer at which the pressure system must be able to operate under worst-case conditions during normal operation

*dewar. A vacuum flask or vacuum-insulated container used for storage of cryogenic fluids*

*fabrication.* The process of mechanically joining pressure system components, parts, or raw materials into a pressure system

*inspection.* A process to determine the condition of a pressure system by visual observations, examination, or testing

*inspector.* A person who by reason of training and experience has demonstrated the ability to safely perform inspections of pressure systems according to applicable codes, standards and this chapter

*inspector, authorized.* A National Board commissioned inspector, employed either by the State of California or by an insurance company authorized to undertake inspection and write boiler and machinery insurance in the state of California

*installation.* The process of placing a pressure system or system component into its location of operation

---

1 See *National Board Inspection Code*, Part 3, "Definitions"

*line management.* Officially designated managers and supervisors who have been entrusted with traditional authorities to make hiring decisions, manage employee performance, and provide a safe and environmentally sound workplace. Scientific programs are often built on people matrixed to a team. This creates shared responsibility for individuals by the supervisor of record and the matrixed supervisor that must be addressed through consultation between the two supervisors. Line management also includes other persons such as area and facility managers, responsible for administration of the line functions in both science and operations programs. Line management may designate another qualified person to perform specific duties but remains responsible for that person's conduct.

*maintenance.* The process whereby a pressure system is kept in a safe operating condition on a planned or time-compliant basis

*manager, pressure system program.* SLAC employee assigned responsibility for the SLAC pressure systems program

*manager, project.* SLAC's line management representative with overall responsibility for a project

*mechanic*. A person who installs, maintains, repairs, and performs pressure testing of pressure systems

*modification.* A change in system configuration that requires design review and approval for change; usually applies to *scientific* pressure systems (see *alteration*)

*operator.* A person who performs routine operation of existing pressure systems, including cylinder changes and loading samples

*owner.* A person exercising direct control over and having line responsibility for the operation of a pressure system

*pressure, design.* The pressure determined by the designer at which the pressure system must be able to operate under worst-case conditions

*pressure, maximum allowable working (MAWP).* The maximum permissible pressure (internal or external) of a pressure system when operated under normal operating conditions

*pressure, maximum operating (MOP)*. The maximum intended operating pressure of a pressure system, typically less than the MAWP

*pressure relief device.* A device actuated by inlet static pressure designed to open during an emergency or abnormal condition to prevent a rise of internal fluid pressure in excess of a specified value. Devices that prevent excessive vacuum are also available. (See *pressure relief valve, rupture disk device*)

*pressure relief valve.* A spring-loaded device designed to open when excess pressure is present and then close to prevent fluid flow once excess pressure is relieved and normal conditions are restored (see *pressure relief device*)

*Pressure Systems Working Group.* A group of subject matter experts representing each directorate whose collective expertise covers all aspects of pressure systems pertinent to SLAC

*pressure test.* The application of pressure or vacuum to a system to verify its mechanical integrity

*repair*. The work necessary to restore a pressure system to a safe and satisfactory operating condition (see *alteration*)[2]

*replacement*. A type of repair completed by fabrication and installation of spare or renewal components

*re-rating.* See *alteration.*

*rupture disk device.* A non-reclosing *pressure relief device* actuated by the static differential pressure between the inlet and outlet of a device. It is designed so that a rupture disk (also called a burst disk) breaks open.

*system, conventional pressure.* A pressure, cryogenic or vacuum system, or system component that is used for conventional services such as boilers, pressure vessels, air receivers, and tanks

*system, cryogenic.* A pressure system containing a refrigerated gas having a boiling point colder than -90°C (-130°F)

*system, excluded.* See Section 1.2, "Excluded Pressure Systems and Activities"

*system, legacy.* Any pressure system installed at SLAC before February 9, 2007

*system, piping.* An assembly of piping components used to convey, distribute, mix, separate, discharge, meter, control, or snub fluid flows

*system, pressure.* All pressure vessels, piping, and pressure sources, including cryogenics, pneumatic, and hydraulic, that have a pressure source greater than 1 atmosphere or that operate under vacuum. Vacuum systems are considered pressure systems due to their potential for catastrophic failure due to backfill pressurization.

*system, scientific pressure.* Any pressure component or system that has a unique use required to support science or experimental needs or unique operating uses, extraordinary pressure service range, unique or special materials, special service uses or restrictions, or vessel geometry

*system, vacuum.* Any system or subsystem designed to operate at sub-atmospheric pressure in an ambient pressure environment

# 6 References

## 6.1 External Requirements

The following are the external requirements that apply to this program:

- Title 10, *Code of Federal Regulations*, "Energy", Chapter 3, "Department of Energy", Part 851, "Worker Safety and Health Program" (10 CFR 851) (as described in SLAC Injury and Illness Prevention Program [SLAC-I-720-0A21B-001])

---

2

- Title 49, *Code of Federal Regulations*, "Transportation", Subtitle B, "Other Regulations Relating to Transportation", Chapter 1, "Pipeline and Hazardous Materials Safety Administration, Department of Transportation", Subchapter C, "Hazardous Materials Regulations"
  - Part 173, "Shippers – General Requirements for Shipments and Packagings" (49 CFR 173)
  - Part 178, "Specifications for Packagings" (49 CFR 178)
  - Part 180, "Continuing Qualification and Maintenance of Packagings" (49 CFR 180)
- Title 8, *California Code of Regulations*, "Industrial Relations", Division 1, "Department of Industrial Relations", Chapter 4, "Division of Industrial Safety"
  - Subchapter 1, "Unfired Pressure Vessel Safety Orders" (8 CCR 450–560)
  - Subchapter 2, "Boiler and Fired Pressure Vessel Safety Orders" (8 CCR 750–797)
- Title 24, *California Code of Regulations,* "California Building Standards Code"
  - Part 4, "California Mechanical Code", Part 4 (24 CCR Part 4)
  - Part 5, "California Plumbing Code", Part 5 (24 CCR Part 5)
- American Society of Mechanical Engineers (ASME). *Boiler and Pressure Vessel Code (BPVC)* (ASME BPVC)
- ASME. *Code for Pressure Piping* (ASME B31), including applicable addenda and code cases
  - ASME B31.1, "Power Piping" (ASME B31.1)
  - ASME B31.2, "Fuel Gas Piping" (ASME B31.2) (NFPA 54 is acceptable)
  - ASME B31.3, "Process Piping" (ASME B31.3)
  - ASME B31.5, "Refrigeration Piping and Heat Transfer Components" (ASME B31.5)
  - ASME B31.9, "Building Services Piping" (ASME B31.9)
  - ASME B31.12, "Hydrogen Piping and Pipelines" (ASME B31.12)
  - ASME B31E, "Standard for the Seismic Design and Retrofit of Above-Ground Piping Systems" (ASME B31E)
- ASME Standards
  - ASME A13.1, "Scheme for the Identification of Piping Systems" (ASME A13.1)
- National Board of Boiler and Pressure Vessel Inspectors (NBBI)
  - NB 23, *National Board Inspection Code (NBIC)* (NBBI NB 23)
- Compressed Gas Association (CGA) Standards
  - CGA S-1.1, "Pressure Relief Device Standards Part 1 – Cylinders for Compressed Gases" (CGA S-1.1)
  - CGA S-1.2, "Pressure Relief Device Standards Part 2 – Cargo and Portable Tanks" (CGA S-1.2)
  - CGA S-1.3, "Pressure Relief Device Standards Part 3 – Stationary Storage Tanks" (CGA S-1.3)
  - CGA C-6, "Standards for Visual Inspection of Compressed Gas Cylinders" (CGA C-6)
- National Fire Protection Association (NFPA)
  - NFPA 54, *National Fuel Gas Code* (NFPA 54)

  - NFPA 55, *Compressed Gases and Cryogenic Fluids Code* (NFPA 55)
- American National Standards Institute (ANSI)
  - ANSI Z49.1, "Safety in Welding, Cutting and Allied Processes" (ANSI Z49.1)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
  - ASHRAE 15, "Safety Standard for Refrigeration Systems" (ASHRAE 15)
- Tubular Exchanger Manufacturers Association (TEMA)
  - *Standards of the Tubular Exchanger Manufacturers Association* (TEMA Standards)

The following are external guidance documents that apply to this program; their use is not mandatory:

- Brookhaven National Laboratory. *Vacuum Systems Consensus Guideline for Department of Energy Accelerator Laboratories* (BNL-81715-2008-IR)

### 6.1.1 International Codes

International codes that are deemed to provide a minimum level of safety that is equivalent to that afforded by Cal/OSHA and other applicable national codes may be approved for use.

A request with the justification to use international codes must be made to the pressure systems program manager. A review will be conducted by the working group and approval may be granted by the chief safety officer.

## 6.2 Related Documents

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 1, "General Policy and Responsibilities"
  - General Policy and Responsibilities: ESH Threshold Review Form (SLAC-I-720-0A24J-001)
- Chapter 12, "Fire and Life Safety"
- Chapter 36, "Cryogenic and Oxygen Deficiency Hazard Safety"
- Chapter 42, "Subcontractor Safety"

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Design and Construction Requirements

Product ID: 128 | Revision ID: 1883 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureReqDesign.pdf

# 1 Purpose

The purpose of these requirements is to ensure that pressure systems are designed and constructed in strict adherence to the pressure systems requirements of Cal/OSHA (8 CCR), applicable codes and standards, and sound engineering principles. They apply to design engineers when they design a new *conventional* or *scientific* pressure system or modify or alter any existing system, including legacy systems; to persons responsible for determining design specifications; and to the Building Inspection Office (BIO), Purchasing, and pressure systems program manager.

When conformance to the requirements of national consensus codes is neither possible nor feasible, refer to the Pressure Systems: Alternate Pressure Systems Qualification Requirements to ensure an equivalent level of safety.

# 2 Requirements

## 2.1 Design Approval

### 2.1.1 Review

The design of any new pressure system and modification or alteration of an existing system, including legacy, used at SLAC must be approved by the pressure systems program manager. The design package may be submitted either to

- The pressure systems program manager directly for review before entering another process such as ESH design review or purchasing
- The Building Inspection Office (BIO) if the system requires ESH design review (see the General Policy and Responsibilities: ESH Project Review Procedure); BIO will then submit the package to the pressure systems program manager
- The Purchasing Department, in the form of a purchase requisition, for which approval is contingent on the design having been approved by the pressure systems program manager (see Pressure Systems: Procurement Procedure)

### 2.1.2 Design Package

In order to be approved, the design must meet all applicable codes and standards and the requirements of this chapter. The design documentation package must include the following:

1. System specifications and drawings identifying design conditions (such as temperature and pressure), material specifications, and fabrication details
2. Design calculations in accordance with the applicable codes, standards, or sound engineering principles
3. Fabrication drawings with details for welding, non-destructive examination, inspection, and testing
4. Stamping information (such as markings and other permanent means of identification)
5. Certification (American Society of Mechanical Engineers [ASME] manufacturer's data report or equivalent) requirements by the fabricator and inspector.
6. When ASME and other national consensus codes cannot be used, see Pressure Systems: Alternate Pressure Systems Qualification Requirements.

## 2.2 Design Standards

The following is an overview.

### 2.2.1 Conventional Pressure Systems

All pressure vessels, boilers, and air receivers and supporting piping systems must be designed in accordance with applicable ASME code, which includes the *Boiler and Pressure Vessel Code (BPVC)* Sections I though XII, including applicable code cases and applicable ASME B31 (*Code for Pressure Piping*) standards.

### 2.2.2 Scientific Pressure Systems

To evaluate and qualify components that were not manufactured under the required national consensus codes, or require modifications not possible within the scope of the approved code, or components that are used in a manner outside the applicability of the code under which they were designed or manufactured, see Pressure Systems: Alternate Pressure Systems Qualification Requirements.

### 2.2.3 Pressure Vessels

Pressure vessels, tanks, and storage systems are to be designed and installed to comply with applicable ASME, ANSI, and other US codes and standards. (Others will be treated as non-coded, which must meet equivalent safety requirements as provided by the ASME code and this program.)

All the designs will be submitted in accordance with Section 2.1 above for review and approval at the appropriate stages of design (such as conceptual, engineering, and procurement readiness reviews).

- ASME-authorized inspector (AI) required
- Application of ASME BPVC to the applicable equipment
- Non-ASME systems designs verified and approved

### 2.2.4 Pressure Piping

All piping must be designed, fabricated, tested, and inspected in accordance with the ASME B31 series of codes or other applicable consensus standards. Piping may be designed under other codes if necessary, based on sound engineering judgment and proven work experience.

The design specifications, drawings, lay-out plans, calculations, and stress analysis reports must be submitted for review in accordance with Section 2.1 above.

If a manufacturer or vendor refuses to submit this information on the basis of "proprietary item or trade secret", that manufacturer or vendor will submit documents to that effect, and secure prior approval from SLAC.

### 2.2.5 Pressure Relief Devices

Adequate relief valves must be installed for all vacuum and pressure vessels, piping and also for any cryogenic lines that have the potential to trap cryogenic fluids.

Relief valves must be sized so that under worst-case failure conditions, the maximum potential pressure or vacuum reached in any system is below the maximum safe working pressure (MSWP) for the vessel, piping or components.

The worst-case failure condition is the maximum pressure or vacuum achievable from the source pumps, cylinders, dewars, and so on.

No fixed prescription can be given to determine valve sizing for all, or even most cases. Each system must be analyzed in detail to properly determine worst-case failure modes and the required relief valve sizing. Relief device calculations must be performed in according to ASME, American Petroleum Institute (API), or Compressed Gas Association (CGA) standards and appropriate published studies on vacuum failures on helium cryogenic systems.

## 2.3 Construction Specifications

The design engineer must specify construction requirements as follows.

### 2.3.1 Materials

The design engineer must follow ASME code material specifications for material type and grade (or supply equivalent specifications). Materials must be specified as new.

Material test reports for the following components must be specified:

- All pressure-containing parts
- All internal parts welded directly to a pressure containing part
- Main support material (skirt/lugs)
- Major supporting piping

Material test reports must be clearly identified with the part number for which the material was used and show cast or heat numbers, chemical analysis, and mechanical properties.

### 2.3.2 Fabrication

The design must specify fabrication requirements according to ASME code or its equivalent, including the following:

- All cylindrical parts must be round in accordance with the ASME *Boiler and Pressure Vessel Code* or ASME *Code for Pressure Piping*. Reforming for out-of-roundness must be performed before any assembly or radiography.
- Cleanliness (free from dirt, grease, paint, and other foreign matter) during hot forming, heat treating, or welding operations must be carefully monitored and maintained. Solvents used to clean or remove scale or oil must be free from organic and inorganic chlorides and sulfides.
- Level of qualification required to perform examinations and inspections of materials, in- process fabrications, non-destructive tests, and acceptance test
- Pressure testing requirements in accordance with the code under which the system was designed
- Vessels only: each plate must be legibly stamped or stenciled showing material grade number and plate number. When metal stamping is done on plate it will preferably be on the long edge of each component.

### 2.3.3 Stamping

The design engineer must specify stamping requirements according to the ASME code or equivalent as follows.

Each pressure vessel must be stamped with information required by the applicable code of construction. The information must include design pressure, design temperature, capacity, fabricator's name, year of manufacture, and manufacturer's serial number. In addition, the ASME certification mark must be stamped as shown in Figure 1 with the appropriate designator under the certification mark.

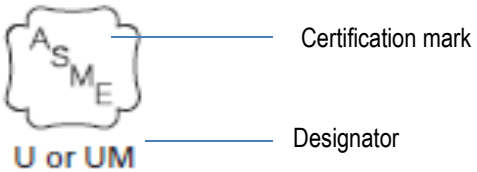


**Figure 1** ASME Certification Mark with Designator U or UM

ASME certification marks will have the following designators for boilers and pressure vessels

- S power boiler
- E electric boiler
- H heating boiler
- HLW lined potable water heater

- U pressure vessel
- UM miniature pressure vessel

### 2.3.4 Certification

The design engineer must specify certification requirements according to the ASME code or equivalent as follows. A manufacturer's data report (MDR) is required for each pressure vessel.

- An ASME MDR is required if the vessel is designed and stamped under ASME code. ASME MDR forms include the following:
  - P-2 Manufacturer's Data Report for All Types of Boilers except Watertube and Electric (BPVC Section 1)
  - H-2 Manufacturer's Data Report for All Types of Boilers except Watertube and Those Made of Cast Iron (BPVC Section 4)
  - U-1 Manufacturer's Data Report for Pressure Vessels (BPVC Section 8, Division 1)
  - U1-A Manufacturer's Data Report for Pressure Vessels (Alternative Form for Single Chamber, Completely Shop- or Field-Fabricated Vessels Only) (BPVC Section 8, Division 1)
- For non-ASME pressure vessels, a fabricator's certificate of compliance confirming that the pressure system has been designed and constructed according to SLAC's specifications and stamping is required.

## 2.4 Additional Requirements for Cryogenic Systems

A *cryogenic system* is considered a pressure system. Therefore, all of the above requirements for pressure systems, including for design packages, apply. The following are additional requirements specific to cryogenic systems.

Cryogenic hazards in cryogenic plants include the potential for oxygen deficient atmospheres due to catastrophic failure of the cryogenic systems, thermal (cold burn) hazards from cryogenic components, pressure hazards, and electrical hazards. Initiators could include the failure/rupture of cryogenic systems from overpressure, failure of insulating vacuum jackets, mechanical damage/failure, deficient maintenance, or improper procedures.

### 2.4.1 Cryomodules and Components

Cryomodules may be considered as a pressure system. The following describes a basic approach, with ramifications for design, manufacturing, and testing, that results in compliant pressure systems:

- Designate each circuit within a cryomodule as a pressure system
- Define a separate design pressure and temperature for each circuit
- Utilize material properties at 2 K (or other operating temperature) where appropriate
- Provide inspection that is conducted by an independent representative
- Apply ASME BPVC and/or B31.3 as appropriate. This results in components that comply with appropriate consensus standards but do not require an ASME code stamp.

In case of a non-ASME-compliant cryomodule, a complete traveler is required to be developed, documenting all stages of material inspection, cryomodule component fabrication, piping and weld inspection, cryomodule assembly, leak checking, and testing.

All the designs will be submitted in accordance with Section 2.1 above for reviews and approval at the appropriate stages of design (such as conceptual, engineering, and procurement readiness reviews).

## 2.5 Additional Requirements for Vacuum Systems

A vacuum vessel can pose a potential hazard to personnel and equipment from collapse, rupture due to back-fill pressurization, or implosion due to vacuum window failure. It is important to design, fabricate, and operate vacuum systems in accordance with applicable codes and sound engineering principles.

The above requirements for pressure systems, including for design packages, apply. The following are additional requirements specific to vacuum systems.

### 2.5.1 Vacuum System Classification

Any new or legacy vacuum system that must be brought into compliance, as described above, must be categorized as follows.

- Category I. Category I vacuum vessels include all vessels in which the differential operating pressure can never exceed 15 pounds per square inch (psi).
- Category II. Category II vacuum vessels include all vessels that can be protected from pressurization exceeding 15 psi through such engineering controls as pressure relief devices.
- Category III. Category III vacuum vessels include all vacuum vessels that are not or cannot be protected from pressurization exceeding 15 psi.

### 2.5.2 Shielding Requirements

The type of component most likely to fail catastrophically in a vacuum system is a brittle component such as a view port (window), glass bell jar, glass ion gauge, glass or plastic vessel, or glass or brittle plastic tubing. Component failure can be caused by, for example, an inadvertent blow or a scratch by a hard, sharp object and can produce sharp-edged shrapnel.

Protective barriers may be used to reduce the likelihood of injury to personnel and damage to equipment. Some common shielding strategies include

- Placing mechanical protective shielding around components such as glass or brittle plastic tubing and glass ion gauges
- Operating a system within a hood with the hood door down (size permitting)
- Operating the system behind or within a polycarbonate (for example, Lexan) or metal shield
- Wearing personal protective equipment (PPE) such as safety glasses or a face shield
- Glass viewports in Category III systems should be protected when not in use. A common strategy is to fasten a polycarbonate cover over the viewport. View ports in Category I and II systems may be protected with clip-on polycarbonate covers if desired.

### 2.5.3 Protecting the System from Overpressure

A second common cause of catastrophic vacuum vessel or system failure, particularly if there are brittle components, is the inadvertent application of internal pressure. Such pressure may be realized as a result of

- Failure of a valve or regulator that is connected to the backfill source
- Pressure generated by a chemical reaction involving reactive gases
- Pressure realized by the accidental connection of the exhaust port of a fore pump to the inlet of the vacuum system. The vacuum pump inlet and outlet should be labelled to avoid switched connections.

Components that can protect a vacuum system that must be purged or backfilled with a high-pressure source capable of causing the system to exceed the *maximum allowable working pressure (MAWP)* include

- A safety manifold
- Relief valves
- Burst discs

A burst disk may be incorporated into a vacuum system design to limit the internal pressure to less than 15 psig following any equipment failure. Burst disks must be adequately sized for the credible identified failure mode and must be rated to fail at internal pressures of less than 15 psig in order to defend the system as intrinsically safe. The burst disk must be connected to the vacuum system and must not be isolated from the system by a valve.

### 2.5.4 Test and Inspection

Most vacuum systems are designed for external pressure and contain components that render an overpressure internal proof test inappropriate. Other means are necessary to document the safety of these systems, and the appropriate method must consider system type, system size (contained energy), system complexity (ease of making errors), and associated hazards.

The following is a partial list of inspection items of special concern:

- General inspection items
  - Check for leaks using the appropriate protocol
  - Ensure that brittle and fragile components are protected to prevent leaks from forming
  - When testing sub-systems, be mindful of unevaluated hazards that would be mitigated in the fully assembled system but may not be mitigated at the sub-system level
- Bellows systems
  - Verify that there is sufficient support at the points of connection so that vacuum force cannot result in an uncontrolled bellows compression and/or injury to personnel

    Vacuum sub-systems with bellows may require additional support against unbalanced atmospheric pressure loads unless the bellows with similar cross-section area are located on opposing sides.
- Kicker-magnet ceramic vacuum chamber
  - Testing before full assembly requires consideration of the overall design in which the fully assembled magnet provides the necessary protection for the fragile subcomponent

- Thin-walled ceramic beam pipes must be checked before installation in a kicker system
- Special care is required during assembly
- Ceramic chambers and metalized joints must never be put in tension or put under torque during assembly or while flanges are bolted

## 2.6 Additional Requirements for Compressed Gas Systems

A compressed gas system is a pressure system, therefore the above requirements for pressure systems, including for design packages, apply. The following are additional requirements specific to compressed gas systems.

There are two types of systems used at SLAC, compressed gas cylinder and tube trailer systems.

### 2.6.1 Compressed Gas Cylinder Systems

A compressed gas cylinder system consists of a cylinder and other associated parts such as regulator, pressure relief valve, valves, and fittings. A compressed gas cylinder system is shown in Figure 2.

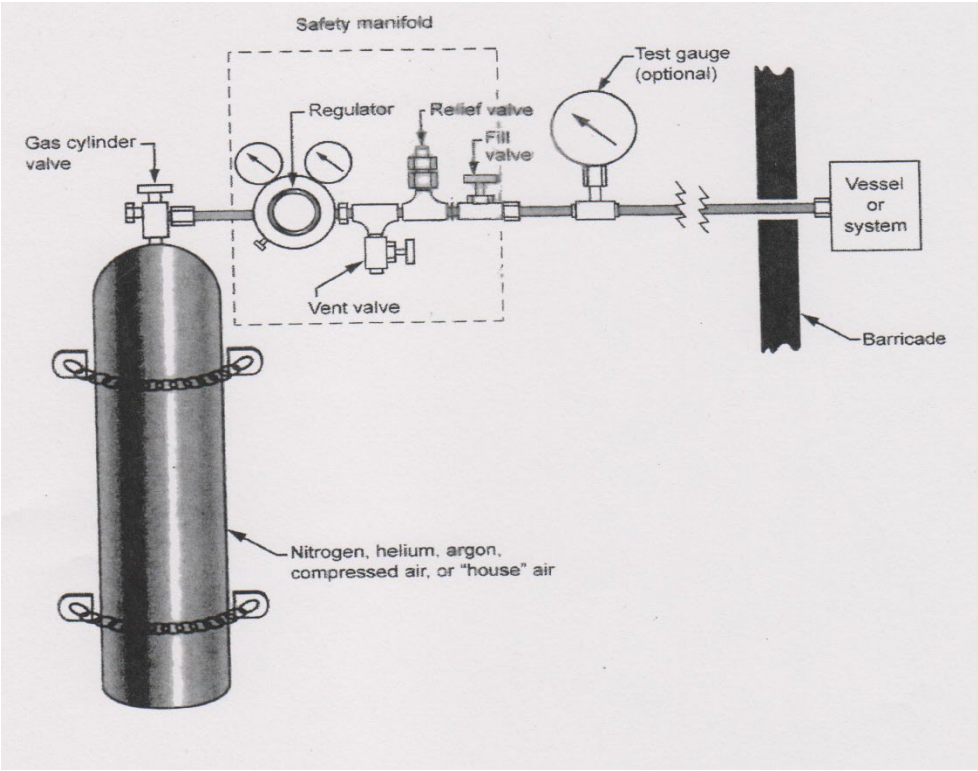


**Figure 2** Example Compressed Gas Cylinder System

#### 2.6.1.1 Cylinders

Cylinders for compressed gases are generally defined in US Department of Transportation (DOT) specifications (49 CFR 180.203) as containers having a maximum water capacity of 1,000 pounds or less. This is equivalent to 120 gallons. The DOT regulates the design, testing, filling, and transportation of commercially available gas cylinders.

Generally, cylinder types 3A or 3AA are used for compressed gas systems. Requalification of a cylinder is required every five years per Table 1 in 49 CFR 180.209. The requalifying means an internal inspection and hydrostatic testing of the cylinder at a pressure 5/3 the service pressure of the cylinder. A cylinder that is filled before retest may remain in service until it is emptied of its charge. In other words, a cylinder that currently has a charge when the five-year retest date occurs does not have to be drained of its charge and retested. The charge can be used and the cylinder retested after the charge has been used. (See Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements for details.)

##### Identification and Color Coding

Stencils, DOT shoulder labels, cautionary side-wall labels, or tags are used to identify the contents of all gas cylinders. Color codes are not used to identify contents.

##### Storage and Handling of Cylinders

The safe storage and handling of cylinders, return to vendor, disposing of damaged cylinders, and tags are covered in Chapter 40, “Chemical Lifecycle Management”.

#### 2.6.1.2 Safety Manifolds

A safety manifold (see Figure 2) is required to reduce the pressure from a standard cylinder and provide relief protection (relief device) for the downstream system. The safety manifold consists of a regulator, a vent valve, a fill valve, and a relief valve.

Safety manifolds must

- Be assembled, inspected, and tested by a qualified pressure system mechanic
- Incorporate a means of shutting down or isolating the pressure source
- Address the safe venting of pressure from any and all parts of the system

##### Regulators

A regulator takes in gas from the cylinder and reduces the pressure to a low working pressure, simultaneously controlling the flow rate. It is important to obtain the correct regulator and ensure it is consistent with the gas involved and operation intended.

- Select a single-stage or double-stage regulator depending on your application.
- Store unused regulators in plastic bags to keep clean.
- Make sure that the threads on the regulator’s CGA connection correspond to those on the cylinder valve outlet.
- Do not lubricate any part of the regulator or cylinder valve.
- Properly label the regulators with the fluid being used.

- Use only oxygen regulators for oxygen service.
- Immediately replace damaged, defective, or unreliable regulators.
- Do not attempt to make repairs or modifications to regulators.
- Inspect regulators at regular intervals, as appropriate to the application.

#### Pressure Relief Devices

A pressure relief device is used to protect the down-stream system from over pressure. There are two types of pressure relief devices, spring loaded relief valves and rupture or burst discs.

- Whenever possible, use ASME-rated pressure relief devices.
- Never set a relief device above the MAWP of the lowest rated system component it is installed to protect.
- Install relief devices of adequate flow capacity. When the port is full open, the pressure must not exceed 110 percent of the MAWP.

### 2.6.2 Tube Trailer Systems

A tube trailer with its fittings and accessories is considered a pressure system. Tube trailers consist of 10 to 36 cluster high-pressure cylinders varying in length from 20 feet for small tubes to 38 feet on the jumbo tube trailers. Each tube may contain as much as 3,000 psig of gaseous product. Tubes may be operated as a unit or one at time.

Typical products stored in tube trailers are hydrogen, helium, and argon. All tube trailers are built to comply with DOT regulations for hazardous material safety, federal motor carrier safety, and national highway traffic safety.

The tubular cylinders of the trailers are made according to cylinder specifications 3A, 3AA, 3AX, 3AAX, or 3T. Specifications 3AX, 3AAX, and 3T are used for long, large containers approximately 22 inches in diameter instead of the older 9-3/8-inch tubes that were made to specifications 3A, and 3AA. Tube trailers have been built to carry as much as 180,000 square feet of helium.

Because of their length, pressure relief devices must be installed on both ends of a trailer tube. For flammable gases, each device must be arranged to discharge upwards, unobstructed to the open air, to prevent any impingement of escaping gas upon the other tubes.

Similar to a compressed gas cylinder, requalification of a tube trailer cylinder is required every five years per Table 1 in 49 CFR 180.209. The requalifying means an internal inspection and hydrostatic testing of the cylinder at a pressure 5/3 the service pressure of the cylinder. A cylinder that is filled before retest may remain in service until it is emptied of its charge. In other words, a cylinder that currently has a charge when the five-year retest date occurs does not have to be drained of its charge and retested. The cylinder can remain in service and the cylinder retested after the charge has been used. (See Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements for details.)

# 3 Forms

The following forms and systems are required by these requirements:

- An ASME MDR is required if the vessel is designed and stamped under ASME code.
- For non-ASME pressure vessels, a fabricator's certificate of compliance confirming that the pressure system has been designed and constructed according to SLAC's specifications and stamping is required.
- Pressure Systems Database. Database of pressure systems

# 4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- The pressure systems program manager retains approved design documents (specifications and/or drawings) (which are submitted to the pressure systems program manager directly or through a related design review process.)

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"
  - Pressure Systems: Alternate Pressure Systems Qualification Requirements (SLAC-I-730-0A21S-065)
  - Pressure Systems: Procurement Procedure (SLAC-I-730-0A21C-030)
  - Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements (SLAC-I-730-0A21S-053)
  - Pressure Systems Safety Program (SharePoint)
- Chapter 1, "General Policy and Responsibilities"
  - General Policy and Responsibilities: ESH Project Review Procedure
- Chapter 40, "Chemical Lifecycle Management"

Other Documents

- Title 10, *Code of Federal Regulations*, "Energy", Chapter 3, "Department of Energy", Part 851, "Worker Safety and Health Program" (10 CFR 851) (as described in SLAC Injury and Illness Prevention Program [SLAC-I-720-0A21B-001])
- Title 49, *Code of Federal Regulations*, "Transportation", Subtitle B, "Other Regulations Relating to Transportation", Chapter 1, "Pipeline and Hazardous Materials Safety Administration, Department of Transportation", Subchapter C, "Hazardous Materials Regulations", Part 180, "Continuing Qualification and Maintenance of Packagings" (49 CFR 180)
- Title 8, *California Code of Regulations*, "Industrial Relations", Division 1, "Department of Industrial Relations", Chapter 4, "Division of Industrial Safety"
  - Subchapter 1, "Unfired Pressure Vessel Safety Orders" (8 CCR 450–560)
  - Subchapter 2, "Boiler and Fired Pressure Vessel Safety Orders" (8 CCR 750–797)

- Title 24, *California Code of Regulations,* "California Building Standards Code"
  - Part 4, "California Mechanical Code" Part 4 (24 CCR Part 4)
  - Part 5, "California Plumbing Code" Part 5 (24 CCR Part 5)
- American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code (BPVC)* (ASME BPVC), including applicable addenda and code cases
- ASME *Code for Pressure Piping* (ASME B31), including applicable addenda and code cases
- Brookhaven National Laboratory. *Vacuum Systems Consensus Guideline for Department of Energy Accelerator Laboratories* (BNL-81715-2008-IR)

*Note* *See Chapter 14, "Pressure Systems" for a complete list of applicable codes and standards.*

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Alternate Pressure Systems Qualification Requirements

Product ID: 733 | Revision ID: 2472 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureReqAlternateQual.pdf

## 1 Purpose

The SLAC pressure systems program requires all piping and pressure vessels to be designed, constructed, and installed in a safe and professional manner. (See Pressure Systems: Design and Construction Requirements.) It is expected that in most cases this will be achieved through the application of Cal/OSHA regulations (8 CCR), applicable codes and standards (including the ASME *Boiler and Pressure Vessel Code*, the ASME *Code for Pressure Piping* [B31 series], and NFPA codes), California building standards codes (mechanical, plumbing, fire) as applicable, and sound engineering principles.

The purpose of these requirements is to provide an option to evaluate and qualify pressure system components that were not manufactured under the required codes, require modifications not possible within the scope of the approved codes, or are to be used in a manner outside the applicability of the code under which they were designed or manufactured.

They apply to design engineers when they design a new *conventional* or *scientific* pressure system or modify or alter any existing system, including a legacy system; to persons responsible for determining design specifications; and to system owners, project managers, and the pressure systems program manager.

Equipment covered by these alternate requirements includes

- Custom vacuum chambers with thin windows designed to allow unimpeded transmission of electron or X-ray beams
- Research equipment that due to the required pressure range, vessel geometry, use of special materials, or temperature cannot be feasibly constructed under national consensus codes
- Specialized equipment manufactured under pressure code systems different than the codes identified in this chapter. This includes equipment that is either: a) not manufactured under national consensus codes, or b) the equipment that cannot be manufactured under national consensus codes and still meet the scientific performance requirements.
- Specialized equipment manufactured under other code systems (such as the European Pressure Equipment Directive (PED 2014/68/EU). Note such equipment meeting the national consensus codes should be used wherever possible or feasible.
- Equipment or components built under the national consensus codes that are used outside the scope of the code under which they were manufactured.
- Equipment or components that do not have documentation to show it was constructed to national consensus codes.

These alternate qualification requirements should not be used to qualify equipment that is otherwise available manufactured under national consensus codes and that meets the performance requirements in support of the laboratory's mission.

## 1.1 Examples of Systems

The following are examples of systems or components where use of the items was allowed through the application of these requirements or their predecessors.

- Cryo-EM microscopes. These precision instruments were constructed under European Pressure Equipment Directive (PED) codes. The instruments were certified to meet the European codes by a professional third-party organization. The application of PED codes was evaluated and accepted in this application. Instruments built under US codes meeting the performance requirements were not available.
- Xenon purification. The purification process uses aluminum DOT-rated gas cylinders in the purification processing. The cylinder is cryogenically cooled to freeze xenon gas and the use will extend beyond the DOT retest date. The choice of this component is driven by chemical purity requirements. An analysis showed that the use of these cylinders in this manner is safe at the process pressures and temperatures.
- Beamline scattering chambers with thin X-ray or electron windows. The windows do not meet the ASME BPVC requirements for material choice and thickness. The chambers cannot be pressure tested due to the window openings. The thin windows are required to allow undisturbed passage of the beam. The construction of the chamber was analyzed and engineering and administrative controls for protecting the window implemented.
- Superconducting accelerator cavities. Pure niobium metal is not a qualified material for an ASME-rated pressure vessel. Niobium is the superconducting material that has the properties required for the cavity performance. An analysis showed that the use of these cavities in the cryogenic modules is safe at the pressures and temperatures involved.

# 2 Requirements

## 2.1 Application

### 2.1.1 Preparation

In all cases the system owner or equipment project manager is encouraged to notify and consult with the pressure systems program manager, who may engage the Pressure Systems Working Group, chief safety officer and/or chief engineer before recommending to proceed with an alternate pressure system qualification.

### 2.1.2 Description of System

The engineering evaluation (see below) must include a description of the pressure system component. The description should include vendor data sheets, drawings, and/or pictures of the device, and why the use of the alternate qualification process is required for this application. If the component is part of a larger

system, a description of that system, including the associated process and instrumentation diagram, should be included.

### 2.1.3 Engineering Evaluation

An engineering evaluation of the suitability and safety of the equipment is required. Examples of engineering evaluation methods that may be utilized include the following:

1. If the equipment was constructed under a non-US code standard. Documentation that the system was designed and constructed under an applicable code standard, that the system meets this code standard, that the code standard used provides equivalent protection at a level of safety comparable to that achieved by complying with the requirements of these national consensus codes, and that the use of the equipment at SLAC is consistent with the standard. An evaluation of the applicable code standard may be required if SLAC has not already accepted its use in a similar application.
2. If the equipment is specialized research equipment designed for or by SLAC to meet the demands of the research program. An engineering note should be written describing the equipment. The note should analyze the design, material properties, stresses, manufacturing methods, and demonstrate that the device has sufficient engineering margin to provide a level of safety comparable to that achieved using the ASME codes. The basic minimum design margin[1] (safety factor) is 3.5 for any pressure system(s) unless a lower design margin can be justified by applicable codes, stress analysis, or engineering calculations. The note should be reviewed and concurred with by other engineers for the line organization before submission.
3. If some aspect of the equipment cannot be manufactured with an engineering margin providing equivalent protection at a level of safety comparable to that achieved by complying with the requirements of these national consensus codes. Similar to above for specialized equipment. The engineering note should additionally identify and analyze the engineering and administrative controls proposed to address the deficiencies.
4. Or some other engineering evaluation process that includes system analysis, hazard controls, and/or other mitigations.

The intent of these requirements is to provide equivalent protection at a level of safety comparable to that achieved by complying with the requirements of these national consensus codes.

The engineering evaluation is the responsibility of the system owner or project manager for the equipment. The evaluation should be in the form of a formal document or engineering note.

### 2.1.4 Alternate Pressure Systems Qualification Application

The complete package must include the following:

1. A description of the system, including a description of its use

---

1 Equivalent to ASME *Boiler and Pressure Vessel Code* requirements. See ASME BPVC, Section II, Part D, Mandatory Appendix 1-100. "At temperatures below the range where creep and stress rupture strength govern the selection of stresses, the maximum allowable stress is the lowest of: (1) the minimum tensile strength divided by 3.5, or (2) two-thirds the minimum yield strength" (simplified by author).

2. An engineering evaluation of the system
3. A completed Pressure Systems: New Pressure System Registration Form
4. A note from the project's associate laboratory director indicating approval of the application

## 2.2 Submission and Review

The engineering evaluation is submitted to the pressure systems program manager. Depending on the complexity of the system, risks, and consequence of a failure, the pressure systems program manager may refer the analysis to members of the Pressure Safety Working Group, chief safety officer and/or chief engineer for a review of the engineering evaluation.

Pressure vessels and pressure systems for which pressure testing is a proposed mitigation may not be pressurized until the engineering evaluation has determined that the vessel or system can withstand the proposed testing protocol. Approval for pressure testing may be given to the system owner by the pressure systems program manager as an interim step to final qualification.

Pressure vessels or pressure systems submitted for qualification under these requirements may not be used until the pressure systems program manager has confirmed to the system owner that the system is considered acceptable and has been qualified.

# 3 Forms

The following forms and systems are required by these requirements:

- For non-ASME pressure vessels, a fabricator's certificate of compliance confirming that the pressure system has been designed and constructed according to SLAC's specifications and stamping is required.
- Pressure Systems: New Pressure System Registration Form (SLAC-I-730-0A21J-040). Form for registering and approving new pressure systems; documents compliance with program requirements
- Pressure Systems Database. Database of pressure systems

# 4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- The pressure systems program manager maintains the registration record and all submitted attachments in the Pressure Systems Database, which serves as the repository for all pressure system records throughout the pressure system's service life.

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"

  - Pressure Systems: Design and Construction Requirements (SLAC-I-730-0A21S-047)
  - Pressure Systems: Registration Procedure (SLAC-I-730-0A21C-031)
  - Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements (SLAC-I-730-0A21S-053)
  - Pressure Systems Safety Program (SharePoint)
- Chapter 1, "General Policy and Responsibilities"
  - General Policy and Responsibilities: ESH Project Review Procedure
- Chapter 40, "Chemical Lifecycle Management"

Other Documents

- Title 10, *Code of Federal Regulations*, "Energy", Chapter 3, "Department of Energy", Part 851, "Worker Safety and Health Program" (10 CFR 851) (as described in SLAC Injury and Illness Prevention Program [SLAC-I-720-0A21B-001])
- Title 49, *Code of Federal Regulations*, "Transportation", Subtitle B, "Other Regulations Relating to Transportation", Chapter 1, "Pipeline and Hazardous Materials Safety Administration, Department of Transportation", Subchapter C, "Hazardous Materials Regulations", Part 180, "Continuing Qualification and Maintenance of Packagings" (49 CFR 180)
- Title 8, *California Code of Regulations*, "Industrial Relations", Division 1, "Department of Industrial Relations", Chapter 4, "Division of Industrial Safety"
  - Subchapter 1, "Unfired Pressure Vessel Safety Orders" (8 CCR 450–560)
  - Subchapter 2, "Boiler and Fired Pressure Vessel Safety Orders" (8 CCR 750–797)
- Title 24, *California Code of Regulations,* "California Building Standards Code"
  - Part 4, "California Mechanical Code" Part 4 (24 CCR Part 4)
  - Part 5, "California Plumbing Code" Part 5 (24 CCR Part 5)
- American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code (BPVC)* (ASME BPVC), including applicable addenda and code cases
- ASME. *Code for Pressure Piping* (ASME B31) (including applicable addenda and code cases)
- Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the Harmonisation of the Laws of the Member States Relating to the Making Available on the Market of Pressure Equipment (Pressure Equipment Directive) (PED 2014/68/EU)

*Note* *See Chapter 14, "Pressure Systems" for a complete list of applicable codes and standards.*

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Procurement Procedure

Product ID: 535 | Revision ID: 1884 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureProcedProcure.pdf

# 1 Purpose

The purpose of this procedure is to ensure that pressure systems, components, and associated services are in strict adherence with Cal/OSHA regulations (8 CCR), applicable codes and standards, and sound engineering principles. It applies to pressure system owners and custodians or others with purchasing authority, the pressure systems program manager, and Purchasing, when purchasing the following:

- Pressure systems such as American Society of Mechanical Engineering (ASME)-rated boilers and pressure vessels; non-ASME-rated vessels such as Department of Transportation (DOT) vessels; custom-fabricated, scientific, cryogenic, vacuum, gas cylinder pressure, refrigeration, mobile pressure, portable tank, and rental pressure systems; and cryogenic dewars
- Specific components including pressure relief valves, rupture disks, safety manifolds, gas cylinder manifolds, vacuum chambers, and mechanical vacuum pumps
- Services related to pressure systems, such as installation, inspection, maintenance, or repair

A core requirement for such purchases is pre-purchase approval by the pressure systems program manager.

## 1.1 Exemptions

The following commercial off-the-shelf components must meet code requirements but are exempt from the pressure systems program manager's pre-purchase approval: pressure regulators and gauges, pipes; tubes; pipe and tube supports; fittings such as unions, elbows, and tees; hoses; flexible hoses and tubing; control valves; flow meters; pressure transducers; flash arrestors; valves, including needle, ball, gate, globe, and check; filters; seals and gaskets; bolts and other closure hardware. Any of the above components procured as custom fabricated are subject to further review.

# 2 Procedure

| Step | Person | Action |
|---|---|---|
| 1. | Requester | Identifies need for pressure system or associated services: goes to Step 2<br>Identifies need for pressure system components: skips to Step 4 |
| 2. | Requester | Determines pre-purchase technical review requirements |
| 3. | Requester | Submits specifications to the appropriate reviewer (as determined in Step 2)<br>The following applies to all pressure systems types, including custom-fabricated systems. If a system is ready made, submit the equivalent documentation. |

| Step | Person | Action |
|---|---|---|
| | | *Note: items d and e can only be obtained once manufacture is complete, but these items must be specified on the purchase requisition.*<br>a. System specifications and drawings identifying design conditions (such as temperature and pressure), material specifications, and fabrication details<br>b. Design calculations in accordance with the applicable codes, standards, or sound engineering principles<br>c. Fabrication drawings with details for welding, non-destructive examination, inspection, and testing<br>d. Stamping information (such as markings and other permanent means of identification)<br>e. Manufacturer's data reports (MDR) or equivalent documents certified by the fabricator and inspector |
| 4. | Requester | *Note: this step applies if purchasing components only.*<br>Submits pressure system component specifications to pressure systems program manager for any components not explicitly listed in Section 1.1, "Exemptions"<br>The following must be provided:<br>▪ Technical specifications and drawings indicating codes or standards<br>▪ Vendor's product catalogs, product literature, or cut sheets |
| 5. | Pressure systems program manager | Approves system(s)/component(s) that meet code requirements or specifies missing or code equivalent information required for approval |
| 6. | Owner / custodian | Submits purchase requisition to Purchasing |
| 7. | Purchasing | Processes purchase requisition<br>▪ If the system was previously approved by the pressure systems program manager (directly or through a review process that includes the pressure systems program manager), and specifications have not changed since approval, no further technical approval is required<br>▪ If the system has not been approved by the pressure systems program manager, forwards purchase requisition to the pressure systems program manager |
| 8. | Pressure systems program manager | Approves purchase requisition if items meet review and code requirements<br>If approval is denied, specifies missing or required code-equivalent information |

# 3 Forms

The following forms and systems are required by this procedure:

- None

# 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- None

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"
  - Pressure Systems: Registration Procedure (SLAC-I-730-0A21C-031)
  - Pressure Systems Safety Program (SharePoint)

Other SLAC Documents

- Purchasing Department

Other Documents

- Title 10, *Code of Federal Regulations*, "Energy", Chapter 3, "Department of Energy", Part 851, "Worker Safety and Health Program" (10 CFR 851) (as described in SLAC Injury and Illness Prevention Program [SLAC-I-720-0A21B-001])
- Title 8, *California Code of Regulations*, "Industrial Relations", Division 1, "Department of Industrial Relations", Chapter 4, "Division of Industrial Safety"
  - Subchapter 1, "Unfired Pressure Vessel Safety Orders" (8 CCR 450–560)
  - Subchapter 2, "Boiler and Fired Pressure Vessel Safety Orders" (8 CCR 750–797)

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Registration Procedure

Product ID: 536 | Revision ID: 1885 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureProcedRegistration.pdf

# 1 Purpose

The purpose of this procedure is to ensure a complete and accurate inventory of all pressure systems. It applies to owners and custodians of all new and *legacy* (installed before February 9, 2007) pressure systems, including *scientific*, *conventional*, *pressure*, *vacuum*, and *cryogenic* systems, and the pressure systems program manager.

- All new pressure systems must be registered before they can be put into operation.
- All legacy systems must be registered as described below, including currently unregistered systems.

This procedure does not apply to pressure systems brought temporarily on-site by subcontractors.

# 2 Procedures

## 2.1 New Systems

| Step | Person | Action |
|---|---|---|
| 1. | Owner or custodian | Submits completed New Pressure System Registration Form to the pressure systems program manager<br>*Note: essential registration items include documentation that the system has been tested and inspected as required for final acceptance. For more information, contact the pressure systems program manager.* |
| 2. | Pressure systems program manager | Reviews form<br>▪ If information is complete, goes to Step 4<br>▪ If information is incomplete, requests missing information |
| 3. | Owner or custodian | Submits additional requested information |
| 4. | Pressure systems program manager | Enters pressure system information into the Pressure Systems Database and assigns a pressure system (PS) number |
| 5. | Pressure systems program manager | Signs registration form. The signed form gives the owner authorization to operate the pressure system.<br>*Note: new systems may only be put into operation once the signed form is on file in the Pressure Systems Database* |

| Step | Person | Action |
|---|---|---|
| 6. | Pressure systems program manager | Issues a pressure system number label |
| 7. | Owner or custodian | Affixes pressure system number label to the pressure system |

## 2.2 Legacy Systems

| Step | Person | Action |
|---|---|---|
| 1. | Owner or custodian | Discovers pressure system not registered in the Pressure Systems Database |
| 2. | Owner or custodian | Submits completed Legacy Pressure System Registration Form to pressure systems program manager |
| 3. | Pressure systems program manager | Reviews form<br>▪ If information is complete, assigns a pressure system number<br>▪ If information is incomplete, interviews owner or custodian to complete the record |
| 4. | Pressure systems program manager | Registers legacy system in the Pressure Systems Database and issues a pressure system number label |
| 5. | Owner or custodian | Affixes pressure system number label to the pressure system |

# 3 Forms

The following forms and systems are required by this procedure:

- Pressure Systems: New Pressure System Form Registration (SLAC-I-730-0A21J-040). Form for registering and approving new pressure systems; documents compliance with program requirements
- Pressure Systems: Legacy Pressure System Registration Form (SLAC-I-730-0A21J-041). Form for registering legacy pressure systems; documents system identification numbers, specifications, status, and risk level
- Pressure Systems Database. Database of pressure systems

# 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- The pressure systems program manager maintains the registration record and all submitted attachments in the Pressure Systems Database, which serves as the repository for all pressure system records throughout the pressure system's service life.
- The owner or custodian must keep all submitted records on file for a period of five years.

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"
  - Pressure Systems Safety Program (SharePoint)

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# New Pressure System Registration Form

Product ID: 539 | Revision ID: 2371 | Date Published: 26 October 2021 | Date Effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormRegistrationNew.pdf

The pressure system owner must submit this completed form to the pressure systems program manager for any new system before it is put into operation. If the submitted documentation meets Cal/OSHA regulations (8 CCR), applicable codes and standards, and sound engineering principles, the pressure systems program manager will approve the system for operation at SLAC by signing this form, entering the information into the Pressure Systems Database, and issuing a pressure system number, which the owner must apply to the pressure system. The completed form must be kept on file by the owner or custodian for five years (see Pressure Systems: Registration Procedure [SLAC-I-730-0A21C-031]).

| | | |
|---|---|---|
| Owner: | Custodian: | Directorate: |
| Property control number: | Location: | Project identifier: |
| Design pressure | Min (psig): | Maximum allowable working pressure (MAWP) (psig): |
| Design temperature | Min: | Max: |
| Material | Shell: | Head: |
| System contents | | |
| ASME-rated system | Design: | |
| | Code stamp: | Year built: |
| | Certification: | ASME data reports: |
| | Manufacturer: | National Board number: |
| Non-ASME-coded system | Design: | |
| | Manufacturer: | SL number: |
| | Materials inspection: | |
| | Fabrication inspection: | |
| | Nameplate information: | |
| | Certification: | |
| | Operation procedures *(attach copy):* | |
| | Maintenance procedures *(attach copy):* | |
| | Approving authority, as applicable *(safety committee):* | |
| Pressure relief device(s) | Device type: | **This section completed by the pressure systems program manager.** |
| | Relieving capacity: | Pressure system number: |
| | Set pressure: | Remarks: |
| Testing and inspection | Pressure test<br>Test pressure: Date: | |
| | Acceptance inspection | Date approved for operation*:* |
| | Inspected by *(print):* | By *(print):* |
| | Signature: | Signature: |

Attachment(s): *(include titles of photos, drawings, and supporting documents such as standard operating procedures, maintenance manuals, etc)*

SLAC NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Legacy Pressure System Registration Form

Product ID: 540 | Revision ID: 2372 | Date Published: 26 October 2021 | Date Effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormRegistrationLegacy.pdf

Any pressure system not already registered in the Pressure Systems Database must be registered by the owner or custodian by submitting all available information to the pressure systems program manager. The completed form must be submitted to the pressure systems program manager and kept on file by the owner or custodian for five years (see Pressure Systems: Registration Procedure [SLAC-I-730-0A21C-031]).

| System Identification | | |
|---|---|---|
| MESI number: | Drawing number: | Directorate: |
| HEEC number: | Serial number: | Project identification number: |
| FAMIS ID: | Manufacturer: | Owner: |
| PC number: | Date of manufacture: | Custodian: |
| CA state number: | National Board (NB) number: | Building / room number: |

| System Specifications | | |
|---|---|---|
| Fixed or portable: | MAWP: | Pressure relief device type: |
| System type: | MOP: | Relief set point: |
| System description: | Design pressure: | Pressure relieving capacity: |
| Parent system or subsystem: | Test pressure: | Stored energy: |
| Status: | Most recent test date: | Design standard: |
| Application: | Minimum temperature: | Hazardous materials: |
| Modified date (if applicable): | Maximum temperature: | Cross contamination: |
| Incident date (if applicable): | System contents: | Shell material: |
| Discard status: | System volume: | Last inspection date: |
| ASME stamp: | Other: | |
| Attachment(s) (include titles of photos, drawings, and supporting documents such as standard operating procedures, maintenance manuals, etc) | | |
| Assessment and Validation | | |
| Inventory date: | Risk level ranking *(preliminary)* ☐ 1 (high) ☐ 2 (medium) ☐ 3 (low) | |
| Completed by *(print):* | | |
| Title *(print):* | | Date: |
| This section completed by pressure systems program manager: | | |
| PS number: | Risk level ranking ☐ 1 ☐ 2 ☐ 3 | |
| Accepted by pressure systems program manager *(print):* | | |
| Signature: | | Date: |

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Installation, Inspection, Maintenance, and Repair Requirements

Product ID: 537 | Revision ID: 1886 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureReqInspectMaintRepair.pdf

# 1 Purpose

The purpose of these requirements is to maintain the mechanical integrity of pressure systems throughout their life. They cover installation, inspection, maintenance, and repair of all types of pressure systems. They apply to equipment owners, custodians, inspectors, mechanics, and installation and repair organizations.

# 2 Requirements

The following are minimum requirements. Systems that present higher risk because of use history, unusual ambient operating temperature and pressure, or special materials or system content may require special installation, inspection, maintenance, and/or repair.

## 2.1 Installation

A manufacturer, supplier, or mechanical subcontractor may install a pressure system. The installer must follow the design documentation, quality assurance, code requirements, and manufacturer's recommendations. The installer is responsible for pressure testing, installation inspection, performance testing, and acceptance testing.

- Installation must be performed by qualified personnel of the manufacturer or mechanical subcontractor or a SLAC pressure system mechanic.
- After installation is complete, a pressure test must be performed and documented. The pressure test plans must be submitted to the pressure systems program manager before performing the pressure test.
- All installation and pressure test records must be submitted to the pressure systems program manager.

*Note* *National Board of Boiler and Pressure Vessel Inspectors (NBBI) NB 23,* National Board Inspection Code (NBIC)*, Part I, "Installation", may be followed as a guideline for installation.*

## 2.2 Inspection

- Inspections will be performed only by pressure system inspectors, designated by line management and trained and qualified by the pressure systems program manager.
- Inspectors will follow one or a combination of the following for performing inspections:

- *National Board Inspection Code (NBIC)*
- International Code Council (ICC) codes
- American Petroleum Institute (API) standards
- Compressed Gas Association (CGA) standards
- Manufacturer's recommendations

### 2.2.1 Types

The two pressure system inspection types are external and internal.

An external inspection is conducted while the system is operating and includes

- Examination of system components, including structural attachments, vessel connections, inlet piping, outlet piping, drain piping, piping supports, and appurtenances
- Identifying evidence of leakage or inadequate insulation or other coverings

An internal inspection is conducted once the pressure has been released and the system is open for inspection. It includes inspecting for corrosion and wear around, and defects at,

- Welded seams, nozzles, and areas adjacent to welds
- Vessel connections
- External fittings or controls

### 2.2.2 Frequency

Minimum inspection intervals for pressure systems are listed in Table 1. Certain systems require more frequent inspection because of higher hazard potential.

**Important** If any system shows signs of wear or a defect, steps must be taken immediately to address the problem. See Sections 2.3 and 2.4 for maintenance or repair requirements.

**Table 1** Pressure System Inspection Frequency

| Equipment | Inspection Type | Inspection Frequency |
|---|---|---|
| Heating boiler | External | 3 years |
| Pressure vessel, corrosive service | External and internal | 2 years |
| Pressure vessel, non-corrosive service | External | 3 years |
| Vacuum vessel | External | 5 years |

### 2.2.3 Pressure Test

A pressure test is required for a new pressure system or an existing pressure system after repair or alteration (see Pressure Systems: Pressure Test Procedures).

Pressure systems or system components designed under federal Department of Transportation (DOT) requirements (49 CFR 178) require hydrostatic pressure tests to ensure mechanical integrity over a period of time. Minimum hydrostatic test frequencies for such DOT systems are listed in Table 2.

**Table 2** Hydrostatic Test Frequency and Pressure

| Pressure System | Test Frequency | Test Pressure |
|---|---|---|
| Tube trailer | 5 years | 5/3 times service pressure |
| Compressed gas cylinder | 5 years | 5/3 times service pressure |

### 2.2.4 Leak Test and Mechanical Integrity for Vacuum Systems

A vacuum system/vacuum component must be leak tested to determine conformance with the maximum permissible leak specified on the drawing, purchase order, or other documents supplied at the order. The mechanical integrity assessment is looking for evidence of vacuum vessel instability or buckling.

The SLAC Leak Test and Mechanical Integrity Standard identifies a standardized approach for helium leak detection, which takes into account the specified target leak rate, the volume of the system, and the detector/system pump capacity.

### 2.2.5 Pressure Relief Devices

*Pressure relief devices* such as safety valves, pressure relief valves, and rupture disks prevent a system from becoming over pressurized. Their proper function is essential. Pressure relief devices must be inspected according to the frequency listed in Table 3. The inspection should verify that

- The device is appropriate to current use
- The set pressure is correct
- The installation is correct and the device functions while system is in operation (test as appropriate)

Defective device(s) must be replaced immediately.

**Table 3** Pressure Relief Device Inspection Frequency

| Equipment | Inspection Frequency |
|---|---|
| Heating boiler | 3 years |
| Pressure vessel, corrosive service | 2 years |
| Pressure vessel, non-corrosive service | 3 years |
| Vacuum vessel | 5 years |

Pressure relief valves are required to be tested and set pressures adjusted when

- The valves are not relieving pressure at designated set pressure,
- The valves are leaking, or

- When recommended by the pressure system inspector

A pressure system that includes an American Society of Mechanical Engineers (ASME) code designed vessel must be equipped with ASME-rated pressure relief devices. It is recommended that ASME-rated pressure relief devices also be used on non-ASME pressure systems of more than 15 psig working pressure.

ASME-rated pressure relief devices bear the following certification mark and designators:


- UV pressure relief valve for pressure vessels
- UD rupture disk for pressure vessels
- HV pressure safety valve for heating boilers

### 2.2.6 Recordkeeping

All inspections must be recorded using Pressure Systems: Inspection Report Form. For additional recordkeeping requirements, see Section 4.

## 2.3 Maintenance

### 2.3.1 Types

Pressure systems must be maintained according to a schedule appropriate to system type and the operating conditions. Maintenance types include

- Preventive, which is generally determined by the manufacturer
- Break down, which is an opportunity for maintenance due to unforeseen equipment shutdown
- Periodic, which is required maintenance as determined by manufacturer's recommendation and/or SLAC policy

Maintenance includes replacement or repair of defective or worn components. Maintenance does not include implementing modifications or alterations.

### 2.3.2 Qualifications

Maintenance must be performed by a qualified mechanic.

*Note* *All work involving hazardous energy must adhere to requirements in Chapter 51, "Control of Hazardous Energy"*

### 2.3.3 Compressed Gas Systems

#### 2.3.3.1 Before First Use

Before a compressed gas system is used the first time:

- Make sure the system is equipped with the correct regulator. Never force connections that do not fit. An improper fit may indicate that the regulator or connector is not suitable.
- Inspect the regulator and valves and remove any grease, oil, dirt, or solvent. Never use grease or oil to lubricate regulators or valves – compressed gas and volatile lubricants can cause an explosion.
- Only use wrenches or tools provided or recommended by the supplier to open or close a valve; never use pliers.
- Place the cylinder so that it is easily accessible, does not become part of an electric circuit, and does not become entangled in experimental apparatus.

#### 2.3.3.2 General Use Requirements

- Keep valve protection caps in place until ready to use.
- Close the valve when equipment is not in use.
- Use the cylinder valve, not the regulator, for turning off the gas.
- Close the cylinder valve and release all pressure before removing the regulator.
- Never heat cylinder – even when partially empty – with any device that could raise the surface temperature of the cylinder to above 125º F.
- Keep the cylinder clear of all electrical circuits, flame, and sparks.

#### 2.3.3.3 Upright and Inverted Use

- System containing flammable liquefied gas (for example, acetylene) must be used valve end up, except those designed for use in a horizontal position and those cylinders containing non-liquefied gases.
- When used upright (inclined no more than 45 degrees from the vertical), the relief device must always in direct communication with the gas phase.
- If inverted, the cylinder must be secured and the dispensing apparatus must be specifically designed for inverted use.

### 2.3.4 Recordkeeping

All maintenance must be recorded using Pressure Systems: Maintenance and Repair Report Form. In addition, if a maintenance procedure includes pressure testing as required by code, a record of the test must be submitted to the pressure systems program manager.

## 2.4 Repair

Repair can take the form of restoring a non-functioning system to approved design specifications or it can include system modification or alteration (which is also referred to as *re-rating*).

The following requirements apply:

- All repairs that restore a system to the formerly approved design specification must be done in accordance with the code of construction, which must be in compliance with ASME code, the *National Board Inspection Code (NBIC)*, national standards, or other approved codes.
- If a system is to be modified or altered, the new design specifications must be verified by engineering calculations and approved by the pressure systems program manager.
- Modifications must be performed by qualified personnel as follows
  - Repairs that require welding to ASME code stamped vessels ("U", "UM", "H", et cetera) must be performed by an organization holding an "R" stamp.[1]
  - Alterations must be performed by an organization holding an "R" stamp.
  - Repairs to pressure relief or pressure safety valves with the ASME code "V" or "UV" stamps must be performed by an organization holding a "VR" stamp.
  - All other repairs must be performed by a *qualified mechanic*.
- Completion of repairs and alterations must be verified by inspection and testing as defined by applicable ASME *Boiler and Pressure Vessel Code (BPVC)*, ASME *Code for Pressure Piping*, and *National Board Inspection Code (NBIC)*.

### 2.4.1 Recordkeeping

All repairs must be recorded using Pressure Systems: Maintenance and Repair Report. In addition, the repair organization (vendor) must complete and submit the following for any work performed on ASME-coded systems:

- For repairs: National Board Form R-1. Supplied by qualified vendor to custodian, who submits a copy to pressure systems program manager
- For alterations: National Board Form R-2. Supplied by qualified vendor to custodian, who submits a copy to pressure systems program manager

# 3 Forms

The following forms and systems are required by these requirements:

- Pressure Systems: Maintenance and Repair Report Form (SLAC-I-730-0A21J-042). Form for documenting maintenance and repair work
- Pressure Systems: Inspection Report Form (SLAC-I-730-0A21J-043). Form for documenting inspections
- National Board Form R-1. Form for documenting repairs by vendors
- National Board Form R-2. Form for documenting alterations by vendors
- Pressure Systems Database. Database of pressure systems

1 The National Board of Boiler and Pressure Vessel inspector issues the "R" and "VR" stamps.

# 4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- Inspection
  - Custodian maintains completed inspection report forms, keeping a copy of record for five years and also forwarding a copy to the pressure systems program manager, who adds it to the Pressure Systems Database
- Maintenance
  - Custodian maintains completed maintenance and repair report forms, keeping a copy of record for five years and also forwarding a copy to the pressure systems program manager, who adds it to the Pressure Systems Database
  - If maintenance procedures include pressure testing as required by code, a record of the test must be submitted to the pressure systems program manager
- Repair
  - Custodian maintains completed maintenance and repair report forms, keeping a copy of record for five years and forwarding a copy to the pressure systems program manager, who adds it to the Pressure Systems Database
  - Qualified vendor supplies completed National Board Form R-1 (repairs) or National Board Form R-2 (alterations) to custodian, who submits a copy to pressure systems program manager

*Note* *If discarding records after the required five-year period, submit to the pressure systems program manager.*

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"
  - Pressure Systems: Pressure Test Procedures (SLAC-I-730-0A21C-033)
  - Pressure Systems Safety Program (SharePoint)
- Chapter 51, "Control of Hazardous Energy"

Other SLAC Documents

- SLAC Leak Test and Mechanical Integrity Standard (SLAC-I-141-201-004-00)

Other Documents

- Title 49, *Code of Federal Regulations*, "Transportation", Subtitle B, "Other Regulations Relating to Transportation", Chapter 1, "Pipeline and Hazardous Materials Safety Administration, Department of Transportation", Subchapter C, "Hazardous Materials Regulations"
  - Part 173, "Shippers – General Requirements for Shipments and Packagings" (49 CFR 173)
  - Part 178, "Specifications for Packagings" (49 CFR 178)

  - Part 180, "Continuing Qualification and Maintenance of Packagings" (49 CFR 180)
- American Society of Mechanical Engineers (ASME). *Boiler and Pressure Vessel Code (BPVC)* (ASME BPVC)
- ASME. *Code for Pressure Piping* (ASME B31) (including applicable addenda and code cases)
- National Board of Boiler and Pressure Vessel Inspectors (NBBI) NB 23, *National Board Inspection Code (NBIC)* (NBBI NB 23)

SLAC NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Inspection Report Form

Product ID: 542 | Revision ID: 2373 | Date Published: 26 October 2021 | Date Effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormInspect.pdf

The custodian must ensure that all required inspections are documented using this form. The completed form must be submitted to the pressure systems program manager and kept on file by the custodian for five years (see Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements [SLAC-I-730-0A21S-053]).

| | | | |
|---|---|---|---|
| Inspection date: | System name: | | Location |
| Inspection type: | Status: | | Building: Room: |
| Last inspection date: | National Board number: | Serial number: | SLAC pressure system number: |
| System type *(check all that apply)*:<br>☐ Scientific ☐ Vacuum<br>☐ Conventional ☐ Compressed gas<br>☐ Cryogenic ☐ Other *(specify)*: | | Year built:<br>Manufacturer: | |
| Dimensions (D x L): | Thickness: | Capacity: | Surface area: |
| Pressure relief devices (PRD)<br>Size:<br>Capacity:<br>Set at: | | Maximum allowable working pressure:<br>Pressure test:<br>PRD test: | |
| Certificate issued:<br>☐ Yes<br>☐ No *(explain)*: | | Pressure allowed<br>This inspection:<br>Last inspection: | |
| Conditions: | | | |
| Requirements: | | | |
| Custodian's name *(print)*: | | Phone: | |
| Inspector's name *(print)*: | | Phone: | |
| Inspector's signature: | | Date: | |

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Maintenance and Repair Report Form

Product ID: 541 | Revision ID: 2374 | Date Published: 26 October 2021 | Date Effective: 26 October 2021

URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormMaintRepair.pdf

The custodian must ensure that all required maintenance and repair work is documented using this form. The completed form must be submitted to the pressure systems program manager and kept on file by the custodian for five years (see Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements [SLAC-I-730-0A21S-053]).

| | | | |
|---|---|---|---|
| Maintenance date: | System name: | | Location<br>Building: Room: |
| Work type:<br>☐ Maintenance<br>☐ Repair<br>☐ Alteration | Status: | | |
| Last maintenance date: | National Board number: | Serial number: | SLAC pressure system number: |
| System type *(check all that apply)*:<br>☐ Scientific ☐ Vacuum<br>☐ Conventional ☐ Compressed gas<br>☐ Cryogenic ☐ Other *(specify)*: | | Year built:<br>Manufacturer: | |
| Routine maintenance: | | Preventive maintenance: | |
| Shut-down maintenance: | | System failure problems: | |
| Repair or alteration description:<br><br>*Note: welding repair(s) must be performed by an ASME-certified welder.* | | | |
| Maintenance description: | | | |
| Maintenance inspection: | | | |
| Pressure test: | | | |
| Custodian's name *(print)*: | | Phone: | |
| Mechanic's name *(print)*: | | Phone: | |
| Mechanic's signature: | | Date: | |

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Pressure Test Procedures

Product ID: 613 | Revision ID: 2375 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureProcedTest.pdf

## 1 Purpose

The purpose of these procedures is to ensure that pressure tests are conducted safely and effectively. They cover pressure testing of new and existing pressure systems and components. They apply to mechanics, supervisors, field construction managers, inspectors, custodians, subcontractors responsible for pressure tests, and the pressure systems program manager.

## 2 Procedures

Pressure tests are performed to ensure the safety, reliability, and leak tightness of pressure systems. A pressure test is required for a new pressure system before use or an existing pressure system after repair or alteration.

There are two methods for pressure tests: hydrostatic and pneumatic. A hydrostatic test is performed by using water as the test medium, whereas a pneumatic test uses air, nitrogen, or any non-flammable and non-toxic gas. At SLAC pressure tests must be hydrostatic unless pneumatic tests can be justified.

All pressure tests are to be conducted using a gauge that has been calibrated within the previous 12 months. The pressure gauge should be sized so that the test pressure is in the middle third of the gauge's pressure range. Gauge materials and fluids are to be compatible with the test fluid.

When possible, the use of blind/blank flanges or caps should be considered for test boundaries to prevent damage to valves..

Pressure tests must always be performed under controlled conditions, following an approved test plan, and documented in a test record. A single approved test plan may be used for several similar tests, but a separate test record is required for each.

### 2.1 Hydrostatic Testing

Hydrostatic is the preferred method of pressure test at SLAC.

### 2.2 Pneumatic Testing

Pneumatic tests are potentially more dangerous than hydrostatic because of the higher level of potential energy. Pneumatic tests may be performed only when at least one of the following conditions exists:

- When pressure systems are so designed that they cannot be filled with water.
- When pressure systems are to be used in services where traces of the testing medium cannot be tolerated.

Using a pneumatic test instead of hydrostatic requires approval by the pressure systems program manager. In addition to a justification, a piping schematic for pneumatic pressure test is required. A recommended typical piping schematic for pneumatic test is shown in Figure 1.

**Important** Installation of a pressure relief valve is required for a pneumatic test.

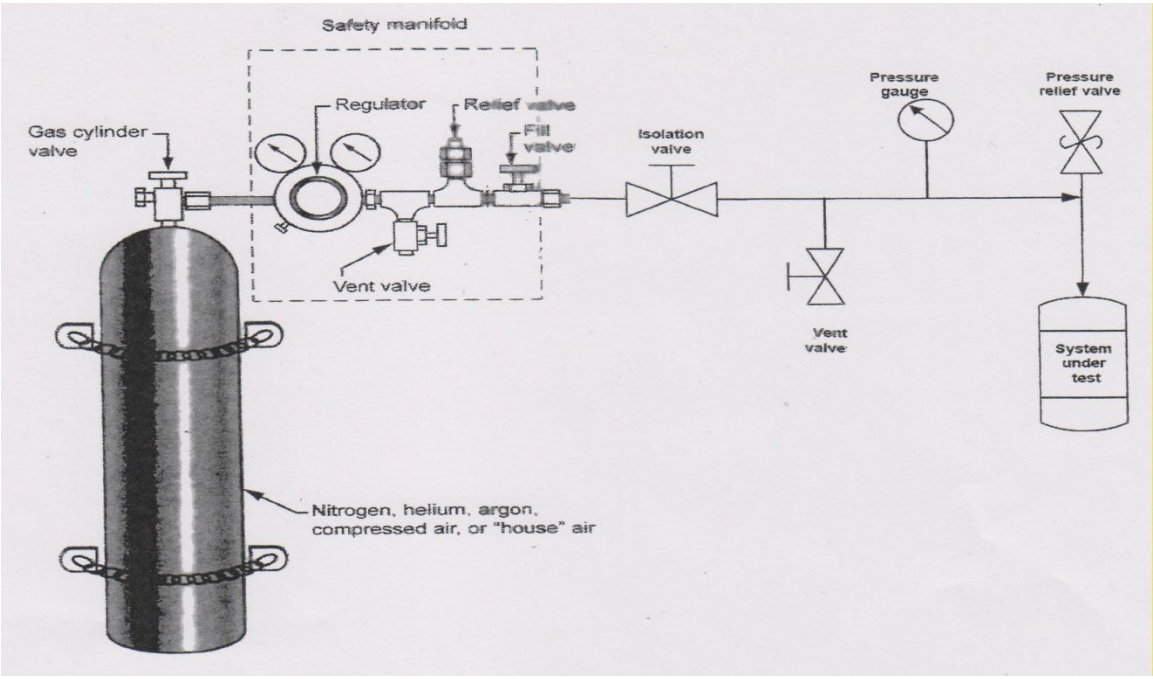


**Figure 1** Recommended Typical Piping Schematic for Pneumatic Testing

## 2.3 Test Procedure

| Step | Person | Action |
|---|---|---|
| **Planning** | | |
| 1. | Mechanic | Completes pressure test plan after consulting the project engineer and submits for approval |
| 2. | Supervisor | Approves plan |
| 3. | FCM in charge of test | Approves plan |
| 4. | Pressure systems program manager | Approves plan (not required for routine testing of existing systems) |
| **Performing** | | |

| Step | Person | Action |
|---|---|---|
| 5. | Mechanic | Ensures the pressure gauges used have current calibration stickers |
| 6. | Mechanic | Removes pressure relief valves or non-reclosing relief devices from the vessel or test boundary where the test pressure will exceed the set pressure of the valve or device<br>OR<br>Holds down each valve by means of an appropriate test clamp and pressurizes both sides of non-reclosing relief devices<br>Installs temporary, higher-rated devices where practical |
| 7. | Mechanic | Installs the calibrated test gauge so it is visible at all times |
| 8. | Mechanic | Ensures the skillet blanks, test plugs, or clamps are appropriate for use and are free of obvious defects |
| 9. | Mechanic | Removes all persons not directly involved with the test from the pressure test exclusion zone. Posts barricades, signage, etc. as specified in Pressure Test Plan to prevent unauthorized personnel entry. |
| 10. | Inspector | Reviews approved test plan; reviews test set-up; verifies test equipment is appropriate for the test |
| 11. | Inspector | Witness entirety of test |
| 12. | Mechanic | Verifies that the pressure is continually monitored to ensure that pressure never exceeds the designated test pressure of the system |
| 13. | Mechanic | **Hydrostatic testing:** Fills and vents system as necessary to remove as much air as practical |
| 14. | Mechanic | Pressurizes system following testing protocol specified in Pressure Test Plan. Holds pressure at test pressure for specified time noting any drop in pressure. |
| 15. | Mechanic | **Pneumatic testing:** reduces the pressure to the design pressure (or as specified in Pressure Test Plan) before proceeding with the inspection; holds the pressure for a sufficient period of time to permit inspection of the system |
| 16. | Mechanic | **Pneumatic testing:** Applies a soap solution to accessible welds, screwed pipe joints, flanges, etc. where leakage is suspected |
| 17. | Mechanic | If there is evidence of structural distortion, either rejects the system or repairs as advised by the inspector |
| 18. | Mechanic | If there is leakage in the system, performs the following as appropriate:<br>▪ Ensure repairs is performed and returns to Step 13 or<br>▪ Rejects the system |
| 19. | Mechanic | **Pneumatic testing:** When the test is completed, vents the test pressure to approved discharge location and returns relief devices to normal configuration<br>**Hydrostatic testing:** Relieves pressure and disposes of test fluid as described in Pressure Test Plan and returns relief devices to normal configuration |
| **Recording** | | |
| 20. | Inspector | Signs pressure test record |

| Step | Person | Action |
|---|---|---|
| 21. | Mechanic | Completes pressure test record and submits copy to the pressure systems program manager and to the Building Inspection Office (when applicable) |
| 22. | Mechanic | Submits copies of the test plan and test record to the custodian |

## 2.4 Test Pressure

Codes and standards organizations (ASME, NFPA) and state regulations (California *Code of Regulations*) specify test pressures and procedures applicable to various systems. The test pressure for a piping system is based on the maximum design pressure of the system, and for a pressure vessel based on the maximum allowable working pressure (MAWP) of the vessel. Systems undergoing retesting should not be tested at pressures higher than the original testing pressure.

The project engineer and the pressure system mechanic are responsible for defining the pressure test plan and documenting it on the Pressure Test Plan Form. The following table provides guidance in selecting the appropriate test pressure and in developing the test procedure.

Unless otherwise noted below; there should be no pressure drop in the system for the required test duration.

**Table 1** Test Pressures for New Pressure Vessel and Piping Systems

| Type of System | Test Medium | Test Pressure | Test Procedure | Code Reference |
|---|---|---|---|---|
| Pressure Vessel (Division 1) | | Hydrostatic 1.3 times MAWP<br>Pneumatic 1.1 times MAWP | | ASME BPVC-VIII UG-99 |
| Pressure Vessel (Division 2) | | Hydrostatic 1.25 times MAWP<br>Pneumatic 1.15 times MAWP | | ASME BPVC-VIII-2 |
| Building Services (Hydrostatic)<br>For non-toxic fluids, air, vacuum, non-flammable gasses installed as part of the building (excepting laboratory and experimental) | Water | 1.5 times design pressure (minimum) | 10 minutes | ASME B31.9 ss 937.3 |
| Building Services (Pneumatic)<br>For non-toxic fluids, air, vacuum, non-flammable gasses installed as part of the | Non-toxic, non-flammable gas | Not exceeding 1.25 times design pressure, and not exceeding 150 psig<br>Pneumatic testing of plastic pipe or brittle materials not allowed | Pressure raised by not more than 25% per step.<br>10 minutes (minimum) at test pressure. | ASME B31.9 ss 937.4 |

| Type of System | Test Medium | Test Pressure | Test Procedure | Code Reference |
|---|---|---|---|---|
| building (excepting laboratory and experimental) | | | Pressure may be reduced to design pressure before examining for leaks. | |
| Process Piping (Hydrostatic)<br>For all gasses and fluids | Water | 1.5 times design pressure (minimum) | 30 minutes | ASME B31.3 ss 345.4<br>CMC 1405 |
| Process Piping (Pneumatic)<br>For all gasses and fluids | Air or a non-toxic, non-flammable gas | 1.1 to 1.33 times design pressure<br>Not exceeding 150 psig without approval of PSWG<br>Pneumatic testing of plastic pipe or brittle materials not allowed | First leak check performed (smaller of) 0.5 times design pressure and 25 psig<br>Raise pressure gradually in steps.<br>30 minutes (minimum) at test pressure.<br>Pressure shall be reduced to design pressure before examining for leaks. | ASME B31.3 ss 345.5<br>CMC 1405 |
| Plumbing Fixture water supply | Water | 1.5 times the maximum system design pressure | 15 minutes | CPC 609.4<br>ASME B31.9 |
| Pressure Sewer Ejector Systems | Water | 10' head of water | 15 Minutes | CPC 712.2 |
| | Air | 5 psi | 15 minutes | CPC 712.3 |
| Sewer Lines within building, drainage and storm drains | Water | 10' head of water except top 10 feet fill to highest point | 15 Minutes | CPC 712.2<br>CPC 1107.2.1 |
| | Air | 5 psi | 15 minutes | CPC 712.3<br>CPC 1107.2.2 |
| Sewer line: Building to sewer | Water | Fill to highest point | | CPC 723.1 |
| Underground Fire Protection water supply | Water | 200 psi or 50 psi above working pressure (whichever is greater) | 2 hours<br>+/- 5 PSI variation allowed | NFPA 13: 6.10.2.2 |

| Type of System | Test Medium | Test Pressure | Test Procedure | Code Reference |
|---|---|---|---|---|
| Wet Pipe Fire Protection Systems | water | 200 psi or 50 psi above working pressure (whichever is greater) | 2 hours | NFPA 13 28.2.1 |
| Dry Pipe Fire Protection System | Air | 40 PSI | Hydrostatic test required in addition to Pneumatic test.<br>Pneumatic test for 24 hours with less than 1.5 PSIG pressure loss. | NFPA 13 28.2.2.1 |
| Field Constructed Refrigerant Piping | Inert gas | Refer to California Mechanical Code section 1116.2 and table 1116.2 | | CMC 1116.2<br>ASHRAE 15:10.1.2 |
| Hydronic Piping<br>(Hydronic systems are building heating, cooling, ventilation, and air conditioning systems) | Water | 1.5 times the maximum system design pressure but not less than 100 PSI | 30 Minutes | CMC 1205.2 |
| Fuel Gas | Pressure test using air, nitrogen, carbon dioxide or an inert test gas - never oxygen | 1.5 times the maximum working pressure, but not less than 10 PSI | 1/2 hour for each 500 cubic feet of pipe volume (or fraction of) but not less than 15 minutes | CPC 1213.3<br>CMC 1313.3<br>NFPA-54 8.1.4 |
| Vacuum Systems | Air extractor | For ordinary vacuum systems: Full atmosphere differential.<br>For systems not intended to be pumped out to full atmospheric pressure differential: 110% of max allowable external differential pressure, but not more than full atmospheric pressure.<br>For vacuum systems within a pressure vessel: 110% of | | ASME Section VIII |

| Type of System | Test Medium | Test Pressure | Test Procedure | Code Reference |
|---|---|---|---|---|
| | | max allowable working pressure differential | | |

## 2.5 Test Plans

A pressure test plan at a minimum contains the following formation:

- Approved Pressure Test Plan Form
- Drawings of the system being tested. Identify the location of test setup, test boundaries, identify all blank/blind flange locations if applicable
- Drawing showing the exclusion zone with location of signage, barricades, or other controls
- Detail of the test setup. Identify the pressure ratings of all components and pressure relief valve setting. Provide product data sheets if needed.
- Pressure gauge calibration sheet
- Detailed test procedure

# 3 Forms

The following forms and systems are required by this procedure:

- Pressure Systems: Pressure Test Plan Form (SLAC-I-730-0A21J-044). A detailed pressure test plan is required for every pressure test conducted at the laboratory. An approved plan may be used for several similar tests.
- Pressure Systems: Pressure Test Record Form (SLAC-I-730-0A21J-045). A separate test record is required for each pressure test.
- Pressure Systems Database. Database of pressure systems

# 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- The custodian of a given pressure system must maintain copies of test plans and records for five years.
- The pressure systems program manager maintains copies of all pressure test plans and records permanently.

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"
  - Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements (SLAC-I-730-0A21S-053)
  - Pressure Systems Safety Program (SharePoint)
- Chapter 51, "Control of Hazardous Energy"

Other Documents

- Title 24, *California Code of Regulations,* "California Building Standards Code"
  - Part 4, "California Mechanical Code", Part 4 (24 CCR Part 4)
  - Part 5, "California Plumbing Code", Part 5 (24 CCR Part 5)
- American Society of Mechanical Engineers (ASME). *Boiler and Pressure Vessel Code (BPVC)* (ASME BPVC)
- ASME. *Code for Pressure Piping* (ASME B31) (including applicable addenda and code cases)
  - ASME B31.1, "Power Piping" (ASME B31.1)
  - ASME B31.3, "Process Piping" (ASME B31.3)
  - ASME B31.9, "Building Services Piping" (ASME B31.9)
- National Board of Boiler and Pressure Vessel Inspectors (NBBI)
  - NB 23, *National Board Inspection Code (NBIC)* (NBBI NB 23)
- National Fire Protection Association (NFPA) 13, "Standard for the Installation of Sprinkler Systems" (NFPA 13)
- Brookhaven National Laboratory. *Vacuum Systems Consensus Guideline for Department of Energy Accelerator Laboratories* (BNL-81715-2008-IR)

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Pressure Test Plan Form

Product ID: 614 | Revision ID: 2376 | Date Published: 26 October 2021 | Date Effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormTestPlan.pdf

This form is required for documenting the test plan required for all pressure tests. The supervisor in charge of the test must approve; tests conducted by subcontractors must also be approved by the FCM; the pressure systems program manager must approve all tests other than routine hydrostatic tests of existing systems. A single approved test plan may be used for several similar tests, but a separate test record is required for each test. Copies of the approved plan are kept by the custodian (for five years), and the pressure systems program manager (permanently) (see Pressure Systems: Pressure Test Procedures [SLAC-I-730-0A21C-033]).

| **System Information** | | |
|---|---|---|
| Pressure test plan number *(by PSPM)*: | Building Inspection Office number *(by PSPM)*: | Pressure system ID *(by PSPM)*: |
| Building number: | Room/area: | |
| System description: | | |
| **Test Information** *(attach project technical document or design specifications supporting this information)* | | |
| Type of test: | ☐ Hydrostatic | ☐ Pneumatic *(attach justification)* |
| System design pressure: | System design temperature: | |
| Description of test configuration *(attach sketch, piping and instrument diagram, or pressure test schematic diagram)*: | | |
| Boundary limits of test *(specify if entire system or a subsystem. If a subsystem, identify parts under test)*: | | |
| **Test Parameters** (see Pressure Systems: Pressure Test Procedures) | | |
| Required test pressure: | Minimum hold time: | |
| Test fluid: | Fluid temperature *(note if ambient or other specific temperature)*: | |
| Test procedures: | | |
| **Test Equipment – Pressure Gauge** | | |
| Type: | Pressure range: | Calibration date: |

| **Environmental Controls** | |
|---|---|
| Exclusion zone for safety of people *(consult project engineer or calculate stored energy)*: | |
| Test area controls *(barricades, signage, etc.)*: | Safe disposal of test fluid *(what and how)*: |
| Fluid disposal requirements *(concerns/confirmed with)*: ☐ Environmental ☐ Radiation ☐ Hazardous waste ☐ Not required | |

| **Administrative Controls** | |
|---|---|
| Mechanic *(print)*: | Qualifications: |
| Inspector *(print)*: | Qualifications: |
| Inspection requirements *(before, during, and after the test)*: | |
| Pressure test procedures *(attach detailed steps)***:** | |

| **Approvals** | | |
|---|---|---|
| Supervisor in charge of test *(print)*: | Signature: | Date: |
| FCM in charge of test *(print)*<br>*(required for tests conducted by subcontractors)*: | Signature: | Date: |
| Pressure System Working Group Representative *(print)*<br>*(required for tests conducted in house):* | Signature: | Date: |
| Pressure systems program manager *(print)*<br>*(not required for routine hydrostatic test of existing systems)*: | Signature: | Date: |



| **Required Attachments** | |
|---|---|
| Pressure test schematic diagram | ☐ |
| Project technical specifications<br>*(noting the design pressures and temperatures)* | ☐ |
| Pressure test procedures<br>*(with detailed steps)* | ☐ |
| Gauge calibration document<br>*(not required for routine hydrostatic test of existing systems)* | ☐ |
| Drawing showing test area and exclusion zone | ☐ |

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Pressure Test Record Form

Product ID: 615 | Revision ID: 2377 | Date Published: 26 October 2021 | Date Effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormTestRecord.pdf

This form is required for documenting the results of every pressure test. Both the mechanic performing the test and the inspector witnessing it must sign. A copy of the completed form must be submitted to the pressure systems program manager. Copies of the completed form are kept by the custodian (for five years) and the pressure systems program manager (permanently) (see Pressure Systems: Pressure Test Procedures [SLAC-I-730-0A21C-033]).

| | | |
|---|---|---|
| Pressure test record number *(1, 2, 3, etc.)*: | Pressure test plan number *(from test plan)*: | Pressure system ID *(from test plan)*: |
| **System Being Tested** *(one system per test record)* | | |
| **Water :** ☐ Domestic ☐ Irrigation ☐ Fire service ☐ Condensate drain<br>☐ LCWS ☐ LCWR ☐ PCWS ☐ PCWR ☐ CTWS ☐ CTWR<br>☐ HHWS ☐ HHWR ☐ CHWS ☐ CHWR ☐ Other: _____ | | |
| **Gas:** ☐ Natural ☐ CA ☐ LN ☐ $N^2$ ☐ HE ☐ AR ☐ $CO^2$ ☐ $O^2$ ☐ Inert ☐ Other: _____ | | |
| **Piping** *(check all that apply to this system)*: ☐ Underground ☐ Under floor ☐ Walls ☐ Above floor ☐ Overhead<br>☐ Manifold ☐ Cabinet ☐ Above ceiling ☐ Other: _____ | | |
| **Piping Labels Installed**: ☐ No ☐ Yes | Color of letters: | Background color: |
| **Test Requirements** | | |
| Type of test: ☐ House/service pressure only ☐ Hydrostatic ☐ Pneumatic | | |
| Extent of system test: | | Material: |
| Design pressure: | Required test pressure: | Actual test pressure: |
| Test fluid: | | Actual test fluid temperature: |
| Test starting time: | Test ending time: | |
| Required hold time: | Actual hold time: | |
| **Test Equipment – Pressure Gauge** | | |
| Manufacturer: | Gauge type: ☐ Dial ☐ Vertical ☐ Digital ☐ Other: _____ | |
| Gauge range: | Calibration date: | Actual test pressure: |
| **Environmental Controls** | | |
| Exclusion zone for safety of people *(actual safe distance)*: | | |
| Test area controls *(barricades, signage, etc.)*:<br>☐ Barricades ☐ Signage ☐ Caution / danger tape<br>☐ Other: _____ | Actual disposal of test fluid:<br>☐ Atmosphere ☐ Sewer ☐ Tank / drum ☐ Hold in pipes<br>☐ Other:_____ | |
| **Results** *(add additional sheets for remarks or explanations as needed)* | | |
| Inspection: ☐ Satisfactory ☐ Unsatisfactory *(explain)*: _____ ☐ Stopped *(explain)*: _____ | | |
| Pressure test: ☐ Satisfactory ☐ Unsatisfactory *(explain)*: _____ ☐ Stopped *(explain)*: _____ | | |
| Company performing test: | | |
| Mechanic performing test *(print)*: | Signature: | Date: |
| Qualified SLAC inspector *(print)*: | Signature: | Date: |

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

*Chapter 14: Pressure Systems*

# Decommissioning Procedure

Product ID: 538 | Revision ID: 2378 | Date published: 26 October 2021 | Date effective: 26 October 2021
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/pressureProcedDecommission.pdf

# 1 Purpose

The purpose of these requirements is to ensure that pressure systems are decommissioned in a manner that does not endanger personnel or harm the environment. They cover temporary and permanent decommissioning and apply to owners and custodians, mechanics, ESH representatives, and the pressure systems program manager.

# 2 Procedures

## 2.1 Temporary Decommissioning

| Step | Person | Action |
|---|---|---|
| 1. | Owner / custodian | Determines pressure system or vessel will not be used for a specified period |
| 2. | Owner | Determines if a written decommissioning plan is needed: systems with hazard potential and systems that require maintenance should be decommissioned according to a written decommissioning plan that describes procedures for protecting the system from degradation, corrosion, and failure.<br>Depending on pressure system type and contents, measures such as backfilling with nitrogen or other approved inert material may be taken to prevent corrosion.<br>*Note: for system specifications, consult the Pressure Systems Database* |
| 3. | Owner | Contacts pressure systems program manager for approval |
| 4. | Pressure systems program manager | Approves plan or specifies additional requirements |
| 5. | Owner / custodian | Applies administrative lockout (see Chapter 51, "Control of Hazardous Energy") that clearly identifies each of the following:<br>▪ Pressure system name<br>▪ Pressure system number (from the Pressure Systems Database)<br>▪ Custodian name<br>▪ Department or division<br>▪ Last date of operation and system content<br>▪ Hazards warning, if any<br>▪ Current date |

| Step | Person | Action |
|---|---|---|
| 6. | Mechanic | Decommissions system |
| 7. | Pressure systems program manager | Determines inspection requirements, if any |
| 8. | Owner / custodian | Recommissions system only after it passes required inspection and is approved by the pressure systems program manager<br>*Note: before bringing a system back into service (recommissioning), repair, assembly, reintegration, or other documents must be submitted to the pressure systems program manager for approval.* |

## 2.2 Permanent Decommissioning

A pressure system with no plans for further use is to be permanently removed or dismantled and disposed of.

| Step | Person | Action |
|---|---|---|
| 1. | Owner or custodian | Determines pressure system or vessel has reached the end of its service life or is no longer required for the current program |
| 2. | Owner | Authorizes decommissioning |
| 3. | Owner / custodian | Before decommissioning is scheduled to begin, submits to the pressure systems program manager a written decommissioning plan.<br>Consult these SLAC resources or services as needed:<br>▪ Chemical lifecycle management program manager (to identify opportunities for content re-use)<br>▪ Air quality program manager (if gasses are present)<br>▪ Waste management program manager (to determine liquid or solids disposal)<br>▪ SLAC Salvage (to dispose of conventional pressure systems)<br>▪ Radiation Protection (to survey for potential activation)<br>*Note: certain decommissioning projects are also subject to ESH project review (see the General Policy and Responsibilities: ESH Project Review Procedure).*<br>*Note: consult the Pressure Systems Database for system specifications.* |
| 4. | Pressure systems program manager | Reviews decommissioning plan and/or takes part in the ESH project review and approves or specifies additional requirements |
| 5. | Custodian | As soon as the vessel is to be no longer used, applies administrative lockout (see Chapter 51, "Control of Hazardous Energy") or other clear label to indicate that the system is to be decommissioned. Ensures that the following are clearly identified:<br>▪ Pressure system name<br>▪ Pressure system number (from the pressure system database)<br>▪ Custodian name<br>▪ Department or division<br>▪ Last date of operation and system content<br>▪ Hazards warning, if any |

| Step | Person | Action |
|---|---|---|
| | | ▪ Current date |
| 6. | Qualified mechanic | Carries out preliminary decommissioning steps, if needed, to ensure safety until full decommissioning can be implemented. Steps can include<br>▪ Controlled and safe removal of non-hazardous fluid from the system and connected piping<br>▪ Close, lockout, and tagout any valves that connect to other system(s) to ensure isolation and disconnection |
| 7. | Qualified personnel | Carry out approved decommissioning plan |
| 8. | ESH representative | Provides decommissioning oversight, as needed |
| 9. | Owner / custodian | Submits final decommissioning report to pressure systems program manager |
| 10. | Pressure systems program manager | Updates system status in the Pressure Systems Database as plans and reports are received |

# 3 Forms

The following forms and systems are required by this procedure:

- Pressure Systems Database. Database of pressure systems

# 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- Decommissioning plan. Submitted to the pressure systems program manager for approval. The approved plan is returned to the owner/custodian, who keeps.
- Final decommissioning report. Submitted to the pressure systems program manager for inclusion in the Pressure Systems Database; may take the form of the decommissioning plan that has been updated to show how it was successfully carried out

# 5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 14, "Pressure Systems"
  - Pressure Systems Safety Program (SharePoint)
- Chapter 1, "General Policy and Responsibilities"
  - General Policy and Responsibilities: ESH Project Review Procedure (SLAC-I-720-0A24C-001)
- Chapter 51, "Control of Hazardous Energy"

# 851>Cal/OSHA Implementation Plan: Pressure Systems

This form is for documenting changes to a program and the program's supporting resources (ESH Manual chapter or similar program description, training courses, databases, and so on) resulting from the adoption of the model Revolutionary Working Group (RWG) contract (see below) and the associated DOE variance from 10 CFR 851, "Worker Safety and Health Program". The purpose is to ensure consistent, concise descriptions of the resulting changes. The form is to be completed by the program manager and sent to the DOE as a cover sheet with the revised documents. The general process is as follows:

1. Program manager completes form
2. Changes to program resources made and reviewed following normal revision processes
3. DOE sent draft form and revisions
4. Changes to program resources published
5. DOE sent final form and revisions

# 1 Introduction

The RWG model contract and 10 CFR 851 variance are intended to simplify and improve the implementation of worker safety and health requirements by tailoring the laws, regulations, and standards that apply while achieving a level of protection equivalent to the requirements of 10 CFR 851. This mostly entails replacing federal Occupational Safety and Health Administration (OSHA) regulations (29 CFR 1910 and 1926) with Cal/OSHA regulations (8 CCR) as external requirements to be complied with but may also involve other laws and regulations and either different versions of industry standards than those cited in 10 CFR 851 or entirely different standards. (One purpose of this form is to capture the specific changes in external requirements for each program.) (For more information on this effort, see the variance application in 851>Cal/OSHA resources.)

# 2 Plan

| Field Number | Field Name | Field |
|---|---|---|
| 1. | Program name | Pressure Systems |
| 2. | Program manager | Coleman, Scott L. |
| 3. | LBNL counterpart | Ettinger, Kurt R (SME list) (LBNL Phonebook) |
| 4. | Program documents | *The following is a list of existing program documents, to be reviewed by the program manager to determine which will need to be revised to reflect 851>Cal/OSHA changes.*<br>▪ ESH Manual Chapter 14: Pressure Systems<br>▪ Pressure Systems: Quick Start Summary<br>▪ Pressure Systems: Design and Construction Requirements<br>▪ Pressure Systems: Procurement Procedure<br>▪ Pressure Systems: Registration Procedure<br>▪ Pressure Systems: New Pressure System Registration Form<br>▪ Pressure Systems: Legacy Pressure System Registration Form<br>▪ Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements<br>▪ Pressure Systems: Inspection Report Form |

| Field Number | Field Name | Field |
|---|---|---|
| | | ▪ Pressure Systems: Maintenance and Repair Report Form<br>▪ Pressure Systems: Pressure Test Procedures<br>▪ Pressure Systems: Pressure Test Plan Form<br>▪ Pressure Systems: Pressure Test Record Form<br>▪ Pressure Systems: Decommissioning Procedure |
| 5. | Training courses | *The following is a list of existing training courses, to be reviewed by the program manager to determine which will need to be revised to reflect 851>Cal/OSHA changes.*<br>*Course materials are available for review.*<br>▪ ESH Course 122, Pressure System Operator (ESH Course 122)<br>▪ ESH Course 125, Pressure System Mechanic Training (ESH Course 125)<br>▪ ESH Course 143, Pressure System Inspector (ESH Course 143) |
| 6. | Other program resources | *The following is a list of existing program resources, to be reviewed by the program manager to determine which will need to be revised to reflect 851>Cal/OSHA changes.*<br>▪ Pressure Systems Safety Program (SharePoint)<br>▪ Pressure Systems Database<br>▪ Competent and Qualified Persons and Engineers |
| 7. | Current external requirements | *The following is a list of current external requirements for this program, as identified in the program documents above.*<br>▪ 10 CFR 851 Appendix A.4<br>▪ 29 CFR 1910<br>▪ 29 CFR 1926<br>▪ 49 CFR 173<br>▪ 49 CFR 178<br>▪ 49 CFR 180<br>▪ 8 CCR 450–560<br>▪ 8 CCR 750–797<br>▪ ASME BPVC-2015<br>▪ ASME B31<br>▪ ASME B31.1-2014<br>▪ ASME B31.2-1968<br>▪ ASME B31.3-2014<br>▪ ASME B31.5-2013<br>▪ ASME B31.9-2014<br>▪ ASME B31.12-2014<br>▪ ASME B31E-2008<br>▪ ASME A13.1-2007<br>▪ NBBI NB 23-2015<br>▪ CGA S-1.1-2007 |

| Field Number | Field Name | Field |
|---|---|---|
| | | ▪ CGA S-1.2-2005<br>▪ CGA S-1.1-2008<br>▪ CGA C-6-2007<br>▪ CGA P-12-2009<br>▪ NFPA 54-2015<br>▪ NFPA 55-2016<br>▪ ANSI Z49.1-2005<br>▪ ASHRAE 15-2010<br>▪ API RP 520 Part I-2014<br>▪ API RP 520 Part II-2015<br>▪ *Standards of the Expansion Joint Manufacture Association*, Ninth Edition, 2007 (EJMA Standards-2007)<br>▪ *Standards of the Tubular Exchanger Manufacturers Association*, Ninth Edition, 2007 (TEMA Standards-2007)<br>▪ Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the Approximation of the Laws of the Member States concerning Pressure Equipment (Pressure Equipment Directive, PED 97/23/EC)<br>▪ Directive 2009/105/EC of the European Parliament and of the Council of 16 September 2009 relating to Simple Pressure Vessels (Simple Pressure Vessel Directive, SPVD 2009/105/EC)<br>▪ European Standard 13445, "Unfired Pressure Vessels" (EN 13445)<br>▪ PED 97/23/EC<br>▪ SPVD 2009/105/EC<br>*The following is a list of current external reference/guidance documents.*<br>▪ Brookhaven National Laboratory. *Vacuum Systems Consensus Guideline for Department of Energy Accelerator Laboratories* (BNL-81715-2008-IR) |
| 8. | Proposed external requirements | *List all the external requirements that will apply to this program. To determine, start by looking up existing external requirements in 851>Cal/OSHA resources (variance, gap analysis, and contract) and finding replacements (for example a specific section in 29 CFR 1910 to a specific section in 8 CCR or a current version of an industry standard).Where Cal/OSHA requirements are less stringent than those of 10 CFR 851, check with Jeremy Sawyer on which to use.* ***Enter "no changes" if none.***<br>▪ 10 CFR 851 as modified by SLAC IIPP<br>▪ 49 CFR 173<br>▪ 49 CFR 178<br>▪ 49 CFR 180<br>▪ 8 CCR 450–560<br>▪ 8 CCR 750–797<br>▪ California Mechanical Code, Title 24 Part 4<br>▪ California Plumbing Code, Title 24 Part 5<br>▪ ASME BPVC<br>▪ ASME B31 series |

| Field Number | Field Name | Field |
|---|---|---|
| | | ▪ ASME A13.1<br>▪ NBBI NB 23<br>▪ CGA S-1.1<br>▪ CGA S-1.2<br>▪ CGA S-1.1<br>▪ CGA C-6<br>▪ NFPA 13<br>▪ NFPA 54<br>▪ NFPA 55<br>▪ ANSI Z49.1<br>▪ ASHRAE 15<br>▪ Standards of the Expansion Joint Manufacture Association, Ninth Edition, 2007 (EJMA Standards)<br>▪ Standards of the Tubular Exchanger Manufacturers Association, Ninth Edition, 2007 (TEMA Standards) |
| 9. | Proposed substantive changes | *Describe (list) the substantive changes to be made in the program, based on the new external requirements.* ***Enter "no changes" if none.***<br>▪ None |
| 10. | Additional proposed substantive changes | *Describe (list) the substantive changes to be made in the program, in addition to those based on the new external requirements. For example, those due to stakeholder input, other reviews and audits, operating experience.* ***Enter "no changes" if none.***<br>▪ Added process for approval of international codes<br>▪ Added a new program document, Alternate Pressure Systems Qualification Requirements<br>▪ Updated roles and responsibilities to reflect the new organization structure<br>▪ Updated training requirements for all roles<br>▪ Updated definitions for all roles<br>▪ Deleted reference to Canadian Standards Association<br>▪ Deleted references to Pressure Systems Design Manual, as this does not exist.<br>▪ Pressure Vessel section was moved and made general to apply to all systems.<br>▪ Pressure Piping section was moved and made general to apply to all systems.<br>▪ Pressure Relief Devices section was moved and made general to apply to all systems.<br>▪ Deleted all information that was specific to LCLS-II systems.<br>▪ Changed the pressure test procedures so there is only one for both hydrostatic and pneumatic testing, and made them their own section.<br>▪ Added language to better explain where test pressure requirements come from.<br>▪ Table 1 Test Pressures for New Pressure Vessels and Piping Systems deleted and replaced with new table.<br>▪ New Pressure Test Plan Form to replace old version.<br>▪ New Pressure Test Record Form to replace old version. Added language for when to use the |

| Field Number | Field Name | Field |
|---|---|---|
| | | Alternate Pressure Systems Qualification Program |
| 11. | Affected program documents | *List program documents affected by the changes above.* ***Enter "no changes" if none.***<br>▪ ESH Manual Chapter 14: Pressure Systems<br>▪ Pressure Systems: Quick Start Summary<br>▪ Pressure Systems: Design and Construction Requirements<br>▪ Pressure Systems: Alternate Pressure Systems Qualification Requirements (new)<br>▪ Pressure Systems: Procurement Procedure<br>▪ Pressure Systems: New Pressure System Registration Form<br>▪ Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements<br>▪ Pressure Systems: Pressure Test Procedures<br>▪ Pressure Systems: Pressure Test Plan Form<br>▪ Pressure Systems: Pressure Test Record Form |
| 12. | Affected training courses | *List training courses affected by the changes above.* ***Enter "no changes" if none.***<br>▪ ESH Course 122, Pressure System Operator (ESH Course 122)<br>▪ ESH Course 125, Pressure System Mechanic Training (ESH Course 125)<br>▪ ESH Course 143, Pressure System Inspector (ESH Course 143) |
| 13. | Other affected program resources | *List other program resources affected by the changes above.* ***Enter "no changes" if none.***<br>▪ Pressure Systems Safety Program (SharePoint) |
| 14. | Comments/Questions/Issues | *Add any comments or questions regarding applicable requirements or changes.*<br>▪ None |
| 15. | Status | ☒ Initial draft (proposed changes) ☒ Draft (for DOE review) ☒ Final (published changes) |
| 16. | Date completed | Date (of form, PM to complete)<br>5/6/2020 (rev 9/23/2020) 10/7/2021 10/26/2021 |