PIP PLSC0021
Pressure Testing of ASME B31.8 Metallic Piping
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

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1. **Scope**

This Practice provides pressure testing procedures for pipelines designed and constructed to ASME B31.8 Gas Transmission and Distribution Piping Systems, hereinafter referred to as the Code, and in accordance with DOT CFR 49 Part 192 Subpart J. This Practice describes the procedures, practices, and precautions to be used in pressure testing metallic pipelines in accordance with the Code, and describes requirements that are in addition to those of the Code.

2. **References**

Applicable parts of the following 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 **Industry Codes and Standards**

- **American Petroleum Institute (API)**
  - API 1110 - Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids or Carbon Dioxide
  - API 1104 - *Welding of Pipelines & Related Facilities*

- **American Society of Mechanical Engineers (ASME)**
  - ASME B31.8 - *Gas Transmission and Distribution Piping Systems (the Code)*
  - ASME B31.8S - *Managing System Integrity of Gas Pipelines*
  - ASME PCC-2 - *Repair of Pressure Equipment & Piping*
  - ASME B16.5 - *Pipe Flanges & Flanged Fittings NPS ½ through NPS 24 Metric/Inch Standard*
  - ASME B16.48 - *Line Blanks*

- **Pipeline Research Council International (PRCI)**
  - *Pipeline Repair Manual*

- **U.S. Department of Transportation**
  - Code of Federal Regulations 49 Part 192 – *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards Part J Test Requirements*

3. **Definitions**

*Owner:* The party who owns the facility where the pressure 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 pressure tests.

4.1.3 Acceptance Criteria

Pressure evaluation calculations should be performed to determine if any anomalous conditions during the test might have indicated a leak. The equations for the calculations are below.

\[ P_{\text{calc}} = P_0 + \Delta T \left( \frac{dV}{dT} \right) \left( \frac{dP}{dV} \right) \]

\[ \left( \frac{dV}{dT} \right) = V_0 (\beta - 2\alpha) \]

\[ \left( \frac{dP}{dV} \right) = V_0 \left[ \left( \frac{D}{Et} \right) (1 - v^2) + C \right] \]

The variables in the equations above are defined as:

- \( P_0 \) = Initial pressure
- \( \Delta T \) = Final temperature − Initial temperature
- \( V_0 \) = Volume of pipe (line fill at 0 psig)
- \( \beta \) = Coefficient of thermal expansion for water
- \( \alpha \) = Coefficient of thermal expansion for steel
- \( D \) = Outer diameter
- \( E \) = Young’s Modulus
- \( v \) = Poisson’s Ratio
- \( C \) = Compressibility of water

Compensations for error in data collection shall be included in the calculations. Sources for error include:

- ± 0.1% error is applied to pressure readings to match the accuracy of a dead weight tester (DWT)
- ± 0.1% error is applied to temperature reading to match the accuracy of many temperature recording devices
- +1 % error is applied to the pipeline volume to account for trapped air
• ±1ºF is applied to account for incorrect pipe temperature probe placement and the possible difference between bulk fluid temperature and outer pipe / ground temperature at one location along the line.

If the actual pressure deviates more than the expected calculated pressure given the temperature and volume at that time interval by more than the anticipated error, the leak evaluation may indicate a failed test. The contractor and/or owner representative must determine if the test passes or fails and identify if conditions are appropriate to satisfy a deviation request.

Hydrostatic leak evaluation calculations do not apply to tests in which all associated piping and equipment is above ground and can be visually inspected for leaks.

4.1.4 Repairs or Additions Following Testing

Repairs or additions made following the pressure test shall be performed in accordance with ASME PCC-2.

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 extent of pipeline and any equipment to be included in each test, test pressures, test temperature, test fluid, line flushing requirements, and safety precautions such as appropriate lockout/tagout practices.

4.2.1.2 More than one pipeline may 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 in particular at the highest and lowest elevations.

4.2.1.4 The effect of elevation on test pressure must be considered for tests if elevation change exceeds 100 feet.

4.2.2 Paint and Insulation

For hydrostatic and pneumatic tests, it is necessary to be able to examine every threaded, flanged 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 for visual inspection.

4.2.3 Test Medium

4.2.3.1 The preferred medium is water but alternative media are available for pressure testing and should abide by the following table from the Code – Table 841.3.3-1, Maximum Hoop Stress Permissible during an Air or Gas Test, based on the % yield strength (SMYS) resulting from the intended test pressure in different class locations.
Comment: If water is selected a bio-degradable dye can be introduced to assist in the location of leaks. If the ambient temperature of the pressure test could be below freezing appropriate inhibitors should also be considered.

4.2.3.2 Liquid Medium

Water is the preferred pressure test medium; however, there are additional considerations that must be addressed.

A hydrostatic test requires that:

a. The owner must ensure sufficient quantities of water of adequate purity are available.

b. Water quality shall abide by the following standards

   o Contain less than or equal to 100 ppm Total Suspended Solids (TSS)
   o Contain less than or equal to 2000 ppm Total Dissolved Solids (TDS)
   o pH between 6-9
   o Contain a chlorination level of at least 0.2 ppm

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

A registered biocide should be added to the test medium if a municipal water source is not used. If biocide cannot be added due to environmental constraints, the line shall be batch treated after the test.

The water in stainless steel systems shall have a chloride content not more than 50 ppm. These systems may also require special flush or drying procedures to avoid chloride concentration.

Any selected test liquid shall be nontoxic and nonflammable, and an acceptable means of recovery or disposal shall be determined.

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: Environmental considerations must be addressed for water disposal after the test.

4.2.3.3 Gaseous Medium

The air quality required for pneumatic testing shall be equivalent to instrument air. Nitrogen or another inert gas may also be used for pneumatic testing in accordance with Code Table 841.3.3-1.

A pneumatic test requires that:

A written procedure shall be prepared for each test loop. The procedure shall be approved by the owner including:
a. Minimum pipeline temperature during the test  
b. Method of limiting access to the area in which the pipeline is being tested  
c. Stored energy in the system when the maximum test pressure is achieved  
d. Appropriate safety precautions should be observed.

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

Compressed air shall be dry (-40°F [-40°C] 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.

The water and condensate shall be drained before testing.

The pipeline shall be pressurized with vents and drains closed.

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.

The pipeline 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.

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.

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

The release of pressure shall be regulated after the test.

4.2.4 Components

4.2.4.1 Components in new pipeline 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 traditional dead weight tester (DWT) shall be used. Current and valid calibration certificates shall be provided for the DWT or equivalent and pen chart recorders. All certifications are valid for 12 months before recertification is required. Field adjustments to the chart recorders are not allowed.

3. Pen charts that record pressure and pipe/fluid temperature shall be used on each pressure test and shall be used when pre-testing any pipe or assembly including bore pipe. Ambient temperature shall also be recorded with a pen chart or other recording device at minimum 30-minute intervals. Any recorders that connect to the pipe segment being tested shall be common on the same manifold. The manifold shall have additional connections for the DWT and a backup manual pressure gauge. The manifold shall be capable of isolating all of the instruments from the pipe segment being tested.

4. The following should be considered when selecting charts and chart recorders:
   - Use large charts whenever possible.
   - Use separate charts (preferred) to record the temperature and pressure; however, dual or combined chart recorders are permissible.
   - Clearly mark each recorded line on the chart if a dual pen chart recorder is used.
   - The chart’s scale should allow easy, identifiable reading of the recording (i.e. a 3,000 psi chart for a 100 psi test is not an appropriate selection).
   - The chart time range shall be an appropriate duration (typically 24 hours).
   - The recording pen should apply enough pressure to draw a heavy, consistent line on the chart.

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

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

7. Pressurized hoses (carrying >10 psig and sized one inch and above) shall be secured in place using adequate staking or another means at a minimum of every 25 feet (excluding instrument lines). All temporary mechanical connections (i.e. hose connections, instrument lines, hammer unions, etc.) shall be protected with whip checks or equivalent.

4.2.4.3 Vents and Drains

Vents shall be provided at all high points in the tested system as needed.
Excluding buried piping, drains shall be provided at all low points in the system and immediately above check valves in vertical lines.

### 4.2.4.4 Temporary Connections and Supports

1. Temporary connections shall be provided for depressurizing and draining the system.

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. Pipelines for gas or vapor not designed to bear the weight of hydrostatic test liquid shall be provided with added support.

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. 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.

### 4.2.4.5 Fittings

The test pressure should not exceed the maximum test pressure rating of any of the fittings within the test section. Table 1 references the pressure ratings and maximum test pressures associated with ASME B16.5 ANSI pressure classes for materials group 1.1. For various material types reference other materials groups in ASME B16.5.

<table>
<thead>
<tr>
<th>Pressure Rating</th>
<th>ANSI 150</th>
<th>ANSI 300</th>
<th>ANSI 600</th>
<th>ANSI 900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Test Pressure</td>
<td>450 psi</td>
<td>1,125 psi</td>
<td>2,225 psi</td>
<td>3,350 psi</td>
</tr>
</tbody>
</table>

### 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 *ASME B16.48* must be referenced in the selection of test blanks suitable for the test pressure to 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 All test termination points shall be isolated from the adjacent pipeline facilities by blind flanges manufactured to *ASME B16.5* specifications. Skillet or spectacle blinds which are stamped with the appropriate pressure rating or for which the material certifications are available may also be used. Field fabricated skillet blinds shall be fabricated according to the dimensions in Table 2 below. Other isolation methods (stopples, etc.) may only be used when pre-approved by the owner prior to product displacement.

All valves which are in-line for the test should be in the open position during the test unless otherwise instructed by the valve manufacturer. *ASME* code pressure vessels shall be isolated from the test. An owner/operator representative will supervise the isolation operation and ensure the isolation has been conducted in accordance with requirements.

### Table 2. Dimensions for Field Fabricated Blinds (code reference ASME B16.48)

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>ANSI 150</th>
<th>ANSI 300</th>
<th>ANSI 600</th>
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<tr>
<td></td>
<td>OD</td>
<td>Minimum Thickness</td>
<td>OD</td>
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<tr>
<td>2</td>
<td>2.375</td>
<td>0.175</td>
<td>4.25</td>
</tr>
<tr>
<td>3</td>
<td>3.5</td>
<td>0.25</td>
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<td>7</td>
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<td>12.75</td>
<td>0.65</td>
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<tr>
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<td>25.625</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>1.375</td>
<td>30.375</td>
</tr>
</tbody>
</table>

**Note:** Dimensions assume A36 or stronger steel plate is used.

4.2.6.3 If a block valve is used for isolating test sections, the differential pressure across the valve seat shall not exceed the rated seat pressure.
4.2.6.4 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.

4.2.6.5 Where applicable, ensure that previously in-service pipelines are thoroughly purged per owner procedures prior to conducting testing activities.

4.3 Pressure Tests

Pressure testing of piping shall be performed after examination and repairs are complete and before start-up.

4.3.1 Test Conditions

Before conducting any pressure 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. Hydrotest stops in spring hangers and supports shall remain in place during the hydrotest.

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

g. Appropriate local and federal government permits or notifications shall be completed prior to the initiation of testing activities.

4.3.2 General Test Procedures

4.3.2.1 Test Pressure

The pressurization shall be performed in a gradual and steady manner and in the presence of an owner representative. Unless metal cracking is a possible threat, it is recommended that the initial pressurization be increased to a pressure equivalent to 110% of the specified minimum yield strength (SMYS) and held for 10 minutes. Subsequently, the pressure should be decreased to the higher of a pressure equivalent to 94% of SMYS or 1.5 times the intended maximum allowable operating pressure (MAOP) and held within approximately 25 percent of the test pressure during the temperature stabilization period.

During pressurization, maintain continuous surveillance for leaks on test equipment, connections, flanges, etc. When making repairs to pipe segments or equipment or when tightening bolts, the pressure shall be bled.
down to 0 psig, and liquid drained as necessary to complete the repair. Then re-fill and re-pressurized once the repairs have been made.

Once the final test pressure is reached, the test duration begins and the individual responsible for conducting the test shall record the following readings on 30-minute intervals:

- Time
- Pressure (dead weight tester or equivalent)
- Temperature (ambient and pipe/test medium)
- Remarks / weather changes
- Volume of water added or withdrawn

4.3.2.2 Pressure Test Duration

Tests performed on a pipeline intended to establish an MAOP or maximum operating pressure (MOP) greater than a pressure equivalent to 30% SMYS shall be held within the specified minimum and maximum test pressures at all elevations along the test section for at least 8 continuous hours.

*Comment:* If DOT compliance is not required tests performed on a pipeline intended to establish an MAOP or MOP greater than a pressure equivalent to 30% SMYS shall be held within the specified minimum and maximum test pressures at all elevations along the test section for at least two continuous hours.

4.3.2.3 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. When possible the test fluid should be injected at the lowest point in the system to minimize trapped air.
3. If the test fluid is liquid, all vents shall be open during filling. The liquid shall be injected behind a cupped pig with a compressor system to fill the pipeline without introducing air.

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.

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.

4.4 Post-Pressure Test Requirements

After pressure testing has been successfully completed and the results approved by the owner, the following operations shall be carried out:
4.4.1 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. If possible pigging operations propelled by compressed air should be used to dewater and dry the line. Air movers can also be utilized if required.

4.4.2 Disposal of Test Fluid
The test fluid shall be disposed of as directed by the owner. Consideration should be made for water disposal when chemicals, biocides, inhibitors or dyes are introduced to the test medium. The owner’s environmental personnel should be consulted in such cases.

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

4.4.4 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.

5. Documentation

Code Appendix N-7 outlines the records that must be created and stored to sufficiently document the pressure test.

A Pressure Test Record Form can be used to document the pressure testing and can become part of the final pressure test report. An explanation of all pressure discontinuities, including test failures appearing on the pressure recording charts, shall also be included. The report shall contain the temperature and pressure recording charts from the test. These charts shall be signed by the testing company and an owner representative. These signatures verify that the charts were produced by the recorder during the pressure test.

A list of the pressure readings taken with the dead weight tester showing comparable pressure recorder readings at the time of the test shall also be included in the report. These dead weight tester readings shall be the pressure readings used in the report and for all calculations and certifications. The pressure recording charts are only to document pressure continuity and will not be used as the official test pressure readings.

Any volume additions or withdrawals must be documented. Sufficient description should be provided in the documentation to designate which pipeline(s) were tested and the extent of
pipeline (stationing, chainage, etc.) included in the test section. A map and/or sketch should also be created to show the locations of the test points, temperature bulb, and pressure pump.

Pipelines with an elevation difference of more than 100 feet from the highest to the lowest test point should include a profile detailing the elevation along the test section and at the test site. All other relevant field data taken during the test shall also be included in the report.

**Final Reporting**

The final report containing the minimum elements listed in Table 3 below shall be generated and submitted to a technical owner representative for final approval.

<table>
<thead>
<tr>
<th>Document</th>
<th>Required</th>
<th>Preferred Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Test Record Form</td>
<td>Yes</td>
<td>Electronic (PDF)</td>
</tr>
<tr>
<td>All field-completed forms</td>
<td>Yes</td>
<td>Originals</td>
</tr>
<tr>
<td>Charts</td>
<td>Yes</td>
<td>Originals</td>
</tr>
<tr>
<td>Calibration certificates</td>
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</tr>
<tr>
<td>Sketches</td>
<td>Optional by Owner</td>
<td>Electronic (PDF)</td>
</tr>
<tr>
<td>Maps</td>
<td>Optional by Owner</td>
<td>Electronic (PDF)</td>
</tr>
<tr>
<td>Photos</td>
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<td>Calculations</td>
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<td>Equipment Specs</td>
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