NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 14: Pressure Systems

Pressure Test Procedures

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

1 Purpose

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

2 Procedures

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

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

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

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

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

2.1 Hydrostatic Testing

Hydrostatic is the preferred method of pressure test at SLAC.

2.2 Pneumatic Testing

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

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

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

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

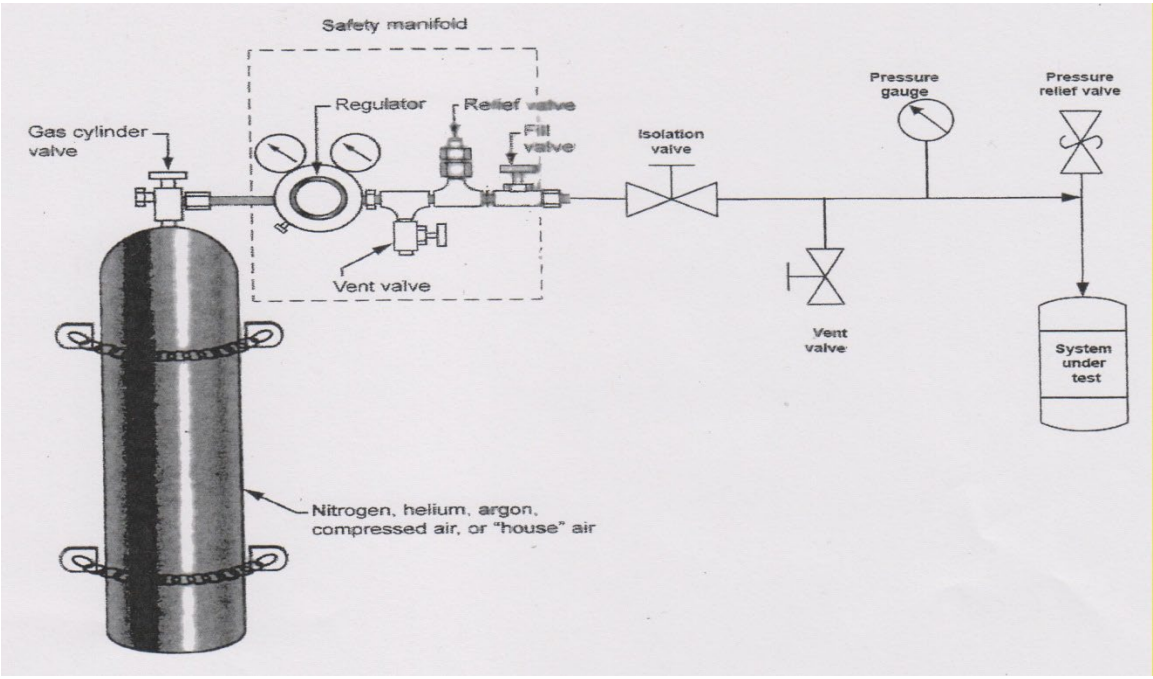

Figure 1 Recommended Typical Piping Schematic for Pneumatic Testing

2.3 Test Procedure

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

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

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

2.4 Test Pressure

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

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

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

Table 1 Test Pressures for New Pressure Vessel and Piping Systems

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

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

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

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

2.5 Test Plans

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

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

3 Forms

The following forms and systems are required by this procedure:

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

4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

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

5 References

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

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

Other Documents

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