PRESSURE TESTING

Integrated Water Services, Inc.
(the Company)

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.

Scope

This procedure applies to all Company employees and subcontractors.

These procedures represent the minimum requirements as per ASME B31.3. It must be understood that although these requirements represent the minimal testing requirements, the customer/client or contract may have more stringent testing requirements.

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.

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.

Codes and standards organizations (ASME, NFPA) and federal and state 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.

Piping system preparation for hydro tests and pneumatic tests

Before starting leakage tests like hydrostatic testing or pneumatic testing, piping network and connected equipments must be prepared for leakage tests. ASME B31.3 provides guidelines for such preparation.

Piping which is normally open to the atmosphere, such as drains, vents, discharge piping from pressure relieving devices, sewers, and stack downstream of the seal drum, shall not be subjected to the piping test pressure.

Compare PID and Isometric Drawing
A comparison of the P&ID drawings and the piping isometrics must be made to determine if there are any discrepancies. Review all valve types, flow directions, branch tie-ins, and any material changes. Recheck all in-line components to verify they can withstand the required test pressure.

Complete Inspection before testing
All radiographic and ultrasonic inspections should be carried out before the pressure test is started. Conducting 100% radiography of all the weld joints assure that your weld joints are defect free but can never provide you with the assurance of mechanical integrity of a system. This is also to be noted that radiography / ultrasonic inspection shall also not to be waived off if the pipeline is to be hydrostatically tested.

Provision of Temporary Supports
As per ASME B31.3 Section 345.3.2 piping designed for vapor or gas shall be provided with additional temporary supports, if necessary, to support the weight of test liquid as the test liquid is heavier than service gas.

Spring Supports in Piping System
Spring supports shall be restrained or removed during hydrostatic testing. Piping which is spring or counterweight supported shall be blocked up temporarily to a degree sufficient to sustain the weight of the test medium. Holding pins shall not be removed from spring supports until testing is completed and the system is drained. Care shall be taken to avoid overloading any parts of the supporting structures during hydrostatic testing.

Piping with Expansion Joints
As per ASME B31.3 Section, when there is an expansion joint in piping system under leakage test, following criteria applies.

(a) An expansion joint that depends on external main anchors to restrain pressure end load shall be tested in place in the piping system.
(b) A self-restrained expansion joint previously shop tested by the manufacturer [see Appendix X, para. X302.2.3(a)] may be excluded from the system under test, except that such expansion joints shall be installed in the system when a sensitive leak test in accordance with para. 345.8 is required.
(c) A piping system containing expansion joints shall be leak tested without temporary joint or anchor restraint at the lesser of:
    (1) 150 % of design pressure for a bellows-type expansion joint, or
    (2) the system test pressure is determined in accordance with para. 345

In no case shall a bellows-type expansion joint be subjected to a test pressure greater than the manufacturer's test pressure.

(d) When a system leak tests at a pressure greater than the minimum test pressure specified in (c), or greater than 150% of the design pressure within the limitations of para. 345.2.1(a) is required, bellows-type expansion joints shall be removed from the piping system or temporary restraints shall be added to limit main anchor loads if necessary.

Limits of Tested Piping
As per ASME B31.3 Section 345.3.4 equipment which is not to be tested shall be either disconnected from the piping or isolated by blinds or other means during the test. A valve may be used provided the valve (including its closure mechanism) is suitable for the test pressure.

Rotary Machinery

For rotating machinery, such as pumps, turbines, and compressors, have lube and seal oil systems which could be impaired by the presence of water. These systems shall not be subject to the piping test pressure.

Temporary Spades and Blanks
Temporary spades and blanks installed for testing purposes shall be designed to withstand the test pressure without distortion. The presence of spades shall be clearly visible during testing. The recommended practice is to use standard blind flanges as per ASME B16.5 or B16.47 and spades acc. to ASME B16.48.

Check Valves
Check Valves shall have the flap or piston removed for testing, where pressure cannot be located on the upstream side of the valve. The locking device of the flap pivot pin shall be reinstated together with the flap and a new cover gasket shall be installed after completion of the test.

Completion of Hot Work
A hydrostatic test should not be performed until after all hot works have been completed on a certain piping system. Hot work includes everything related to welding or the post weld heat treatment (PWHT).

Installation of Barriers
Prior to any pressurization related to testing, it is essential to install barriers around the piping system under test. Under no circumstances should anyone other than an authorized person be allowed within the safety barriers.

Control Valves
Control Valves and soft-seal block Valves shall be removed from the piping prior to the test and replaced with pipe spools.

Physical Inspection
Complete a physical inspection to check for following:

- Completed and torqued flanges with no missing bolts or gaskets.
- All gravity supports installed.
- Proper pipe routing.
- Correct valve type and orientation.
- Vents and drains installed to allow proper filling and draining
- Proper material type verified using color codes or markings, and heat numbers recorded if required by the codes.
- All required piping stress relief, weld examinations, and welding documentation completed and acceptable.

Testing Documentation
The individual system documentation i.e., test pack shall be available prior to any testing and shall include information such as test limits, test pressure, test medium, duration, test blinds, blind flanges, vents, and drains.

Pressure Test Data Sheet
The use of marked up P&Ids coupled with isolation registers should be utilized to identify the locations of blinds, Valves, vents, and drains.

Testing Equipment
Testing equipment such as pumps, manifold, pressure and temperature recorders, pressure gauges should be within calibration/certification (as per owner and PEM procedures) and connected to the lowest convenient connection within the system to ensure best results.

Hydrostatic Testing of Water Pipelines

Hydrostatic testing is the most used leakage checking method for piping networks. ASME B31.3 Process piping code specifies criteria for hydrotesting in a process industry.

Test Fluid

As per ASME B31.3 Section 345.4.1, the test fluid shall be water unless there is the possibility of damage due to freezing or if water will cause adverse effect on the piping or the process. In that case another suitable nontoxic liquid may be used. If the used test liquid is flammable, its flash point shall be at least 49°C (120°F), and consideration shall be given to the test environment.

Test Pressure

As per ASME B31.3 Section 345.4.2 the hydrostatic test pressure at any point in a metallic piping system shall be as follows:

(a) not less than 11⁄2 times the design pressure.

(b) for design temperature above the test temperature, the minimum test pressure shall be calculated by Eq. (24), except that the value of ST/S shall not exceed 6.5:

$$P_T = \frac{1.5\times{P}\times{S_T}}{S}$$

Where

P = internal design gauge pressure.
PT = minimum test gauge pressure.
S = stress value at design temperature (see Table A-1 of B31.3)
ST = stress value at test temperature.

If the test pressure as defined above would produce a nominal pressure stress or longitudinal stress in excess of the yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

Hydrostatic test of piping with vessels as a system

As per ASME B31.3 Section 345.4.3 where the test pressure of piping attached to a vessel is the same as or less than the test pressure for the vessel, the piping may be tested with the vessel at the piping test pressure.

Where the test pressure of the piping exceeds the vessel test pressure, and it is not considered practicable to isolate the piping from the vessel, the piping and the vessel may be tested together at the vessel test pressure, provided the owner approves and the vessel test pressure is not less than 77% of the piping test pressure calculated in accordance with para. 345.4.2(b).

Safety Considerations

Prior to testing a Job Hazard Assessment (JHA) must be completed and reviewed with all affected personnel. The JHA must cover the following:

- Job tasks associated with the testing

- Hazards associated with the tasks
- Controls that will be implemented to remediate the hazards
- All workers have an obligation to stop work if something is not right.

After the JHA has been submitted, if there are changes to the job scope, the JHA must be edited and updated in order to accommodate the following:

- Changes to the testing plan
- Changes to the job tasks
- Changing hazards associated with the tasks
- Changing controls and hazard mitigation measures
- Changes in personnel and or tools
- Any other changes or shifting conditions associated with the testing process

The following table includes some of the mitigation and control measures that must be incorporated with any testing Job Hazard Assessment for Hydrostatic or Pneumatic Testing:

Job Tasks/ Equipment	Hazards	Controls & Mitigations
1. Hydrostatic Pipe Testing. **Equipment:** • First-aid kit • Equipment and operations manual for equipment • Compressed air • Pressurized water • Hand tools • Personal protective equipment	1. Caught in or between moving parts.	1. Identify and understand parts of equipment which may cause crushing, pinching, rotating or similar motions • Provide and use proper work gloves when the possibility of pinching, or other injury may be caused by moving/ handling large or heavy objects • Maintain all equipment in a safe condition • Keep all guards in place during use • De-energize and lock-out machinery before maintenance or service
	1a. Slips, trips and falls	1a. Clear walkways work areas of equipment, tools, vegetation, excavated material and debris • Mark, identify, or barricade other obstructions • Maintain 3-point contact when ascending/descending ladders/ mounting/dismounting from heavy equipment • Halt exterior work in high winds, lightning, severe weather • The laser beam must never be directed at employees.
	1b. Handling heavy objects	1b. Observe proper lifting techniques • Obey sensible lifting limits (60 lb. maximum per person manual lifting) • Use mechanical lifting equipment (hand carts, trucks) to move large, awkward loads
	1c. Eye Injuries	1c. Wear face shield, goggles when operating powered clearing / grubbing equipment
	1d. Sharp objects	1d. Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects • Maintain all hand and power tools in a safe condition • Keep guards in place during use

		• Close doors, windows on heavy equipment to prevent injuries from tree branches and other vegetation
	1e. Contact with pressurized water	1e. Provide workers with proper skin and eye protection based on the hazards present • Review hazardous properties of any site contaminants with workers before operations begin
	1f. Pressurized lines	1f. Prepare written test procedure checklist • Place test in progress or similar signs / appropriate barriers to prevent access by unauthorized personnel to the testing area • All changes to test procedures must be approved by qualified engineer • Inspect testing equipment for defects prior to each use • Maintain an appropriate pressure release system to safely release pressures when testing is complete • Wire quick connections, temporary lines closed before operating
	1i. High/Low ambient temperatures	1i. Monitor for Heat/Cold stress • Provide fluids to prevent worker dehydration • Establish work/rest cycles for the crew
	1j. Other precautions	1j. Inspect Equipment and Tools • Inspect equipment and tools daily per manufacturers requirements and document the same using the IWS inspection forms • Inspect all emergency equipment (i.e. first aid kits, fire extinguishers)

Pneumatic Testing of Piping Systems

Pneumatic testing is used where hydrostatic testing cannot be used e.g., when residual water can damage the piping system.

Pneumatic Testing as per ASME B31.3

345.5.1 Precautions.
Pneumatic testing involves the hazard of released energy stored in compressed gas. Particular care must therefore be taken to minimize the chance of brittle failure during a pneumatic leak test. Test temperature is important in this regard and must be considered when the designer chooses the material of construction. See para. 345.2.2(c) and Appendix F, paras. F323.4 and F345.5.1.

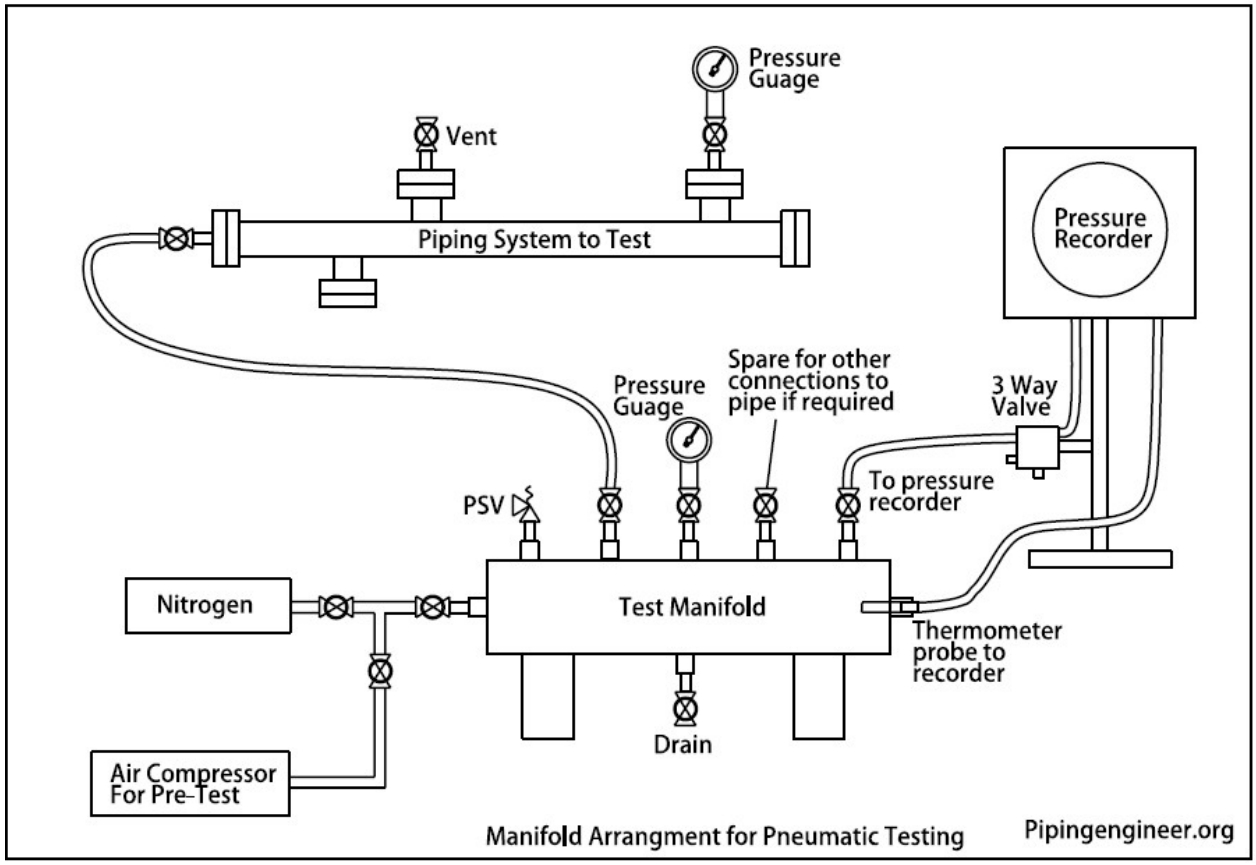
345.5.2 Pressure Relief Device.
A pressure relief device shall be provided, having a set pressure not higher than the test pressure plus the lesser of 345 kPa (50 psi) or 10% of the test pressure.

345.5.3 Test Fluid.
The gas used as test fluid, if not air, shall be nonflammable and nontoxic.

345.5.4 Test Pressure.
The test pressure shall be not less than 1.1 times the design pressure and shall not exceed the lesser of:

(a) 1.33 times the design pressure
(b) the pressure that would produce a circumferential pressure or longitudinal stress (based on minimum pipe wall thickness) in excess of 90% of the yield strength of any component at the test temperature

345.5.5 Procedure.
The pressure shall be gradually increased until a gage pressure that is the lesser of one half the test pressure or 170 kPa (25 psi) is attained, at which time a preliminary check shall be made, including examination of joints in accordance with para. 341.4.1(a). Thereafter, the pressure shall be gradually increased in steps until the test pressure is reached, holding the pressure at each step long enough to equalize piping strains. The pressure shall then be reduced to the design pressure before examining for leakage in accordance with para. 345.2.2(a).



Blank Pneumatic Testing Manifold Arrangement

Salient Features of Pneumatic Testing

- Pneumatic testing pressure is normally 10% higher than the design pressure of a piping system.

- Pneumatic testing is recommended only for low pressure applications.
- Test media (Air) used is compressible by pressure application.
- The energy stored per unit volume of compressed air under test pressure is very high.
- Easy to clean equipment and pipelines after pneumatic testing.
- Pressure relief devices are a must during tests to ensure no over pressurization.
- Chances of equipment/ Pipe / test apparatus failures are very high in pneumatic testing.
- Weight of equipment with test medium as air is comparatively less.
- Before pneumatic testing, it is highly essential to carefully check all welded joints.
- Pneumatic testing needs supervision and guidance of senior experienced staff.
- When doing pneumatic testing of pipelines, they should be tested on small segments of pipeline at a time.
- Damages caused by failures in pneumatic testing are generally extensive.
- Pneumatic testing needs special attention and safety precautions.

Difficulties with Pneumatic testing:

- Pneumatic tests are potentially more dangerous than hydrostatic tests because of the higher level of potential energy stored during compressing the gas.
- Care must be exercised to minimize the chance of brittle failure during testing by initially assuring the system is suitable for pneumatic testing.
- Pneumatic tests could be performed only when at least one of the following conditions exists:
- When the systems are designed in such a way that it cannot be filled with water.
- When the systems are such that it is to be used in services where traces of the testing medium cannot be tolerated.

Note: Using a pneumatic test instead of hydrostatic requires approval from proper authority or body.