PIP PNSC0021
Leak Testing of Piping Systems
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.
PIP PNSC0021
Leak Testing of Piping Systems

Table of Contents

1. Introduction ............................................. 2
   1.1 Purpose ............................................. 2
   1.2 Scope ............................................. 2

2. References ............................................ 2
   2.1 Process Industry Practices ................. 2
   2.2 Industry Codes and Standards .......... 2

3. Definitions ........................................... 2

4. Requirements .......................................... 2
   4.1 General Requirements ....................... 2
   4.2 Preparation for Testing .................... 3
   4.3 Leak Tests ....................................... 5
   4.4 Post-Leak Test Requirements ............ 9
1. Introduction

1.1 Purpose

This Practice provides leak-testing procedures for piping designed and constructed to ASME B31.3 Process Piping, hereinafter referred to as the Code.

1.2 Scope

This Practice describes the procedures, practices, and precautions to be used in leak testing metallic and nonmetallic piping in accordance with the Code, and describes requirements that are in addition to those of the Code.

2. References

Applicable parts of the following Practices and industry codes and standards references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

– PIP PNE00012 – Piping Examination and Leak Test Guide

2.2 Industry Codes and Standards

– American Society of Mechanical Engineers (ASME)
  – ASME B31.3 Process Piping (the Code)
  – ASME Boiler and Pressure Vessel Code
    Section V Nondestructive Examination (BPV Code, Section V)
  – ASME PCC-2 – Repair of Pressure Equipment and Piping

3. Definitions

owner: The party who owns the facility wherein the leak-testing services will be provided

4. Requirements

4.1 General Requirements

4.1.1 Prior Work

Fabrication and/or installation, examination, and required cleaning shall be complete and in accordance with the applicable specification.

4.1.2 Approval

The owner shall approve preparations for and witness all leak tests.

4.1.3 Acceptance Criteria

Piping that is free of leakage for the duration of the specified tests shall be accepted.

4.1.4 Report

A report shall be provided to the owner in accordance with the Code, Paragraph 345.2.7.
4.1.5 Repairs or Additions Following Leak Testing
Repairs or additions made following the leak test shall be tested in accordance with the Code, Paragraph 345.2.6.

4.1.6 Exempt Piping
Leak testing of the piping system is not required for the following cases:

a. If postweld heat treatment (PWHT) is not required, attachment welds of nonpressure-containing parts to pressure-containing parts that have been previously tested

b. Piping that discharges directly to the atmosphere with a maximum internal pressure not exceeding 69 kPag (10 psig)

4.2. Preparation for Testing

4.2.1 Define Test Loops and Procedures

4.2.1.1 Test diagrams and test procedures shall be prepared. They shall include the limits of piping and equipment included in each test, test pressures, test temperature, test fluid, line flushing requirements, and safety precautions.

4.2.1.2 In most cases, to facilitate including as much piping as practical in one test circuit, more than one pipeline will be included in the test circuit. If there are in-line items (valves, sensors, relief valves, etc.) that are not designed for the test pressure, it shall be decided whether to blind off (if flanged ends) and test each piping segment separately, or replace items with a spool and test the whole pipeline.

4.2.1.3 The effect of static head of the testing liquid shall be considered in determining the effective test pressure of any elements within a tested system.

4.2.2 Painting and Insulation

4.2.2.1 For hydrostatic and pneumatic tests, it is necessary to be able to examine every threaded, bolted, and welded joint for leakage (excluding welds made by a piping component manufacturer and any welds previously tested to this specification by a manufacturer). The insulation shall be left off. Joints may be painted except when a sensitive leak test is specified by the owner.

4.2.2.2 For a sensitive leak test, castings and factory welds (excluding 100% radiographed welds) shall be accessible for examination. Except for welds previously tested to this Practice, both insulation and paint shall be left off.

Comment: In some cases, paint may have to be removed from prepainted items.

4.2.3 Test Fluid Supply

4.2.3.1 The availability of water of adequate purity in the quantities needed for hydrostatic tests shall be verified.

4.2.3.2 For stainless steel piping, the chloride content shall be <50 ppm.

4.2.3.3 Any selected test liquid shall be nontoxic and nonflammable, and an acceptable means of recovery or disposal shall be determined. A
combustible liquid with flash point $\geq 60^\circ$C ($140^\circ$F) may be used, but a risk assessment should be performed to evaluate the potential and the consequence of the liquid being ignited. Flammable liquids with a flash point $< 60^\circ$C ($140^\circ$F) shall not be used.

4.2.3.4 The air quality required for pneumatic testing shall be equivalent to instrument air.

4.2.4 Components

4.2.4.1 Components in new piping systems that interfere with filling, venting, draining, or flushing shall not be installed until after line flushing and pressure testing are completed. These components include orifice plates, flow nozzles, sight glasses, venturis, positive displacement and turbine meters, and other in-line equipment.

4.2.4.2 Pressure Gages and Recorders

1. Pressure gages and recorders shall be calibrated before the tests. The calibration interval shall not exceed one year. Calibration certificates shall be made available before commencement of the pressure test. Stickers shall be applied indicating the latest calibration date.

2. A pressure gage shall be provided at the low point of the test loop. The gage shall have a dial scale $\geq 110$-mm (4 1/2-inch) diameter, a range such that the test pressure is within 40% to 80% of the full scale and accompanied by documentation showing that it has been calibrated within 2% at full-scale reading.

3. If large systems are tested, the owner shall determine the need for additional gages.

4.2.4.3 Instrument take-off piping and sampling system piping up to the first isolation block valve shall be pressure tested together with the piping or equipment to which it is attached.

4.2.4.4 Vents and Drains

1. Vents shall be provided at all high points in the tested system as needed.

2. Excluding buried piping, drains shall be provided at all low points in the system and immediately above check valves in vertical lines.

4.2.4.5 Temporary Connections and Supports

1. Temporary connections shall be provided for depressurizing and draining the system to the sewer or disposal area.

2. If required, temporary supports shall be installed before hydrostatic testing and flushing of the piping. These supports shall not be removed until after the system has been fully drained. The structural support system shall be verified for hydrostatic loads before testing.

3. Piping for gas or vapor not designed to bear the weight of hydrostatic test liquid shall be provided with added support. If additional support is not practical, a pneumatic test may be used with the owner’s written consent.
4. A bleed valve shall be provided to protect the piping and equipment from overpressure. The bleed valve shall be readily accessible if immediate depressurization is required.

5. Expansion joints, spring hangers, and spring supports shall be provided with temporary restraints if needed to prevent excessive travel or deformation under the weight of the hydrotest fluid loads.

4.2.5 **Equipment Excluded from Pressure Test**

The following list defines the equipment that shall be excluded from the test. Other unlisted sensitive equipment or those designated by the owner may be added:

- a. Rotating machinery, such as pumps, turbines, and compressors
- b. Strainers and filter elements
- c. Pressure-relieving devices, such as rupture disks and pressure-relief valves
- d. Locally mounted indicating pressure gages, if the test pressure exceeds the scale range
- e. Instrument devices
- f. Skid-mounted piping systems that have been successfully shop-tested

4.2.6 **Isolation of Test Sections**

4.2.6.1 *ASTM A-36* test blanks of a thickness suitable for the test pressure shall be used to isolate the test sections. If test blanks are not workable, closed block valves (gate, globe, plug, ball, etc.) can be used to isolate equipment or piping sections provided that the valves are not leaking. Otherwise, the spectacle plate/blind shall be installed in the closed position. If closed block valves are used in lieu of blinds, provision shall be made to ensure that no overpressure can occur in the system that is not being tested because of a possible leak through the valves.

4.2.6.2 If a block valve is used for isolating test sections, the differential pressure across the valve seat shall not exceed the rated seat pressure.

4.2.6.3 An isolation valve shall be provided between the pressure-testing manifold and the system that is being tested. The isolation valve shall be rated for the manifold test pressure if in the closed position.

4.3 **Leak Tests**

Leak testing of piping shall be performed after examination and repairs are complete and before start-up. Refer to *PIP PNE00012* for the definition of the test symbols.

4.3.1 **Test Conditions**

Before conducting any leak test, the following conditions shall be met:

- a. Plant safety rules and personnel precautions shall be observed.
- b. An approved test procedure shall be available at the site before commencing any pressure testing activities.
- c. Temporary supports, blinds, spool pieces, and other preparatory items shall be in place.
d. Items to be excluded from testing shall be removed or blanked.

e. Hydrottest stops in spring hangers and supports shall remain in place during the hydrotest.

f. If ambient temperature is not above 4°C (40°F), the owner shall specifically approve the test procedure considering the need to drain the piping before it freezes. Testing shall not be performed at an ambient temperature lower than the design minimum temperature for carbon and low alloy steel piping. See the Code, Paragraph 301.3.1 and Paragraph 323.

4.3.2 General Test Procedures

4.3.2.1 Filling the System

1. Filling and pressurizing shall be done on the upstream side of check valves in the system. If this is not possible, the check valves shall either be removed or blanked off.

2. The test fluid shall be injected at the lowest point in the system to minimize entrapped air.

3. If filling at the lowest point is not practical, the owner shall be consulted.

4. If the test fluid is liquid, all vents shall be open during filling.

4.3.2.2 After the test pressure is reached and before commencement of inspection of the system, the isolation valve between the temporary test manifold/piping and the piping/equipment under pressure test shall be closed and the test pump disconnected.

4.3.2.3 During the application of the test pressure, all in-line valves (if not used as test isolation valves) shall be in an open position with the provision that double block and bleed valves with cavities shall be kept only partially open to allow the cavity to be filled and pressurized.

4.3.3 Test Symbol “B”

A Sensitive Leak ("B") Test requires that:

a. The owner shall specify the sequence of tests and any required additional cleaning or drying for each pipeline.

b. A written qualified procedure, and evidence of operator qualifications for each type of leak test shall be provided in accordance with BPV Code, Section V, Article 1, and Article 10, and approved by the owner.

c. An acceptable bubble formation solution that produces an adherent and persistent film shall be used.

d. The piping shall be gradually pressurized to the lesser of 170 kPag (25 psig) or one-half the test pressure. The piping shall then be preliminarily checked for leaks and repaired if any leaks are found.

e. The pressure shall be raised in steps of 25% of test pressure or 170 kPa (25 psi), whichever is greater, and held for 1 minute at each step. The check
for leaks shall be repeated, repairing any found, until the full test pressure is reached. Then, a final check of all joints shall be made.

f. Bubble solution shall be applied to welds and to threaded, flanged, and other joints by a technique that minimizes initial bubbles in the solution.

Comment: Application of tape to the perimeter of the flanges and checking leaks through a punched hole is one method to check flanges.

4.3.4 Test Symbol “H”

A Hydrostatic (“H”) Test requires that:

a. Water is used as test liquid and obtained from a source approved by the owner.

b. Water temperature shall not be less than 4°C (40°F) nor greater than 60°C (140°F). The preferred water temperature range is between 16°C (60°F) and 38°C (100°F).

c. Water used for hydrostatic testing shall be free of suspended solids and biologically inert. Chlorination at a level of 0.2 ppm to 1.0 ppm is recommended to prevent biological attack.

d. The system shall be drained after the test, with vents open, through lines or hoses leading to a discharge or recovery point acceptable to the owner.

Comment: Stainless steel systems may require special flush or drying procedures to avoid chloride concentration.

4.3.5 Test Symbol “H1”

4.3.5.1 The requirements for Test Symbol “H1” are the same as for Test Symbol “H” except that the test fluid shall be specified by the owner.

4.3.5.2 The liquid shall be nontoxic, noncorrosive, and otherwise noninjurious to human tissue, piping, and the environment as determined by the owner.

4.3.5.2 If flammable, the flash point shall be ≥60°C (140°F) and suitable precautions shall be taken against ignition and the spread of fire.

4.3.6 Test Symbol “P”

A Pneumatic (“P”) Test requires that:

a. A written procedure shall be prepared for each test loop. The procedure shall be approved by the owner and include the following:

(1) Minimum piping temperature during the test.

(2) Method of limiting access to the area in which the piping is being tested.

(3) The calculated stored energy in the system at the maximum test pressure. The stored energy shall be calculated as follows:

\[ \text{P} \times \text{V} < 50,000 \]

where P is in psig, and V is in cu ft.
Comment: If the calculated stored energy is greater than 50,000, a detailed hazard analysis is required. Refer to Paragraph 6.5 of PIP PNE00012 for details.

b. Pneumatic testing with air of piping systems that have been in flammable service shall include procedures to avoid explosive flammable air mixtures.

c. Compressed air shall be dry (-4°C [-40°F] dew point) and free of oil, dirt, and other foreign matter. Other nonflammable gases (e.g., dry nitrogen) may be used with the owner’s approval.

Comment: Precautions shall be taken against asphyxiation if gas could be released in a confined area.

d. The water and condensate shall be drained before testing.

e. The piping shall be pressurized with vents and drains closed.

f. A pressure-relief valve shall be provided in the test loop. The set pressure shall be test pressure + 345 kPa (50 psi) or test pressure + 10% of test pressure, whichever is the lower.

g. The piping shall be initially pressurized to 170 kPag (25 psig) or one-half the test pressure, whichever is less; and then preliminarily checked for leaks and repaired if any leaks are found.

h. The pressure shall be gradually increased in steps to the test pressure, and the pressure shall be held at each step so that piping strains are equalized.

i. The pressure shall be reduced from 110% of design to design pressure. Checks for leaks shall be made, and repaired if any are found.

j. The release of pressure shall be regulated after the test.

4.3.7 Test Symbol “F”

A Service (“F”) Test requires that:

a. Piping shall be filled with the service fluid as specified by the owner. Vents shall be open for liquid filling.

Comment: Water or air can be substituted for liquid or gas if necessary.

b. The vents shall be closed and the piping shall be pressurized by using the source of pressure that is normal for the service.

Comment: Use the same pressure if water or air is substituted.

c. Any excess liquid or gas shall be released to an acceptable discharge point.

d. Test pressure shall be increased, and a preliminary check made, in steps in accordance with the Code, Paragraph 345.7.2.


4.4 Post-Leak Test Requirements

After leak testing has been successfully completed and the results approved by the owner, the following operations shall be carried out:

a. Draining of Test Fluid

The pressure shall be released and the system shall be drained from the downstream side of check valves. All vents shall be opened before draining to facilitate drainage and to prevent the formation of a vacuum. No test fluid shall remain in low points.

b. Disposal of Test Fluid

The test fluid shall be disposed of as directed by the owner.

c. Test Vents and Drains

Vents and drains used only for the pressure test shall be removed and the connections permanently sealed.

d. Removal and Reconnection of Components

   (1) All temporary items installed for testing purposes (e.g., manifolds, valves, blinds, spacers, and supports) shall be removed.

   (2) Items that were removed for testing shall be reinstalled.

   (3) Items such as instrument air tubing, etc., which were disconnected before testing, shall be reconnected.

   (4) Isolation valves that were closed for the test and that are required to be in the open position for process reasons shall be opened. If the valve cavity has a drain, the cavity shall be drained.

   (5) Paddle blinds and spectacle blinds shall be removed.

   (6) Use new gaskets when reassembling flanged joints that were disassembled for testing purposes. Do not reuse gaskets.

e. Pickling

If required, piping shall be pickled after the hydrostatic test.