Chapter 14: Pressure Systems

Quick Start Summary

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 10 CFR 851 requirements 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 18 December 2014.

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.
Chapter 14

Pressure Systems

The purpose of this program is to ensure worker safety and that pressure systems comply with Title 10, Code of Federal Regulations, “Energy”, Chapter 3, “Department of Energy”, Part 851, “Worker Safety and Health Program” (10 CFR 851 Appendix A.4) and all applicable codes and standards. 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, with pressure greater than 15 pounds per square inch gauge (psig) subject to American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) and ASME Pressure Piping Code
- Cryogenic systems not open to the atmosphere at all times
- Vacuum systems that can be pressurized due to backfill
- Conventional systems used for utilities and facilities, and low conductivity water (LCW) systems with pressure greater than 15 psig
- 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 designed following federal Department of Transportation (DOT) and Compressed Gas Association (CGA) standards
- Refrigeration systems designed following ASME and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards

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

1.1 Excluded Pressure Systems and Activities

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

- Pressure system-related activity for systems that fall below the lower limit thresholds listed in the General Policy and Responsibilities: ESH Threshold Review Form, with the concurrence of owner (or designee). The pressure systems program manager may be consulted as deemed necessary.
Unique scientific systems such as thin windows for beam passage, test apparatus involving novel materials, systems assembled from glassware, and systems that work at unusual temperatures, provided owner-approved engineering controls are in place

Pressure systems with source pressures that never exceed 15 psig

Fire systems (see Chapter 12, “Fire and Life Safety”)

Pressure containers that are integral parts or components of rotating or reciprocating mechanical devices, such as pumps, compressors, turbines, generators, engines, and hydraulic or pneumatic cylinders

Vessels with an inside diameter, width, height, or cross section diagonal not exceeding 6 inches; there is no limitation on length of vessel or pressure

Pneumatic and hydraulic systems that are an integral part of a vehicle

Existing piping systems used for conventional facilities (applicable code: ASME B31.9, “Building Services Piping”)

Conventional facility water, sewer, vent, and drain systems

Conventional facility water wells, water tanks, and water distribution piping

Storage tanks that are open to atmosphere at all times

Hot water heaters or hot water storage tanks less than 50 gallons

Welding, brazing, or soldering equipment

Cryogenic systems open to the atmosphere at all times (see Chapter 36, “Cryogenic and Oxygen Deficiency Hazard Safety”)

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 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, and 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 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, 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 for a specific pressure system (see Competent and Qualified Persons and Engineers). (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, standards, and the requirements of this chapter

2.6 Design Engineer

- Designs systems according to ASME code or equivalent, as specified in the Pressure Systems Design Manual (forthcoming)
- 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 Requirements)

2.7 Project Manager

- Ensures that pressure systems meet applicable codes, 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 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

2.9 Pressure Systems Working Group
- Helps establish pressure system evaluation criteria based on 10 CFR 851
- Determines systems to be evaluated
- Evaluates identified systems for risk
- Participates in peer review of SLAC pressure systems

2.10 Pressure Systems Program Manager
- Develops, maintains, and manages the pressure systems program
- Acts as subject matter expert and chief inspector
- Advises management on applicable regulations and codes
- Establishes procedures and policies for pressure systems and reviews and updates this chapter as required
- Develops training and qualifying standards for pressure system operators, mechanics, designers, and inspectors
- Trains and qualifies pressure system operators, mechanics, designers, and inspectors
- Administers the pressure systems database
- Evaluates pressure system hazards and mitigates problems
- Reviews purchase requisitions for pressure systems to ensure compliance
- Reviews decommissioning plans
- Chairs the Pressure Systems Working Group

3 Procedures, Processes, and Requirements
The following documents list the core requirements for this program and describe how to implement them:
- Pressure Systems: Design and Construction Requirements (SLAC-I-730-0A21S-047)
- Pressure Systems: Procurement Procedure (SLAC-I-730-0A21C-030)
- Pressure Systems: Registration Procedure (SLAC-I-730-0A21C-031)
- Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements (SLAC-I-730-0A21S-053)
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) (repeat every five years)

4.2 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) (repeat every five years)
- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (repeat every five years)

4.3 Inspector

To become a qualified pressure system inspector, a person must complete the following:

- ESH Course 122, Pressure System Operator (ESH Course 122) (repeat every five years)
- ESH Course 125, Pressure System Mechanic Training (ESH Course 125) (repeat every five years)
- National Board of Boiler and Pressure Vessel Inspector Commission or one of the following specific pressure system inspector training courses developed by the pressure systems program manager:
  - Boilers
  - Compressed gas cylinders
  - Cryogenic vessels
  - Pressure vessels and piping
  - Tube trailers
  - Vacuum vessels

A pressure system inspector’s certificate will remain valid for five years, and subsequently will be renewed every five years.

4.4 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)

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) (repeat every five years)

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. 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 -90°C (-130°F 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.

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

**Device, pressure relief.** 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)

**Device, rupture disk.** 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.

**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, 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

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

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

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

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

Repair. The work necessary to restore a pressure system to a safe and satisfactory operating condition (see alteration)

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

Re-rating. See alteration.

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 1.1, “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, and pressure sources including cryogenics, pneumatic, hydraulic, and vacuum. Vacuum systems are considered pressure systems due to their potential for catastrophic failure due to backfill pressurization.

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

Temperature, design. The temperature determined by the designer at which the pressure system must be able to operate under worst-case conditions during normal operation
Test, pressure. The application of pressure or vacuum to a system to verify its mechanical integrity

Valve, pressure relief. 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)

6 References

6.1 External Requirements

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

- Title 29, Code of Federal Regulations, “Labor”, Chapter 17, “Occupational Safety and Health Administration, Department of Labor”
  - Part 1910, “Occupational Safety and Health Standards” (29 CFR 1910)
  - 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)
- American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), 2013 (ASME BPVC-2013)
- ASME Pressure Piping Code, including applicable addenda and code cases
  - ASME B31.3-2012, “Process Piping” (ASME B31.3-2012)
  - ASME B31.5-2013, “Refrigeration Piping and Heat Transfer Components” (ASME B31.5-2013)
  - ASME B31.9-2014, “Building Services Piping” (ASME B31.9-2014)
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- ASME Standards

- National Board of Boiler and Pressure Vessel Inspectors (NBBI)
  - NB 23-2013, National Board Inspection Code (NBIC) (NBBI NB 23-2013)

- Compressed Gas Association (CGA) Standards
  - CGA S-1.2-2005, “Pressure Relief Device Standards Part 2 – Cargo and Portable Tanks” (CGA S-1.2-2005)
  - CGA S-1.3-2008, “Pressure Relief Device Standards Part 3 – Stationary Storage Tanks” (CGA S-1.3-2008)
  - CGA C-6-2007, “Standards for Visual Inspection of Compressed Gas Cylinders” (CGA C-6-2007)
  - CGA P-12-2009, “Safe Handling of Cryogenic Liquids” (CGA P-12-2009)

- National Fire Protection Association (NFPA)
  - NFPA 54-2012, National Fuel Gas Code (NFPA 54-2012)
  - NFPA 55-2013, Compressed Gases and Cryogenic Fluids Code (NFPA 55-2013)

- American National Standards Institute (ANSI)

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

- American Petroleum Institute (API)

- Expansion Joint Manufacture Association (EJMA)

- Tubular Exchanger Manufacturers Association (TEMA)

6.1.1 International Codes

The following international codes are acceptable equivalents to the American codes listed above.
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- Canadian Standards Association (CSA), B51-2014, *Boiler, Pressure Vessel and Pressure Piping Code* (CSA B51-2014)

- European Parliament and Council
  - European Standard 13445, “Unfired Pressure Vessels” (EN 13445)

### 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”

**Other SLAC Documents**

- Pressure Systems Safety Program (SharePoint)
- Pressure Systems Design Manual (forthcoming)
- Pressure Systems Database
- Competent and Qualified Persons and Engineers

**Other Documents**

Chapter 14: Pressure Systems

Design and Construction Requirements

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 10 CFR 851 and applicable codes, 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, legacy, system; to persons responsible for determining design specifications; and to the Building Inspection Office (BIO), Purchasing Department, and pressure systems program manager.

2 Requirements

2.1 Design Approval

2.1.1 Review

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

2.2 Design Standards

The following is an overview. See the Pressure Systems Design Manual (forthcoming) for technical detail.

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 through XII, including applicable code cases and applicable ASME B31 (*Pressure Piping Code*) standards.

2.2.2 Scientific Pressure Systems

10 CFR 851 specifies that when national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials), measures must be implemented to provide equivalent protection to ensure a level of safety greater than or equal to the level of protection afforded by the ASME code.

Required measures include

- Applying a basic minimum design margin\(^1\) (safety factor) of 3.5 for any pressure system(s) unless a lower design margin can be justified by applicable codes or stress analysis or engineering calculations
- Design drawings, sketches, and calculations must be reviewed and approved by a qualified independent design professional such as a professional engineer. Documented organizational peer review of such design is acceptable.

2.3 Construction Specifications

The design engineer must specify construction requirements as follows.

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\(^1\) Equivalent to ASME *Boiler and Pressure Vessel Code* requirements
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 *Pressure Piping Code*. 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.
ASME certification marks will have the following designators for boilers and pressure vessels

- S  power boiler
- E  electric boiler
- H  heating boiler
- HLW  water heater
- U  unfired pressure vessel
- UM  unfired 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 Vessels) (BPVC Section 8, Division 1)

- For non-ASME pressure vessels, a fabricator’s certificate 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.

Note  The material in this section is excerpted from LCLS-II Engineering Note, “Pressure System Requirements per ES&H Manual Chapter 14” (LCLSII-1.2-EN-0020). Some of the description may be relevant only to LCLS-II, but the requirements apply to all 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.

The linac cryogenic system consists of four major subsystems:

1. Cryogenic plant
2. Cryogenic distribution system
3. Cryomodules
4. Associated auxiliary systems

The cryogenic plant consists of warm recirculation compressors with associated cooling, oil-removal systems, and dryers and cold boxes with ancillary support equipment. The system converts compressed, ambient-temperature helium into superfluid.

The cryogenic distribution system consists of the equipment needed to feed and return the cryogens via vacuum insulated pipelines to the linac components needing these services throughout the entire linac. This equipment includes distribution boxes, cryogenic transfer lines, feed and end caps, and cryogenic bypasses to facilitate warm linac beam line elements.

The auxiliary systems consist of warm helium gas-storage tanks, interconnecting piping between the various systems and components, a liquid-nitrogen (LN2) storage-dewar system, liquid-helium (LHe) storage dewar, a purifier system, an instrument air system, cold box chilled water system, and associated cryogenic safety systems.

### 2.4.1 Pressure Vessels

Most of the pressure vessels, tanks, and storage systems will 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.)

All the designs will be submitted to the pressure systems program manager for review and approval at the appropriate stages of design (such 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

### 2.4.2 Pressure Piping

All the pressure piping and refrigeration piping must be designed, fabricated, tested, and inspected in accordance with ASME B31.3, “Process Piping”. Piping may be designed under other code 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 to the pressure systems manager for verification and approval.
If a vendor refuses to submit this information on the basis of “proprietary item or trade secret”, that vendor will submit documents to that effect, and secure prior approval from SLAC.

### 2.4.3 Cryomodules and Components

The function of the *cryomodule* is to support the dressed radiofrequency (RF) cavities, efficiently maintain them at operating temperature of about 2 K, ensure proper alignment, and accommodate associated hardware such as RF input couplers, higher order mode absorbers, and instrumentation.

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 10 CFR 851, but do not require an ASME code stamp.

![Cryomodule Cross-section](image)

*Figure 2 Cryomodule Cross-section*

Following this approach, the niobium superconducting RF cavity strings and surrounding titanium vessels are considered as pressure vessels subject to ASME BPVC. Cryomodule piping circuits shown in Figure 2, A through H, are considered pressure piping systems subject to ASME B31.3.
It is permissible to use the above approach. 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 to the pressure systems program manager for reviews and approval at the appropriate stages of design (such conceptual, engineering and procurement readiness reviews). The pressure systems program manager will provide a memo to the LCLS-II quality assurance manager documenting successful design review.

2.4.4 Pressure Relief Devices

Within a cryogenic system, adequate relief valves must be installed for all vacuum and cryogenic vessels, 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 pressure reached in any vessel is below the maximum safe working pressure (MSWP) for the vessel. 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 accordance to ASME, American Petroleum Institute (API), or Compressed Gas Association (CGA) standards and appropriate published studies on vacuum failures on helium cryogenic systems.

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 vacuum system, or any legacy 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 gauges, 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 3.
Figure 3  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 cylinders 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 if 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 3) is required to reduce the pressure from a standard cylinder and provide relief protection (relief device) for the down-stream 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 a 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 ends. 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 if 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.)

3 Forms

The following are forms 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 confirming that the pressure system has been designed and constructed according to SLAC’s specifications and stamping is required.

4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- The pressure systems program manager retains approved design specifications (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: Procurement Procedure (SLAC-I-730-0A21C-030)
- Pressure Systems: Installation, Inspection, Maintenance, and Repair Requirements (SLAC-I-730-0A21S-053)

Chapter 1, “General Policy and Responsibilities”

- General Policy and Responsibilities: ESH Project Review Procedure

Chapter 40, “Chemical Lifecycle Management”

Other SLAC Documents

- Pressure Systems Safety Program (SharePoint)
- Pressure Systems Design Manual (forthcoming)
- LCLS-II Engineering Note, “Pressure System Requirements per ES&H Manual Chapter 14” (LCLSII-1.2-EN-0020)

Other Documents

- American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), 2013 (ASME BPVC-2013), including applicable addenda and code cases
- ASME Pressure Piping Code, 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.
1 Purpose

The purpose of this procedure is to ensure that pressure systems, components, and associated services are in strict adherence with the pressure systems requirements of 10 CFR 851. It applies to pressure system owners and custodians or others with purchasing authority, the pressure systems program manager, and Purchasing Department, when purchasing the following:

- Pressure systems such as American Society of Mechanical Engineering (ASME)-coded boilers and pressure vessels; non-ASME-coded 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 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, glove, check; filters; seals and gaskets; bolts and other closure hardware.

2 Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
</table>
| 1.   | Requester | Identifies need for pressure system or associated services: goes to Step 2
|      |         | 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) |

The following applies to all pressure systems types, including custom-fabricated systems. If a system is ready made, submit the equivalent documentation.

Note: items d and e can only be obtained once manufacture is complete, but these...
<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>items must be specified on the purchase requisition.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. System specifications and drawings identifying design conditions (such as temperature and pressure), material specifications, and fabrication details</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Design calculations in accordance with the applicable codes, standards, or sound engineering principles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Fabrication drawings with details for welding, non-destructive examination, inspection, and testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. Stamping information (such as markings and other permanent means of identification)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e. Manufacturer's data reports (MDR) or equivalent documents certified by the fabricator and inspector</td>
</tr>
<tr>
<td>4.</td>
<td>Requester</td>
<td>Note: this step applies if purchasing components only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Submits pressure system component specifications to pressure systems program manager for any components not explicitly listed in Section 1.1, “Exemptions”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following must be provided:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Technical specifications and drawings indicating codes or standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Vendor's product catalogs, product literature, or cut sheets</td>
</tr>
<tr>
<td>5.</td>
<td>Pressure systems program manager</td>
<td>Approves system(s)/component(s) that meet code requirements or specifies missing or code-equivalent information required for approval</td>
</tr>
<tr>
<td>6.</td>
<td>Owner or custodian</td>
<td>Submits purchase requisition to the Purchasing Department using the Business Information System (BIS)</td>
</tr>
<tr>
<td>7.</td>
<td>Purchasing</td>
<td>Processes purchase requisition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ 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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ If the system has not been approved by the pressure systems program manager, forwards purchase requisition to the pressure systems program manager</td>
</tr>
<tr>
<td>8.</td>
<td>Pressure systems program manager</td>
<td>Approves purchase requisition if items meet review and code requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If approval is denied, specifies missing or required code equivalent information</td>
</tr>
</tbody>
</table>

### 3 Forms

The following forms are required by this procedure:

- BIS: Business Information System

### 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:
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)

Other SLAC Documents
- Pressure Systems Safety Program (SharePoint)

Other Documents
Chapter 14: Pressure Systems

Registration Procedure

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

- 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.

2 Procedures

2.1 New Systems

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
</table>
| 1.   | Owner or custodian | Submits completed New Pressure System Registration Form to the pressure systems program manager  
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  
- If information is complete, goes to Step 4  
- 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.  
Note: new systems may only be put into operation once the signed form is on file in the Pressure Systems Database |
| 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

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Owner or custodian</td>
<td>Discovers pressure system not registered in the Pressure Systems Database</td>
</tr>
<tr>
<td>2.</td>
<td>Owner or custodian</td>
<td>Submits completed <a href="#">Legacy Pressure System Registration Form</a> to pressure systems program manager</td>
</tr>
</tbody>
</table>
| 3.   | Pressure systems program manager | Reviews form  
|      |                         |   - If information is complete, assigns a pressure system number  
|      |                         |   - 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 are required by this procedure:

- [Pressure Systems: Legacy Pressure System Registration Form](#) (SLAC-I-730-0A21J-041). Documents system identification numbers, specifications, status, and risk level
- [Pressure Systems Database](#)

## 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”

Other SLAC Documents

- [Pressure Systems Safety Program](#) (SharePoint)
Chapter 14: Pressure Systems
New Pressure System Registration Form

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 10 CFR 851 requirements, 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]).

<table>
<thead>
<tr>
<th>Owner:</th>
<th>Custodian:</th>
<th>Directorate:</th>
</tr>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Property control number:</th>
<th>Location:</th>
<th>Project identifier:</th>
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<tr>
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<table>
<thead>
<tr>
<th>Design pressure</th>
<th>Min (psig):</th>
<th>Maximum allowable working pressure (MAWP) (psig):</th>
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<tbody>
<tr>
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<thead>
<tr>
<th>Design temperature</th>
<th>Min:</th>
<th>Max:</th>
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<table>
<thead>
<tr>
<th>Material</th>
<th>Shell:</th>
<th>Head:</th>
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</table>

**System contents**

**ASME-coded System**

<table>
<thead>
<tr>
<th>Design:</th>
<th>Year built:</th>
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<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>Code stamp:</th>
<th>ASME data reports:</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Certification:</th>
<th>Manufacturer:</th>
<th>National Board number:</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**Non-ASME-coded System**

<table>
<thead>
<tr>
<th>Design:</th>
<th>SL number:</th>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Manufacturer:</th>
<th>Materials inspection:</th>
</tr>
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<tbody>
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<table>
<thead>
<tr>
<th>Fabrication inspection:</th>
<th>Nameplate information:</th>
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</table>

<table>
<thead>
<tr>
<th>Certification:</th>
<th>Operation procedures (attach copy):</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Maintenance procedures (attach copy):</th>
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<table>
<thead>
<tr>
<th>Approving authority, as applicable (safety committee):</th>
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<tbody>
<tr>
<td></td>
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</tbody>
</table>

**Pressure Relief Device(s)**

<table>
<thead>
<tr>
<th>Device type:</th>
<th>This section completed by the pressure systems program manager.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure system number:</td>
</tr>
<tr>
<td></td>
<td>Remarks:</td>
</tr>
</tbody>
</table>

| Relieving capacity: | |
|---------------------| |
|                     | |

| Set pressure: | |
|--------------| |
|              | |

**Testing and Inspection**

<table>
<thead>
<tr>
<th>Pressure test</th>
<th>Date approved for operation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date approved for operation:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test pressure:</th>
<th>Date:</th>
</tr>
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<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Acceptance inspection</th>
<th>Date approved for operation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date approved for operation:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspected by (print):</th>
<th>By (print):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

| Signature: |
|           |
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 safety program manager and kept on file by the owner or custodian for five years (see Pressure Systems: Registration Procedure [SLAC-I-730-0A21C-031]).

<table>
<thead>
<tr>
<th>System Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesi number:</td>
</tr>
<tr>
<td>Drawing number:</td>
</tr>
<tr>
<td>Directorate:</td>
</tr>
<tr>
<td>HEEC number:</td>
</tr>
<tr>
<td>Serial number:</td>
</tr>
<tr>
<td>Project identification number:</td>
</tr>
<tr>
<td>FAMIS ID:</td>
</tr>
<tr>
<td>Manufacturer:</td>
</tr>
<tr>
<td>Owner:</td>
</tr>
<tr>
<td>PC number:</td>
</tr>
<tr>
<td>Date of manufacture:</td>
</tr>
<tr>
<td>Custodian:</td>
</tr>
<tr>
<td>CA state number:</td>
</tr>
<tr>
<td>National Board (NB) number:</td>
</tr>
<tr>
<td>Building / room number:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed or portable:</td>
</tr>
<tr>
<td>MAWP:</td>
</tr>
<tr>
<td>Pressure relief device type:</td>
</tr>
<tr>
<td>System type:</td>
</tr>
<tr>
<td>MOP:</td>
</tr>
<tr>
<td>Relief set point:</td>
</tr>
<tr>
<td>System description:</td>
</tr>
<tr>
<td>Design pressure:</td>
</tr>
<tr>
<td>Pressure relieving capacity:</td>
</tr>
<tr>
<td>Parent system or subsystem:</td>
</tr>
<tr>
<td>Test pressure:</td>
</tr>
<tr>
<td>Stored energy:</td>
</tr>
<tr>
<td>Status:</td>
</tr>
<tr>
<td>Most recent test date:</td>
</tr>
<tr>
<td>Design standard:</td>
</tr>
<tr>
<td>Application:</td>
</tr>
<tr>
<td>Minimum temperature:</td>
</tr>
<tr>
<td>Hazardous materials:</td>
</tr>
<tr>
<td>Modified date (if applicable):</td>
</tr>
<tr>
<td>Maximum temperature:</td>
</tr>
<tr>
<td>Cross contamination:</td>
</tr>
<tr>
<td>Incident date (if applicable):</td>
</tr>
<tr>
<td>System contents:</td>
</tr>
<tr>
<td>Shell material:</td>
</tr>
<tr>
<td>Discard status:</td>
</tr>
<tr>
<td>System volume:</td>
</tr>
<tr>
<td>Last inspection date:</td>
</tr>
</tbody>
</table>

Attachment(s) (include titles of photos, drawings, and supporting documents such as SOPs, maintenance manuals, etc)

Assessment and Validation

| Inventory date: |
| Risk level ranking (preliminary) |
| ☐ 1  ☐ 2  ☐ 3 |

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:
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 manager.

Note: The 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:
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

- 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>
<thead>
<tr>
<th>Equipment</th>
<th>Inspection Type</th>
<th>Inspection Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating boiler</td>
<td>External</td>
<td>3 years</td>
</tr>
<tr>
<td>Pressure vessel, corrosive service</td>
<td>External and internal</td>
<td>2 years</td>
</tr>
<tr>
<td>Pressure vessel, non-corrosive service</td>
<td>External</td>
<td>3 years</td>
</tr>
<tr>
<td>Vacuum vessel</td>
<td>External</td>
<td>5 years</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Pressure System</th>
<th>Test Frequency</th>
<th>Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube trailer</td>
<td>5 years</td>
<td>5/3 times service pressure</td>
</tr>
<tr>
<td>Compressed gas cylinder</td>
<td>5 years</td>
<td>5/3 times service pressure</td>
</tr>
</tbody>
</table>

#### 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.

Leak Test and Mechanical Integrity Standard (SLAC-I-020-203-001-00) (forthcoming) 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

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Inspection Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating boiler</td>
<td>3 years</td>
</tr>
<tr>
<td>Pressure vessel, corrosive service</td>
<td>2 years</td>
</tr>
<tr>
<td>Pressure vessel, non-corrosive service</td>
<td>3 years</td>
</tr>
<tr>
<td>Vacuum vessel</td>
<td>5 years</td>
</tr>
</tbody>
</table>

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,
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 relief 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.
- Equip the system discharge lines with approved check valves when connected to a closed system. This prevents inadvertent backflow contamination of cylinders.

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 as listed in the Pressure Systems Design Manual (forthcoming).
- 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 Pressure Piping Code, 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 are forms required by these requirements:

- Pressure Systems: Maintenance and Repair Report Form (SLAC-I-730-0A21J-042). Record of required maintenance and repair work
- Pressure Systems: Inspection Report Form (SLAC-I-730-0A21J-043). Record of required inspection

¹ The National Board of Boiler and Pressure Vessel inspector issues stamps 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* Always submit records to the pressure safety program manager before discarding if the record is older than the required five-year period.

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)
- Chapter 51, “Control of Hazardous Energy”

Other SLAC Documents
- Pressure Systems Safety Program (SharePoint)
- Pressure System Design Manual (forthcoming)
- Leak Test and Mechanical Integrity Standard (SLAC-I-020-203-001-00) (forthcoming)
Other Documents

  - 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)*, 2013 (*ASME BPVC-2013*)
- ASME *Pressure Piping Code*, 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)
**Chapter 14: Pressure Systems**

**Inspection Report Form**

The custodian must ensure that all required inspections are documented using this form. The completed form must be submitted to the pressure safety 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]).

<table>
<thead>
<tr>
<th>Inspection date:</th>
<th>System name:</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Building:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Room:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspection type:</th>
<th>Status:</th>
<th></th>
<th>Serial number:</th>
<th>SLAC pressure system number:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Last inspection date:</th>
<th>National Board number:</th>
<th>Year built:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System type (check all that apply):</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Scientific</td>
<td>☐ Vacuum</td>
</tr>
<tr>
<td>☐ Conventional</td>
<td>☐ Compressed gas</td>
</tr>
<tr>
<td>☐ Cryogenic</td>
<td>☐ Other Specify</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions (D x L):</th>
<th>Thickness:</th>
<th>Capacity:</th>
<th>Surface area:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure relief devices (PRD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size: Maximum allowable working pressure:</td>
</tr>
<tr>
<td>Capacity: Pressure test:</td>
</tr>
<tr>
<td>Set at: PRD test:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Certificate issued:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure allowed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>This inspection: Last inspection:</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conditions:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Custodian name (print):</th>
<th>Phone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspector’s name (print):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspector’s signature:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
</tr>
</tbody>
</table>

URL: [http://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormInspect.pdf](http://www-group.slac.stanford.edu/esh/eshmanual/references/pressureFormInspect.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]).

<table>
<thead>
<tr>
<th>Maintenance date:</th>
<th>System name:</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance type:</td>
<td>Status:</td>
<td>Building:</td>
</tr>
<tr>
<td>Routine</td>
<td>Service</td>
<td>Room:</td>
</tr>
<tr>
<td>Breakdown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Last maintenance date:</th>
<th>National Board number:</th>
<th>Serial number:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SLAC pressure system number:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System type (check all that apply):</th>
<th>Year built:</th>
<th>Manufacturer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific</td>
<td>Vacuum</td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>Compressed gas</td>
<td></td>
</tr>
<tr>
<td>Cryogenic</td>
<td>Other Specify:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Routine maintenance:</th>
<th>Preventive maintenance:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Shut-down maintenance:</th>
<th>System failure problems:</th>
</tr>
</thead>
</table>

| Repair description: | |

*Note: welding repair(s) must be performed by an ASME-certified welder.*

| Maintenance description: | |

| Maintenance inspection: | |

| Pressure test: | |

<table>
<thead>
<tr>
<th>Custodian name (print):</th>
<th>Phone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanic’s name (print):</th>
<th>Phone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanic’s signature:</th>
<th>Date:</th>
</tr>
</thead>
</table>
Chapter 14: Pressure Systems

Pressure Test Procedures

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 or components at a test pressure more than 0 psig. They apply to mechanics, supervisors, inspectors, custodians, and subcontractors responsible for pressure tests.

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.

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 Test Procedure

Hydrostatic is the preferred method of pressure test at SLAC.

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Mechanic</td>
<td>Obtains test pressure after consulting the project engineer. Note: when hydrostatic test is performed on an existing pressure system, the original hydrostatic test pressure must not be exceeded.</td>
</tr>
<tr>
<td>2.</td>
<td>Mechanic</td>
<td>Completes pressure test plan and submits for approval</td>
</tr>
<tr>
<td>3.</td>
<td>Supervisor</td>
<td>Approves plan</td>
</tr>
<tr>
<td>4.</td>
<td>Pressure systems program manager</td>
<td>Approves plan (not required for routine testing of existing systems)</td>
</tr>
<tr>
<td>Step</td>
<td>Person</td>
<td>Action</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>5.</td>
<td>Mechanic</td>
<td>Ensures the pressure gauges used have current calibration stickers</td>
</tr>
<tr>
<td>6.</td>
<td>Mechanic</td>
<td>Removes all persons not directly involved with the test from the immediate test area</td>
</tr>
<tr>
<td>7.</td>
<td>Mechanic</td>
<td>Removes pressure relief valves or non-reclosing relief device from the vessel or test boundary where the test pressure will exceed the set pressure of the valve OR Holds down each valve by means of an appropriate test clamp and pressurizes both sides of non-reclosing relief devices Installs temporary, higher-rated devices where practical</td>
</tr>
<tr>
<td>8.</td>
<td>Mechanic</td>
<td>Installs the calibrated test gauge so it is visible at all times</td>
</tr>
<tr>
<td>9.</td>
<td>Mechanic</td>
<td>Ensures the skillet blanks or test plugs or clamps are appropriate for use and are free of obvious defects</td>
</tr>
<tr>
<td>10.</td>
<td>Mechanic</td>
<td>Fills and vents system as necessary to remove as much air as practical</td>
</tr>
<tr>
<td>11.</td>
<td>Mechanic</td>
<td>Ensures that water used for the test is at not less than ambient temperature, but in no case less than 70°F</td>
</tr>
<tr>
<td>12.</td>
<td>Mechanic</td>
<td>Pressurizes the system, raising the pressure in the system gradually until the designated test pressure is achieved</td>
</tr>
<tr>
<td>13.</td>
<td>Mechanic</td>
<td>Maintains this test pressure for 10 minutes before inspection. Then, if test is above maximum allowable working pressure (MAWP), reduces to MAWP while making a full thorough inspection for leaks.</td>
</tr>
<tr>
<td>14.</td>
<td>Mechanic</td>
<td>Ensures the metal temperature at the time of the hydrostatic test does not exceed 120°F</td>
</tr>
<tr>
<td>15.</td>
<td>Mechanic</td>
<td>If there is evidence of structural distortion, either rejects the system or repairs as advised by the inspector</td>
</tr>
<tr>
<td>16.</td>
<td>Mechanic</td>
<td>If there is leakage in the system, performs the following as appropriate: • Ensure repairs is performed and returns to step 12 or • Rejects the system</td>
</tr>
<tr>
<td>17.</td>
<td>Mechanic</td>
<td>When the test is completed, vents the test pressure to atmosphere and returns relief devices to normal configuration</td>
</tr>
</tbody>
</table>

**Recording**

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.</td>
<td>Inspector</td>
<td>Signs pressure test record</td>
</tr>
<tr>
<td>19.</td>
<td>Mechanic</td>
<td>Completes pressure test record and submits copy to the pressure systems program manager</td>
</tr>
<tr>
<td>20.</td>
<td>Mechanic</td>
<td>Submits copies of the test plan and test record to the custodian</td>
</tr>
</tbody>
</table>
2.2 Pneumatic Test Procedure

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](image)
## Pressure Test Procedures

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planning</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1. | Mechanic | Obtains test pressure after consulting the project engineer  
*Note: ensures that the pneumatic test pressure does not exceed the established test pressure of the system, unless otherwise specified in the design documents.* |
| 2. | Mechanic | Completes pressure test plan, including justification for pneumatic testing and a piping schematic for the test, and submits for approval |
| 3. | Supervisor | Approves plan |
| 4. | Pressure systems program manager | Approves plan |
| **Performing** | | |
| 5. | Mechanic | Ensures that the test gauge has a current calibration sticker. (A pressure relief valve or non-reclosing relief device may be installed in the test medium supply line to ensure that this limit is not exceeded.) |
| 6. | Mechanic | Ensures that the test area is properly flagged, barricaded, or otherwise controlled to prevent unauthorized personnel entry |
| 7. | Mechanic | Removes from the immediate area all persons not directly involved in the test |
| 8. | Mechanic | Installs the calibrated test gauge so it is visible at all times |
| 9. | Mechanic | Verifies that the pressure is continually monitored to ensure that pressure never exceeds the designated test pressure of the system |
| 10. | Mechanic | Removes relief devices from the system to be tested, where the test pressure will exceed the set pressure of the device  
OR  
Holds down each valve disk by an appropriate test clamp and equalizes pressure on non-reclosing relief devices |
| 11. | Mechanic | Pressurizes the system, raising pressure in the system gradually until not more than 1/2 of the test pressure is achieved |
| 12. | Mechanic | Increases the pressure slowly in steps of approximately 1/10 of the test pressure until the required test pressure has been reached |
| 13. | Mechanic | Reduces the pressure to the maximum operating pressure before proceeding with the inspection; holds the pressure for a sufficient period of time to permit inspection of the system |
| 14. | Mechanic | Checks the pressure gauge periodically for indications of leakage |
| 15. | Mechanic | Applies a soap solution to accessible welds, screwed pipe joints, flanges, et cetera where leakage is suspected |
| 16. | Mechanic | If there is evidence of structural distortion, either rejects the system or repairs as advised by the inspector |
| 17. | Mechanic | If there is leakage in the system, performs the following as appropriate:  
- Ensures repair is performed and return to Step 11 or |
Step | Person | Action
--- | --- | ---
18. | Mechanic | Rejects the system

When the test is completed, vents the test medium to approved discharge vicinity/atmosphere

**Recording**

19. | Mechanic | Signs pressure test record

20. | Mechanic | Completes pressure test record and submits copy to the pressure systems program manager

21. | Mechanic | Submits copies of the test plan and test record to the custodian

### 2.3 Test Pressure

There are many types of pressure systems designed under American Society of Mechanical Engineers (ASME) code, and repaired under the National Board Inspection Code (NBIC). The test pressure of various pressure systems must be calculated based on following.

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

<table>
<thead>
<tr>
<th>System</th>
<th>Code</th>
<th>Hydrostatic</th>
<th>Pneumatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler – power</td>
<td>ASME Section I</td>
<td>1.5 × MAWP</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Boiler – heating</td>
<td>ASME Section IV</td>
<td>1.5 × MAWP</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Pressure vessel</td>
<td>ASME Section VIII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division 1</td>
<td></td>
<td>1.3 × MAWP</td>
<td>1.1 × MAWP</td>
</tr>
<tr>
<td>Division 2</td>
<td></td>
<td>1.43 × MAWP</td>
<td>1.15 × MAWP</td>
</tr>
<tr>
<td>Power piping</td>
<td>ASME Section B31.1</td>
<td>1.5 × design pressure</td>
<td>1.2 × design pressure</td>
</tr>
<tr>
<td>Process piping</td>
<td>ASME Section B31.3</td>
<td>1.5 × design pressure</td>
<td>1.1 × design pressure</td>
</tr>
<tr>
<td>Building services piping</td>
<td>ASME Section B31.9</td>
<td>1.5 × design pressure</td>
<td>1.25 × design pressure</td>
</tr>
</tbody>
</table>

**Table 2** Test Pressures for Existing Pressure Vessel and Piping Systems

<table>
<thead>
<tr>
<th>Type of Work</th>
<th>Code</th>
<th>Hydrostatic</th>
<th>Pneumatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection</td>
<td>NBIC</td>
<td>0.9 × SV setting</td>
<td>Agreement between owner and inspector</td>
</tr>
<tr>
<td>Alteration</td>
<td>NBIC</td>
<td>1.5 × MAWP</td>
<td>According to original code of construction</td>
</tr>
<tr>
<td>Repair</td>
<td>NBIC</td>
<td>1.5 × MAWP</td>
<td>Minimum pressure required verifying leak tightness</td>
</tr>
</tbody>
</table>

Notes:
3 Forms

The following forms 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.

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)
- Chapter 51, “Control of Hazardous Energy”

Other SLAC Documents

- **Pressure Systems Safety Program** (SharePoint)

Other Documents

- American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code (BPVC)*, 2013 ([ASME BPVC-2013](https://www.asme.org))
- **ASME Pressure Piping Code**, including applicable addenda and code cases
  - ASME B31.3-2012, “Process Piping” ([ASME B31.3-2012](https://www.asme.org))
- National Board of Boiler and Pressure Vessel Inspectors (NBBI)
This form is required for documenting the test plan required for all pressure tests. The supervisor in charge of the test must approve; 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]).

<table>
<thead>
<tr>
<th>Pressure test plan number:</th>
<th>Project number:</th>
<th>Pressure system ID:</th>
</tr>
</thead>
</table>

## Test Information

- **Type of test:**
  - ☐ Hydrostatic
  - ☐ Pneumatic (attach justification)

## System description:

### Test Parameters

- **Required test pressure:**
- **Holding time:**
- **Test fluid:**
- **Fluid temperature:**

## 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:**

## Administrative Controls

- Qualifications of the inspector(s) and mechanic(s):
- Inspection requirements (before, during, and after the test):
- Pressure test procedures (attach detailed steps):

## Approvals

- **Supervisor in charge of test (print):**
  - Signature:  
  - Date:
- **Pressure systems program manager (print)** *(not required for routine hydrostatic test of existing systems):*
  - Signature:  
  - Date:
This form is required for documenting the results of every pressure test. Both the technician 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]).

<table>
<thead>
<tr>
<th>Pressure test record number:</th>
<th>Pressure test plan number:</th>
<th>Pressure system ID:</th>
</tr>
</thead>
</table>

### Test Parameters

- **Type of test:**
  - [ ] Hydrostatic
  - [ ] Pneumatic

- **Required test pressure:**
  - Test fluid:
  - Actual test fluid temperature:

- **Test starting time:**
  - Test ending time:

- **Test duration (ending – starting time):**
  - Actual holding time:

### Test Equipment – Pressure Gauge

- **Type:**
  - Pressure range:
  - Calibration date:

- **Actual test pressure:**

### Environmental Controls

- **Exclusion zone for safety of people (actual safe distance):**

- **Test area controls (barricades, signage, etc.):**
  - Actual disposal of test fluid:

### Results

- **Inspection:**
  - [ ] Satisfactory
  - [ ] Unsatisfactory (explain)

- **Pressure test:**
  - [ ] Satisfactory
  - [ ] Unsatisfactory (explain)

### Remarks:

- Mechanic performing test: *(print)*
- Inspector witnessing test: *(print)*

### Dates

- Signature:
- Date:
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

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Owner or custodian</td>
<td>Determines pressure system or vessel will not be used for a specified period</td>
</tr>
<tr>
<td>2.</td>
<td>Owner</td>
<td>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. Depending on pressure system type and contents, measures such as backfilling with nitrogen or other approved inert material may be taken to prevent corrosion. Note: for system specifications, consult the Pressure Systems Database</td>
</tr>
<tr>
<td>3.</td>
<td>Owner</td>
<td>Contacts pressure systems program manager for approval</td>
</tr>
<tr>
<td>4.</td>
<td>Pressure systems program manager</td>
<td>Approves plan or specifies additional requirements</td>
</tr>
</tbody>
</table>
| 5.   | Owner or custodian | Applies administrative lockout (see Chapter 51, “Control of Hazardous Energy”) that clearly identifies each of the following: 
- Pressure system name
- Pressure system number (from the Pressure Systems Database)
- Custodian name
- Department or division
- Last date of operation and system content
- Hazards warning, if any
- Current date |
### 2.2 Permanent Decommissioning

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

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Owner or custodian</td>
<td>Determines pressure system or vessel has reached the end of its service life or is no longer required for the current program</td>
</tr>
<tr>
<td>2.</td>
<td>Owner</td>
<td>Authorizes decommissioning</td>
</tr>
</tbody>
</table>
| 3.   | Owner or custodian | Before decommissioning is scheduled to begin, submits to the pressure systems program manager a written decommissioning plan.¹ Consult these SLAC resources or services as needed:  
  - Chemical lifecycle management program manager (to identify opportunities for content re-use)  
  - Air quality program manager (if gasses are present)  
  - Waste management program manager (to determine liquid or solids disposal)  
  - SLAC Salvage (to dispose of conventional pressure systems)  
  - Radiation Protection (to survey for potential activation)  
  
  Note: certain decommissioning projects are also subject to ESH project review (see the General Policy and Responsibilities: ESH Project Review Procedure).  
  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:  
  - Pressure system name  
  - Pressure system number (from the pressure system database)  
  - Custodian name |

### Step 14.1 Decommissioning Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Person</th>
<th>Action</th>
</tr>
</thead>
</table>
| 6.   | Qualified mechanic | Carries out preliminary decommissioning steps, if needed, to ensure safety until full decommissioning can be implemented. Steps can include:  
  - Controlled and safe removal of non-hazardous fluid from the system and connected piping  
  - 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 or 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 are required by this procedure:

- Pressure Systems Database

### 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- Decommissioning plan. Submitted to the pressure systems program manager for approval
- 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”
- 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”
Other SLAC Documents
- Pressure Systems Safety Program (SharePoint)

Other Documents