



GUIDELINE FOR PRESSURE TESTING OF FIELD-INSTALLED PIPING AND EQUIPMENT

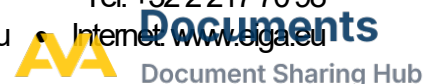
Doc 254/24

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GUIDELINE FOR PRESSURE TESTING OF FIELD-INSTALLED PIPING AND EQUIPMENT

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Published in August 2024

As part of a programme of harmonisation of industry standards, the European Industrial Gases Association (EIGA) has published *EIGA Doc 254 Guideline for Pressure Testing of Field-Installed Piping and Equipment*. This publication was jointly produced by members of the International Harmonisation Council.

This publication is intended as an international harmonised publication for the worldwide use and application by all members of the International Harmonisation Council whose members include the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Regional editions have the same technical content as the EIGA edition, however, there are editorial changes primarily in formatting, units used and spelling. Regional regulatory requirements are those that apply to Europe.

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1 Introduction

Pressure testing of components and systems is an essential part of the activities of the industrial gases industry to demonstrate the integrity of equipment. Pressure testing typically involves introducing sufficient gas and/or liquid into an assembly of parts to increase internal pressure and verify the strength, integrity, and/or functionality of the assembly.

Pressure tests are required when equipment is first placed in service or to confirm its integrity during service, after equipment repair, and modification to satisfy code, company, or legal requirements.

The stored energy of pressurised systems creates a hazard that could result in injury to personnel or damage to property. Most of the hazards associated with pressure testing come from the sudden, unintended release of stored energy. Safe work procedures and practices should be implemented to ensure that the pressure test activity is planned carefully and completed safely.

Management systems are necessary to ensure that procedures are in place for energized systems to be isolated and that personnel involved in the pressure test activity are trained in the hazards, procedures, setup, and equipment necessary to complete a pressure test.

This publication provides guidelines to ensure that hazards inherent of pressure tests are mitigated, risks are managed and exposure to personnel and public is limited.

The goal of this publication is to provide a framework for users to develop specific pressure and leak testing procedures for piping and equipment that cannot be isolated from the piping being tested.

2 Scope

This publication provides guidelines for managing and planning pressure tests (leak tests and proof tests) of field-installed process piping. This includes all operations necessary for planning, preparation, pressure test of the piping, depressurisation, and restoring the system back to service.

The following are included in the scope of this publication:

- Field-installed piping connecting pieces of equipment and such equipment only if it is part of field testing for example, if the equipment cannot be isolated from the field piping;
- Proof testing for integrity of the piping system components; and
- Leak testing to confirm ability to contain fluid.

The following are specifically excluded from the scope of this publication:

- Pressure tests performed in the shop on fabricated pipe spools, manifolds, and assemblies;
- Pressure vessels and other equipment that have been shop-fabricated and pressure tested prior to delivery;
- Pressure vessels built to and tested under the local codes (ASME, etc.). This publication can be used as a compliment to those codes but is not intended to replace them; and
- Pressure tests completed at manufacturing locations or workshops. These facilities have their own procedures for pressure testing process equipment and are typically carried out indoors or in pressure test enclosures.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Authority having jurisdiction (AHJ)

Organization, office, or individual responsible for enforcing the requirements of a code or standard, or responsible for approving equipment, materials, an installation, or a procedure.

3.2.2 Dry, oil-free

Gas with a dew point of $-40\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F}$) or less and an oil content of 0.5 mg/m^3 or less.

3.2.3 Maximum allowable working pressure (MAWP)

Maximum pressure at the coincident temperature to which a piece of equipment or piping is designed for during a normal operation cycle.

NOTE—For the purposes of this publication, design pressure is synonymous with maximum allowable working pressure [1].¹

3.2.4 Owner

Any person, firm, or corporation legally responsible for the safe operation of any pressure-retaining item.

3.2.5 Pressure test

Application of pressure to determine if components have acceptable integrity and/or leak tightness.

NOTE—For the purposes of this publication, pressure testing encompasses both leak testing and proof testing.

3.2.5.1 Leak test

Pressure test of equipment and piping to determine if an unacceptable amount of fluid is able to escape through mechanical connections or flaws in metal joining, cracks, and other escape paths.

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2.5.2 Proof test

Pressure test of equipment and piping to test the mechanical integrity of the components and welded connections at some pressure greater than the MAWP. Typically, proof test pressure is in the range of 110% to 150% of MAWP.

NOTE—Proof testing is also commonly known as strength testing in some regions.

3.2.6 Test fluid

Fluid being introduced into the system to perform a pressure test.

3.2.7 Working fluid

Fluid that the system will contain during normal operation.

3.2.8 Test manifold

Assembly of piping, valves, regulators, relief devices, pressure indicators, and other components required to control the introduction of test fluid into the piping system being tested.

3.2.9 Pressure test execution personnel (PTEP)

Personnel who are actively involved in pressure testing, both leak testing and proof (strength) testing.

NOTE—They are aware of the hazards from pressure testing and wear appropriate personal protective equipment (PPE) such as hard hats, hearing protection, and safety glasses.

3.2.10 Non-pressure test execution personnel (NPTEP)

Personnel who are not actively involved in pressure testing.

NOTE—They might not be aware of the hazards from pressure testing and may not be wearing PPE appropriate for pressure testing.

3.2.11 Restricted access distance

Minimum separation distance for any personnel from any points of the piping system that will be pressure tested. This separation distance is determined from a source such as ASME PCC-2, *Repair of Pressure Equipment and Piping*, and *New Criteria for Safety Distances During Pneumatic Pressure Testing of Vessels and Pipes*, or owner requirements and is a function of the maximum test pressure and the pipe size [2, 3].

3.2.12 Restricted access area

Area bounded by the restricted separation distance from the piping system to be tested.

NOTE—Also designated the PTEP access area.

3.2.13 Non-restricted access area

Any space not located within the restricted access area.

NOTE—Also designated the NPTEP access area.

4 Types of Testing

The purpose of pressure testing is to check that, at a pressure with a defined safety margin in relation to the maximum allowable working pressure (MAWP), the equipment does not exhibit significant leaks or deformation exceeding a permissible threshold.

Pressure equipment shall be tested before its first use. This can happen for individual sections of the final assembly separated by detachable connections, or the whole assembly. A risk analysis shall be done, and safety precautions have to be taken accordingly. Testing is typically done in pressure steps to the MAWP, then increasing up to a pressure greater than MAWP (and all personnel shall be a safe distance away or behind a barrier).

4.1 Leak testing

A piping system is leak tested to verify that it can operate at its operating pressure while not suffering an unacceptable loss of product through leaks. This is done by pressurizing the system with a suitable medium (for example, dry oil-free air, nitrogen, or helium). Leak testing is performed at or less than the MAWP of the system. Leak testing is frequently pneumatic, but hydrostatic leak testing is possible. Refer to ASME B31.3, *Process Piping*, Section V, Article 10 or EN 13480-5, *Metallic industrial piping Inspection and testing* for more details [1, 4].

Typically leak testing is conducted at the final system location when all the process piping has been installed and connected.

To check for leaks, a visual inspection with a leak detection spray may be done. Only use approved leak detection fluid (see EIGA Doc 78, *Leak Detection Fluids with Gas Cylinder*) and confirm that it does not cause stress corrosion cracking [5]. Other methods of leak detection may also be used, such as helium leak detection where the system is pressurised with helium or a mixed gas containing helium and helium detectors are placed adjacent to the tested system to detect leaks.

Another method is to test for leaks over time. Once the pressure is set, the system is closed and monitored. If the system is sealed, the pressure reading should not change by more than an allowable amount over time. Any change in temperature shall be considered when evaluating the pressure gauge reading, if the tested system is not at a constant temperature. The allowable change in pressure shall also include acceptable levels of leakage through mechanical seals.

Leaks can also be detected by pressurizing with inert gas or air, immersing in water, and checking the rate of bubble formation.

Personnel may be present for this testing.

4.2 Proof testing

Proof testing is done in connection with leak testing and visual inspection to ensure that the pressure equipment is safe to use.

Proof testing verifies the system's mechanical integrity at a pressure greater than its MAWP. Proof testing is often required by the code of construction and may also be required by the authority having jurisdiction (AHJ). The proof test pressure is usually prescribed by the code of construction.

There are two types of proof testing, hydrostatic and pneumatic. Hydrostatic testing uses a liquid, typically water, as pressure test medium, whereas pneumatic testing uses a gas, typically dry, oil-free air or nitrogen.

Whenever practicable, hydrostatic testing should be used in preference to pneumatic testing. While hydrostatic testing is generally safer than pneumatic testing due to lower stored energy, it is not without risk and appropriate safeguards are required. Where hydrostatic testing is not practical or possible, for example for piped plant systems or for cryogenic systems, pneumatic testing may be preferred. If a complete system dry out is essential, as in cases where water residue will cause operating problems, then pneumatic testing is preferred.

The pressure levels used in testing will depend on the testing method (hydrostatic or pneumatic) and the design code used for the equipment. Different design codes call for different testing pressure levels, for example ASME B31.3 uses a test pressure of 1.5 times the MAWP for hydrostatic testing whereas equipment designed to the *Pressure Equipment Directive* uses a test pressure of 1.43 times the MAWP for hydrostatic testing [1,6].

Pneumatic test pressures are typically lower due to the higher stored energies and risks associated with pneumatic testing.

In general, design codes call for a proof test pressure that exceeds MAWP or design pressure

5 Hazards associated with pressure testing

Hazards of pressure testing include:

- Catastrophic failure;
- Domino effects (chain reactions) that occur when a small change causes a similar change nearby, which then will cause another similar change, and so on in a linear sequence;
 - Contact with released liquid or gas, such as steam or cryogenic liquids or damaged electrical power lines
 - Fire resulting from the escape of flammable liquids or gases
- Systems that have been in hydrogen service are susceptible to hydrogen embrittlement for certain materials of construction, see CGA G-5.4, Standard for Hydrogen Piping Systems at User Locations [7]. The likelihood of embrittlement increases as a material's tensile strength increases above 483 MPa (70 psi). Embrittled piping is more likely to crack during a pressure test. It can also crack after being completely depressurised, meaning the system could pass the pressure test and fail shortly thereafter for mitigation techniques see ASME B31.12, *Hydrogen Piping and Pipelines* [8]. Cryogenic systems exposed to hydrogen at temperatures near -200°C (-328°F) are also at risk for hydrogen embrittlement; and
- Temperature fluctuations resulting from Joule-Thomson cooling or adiabatic compression heating can exceed allowable temperature limits for system components.

5.1 Hydrostatic testing hazards

Hazards of hydrostatic testing include:

- Difficulty in completely removing water after testing;
 - Water might not be compatible with the working fluid. Working fluid reacting with leftover water can result in uncontrolled reactions
 - Residual water can cause the working fluid to exceed desired moisture levels
 - Residual water can damage soft goods, especially if the water freezes
 - Residual water can act as a breeding ground for bacteria
 - Wet particles can combine together and plug strainers or damage valve seats
 - Pockets of water or ice can restrict fluid flow
 - Freezing water can expand due to low ambient or working fluid temperatures, and damage piping;
- Pipe support failures and inelastic deformation of piping can occur under the weight, when the piping system is filled with water, if not designed for hydrostatic testing;
- Spilled water can create slipping hazards;
- If water is not correctly treated, it can contribute to piping corrosion;
- "Water hammer" effects can cause damage to system components and pipe supports if valves are closed too quickly; and
- Residual air is compressed as water is introduced to the system, which can result in higher pneumatic pressures than intended. This can result in additional stored energy and higher