Analysis of Pressure Vessel Hydrostatic Test

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Abstract: The purpose of the hydrostatic test is a comprehensive test of the strength of the pressure vessel pressure parts of the container selection, design calculations, structures and integrated manufacturing quality checks. Introduction The purpose, function and test pressure hydrostatic test requirements, describes the preparatory work before the hydrostatic test, safety measures and after work, analysis of control measures water pressure test, pressure test the eligibility criteria set forth and Precautions.
[Xiao-Jie W, Tang T, Gui-Lin C. **Analysis of Pressure Vessel Hydrostatic Test.** *N Y Sci J* 2014;7(1):129-132]. (ISSN: 1554-0200). http://www.sciencepub.net/newyork. 18

Keywords: pressure vessel; hydrostatic test; Control Measures

1. Introduction

After the pressure vessel manufacturing good, to be the last of the pressure vessel pressure test, pressure test aims to comprehensively examine the strength of the pressure vessel pressure parts (pressure test) and rigor (tightness test), is a container selection, design computing, integrated structure and the manufacturing quality check. During the test, by observing the pressure parts for visible deformation or rupture, to verify whether the pressure vessel pressure capability for safe operation under design pressure necessary; same time, by observing the welds, flanges and other connections or without bleeding drain, pressure vessel inspection rigor. Since the test pressure is higher than the pressure test the maximum working pressure, so it should take into account the pressure vessel can be dangerous in the presence of the pressure test is in progress, such as the rupture spray pressure test media products and even metal debris. Pneumatic test pressure test can also be used hydrostatic test. Select reason hydrostatic test, the main reason is more dangerous pressure tests.

The purpose and effect of a hydrostatic test:

(1) pressure vessel inspection for defects;

(2) determine the maximum operating pressure (pressure confirmatory test).

Hydrostatic testing role:

(1) through a short overpressure, the peak stress is likely to slow in some of the local area to some extent serve to eliminate or reduce the (residual) stress, the stress distribution more uniform effect.

(2) According to the modern view of fracture mechanics, short overpressure can crack closure effect, that the passivation of the crack tip, so that under normal operating pressure of the container is more secure runtime.

2. Test Pressure Requirements

Hydrostatic test pressure shall be able to assess the strength of pressure parts, exposing its flaws, but without compromising the pressure parts better. Usually provide pressure parts in the film stress hydrostatic test pressure shall not exceed the material under test temperature yield 90% limit. Hydrostatic test pressure within the pressure vessel shall comply with the provisions of the design drawings, and not less than the calculated value:

$$P_T=\eta P[\sigma]/[\sigma_t]$$

In the formula,

P-pressure design pressure vesse，MPa

η- hydraulic test pressure coefficient, as shown in Table 1

P_T--hydraulic test pressure, MPa

[σ]- materials Stress under testing temperature, MPa;

[σ]t- materials Stress under design temperature, MPa;

Table 1. hydraulic test pressure coefficient

Material of pressure vessel	Pressure level	hydraulic test pressure coefficient
Steel and non-ferrous metals	depression	1.25P
	Medium pressure	1.25P

And other similar cylindrical member, the hydrostatic test [1] should be 1.25 times the design pressure; failure mode outside the vacuum vessel pressure instability is mainly due to external pressure stability assessment

test is difficult, and therefore external pressure and internal pressure of the vacuum vessel is also used pressure test vessel manner. External pressure and vacuum vessel, the main purpose of the assessment is not to pressure test the strength, but to check the density of the product. ASU manner by using the non-ferrous metal outer pressure vessel internal pressure vessel hydrostatic test, the test pressure requirements are shown in Table 2.

Table 2 A water pressure test requirements of ASU outer pressure vessel

Name	waters test pressure P_T / MPa	air tightness test pressure P_T / MPa
External pressure vessel	≥1．25P	According to design requirements
Vacuum vessel	≥0．2	

Aluminum coil heat exchanger water pressure test requirements:

1. Coil respond before pressure test tube, without leakage, the test pressure specified by the pattern [2],
2. Coils, each coil layer finish required (see Table 3) pressure test, shall not leak [3].

Table 3. Aluminum coil heat exchanger water pressure test requirements

Type	design pressure /MPa	Water test pressure /MPa	Time under pressure
Water test pressure	P≤0．6	P_T≥1.5P PT≥1	More than 10 min

Upright containers made in horizontal hydraulic test, the test pressure should be set upright when the test pressure plus the static pressure of the liquid column.

3 Hydrostatic Testing Of Control Measures

3.1 Preparation Before The Hydrostatic Test

Before the pressure test, the Department should fully seam welded design requirements and passed the test; pressure vessel has a weld heat treatment requirements, hydrostatic test should be performed after heat treatment; fastening bolts connecting the various components must be assembled complete, when pressure test, shall be equipped with intake and exhaust valves, valve test shall only use one; and the same two ranges, calibrated pressure gauge mounted on the test device where easy to observe, the test pump on the container and each piece of equipment gauges to control each other, connect the water pipes, test gauge must have been checking, and within a given period in school. Gauge range to 2 times the test pressure is appropriate, the accuracy of not less than 2.5 gauge, precision gauges used in pressure vessels should not fall below 1.5. Since the initial boost gauge and near full scale measurement error is too large, the pressure gauge range selected about 2 times the test pressure is appropriate, but not less than 1.5 times and not more than four times [3]. The dial gauge diameter of not less than 100mm [4], and pressure testing program installed in the location specified - top of the container (the highest point of the vessel).

Before the pressure test should be ready to facilitate the inspection of facilities, such as: communication facilities, temporary lighting, I temporary platforms and walkways, etc., before the pressure test response to pressure test the entire container, the venue and pressure test equipment, temporary piping and other pressure test conduct a comprehensive and detailed examination to confirm the pressure test can be carried out after the work has been completed as required pressure test program.

0.4MPa ~ 0.5MPa air should be pass into before the hydrostatic test to check weld quality container open Reinforcement ring; pressure test the application of clean water, austenitic stainless steel container with water hydraulic test should controlling the water content of chlorine ions does not exceed 25mg / L, if the water quality can not meet this requirement, the addition of nitrate solution, of a water pretreatment.

3.2 Hydrostatic Test Security Measures

Hydrostatic test site should be reliable safety measures, and by pressure testing and safety inspection by the responsible engineer approved test site should be a reliable safety devices; nothing to stop the test operation during the test, the operator shall not be absent without leave, evacuation nothing to do with the trial staff. During the test, the ambient temperature should not be lower than 5 ℃, otherwise reliable freezing measures should be taken. Test temperature test measurements should strictly prohibited materials testing temperature close to brittle transition temperature, when carbon steel Q345R, 15MnNbR and normalizing 15MnVR steel vessel pressure test, water temperature not lower than 5 ° C [1]; Other low-alloy steel containers when hydrostatic test, water temperature not lower than 15 ℃. If due to the thickness of the material and other factors nil-ductility

transition temperature, you need a corresponding increase in water temperature, low temperature ferritic steel pressure vessel hydrostatic test water temperature shall not be lower than the shell material and welded joints between Charpy impact high test value plus a predetermined temperature 20 ℃ [5]. When the pressure test, required to take effective security measures, including protection of personnel and protection of equipment, supplies, etc. When necessary, equipped with adequate fire-fighting facilities, pressure test to ensure the safe and orderly manner.

3.3 Hydrostatic Test Process Control

When pressure test, should be located at the top of the container vent closed other orifices, from intake when injected into the clean water filling, drain the internal gas release valve at the top; and check whether the exhaust vent, as seen exhaust, injection should be stopped, identify the cause and correct the problem before continuing water. After the water filled container response systems for a checkup, drain out the exhaust port 3 to 5 minutes before closing the exhaust valve, closed vent. Pressure test process, the container should be kept to observe the surface dry; required hydrostatic test pressure test shall process the files and installed all the tools diagram pressure test tooling, holding pressure during the pressure test, the pressure should remain unchanged; hydrostatic test security pressure time not too long, to avoid creep and brittle failure. Shall be continuous pressure to maintain constant pressure on the practice test. Check the pressure in the container with the situation, the non- pressurized fastening bolts, welding, or any part of any object percussion instruments pressurized containers is prohibited.

When the leak was found during the test, you should stop pressurizing not deal with pressure, pressure relief system should eliminate the defects after repair or deeper than half the thickness of the pressure vessel, the hydrostatic test shall be repeated.

Only when the pressure vessel wall temperature and the temperature close to, confirm the same, only the boost and slowly increased to the test pressure and holding pressure over 30 minutes, then lowered to 80% of the required test pressure, and time sufficient to maintain all welds and joints to be checked. Pressure should remain unchanged during the inspection, no leaks, no visible distortion.

When the pressure test program gives boost curve, boost speed should not exceed the prescribed speed boost curve, boost speed shall comply with the test program, the regulator, the eligibility criteria to stop the pressure of time and the test should be consistent with the design documents or related specification. After the pressure test shall be carried out welding operations on the container.

Pressure test during the pressure test personnel to participate in a clear division of labor, serious operation, and promptly prepare the relevant records. Pressure test site should cordon off areas and take effective quarantine measures to prevent unauthorized personnel to enter.

3.4 Work After Pressure Test

(1) the timely removal of isolation, temporary fixed facilities and limit the net drain liquid inside the container. When draining, open the exhaust valve, and control the speed out, to avoid the formation of negative pressure inside the container; liquid must be drained to a designated location, such as design or pressure test program is required, use compressed air piping system within the residual liquid blow.

(2) Examination of the pressure test reports.

(3) issued by the default file.

4 Hydraulic Test Eligibility Criteria

(1) pressure vessel hydrostatic test, no leakage, no visible abnormal deformation, no abnormal noise during the test [6], the hydrostatic test is considered qualified.

(2) pressure test, the pressure parts and weld metal walls and no water and mist; bulging mouth, not dripping beads down after working pressure; After the pressure test, no residual deformation occurred, in line with above, the hydrostatic test is considered qualified.

5 Hydrostatic Test Precautions

(1) stainless steel pressure vessel shall be hydrostatically tested to control the chloride ion content.

(2) The test temperature shall comply with the specifications and process requirements.

(3) pressure test requirements, pressure checks.

(4) tower in horizontal container should be considered when doing the hydrostatic test fluid column hydrostatic pressure.

(5) Record the temperature and humidity test site.

If you have done a pressure test and visual inspection of the pressure vessel manufacturing finished and qualified, it can be considered qualified products. If storage conditions are good, then do not do the place six months after the inspection; If you just open storage, six months after placement, first check the appearance, if rust hydrostatic test must be done.

6 Conclusion

As science and technology, welding and inspection techniques gradually skilled, standardization, especially the hydrostatic test pressure vessel gradually scientific, it is not only related to product safety index is more related to the quality of the product, so the only scientifically controlled hydrostatic testing process pressure vessels, know all the preparatory work before the pressure test, pressure test specifications, methods and several issues must be taken in order to ensure the quality of the pressure vessel, to avoid significant safety course in the future problems.

Acknowledgements:

Hydrostatic Test: A hydrostatic test is a way in which pressure vessels such as pipelines, plumbing, gas cylinders, boilers and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurization of the vessel to the specified test pressure. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss. The location of a leak can be visually identified more easily if the water contains a colorant. Strength is usually tested by measuring permanent deformation of the container. Hydrostatic testing is the most common method employed for testing pipes and pressure vessels. Using this test helps maintain safety standards and durability of a vessel over time. Newly manufactured pieces are initially qualified using the hydrostatic test. They are then re-qualified at regular intervals using the proof pressure test which is also called the modified hydrostatic test. Testing of pressure vessels for transport and storage of gases is very important because such containers can explode if they fail under pressure.

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References

1. GB150.1 ~ GB150.4-20l1. Pressure vessel [S]. 2011.
2. GB/T2,41-2007. Metal pipe hydraulic test methods [S]. 2007.
3. JB/T4734-2002. Aluminum welding container [S]. 2002.
4. Li Shiyu. Pressure vessel design engineer training course [M]. Beijing: Xinhua Publishing House, 2005.
5. Wong Zi You. A pressure vessel manufacturing technology [M]. Beijing: China Petrochemical Press, 1999.
6. TSG R0004-2009. Safety Technology Supervision Stationary Pressure Vessels [S]. 2009.
7. JB/T2549-1994. Aluminum air separation equipment manufacturing specifications [S]. 1994.

11/22/2013