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HYDROSTATIC PRESSURE TEST

(ENGINEERING BEST PRACTICES)

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SCOPE

This Best Practice specifies the major requirements of hydrostatic testing of pressure piping and vessels, while providing guidelines on some issues that may arise.

Hydrostatic pressure testing is universally known and accepted as a means of demonstrating the fitness of a pressurized component for pipe service. After a test, a pipe can be expected to safely contain its intended operating pressure. The confidence level that a pipe or pressure vessel is fit for safe service increases as the ratio of test pressure to operating pressure increases. Hydrostatic test reveals weaknesses of pipe by causing ruptures or leaks.

When compared to other equipment in a hydrocarbon processing plant, the piping network is designed to the most stringent standards. Mechanical Engineering codes require a 400% safety factor in the design of these systems. The piping system is normally considered the safest part of the plant. However, even with this level of safety, reviews of catastrophic accidents show that piping system failures represent the largest percentage of equipment failures.

Since these systems are responsible for many catastrophic accidents, operations, design, and maintenance personnel should understand the potential safety concerns. Failure of an operating piping can result in health and safety concerns, damage to property and has the potential for significant environmental impact. Consequently, it is important to ensure that a pipe is free of leaks and can maintain its integrity at an approved operating pressure in order to limit the risk to the public and the environment.

In some countries, approval from regulatory agencies must be acquired prior to testing. Regulatory approvals have been put in place to minimize the risk of unacceptable environmental impact or adverse impacts on other users as a result of testing activities. This test has a lot of considerations that must be considered (before or after the test) to obtain the maximum result. The purpose of this best practice is to show how to do the hydrostatic pressure testing in accordance with the steps, procedures and rules.

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INTRODUCTION

Pressure testing of a new pipe is required prior to commissioning to prove its integrity at operating pressure. Hydrostatic testing is the most common pressure testing method. Testing of an in-service pipeline may be done as part of a preventative program to verify pipe integrity. In-service pipelines may also be tested if operating pressure is to be increased, modifications to the pipe are made or a change in line service planned.

Hydrostatic testing of pressure piping is a mandatory activity before finalization of any new or modified piping system. It is the final check of mechanical integrity of the whole system under pressurized conditions in the form of strength and leak testing of piping with components, pressure vessels, gas cylinders, boilers and others pressure equipment and systems.

It should be followed religiously as after this activity the piping system has to be commissioned. Typically, water is used as test media in hydrostatic test process. The name comes from when engineers used compressed air as their hydraulic fluid instead of water; the term “hydro” meaning water in Greek) and “statikos,” which means solid (as in static).

Hydrostatic testing is a common tool used by engineers to ensure that equipment has been rebuilt or repaired properly. It’s most commonly employed for DOT-required containers with the aim to work out any potential leaks and verify it is fully safe for use. A hydrostatic test will bring up any potential leaks in equipment and also show if there are any structural problems with the exterior or interior of the tank that might lead to leaks later on.

Hydrostatic testing involves filling the vessels, pipeline or system (which need to be tested) with water, then pressurized with a hydraulic pump until the test pressure reaches (normally 1.5 times design pressure of a system regardless of the service conditions of a piping system), hold the pressure for a specified time by shutting off the supply valve and checking for any leakage or pressure drop. The process works because water will breach any gap between two pieces of imperfectly sealed pipe if there’s enough pressure applied to force its way through. If the pressure drops beyond the standard tolerable limit, the test is declared failed.

Although water is most commonly used, other fluids such as oil or hydraulic fluid are sometimes used based on the materials under test and corrosion considerations. It is important to understand that water or oil are considered to be incompressible under the most reasonable pressures used in pressure testing. This is beneficial in that the test requires less energy to exert the required pressure than if a compressible medium is used. Less energy in means less energy out in the case of a failure.

Working with a company that offers hydrostatic testing services can be more beneficial than purchasing and operating the equipment because of cost, time, and resources. Additional benefits include a faster turnaround time, increased safety for staff and customers resulting in improved product quality assurance; decreased repair costs; minimizing risk exposure and liability claims. A team of highly trained hydro-testers can help chemical, industrial or other companies to stay compliant with hydrostat specifications.

SAFETY IN HYDROSTATIC PRESSURE TEST

Hydrostatic testing is a risky process as it involves pressurizing the system with high pressure which can fail and cause serious personal injury or property damage. Although testing is performed under the supervision of a competent person, the following is the risk associated with hydrostatic testing:

1. In the event of a leak or burst, a person can be injured by exposure to high pressure liquid. High pressure fluid can tear the skin and damage internal organs.
2. The pressure hose connection of hydraulic pump to test piping/ vessels can be detached and may hit a person nearby.
3. To control the above hazards, appropriate safety precautions must be ensured while performing hydrostatic test
4. The hydrostatic test must only be performed under the supervision of a competent person.
5. Follow the permit to work system and establish well communication
6. Barricade the area to restrict the man movement and display caution boards to alert people.

7. Provide whip latch arrester to secure the hoses
8. Equipment and accessories used for pressure build-up and inspections must be certified and calibrated.

Hydrostatic pressure testing is a hazardous activity and poses a risk of serious injury to persons or property damage. Proper job planning with a permit to work system and a skilled and competent workforce can minimize the risk of failure and help prevent accidents. This safety Do's and Don'ts of hydrostatic testing can be displayed on the job site to remind the workers about safety precautions. A toolbox talk must be conducted before starting the daily work to enhance the competency of involved workforce and also to communicate the safety measures on changing operational conditions.

Do's

1. Follow the permit to work system and communicate the associated hazards to engaged manpower.
2. Perform hydrostatic test under the supervision of a competent person only.
3. Clearly mark the scope of hydrotest on P&ID and ensure positive isolation of equipment and piping that are not included in the hydrostatic test loop.
4. Inspect all test equipment and tools, even if they are brand new.
5. Check the design pressure of equipment such as vessel, piping, etc. before the test.
6. Ensure calibration of pressure measuring instruments and tools.
7. All fittings must be rated above the maximum hydrostatic pressure.
8. Ensure the setting and calibration of safety relief valve.
9. Install at least two pressure gauges at an appropriate place so that it is easily readable.
10. Isolate, barricade the test area with safety signages in local and English language.
11. If possible, perform the test from a remote area.

12. Make sure that all pipeline and vessel supports are firm, in good condition and have been inspected prior to start hydrotest.
13. Start the de-pressurization by gradually opening the vent valve.
14. Open the lowest drain point to remove water from the vessel, pipeline, etc.
15. Always wear appropriate personal protective equipment (PPEs).

Don’ts

1. Don’t monitor the pressurization step directly in front of the pressure gauges.
2. Don’t forget to remove the air pockets through the vent line.
3. Don’t attempt to tighten the bolts if the flange leaks during hydrotesting and system is pressurized.
4. Don’t open the drain valve if the vent valve is closed.
5. Don’t use a pressure gauge with under rated capacity.
6. Don’t allow unauthorized person to enter the test area.
7. Don’t forget to obtain work permit and wear appropriate PPEs.
8. Don’t leave any electrical equipment without adequate protection
9. Don’t leave the remaining/ residual pressure trapped inside the pipeline or vessel after testing.
10. Don’t forget to provide proper access and egress for work at height.
11. Don’t drain the hydrotest water on the floor, make sure there is adequate drainage.
12. Don’t miss to isolate monitoring devices/ site glass.
13. Don’t allow other activities in the vicinity of the hydrotesting work area.

Piping under hydrostatic test contains considerable stored energy. If the piping ruptures in a ductile manner, it releases this energy rapidly. The resulting jet of water can cause serious injury to personnel in the immediate area. If the piping fails in a brittle manner, which may occur at cooler temperatures, pieces of steel may become projectiles.

Therefore, the following safety precautions shall be adhered to during hydrostatic testing.

1. Only personnel directly involved in the test shall be allowed in the test area, all other personnel shall remain outside the test area;
2. All equipment which must be attended by personnel during the test shall be located behind a protective structure such as an earthen berm or be located a minimum of 15 m away from the test section during the strength test;
3. Visual inspection of the test section shall not be conducted while the test pressure exceeds 115% of MOP

DEFINITIONS

American Society of Mechanical Engineers (ASME)—organization that provides laws of regulation for boilers and pressure vessels

Average stress and minimum stress - stresses determined from published or manufacturer's data on the subject material.

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

Corrosion - The wasting away of metals as a result of chemical action usually cause by the presence of O2, CO2, or an acid. Corrosion allowance - Any additional thickness specified for corrosion during the vessel service life.

Hydrostatic testing - 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

Main line piping - includes those items through which oil industry fluids are conveyed, which includes pipe, components, and any appurtenances attached thereto, up to and including the isolating valves used at pump stations and other facilities.

NPS - means Nominal Pipe Size, and the NPS system of nominal size designation is contained in standards prepared by the American Society of Mechanical Engineers.

MOP - Maximum Operating Pressure expressed in kPa. The MOP shall be the lesser of the design pressure and 80% of the strength test pressure.

Station piping - includes all pipe, components and any appurtenances at Pump Stations, Tank Farms and Terminals downstream from the first station isolating valve or sectionalizing valve within the station.

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

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

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

Pressure Vessel - Any vessel designed to hold contents under pressure; these include storage tanks, valves, and various types of pipe

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.

Maximum Allowable Working Pressure (MAWP) - the maximum permissible pressure at the top of the vessel in its normal operating position at a specific temperature, usually the design temperature. It is the least of the values calculated for the MAWP of any of the essential parts of the vessel, and adjusted for any difference in static head that may exist between the part considered and the top of the vessel.

Maximum design temperature - The highest temperature considered in the design, equal to or greater than the highest expected operating temperature during the servke life of the tank.

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.

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

Absolute Pressure - The pressure referenced to a perfect vacuum as zero pounds per square inch absolute.

Atmospheric Pressure - The pressure exerted by the atmosphere. Although this pressure varies with altitude, barometric pressure and humidity, the atmospheric pressure can be defined in custody transfer contracts, or by state and federal authorities. Atmospheric pressure is most often stated as 14.696 pounds per square inch absolute.

- **Back Pressure** - The operating pressure level measured upstream from a control valve.
- **Gauge Pressure** - That pressure measured relative to atmospheric pressure as zero, usually designated psig.
- **High Vapor Pressure -** A fluid which, at the measurement or proving temperature, has a vapor pressure that is equal to or higher than atmospheric pressure.
- **Low Vapor Pressure** - A fluid which, at the measurement or proving temperature, has a vapor pressure that is less than atmospheric pressure.
- **Reid Vapor Pressure (RVP)** - The vapor pressure of a fluid at 100 degrees Fahrenheit as determined by test method ASTM D 323-58. RVP is one of the important specifications for gasoline and solvents. It is a measure of the vapor pressure of a sample at 100°F (38°C), in the presence of air. A test is made in a bomb, and the results are reported in pounds per square inch absolute.

- **Static Pressure** - The pressure in a fluid that is exerted normal to the surface. In a moving fluid, the static pressure is measured at right angles to the direction of flow.

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

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