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BEST PRACTICE FOR PNEUMATIC PRESSURE TESTING

(BEST PRACTICES)

TABLE OF CONTENTS

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LIST OF FIGURE

LIST OF TABLE

SCOPE

This Best Practice specifies the major requirements of penumatic testing of pressure piping and specifically provides guidelines on some issues.

Chemical Plant Equipment like Pressure Vessels, Heat Exchangers, Columns, Pipelines etc. need to be tested for leak tightness at various stages like completion of fabrication, before commissioning and at regular intervals during plant operation to ensure adherence to Statutory regulations and Safe operation. Normally employed methods of testing are Hydrostatic and Pneumatic tests.

Pneumatic tests are widely used to achieve minimum down time and economy and convenience of testing as compared to hydrostatic tests. It is also useful to detect very fine leak paths which may not be found in Hydrostatic Test.

Pressure testing, in general, introduces hazards that must be identified and understood. Appropriate measures to manage the risk of a potential failure must be considered. Pneumatic testing is inherently more hazardous than a hydrostatic test of the same conditions of volume, pressure and temperature. Appropriate safety precautions must be taken based on the stored energy contained in a pneumatic test.

INTRODUCTION

Pressure tests are a non-destructive way to guarantee the integrity of equipment such as pressure vessels, pipelines, plumbing lines, gas cylinders, boilers and fuel tanks. It is required by the piping codes to confirm that a piping system is able to bear its rated pressure and it has no leaks. Pressure testing, is carried out after the cooling or heating installation of any pipeline and before it is put into use.

By performing a pressure test we find a reliable method for testing all types of pipework, including the ones in district cooling or district heating systems. This type of analysis, besides guaranteeing the right functioning, will also allow us to detect if there are leaks in a specific pipe so that reparations can be made.

General requirements of pressure test

1. Stress exceeding yield strength: the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.
2. Test fluid expansion: If the test pressure is to be maintained for a period of time and the fluid in the system is subject to thermal expansion, precautions shall be taken to avoid excessive pressure.
3. Preliminary pneumatic test: a preliminary test using air at no more than 170 kPa (25 psi) gage pressure may be made prior to hydrostatic or pneumatic testing to locate major leaks.
4. Examination for leaks: a leak test shall be maintained for at least 10 minutes, and all joints and connections shall be examined for leaks.
5. Heat treatment: Leak tests shall be conducted after any heat treatment has been completed.
6. Low-test temperature: The possibility of brittle fracture shall be considered when conducting leak tests at metal temperatures near the ductile-brittle transition temperature.
7. Personnel protection: Suitable precautions in the event of piping system rupture shall be taken to eliminate hazards to personnel in the proximity of lines being tested.
8. Repairs or additions after leak testing: If repairs or additions are made after the leak test, the affected piping shall be retested.

9. Test records: Records shall be made of each piping system during the testing, including:
    - Date of test
    - Identification of piping system tested
    - Test fluid
    - Test pressure
    - Certification of results by examiner

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.

A pressure test plan at a minimum contains the following formation:

- Approved Pressure Test Plan Form
- Drawings of the system being tested. Identify the location of test setup, test boundaries, identify all blank/blind flange locations if applicable
- Drawing showing the exclusion zone with location of signage, barricades, or other controls
- Details of the test setup. Identify the pressure ratings of all components and pressure relief valve setting. Provide product data sheets if needed.
- Pressure gauge calibration sheet
- Detailed test procedure

While pressure tests are mandatory, pneumatic testing is not the first option. Before considering pneumatic testing, most services will attempt performing a standard hydrostatic test. Both are viable options, but pneumatic testing is potentially more dangerous. Hydrostatic testing indicates similar things as pneumatic testing but uses water instead of gas as the pressure testing medium.

Compressed air or nitrogen can contain 200 times more stored energy for the same free volume and pressure conditions compared to water. With much higher amounts of stored energy, it is more likely to cause damage if mishandled. Pneumatic testing is convenient and more accurate than hydrostatic testing, but the industry requires hydrostatic testing to be considered beforehand.

Pneumatic test is an alternative method of pressure test in lieu of Hydrostatic test, allowed by codes at certain conditions, by using air or any other gas as test media. It is mostly recommended only for equipment already tested and proved safe by hydrostatic pressure test. Preferably done only for low pressure applications and vessels having low volumetric capacity.

Pneumatic testing may only be performed when the vessels are so designed and/or supported that they cannot be safely filled with water; not readily dried, used in services where traces of the testing liquid cannot be tolerated.

Pneumatic testing involves the hazard of released energy stored in compressed gas. Particular care must be taken. It is recommended to be used only when piping systems are so designed that they cannot be filled with water, i.e, refrigerant systems; or when piping systems are to be used in services where traces of the testing medium cannot be tolerated.

The following systems may be considered for pneumatic testing:

- Relief or flare systems outside the plant area.
- Piping with internal linings which may be subject to damage by the hydrotest fluid.

- Piping systems in which moisture is undesirable or cannot be tolerated such as in instrument air systems or refrigerant systems.
- Large bore piping carrying gas (example flare gas) over long runs for which the supporting structure is not designed to take care of hydrostatic test loads.

A standard pneumatic test procedure for pressure piping systems may be used with the following limitations:

1. The stored energy value will not exceed 1677 kJ,
2. The pressure piping system is made of P-1 or P-8 materials,
3. The test medium is air or nitrogen,
4. Testing will be conducted at a temperature at least 17°C (30°F) **above** the piping system design minimum temperature, and

   Note: If the design minimum temperature is not specified, then the owner or his designee must establish the minimum test temperature but in any case the testing shall not be conducted at a temperature lower than 16°C (61°F),
5. Refer to the appropriate code of construction for possible additional requirements.

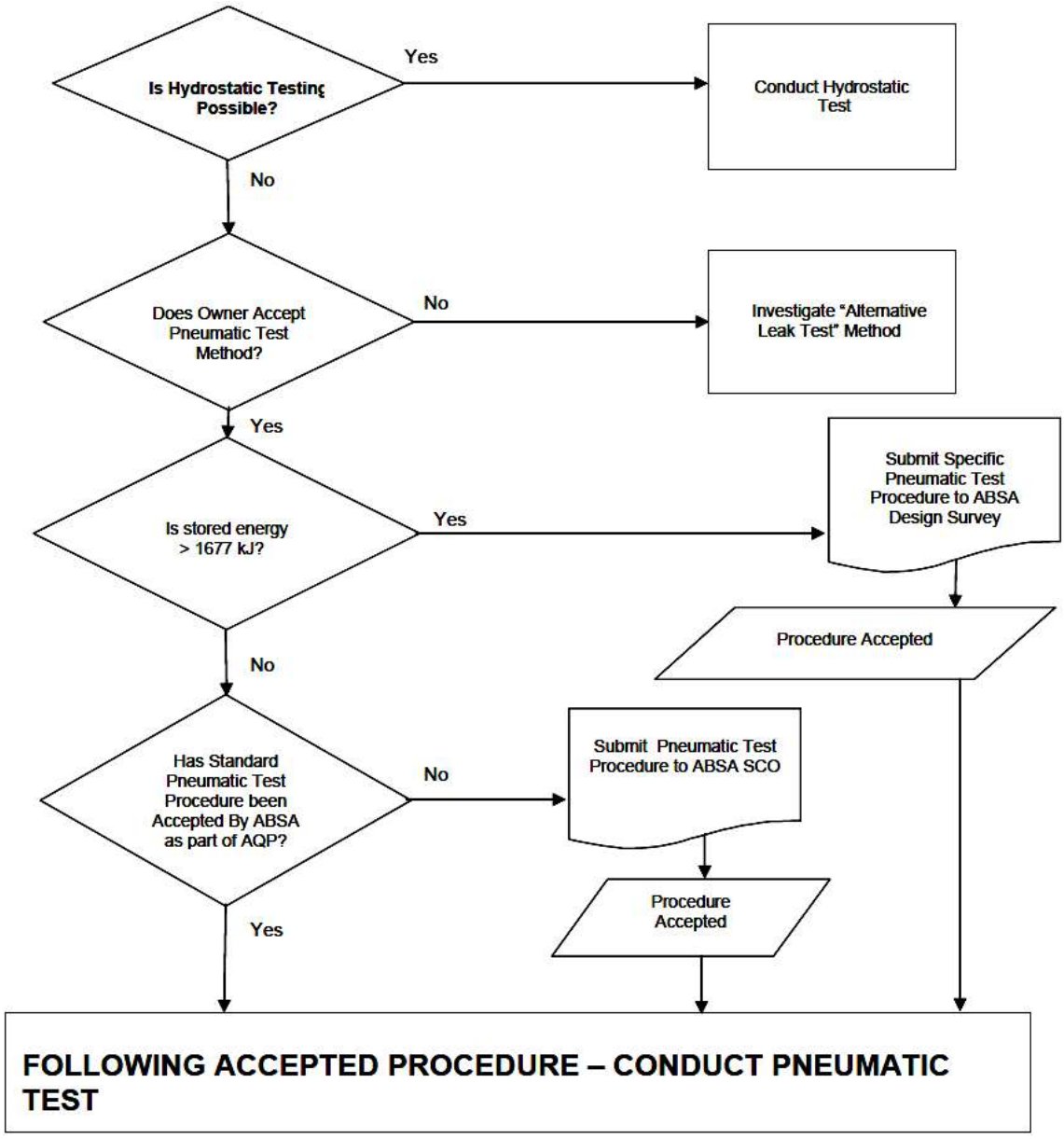

Figure 1. Pneumatic Testing Flow Chart

Pneumatic tests and all pressure tests are necessary to ensure pressure system's safety, reliability, and leak tightness. This is required before utilizing newly installed pressure systems and ones that have been recently repaired. Pressure tests are performed to help understand the limits and capabilities of a pressure system. These components are crucial to know before putting the pipeline into service. Of course, they also help to prove that the equipment meets industry qualifications and requirements.

When Pneumatic Testing Is Utilized

In certain scenarios — pneumatic testing becomes the only option available. While potentially dangerous, an experienced service will follow all guidelines and ensure that equipment is not harmed.

Pneumatic testing is utilized when:

• Pressure systems are designed so that they cannot be filled with water.
• Traces of water cannot be tolerated when the system is in service.

For piping systems that transport primarily gas, like natural gas pipelines, pneumatic testing would be used. Water or any other liquid would be too heavy and potentially damage the pipelines from their weight.

But, as mentioned before — a leak or sudden collapse of pressure systems can cause tremendous financial damage. That's why it should get a pneumatic test done at least once a year. If applicable, keep in mind that only have to get a pneumatic test or hydrostatic test — not both.

Benefits of Pneumatic Testing

Even if pneumatic testing is the less used test, certain benefits should be brought to attention.

- More accurate at detecting leaks – The small atomic structure of gases — particularly helium — allow them to pass through leaks that liquid cannot. Paired with mass spectrometry, it's easy to tell if gases have leaked out of the pressure system.
- No water damage – There's no need to worry about the weight of water collapsing the structure of the pressure system.
- Easy to clean

The accuracy is especially important if piping or other pressure systems are sensitive to leaks. Pinpointing the location of leaks can prevent catastrophic damage before they occur.

Limitations of Pneumatic Testing

Working with gases ends up being the main cause of limitations when it comes to pneumatic testing. There would be hundreds more stored energy in compressed gases than liquid and volatile if anything were to go wrong. If an old piping system ends up collapsing during the pneumatic test, the energy is released — causing fatal damage.

Because of this intensity, some limitations are put on pneumatic testing:

- Recommended only for low-pressure applications.
- Chances of equipment or pipe failure are high.
- Only small segments of the piping can be tested at a time.
- The damage tends to be extensive if handled improperly.
- Must be conducted by an experienced service or personnel — this is *not* a suggestion.
- Needs special attention and safety regulations — barriers must be installed, and people cannot be working during the entirety of testing.

Before a pneumatic test can be carried out, the service will need a written justification for the pneumatic testing along with a piping schematic. While service will handle the schematic and other documentation, it may delay the speed at which pressure systems can be tested.

Table 1. Comparison of hydrostatic test and pneumatic test.

Hydrostatic Test	Pneumatic Test
• Test pressure normally 30 % above the Design pressure	• Test pressure normally 10 % above the design pressure
• Recommended for high pressure applications	• Recommended for only low pressure applications
• Test media used is not compressible by pressure application	• Test media is compressible by pressure application
• Energy stored per unit volume of water under pressure is very negligible	• Energy stored per unit volume of compressed air is very high
• Recommended to prove the strength of equipment	• Recommended mainly for leak test on equipment which have already proved their strength by Hydrostatic test.
• Needs thorough cleaning after test to eliminate moisture especially for service which are reactive to moisture / fluids	• Easy to clean after testing
• Normally water is used as medium of test	• Air, Nitrogen, Argon etc. used for pneumatic test
• Pressure Relief valves are recommended to control sudden increase in pressure during testing.	• Pressure relief valves are must during test to ensure no over pressurization
• Needs less safety distance to cordon	• Needs large area to be cordoned off during testing as accidental release of pressure travels long distance due to high energy stored

off from man entry during test period • Chances of equipment failures are less • Weight of equipment with test medium as water is high hence special attention should be given to floor and supporting arrangements. • Needs verification and examination of joints and connections before testing • Test media can be reused and transferred to • Skilled and semi skilled personnel can carry out test • Recommended where large volumes are to be tested at same time (example pipe lines) • Damages due to failures are less compared to failures in pneumatic testing • Is a regular practice and safe procedure and can be followed in any work site	• Chances of equipment / test apparatus failures are high • Weight of equipment with test medium as air is comparatively less • Needs very careful and specific checking of weld joints thoroughly before testing • Test media can not be transferred or reused after testing • Needs involvement of senior experienced staff to monitor test. • If pipe lines are tested should be done with small segmental lengths at a time. • Damages due to failure in testing are very huge and extensive. • Needs special attention and safety precautions.

SAFETY

It is well known fact that as water cannot be compressed (Boyles law), the energy stored in a vessel under hydrostatic pressure is very less as compared to that of vessel under same pressure with Air. Air / gas used for pneumatic test is compressible to large extent and has very high potential energy stored when compressed. Any minor leak path can lead to a rupture and blast within no time releasing total energy with an impact of sudden explosion. Time gap between identifying a leakage and failure is very small making it almost impossible to take remedial action. Damages associated with failure are uncontrollable and huge. This stored potential Energy gets converted to kinetic energy at the time of rupture and that is what makes pneumatic test very dangerous.

Compared to hydrostatic test, water or liquid used for pressure test are not compressible compared to air or gases. Energy stored is much less. Small leak will reduce gauge pressure immediately which does not happen when Air is the test medium. It has less potential energy hence damages are mostly limited to near by area. There is a possibility that can take remedial action once minor leakages are noticed before total failure occurs. Leakages are easy to detect in case of hydrostatic test.

DEFINITIONS

Blowdown systems – Temporary piping valves and supports designed to reduce the pressure of test systems in a safe and timely manner.

Construction - The complete manufacturing process, including design, fabrication, inspection, examination, hydrotest, and certification. Applies to new construction only.

Category D fluid service (per ASME B31.3) – A fluid service in which all the following apply: - The fluid hanged is nonflammable, nontoxic, and not damaging to human tissues. - The design gauge pressure does not exceed 10.35 bar. - The design temperature is between -29°C and 186°.

Category M fluid service (per ASME B31.3) – A toxic fluid service in which exposure to very small quantities of the fluid in the environment can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken.

Damaging to human tissues (per ASME B31.3) – A fluid which, under expected operating conditions, can harm skin, eyes, or exposed mucous membranes so that irreversible damage may be done unless prompt restorative measures are taken.

Design pressure – The pressure of each component in a piping system which is not less than the pressure at the most severe condition of coincident internal or external pressure (minimum or maximum) expected during service.

DMT - Design Minimum Temperature.

Fabricated - include prefabricated components such as: piping spools; scraper traps; and main line block valves with end extensions and associated by-pass piping. The term excludes such manufactured components as: valves; strainers; and pump casings

Flange - A circular metal plate threaded or otherwise fastened to an end of a pipe for connection with a companion flange on an adjoining pipe. Also that part of a boiler head (dished or flat) which is fabricated to a shape suitable for riveted or welded attachment to a drum or shell

Hydrostatic Test - A pressure or tightness test where liquid, typically water, is the test medium. The application of internal pressure above the normal or maximum operating pressure to a segment of piping or pressure containing component. This pressure is applied under no flow conditions (in the case of a pipeline) for a fixed period of time, utilizing a liquid test medium

Lining - An internal coating that consists of an applied liquid material which dries and adheres to the substrate, or a sheet material that is bonded to the substrate. It is designed for immersion service or vapor-space service. A lining can be reinforced or unreinforced

Maximum Allowable Pressure (MAP) - It refers to the maximum permissible pressure based on the weakest part in the new (uncorroded) and cold condition and all other loadings are not taken into consideration.

MAWP - Maximum Allowable Working Pressure. The maximum gauge pressure which can be safely applied to a test system. This pressure is established by calculations which exclude material thickness intended as corrosion allowance, while allowing for static head.

Operating Pressure - The pressure at the top of the vessel at which it normally operates. It shall be lower than the MAWP, design pressure, or the set pressure of any pressure relieving device.

P&ID (Piping and Instrument Diagram) - A diagram which shows the interconnection of process equipment and the instrumentation used to control the process.

Pressure - The amount of force exerted on a unit of area by a fluid.

Piping rigs for pneumatic testing (or piping manifolds for pneumatic testing) – A system of piping valves, instrumentation, etc. designed for safety pressurizing the piping to be tested

Pneumatic Test - A pressure or tightness test where a gas, generally nitrogen or air, is the test medium.

Pressure piping system - means pipes, tubes, conduits, fittings, gaskets, bolting and other components that make up a system for the conveyance of an expansible fluid under pressure and may also control the flow of that fluid.

Pressure vessel - means a vessel used for containing, storing, distributing, processing or otherwise handling an expansible fluid under pressure.

Restricted Distance – The distance from the equipment undergoing pneumatic testing that is restricted to all personnel. This distance is calculated using a method developed by the NASA Glenn Research Center. No personnel are allowed within the restricted distance during the period when the equipment is undergoing testing at pressures which exceed the design pressure to meet code requirements. Test personnel will be allowed within the restricted distance when the pressure is lowered to design pressure for the purpose of leak detection

Repair – Any work necessary to restore an existing pressure vessel to a condition suitable for safe operation at the design condition that affects the pressure containment.

Safe Distance - The minimum distance between all personnel and the equipment being tested.

Safety Codes Officer - means a safety codes officer, designated under the Safety Codes Act, in the pressure equipment discipline.

Standard Pneumatic Test - means a leak test of a pressure piping system using air or nitrogen, conducted by an organization that holds an Alberta certificate of authorization permit to construct pressure piping, using a procedure referenced in their QMS manual, and within the stored energy, temperature and material limitations established in this document

Strength Test – Any hydrostatic, pneumatic, or combination pressure test which exceeds the lowest MAWP of any item in the test system.

System volume – The internal volume of piping and equipment subjected to pressure testing

Test pressure – The pressure does not exceed stress intensity of yield strength of each component in a piping system at test temperature and should not be lower than design pressure

Test System – Any vessel, exchanger, furnace, piping system, or combination thereof which will be tested as an isolated system.

Tightness Test – Hydraulic Tightness Pressure Test is any test that is below the lowest relief valve setting of the equipment or test system. Pneumatic or combination tightness pressure test is any test that is at or below 35 % MAWP of the equipment or test system.

Welded joint - A union of two or more members produced by the application of a welding process

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