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1. **Scope**

This Practice provides guidelines for specifying the requirements for the examination and leak testing of metallic, lined metallic, and nonmetallic piping systems designed in accordance with *ASME B31.3 Process Piping*, hereinafter referred to as the Code. The requirements include examination of piping materials, components, fabrication, assembly, installation; and associated documentation. This Practice also covers the extent of examination, criteria for acceptance, and correction of defective work. It describes the types of leak tests, bases for selecting the appropriate tests, and arrangements for testing piping.

2. **References**

Applicable parts of the following Practices and industry codes and standards 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 PNSC0001 – *ASME B31.3 Metallic Piping Fabrication and Examination Specification*
- PIP PNSC0021 – *Leak Testing of Piping Systems*

2.2 **Industry Codes and Standards**
- American Society of Mechanical Engineers (ASME)
  - ASME B16.5 – *Pipe Flanges and Flanged Fittings*
  - ASME B31.3 – *Process Piping (Code)*
  - ASME PCC-2 – *Repair of Pressure Equipment and Piping*

3. **Definitions**

For definitions of terms used in this Practice, see the *Code*, Paragraph 300.2.

4. **Scope of Examination**

4.1 The *Code* requires that each pipeline be examined to the extent specified using the methods specified.

4.2 The purpose of this practice is to specify the minimum leak tightness requirements for post-fabrication testing of pressure piping systems, and to obtain consistency in the leak testing process.

4.3 Piping systems should be examined for conformance with design drawings and project specifications.

   The following design and construction requirements should be verified:
   a. P&ID Conformance
      1. Line number
(2) Line size(s)
(3) Terminals, nozzle connections
(4) Shut-off valves, other valves
(5) In-line equipment, instruments, blinds
(6) Vents and drains
(7) Conformance to all notes on drawings

b. Line Class Conformance

Pipe, fittings, flanges, valves, and piping specialties should be verified in regard to the following characteristics. Nipples, bolts, gaskets, and joining materials should be similarly verified, to the extent possible.

(1) Material (e.g., ASTM Standard and grade)
(2) Rating or wall thickness
(3) Type and end connection
(4) Standard if applicable (e.g., ASME, MSS, API)
(5) Dimensions if applicable
(6) Freedom from visible defects or damage
(7) Freedom from defects in metallic components that are examined by radiography or other means

c. Joints and Fabrication Conformance

(1) Condition and make-up of threaded joints
(2) Alignment and make-up of flanged joints and other bolted joints
(3) Freedom from visible defects in welds; brazed, soldered, and bonded joints; bends; formed and machined work
(4) Freedom from defects in metallic welds examined by radiography or other means
(5) Condition and tightness of packing glands

d. Installation Conformance

(1) Piping location, in accordance with drawings or model
(2) Locations and details of anchors, guides, and supports
(3) Clearances from other piping
(4) Clearances from electrical and instrument lines, equipment, other structures, and spaces reserved for personnel and vehicle traffic
(5) Clearances at operating temperature
(6) Accessibility for operation and maintenance
5. **Examination Selection Basis**

5.1 Important factors governing the selection of examination requirements are as follows:
   a. *Code* requirements for fluid service
   b. Piping material and types of components and joints
   c. Pressure-temperature design conditions
   d. Safeguarding, consequences of piping failure, and other design considerations

5.2 Examination selections recommended in this Practice for various service types are identified by Examination Symbols as follows:
   a. **Category D Fluid Service** – Examination Symbol “D”
   b. **Normal Fluid Service** – Examination Symbol “N”

   *Comment:* Normal Fluid Service is used for a wide range of services. More thorough examinations may be warranted in services in which fluids are unusually flammable, unstable, carcinogenic, damaging to human tissue, dangerous to the environment or toxic; or if piping material failure could have serious consequences (e.g., harmful spills, injuries, costly downtime).

   c. **Severe Cyclic Conditions** – Examination Symbol “S”
   d. **High Pressure Fluid Service** – None

   *Comment:* Examination requirements for High Pressure Fluid Services should be defined in accordance with the *Code*.

   e. **Category M Fluid Service** – Examination Symbol “M”
   f. **Elevated Temperature Fluid** – None

5.3 The examinations required, the extent of examination, and the procedures to be used for each Examination Symbol are described in [PIP PNSC0001](#).

5.4 The Category & Examination Symbol for each line should be shown on the piping line list.

6. **Testing Selection Basis**

6.1 The following leak tests are required by the *Code* for the listed fluid services:
   a. **Category D Fluid Service** – Initial Service Leak Test
   b. **Normal Fluid Service** – Hydrostatic or Pneumatic Leak Test
   c. **Category M Fluid Service** – Hydrostatic or Pneumatic Test, and Sensitive Leak Test

6.2 A hydrostatic leak test should be preferred over a pneumatic leak test.

6.3 Brittle materials (e.g., cast iron, ductile iron) should not be pneumatically tested.

6.4 A pneumatic test should be used only if a hydrostatic test is impractical. A hydrostatic leak test may be impractical in the following cases:
   a. Piping cannot sustain the weight of water or other test liquid
b. Piping is to contain fluid that is incompatible with any available test liquid

6.5 If the product of volume in cubic feet and pressure in psig is greater than 50,000 cu. ft. psig, a detailed hazard analysis is required to be performed in accordance with ASME PCC-2, Section 6.2 (f), Article 5.1 to evaluate all the risks associated with pneumatic testing. If the hazard analysis requires, one or more of the following mitigation measures may apply:

a. Establish a minimum safe distance in accordance with ASME PCC-2, Article 5.1, Mandatory Appendix III

b. Install a barricade in accordance with ASME PCC-2, Article 5.1, paragraph 6.2 (g)

c. Perform additional NDE (e.g., Acoustic Emission) during the pressurization procedure to detect signals at unsafe energy level

d. Develop and perform a step by step Pneumatic Test Procedure in accordance with ASME PCC-2, Article 5.1, paragraph 6.2.1

e. Break the piping system down to smaller test packages to keep the energy level below 50,000 cu ft psig

6.6 A sensitive leak test may be required following a primary leak test in accordance with the Code or process requirements.

7. Leak Test Methods

Leak test methods are described in this section and are identified by Test Symbols. Test conditions, procedures, and post-test requirements for each Test Symbol are described in PIP PNSC0021.

7.1 Hydrostatic Test – Symbol “H”

7.1.1 For all but Category D Fluid Services, the Hydrostatic Test should be the preferred test method and should be used whenever feasible.

7.1.2 Water should be the preferred test liquid.

7.1.3 Chloride deionization should be used only if shown to be necessary.

7.1.4 If a large test volume is involved, the method of disposal of the test fluid from the system after the test should be considered. The fluid may be useable for hydrotesting other systems.

7.1.5 If the piping is required to be water-free after a hydrostatic leak test, warm, dry air should be circulated through the piping or a vacuum may be applied, rather than selecting a different test liquid or a pneumatic leak test.

7.1.6 It is typically acceptable to use a water header (e.g., potable, deionized, well water) for the test supply. For a large project, several taps from a water header may be required.

7.1.7 The construction contractor may be requested to provide an acceptable test water supply.
7.2 Special Hydrostatic Test – Symbol “H1”, “H2”, etc.
7.2.1 Test Symbols “H1,” “H2,” etc. may be used for special test conditions (e.g., use of a liquid other than water, longer hold times).
7.2.2 Instructions should be provided for recovery or disposal arrangements if liquids other than water are used.

7.3 Pneumatic Test – Symbol “P”
7.3.1 Because of the hazard of a possible disruptive release of energy stored in the compressed gas, pneumatic leak testing should be used only after reasonable alternates to test with a liquid have been exhausted.
7.3.2 Pneumatic testing should not be permitted for the following piping materials:
   a. Brittle material (e.g., cast iron)
   b. Plastics not specified for compressed gas service
7.3.3 For carbon and low-alloy steel piping, pneumatic leak testing should not be permitted if the ambient temperature is less than the design minimum temperature. See Code, Paragraph 323.2.2.
7.3.4 A piping system should be prepared for a pneumatic leak test in accordance with PIP PN020.
7.3.5 The area surrounding the piping system should be vacated during a pneumatic leak test until the pressure is lowered for close inspection.
7.3.6 Pneumatic testing may limit Code-allowed pressure and temperature excursions. See Code, Paragraph 302.2.4.

7.4 Initial Service Leak Test – Symbol “F”
7.4.1 The Initial Service Leak Test should be the preferred test method for Category D Fluid Service Piping.
7.4.2 The Initial Service Leak Test can be performed when the service fluid is first introduced to the piping system.
7.4.3 If an Initial Service Leak Test is to be performed as part of a contract, use of water or air instead of the service fluid may be preferable.
7.4.4 The piping system should be pressurized to a maximum of the operating pressure but not greater than 150 psig (1035 kPa).
7.4.5 See Code, Paragraph 345.7 for additional requirements.

7.5 Sensitive Leak Test – Symbol “B”
7.5.1 If a sensitive leak test is required in addition to test “H” or “P” for Code compliance or to minimize fugitive emissions, a gas and bubble test should be the preferred method.
7.5.2 Typically two Test Symbols are specified (e.g., “H,” “B”).
7.5.3 Air should be of the same quality as for a pneumatic leak test.
7.5.4 If a Sensitive Leak Test is required, it should follow the primary test (i.e., “H” or “P”).

7.5.5 Because the piping system should be dry for test “B” to be effective, warm air should be circulated or a vacuum should be applied to thoroughly remove the residual water after hydrostatic testing.

7.5.6 Other types of Sensitive Leak Tests (e.g., helium mass spectrometry) shall be in accordance with the Code, Paragraph 345.8.

7.6 **Alternative Leak Test – Symbol “A”**

7.6.1 An Alternative Leak Test may be performed in accordance with the Code if neither the hydrostatic nor pneumatic leak test can be performed (e.g., at a tie-in location).

7.6.2 Alternative Leak Testing includes the performance of the following:

a. A formal flexibility analysis of the piping system
b. 100 percent radiography or permitted alternates of ultrasonic and in-process examination of circumferential, longitudinal, and spiral groove welds that cannot otherwise be leak tested

c. 100 percent examination by the liquid penetrant method of all other welds, including structural attachment welds

d. A bubble test, Symbol “B”

7.7 **Project Special Test – Symbol “Z”**

If a piping system has special project requirements for a leak test that cannot be performed in accordance with the previously described leak test methods, a Project Special Test may be performed.

8. **Test Pressure**

Test pressures for the leak test methods described in this Practice should be in accordance with the following table:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>150% of design pressure corrected for temperature (minimum)</td>
</tr>
<tr>
<td>P</td>
<td>110% of design pressure</td>
</tr>
<tr>
<td>F</td>
<td>The operating pressure</td>
</tr>
<tr>
<td>B</td>
<td>The lesser of 15 psig (103 kPa) or 25% of the design pressure</td>
</tr>
<tr>
<td>A</td>
<td>See Symbol B</td>
</tr>
<tr>
<td>Z</td>
<td>See Section 7.7</td>
</tr>
</tbody>
</table>