GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 23.020.30

CCS J 74

GB/T 9251-2022

Replacing GB/T 9251-2011

Methods for hydrostatic test of gas cylinders

气瓶水压试验方法

Issued on: March 09, 2022 **Implemented on: October 01, 2022**

Issued by: State Administration for Market Regulation;
Standardization Administration of the People's Republic of China.

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Methods for hydrostatic test of gas cylinders

1 Scope

This document specifies the basic requirements for hydrostatic test methods and devices of gas cylinders.

This document is applicable to the hydrostatic test of gas cylinders whose nominal working pressure is not more than 70MPa (gauge pressure, the same below).

This document does not apply to gas cylinders filled with solid fillers.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 13005, *Terminology of gas cylinders*

GB/T 35015, *Calibration method for calibrated cylinder used in water jacket hydrostatic test*

JJG 539, *Digital Indicating Weighing Instruments*

JJG 1036, *Verification Regulation for Electronic Balance*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 13005 as well as the followings apply.

3.1 testing cylinder

Cylinders to be tested or being tested.

3.2 pressure proof test

A process of testing and verifying the safe bearing capacity of the testing cylinder after it is pressurized to its hydraulic test pressure and maintained for a specified period of time.

3.3 water jacket method

A test method that puts the testing cylinder into a special water jacket, pressurizes it to its hydrostatic test's pressure and holds the pressure for a specified time, to determine the total volumetric deformation, volumetric elastic deformation and volumetric residual deformation of the testing cylinder by the amount of water overflowing from the water jacket and the remaining overflowing volume after pressure relief.

3.4 direct expansion method

A test method that pressurizes the testing cylinder to its hydrostatic test pressure and holds the pressure for a specified time, to determine the total volumetric deformation, volumetric elastic deformation and volumetric residual deformation of the testing cylinder by the pressurized water volume after pressurizing and the indication value of water volume measuring instrument after pressure relief.

3.5 special water jacket

A special equipment for measuring the volumetric deformation of the testing cylinder during the hydrostatic test by water jacket method.

3.6 calibrated cylinder

A bottle equipment that if the corresponding relationship between the calibration pressure and the expansion value has been determined, the expansion value shall have the characteristics of repeatability and linearity, and there will be no permanent deformation under the calibration pressure. It is used to verify the accuracy of the hydrostatic test device of gas cylinders.

3.7 calibrated gauge

A pressure measuring instrument for verifying the pressure value of the test system. Its accuracy level shall not be less than that of other pressure measuring instruments.

3.8 reference zero point

Zero reading on water volume measuring instrument. The error shall be the larger value of ±0.1% of the total volumetric deformation value and ±0.1mL.

4 Principle

The hydrostatic test of gas cylinders uses water as the pressurized medium. Gradually increase the pressure in the testing cylinder to its hydrostatic test pressure according to the specified pressurization rate. Hold the pressure for a specified time. Use different test methods to test and verify the safe bearing capacity of the testing cylinder. Measure the total volumetric deformation, volumetric elastic deformation (if required) and volumetric residual deformation of the testing cylinder under the hydraulic test pressure.

6.1.5 The dimensions and materials of all associated piping of the hydrostatic test devices for water jacket method and direct expansion method shall be such that they do not deform under the weight of water. The size shall be large enough. The installation shall be able to prevent air accumulation, flow obstruction and external damage. All associated piping valves shall be properly selected and installed to ensure no leakage.

6.1.6 The calibration of the calibrated cylinder shall comply with the provisions of GB/T 35015. The calibration data of the calibrated cylinder shall be able to meet the test requirements of the testing cylinder (at least three pressure levels). A clearly identifiable calibration certificate and label shall be attached.

6.1.7 The test device shall be able to display, record and save test data including time, pressure and water volume automatically, accurately and in real time. All original test records stored in real time shall be immutable.

6.1.8 The test device shall be able to automatically generate and output test records. The test records shall meet the requirements of 7.4.1, 8.4.1 and 9.4.1 respectively.

6.1.9 The frequency of collecting pressure and water volume data by the test device shall not be less than 10 times/s.

6.1.10 The test system shall take appropriate safety precautions to ensure the safety of operators and equipment during the test.

6.2 Measuring instruments

6.2.1 Pressure measuring instrument

6.2.1.1 A pressure gauge and a calibrated gauge for calibration shall be installed on the pressure proof test device. A pressure gauge, a pressure transmitter (or a digital pressure gauge that can output pressure signals) and a calibrated gauge for calibration shall be installed on the test devices for water jacket method and direct expansion method at the same time. The installation position of pressure gauge, pressure transmitter (or digital pressure gauge that can output pressure signal) and calibrated gauge shall be able to display the test pressure correctly.

6.2.1.2 The pressure display value of the pressure measuring instrument shall be verified via a calibrated gauge before the test. If the pressure display value is abnormal, it shall be replaced in time. A calibrated gauge may not be used when performing a hydrostatic test.

6.2.1.3 The range of the pressure measuring instrument shall be 1.5 times to 3 times the pressure of the hydrostatic test of the testing cylinder. The accuracy level of the pressure gauge shall not be lower than level 1.0. The accuracy level of the pressure transmitter (or digital pressure gauge that can output pressure signals) shall not be lower than level 0.5.

6.2.1.4 Pressure measuring instruments shall be regularly verified or calibrated. The verification or calibration cycle shall be carried out in accordance with relevant regulations.

6.2.2 Water volume measuring instrument

6.2.2.1 Electronic balances, measuring tubes or other suitable measuring instruments can be used as water volume measuring instruments. They are used to measure the total volumetric deformation value, volumetric residual deformation of the testing cylinder in the water jacket method and the total pressurized water volume in the direct expansion method.

6.2.2.2 The range of the electronic balance shall meet the test requirements. The accuracy level and allowable error shall at least meet the requirements of level III specified in JJG 1036. The calibration division value shall not be greater than 5g. The actual division value shall meet the requirements of measurement error.

6.2.2.3 The range of the measuring tube shall meet the test requirements. The relative error of the scale value on the total volumetric deformation value measuring section AND corresponding total pressurized water volume measuring section shall not be greater than ±1%. Its minimum scale value shall be compatible with the error requirement.

6.2.2.4 The range of other water measuring instruments shall meet the test requirements. The accuracy level shall meet the requirements of measurement error.

6.2.2.5 Water volume measuring instruments shall be regularly verified or calibrated. The verification or calibration cycle shall be carried out in accordance with relevant regulations.

6.2.3 Weighing instrument

For the weighing instrument used to weigh the mass of the testing cylinder, the maximum weight shall be 1.5 times to 3 times the commonly used weighing value. The allowable error shall meet the requirements of "medium accuracy level" specified by JJG 539.

6.2.4 Temperature measuring instrument

For the temperature measuring instruments used to measure the temperatures of the test water and the ambient temperature, the minimum scale value shall not be greater than 1°C. The temperature measuring instruments shall be regularly verified or calibrated. The verification or calibration cycle shall be carried out in accordance with relevant regulations.

7.3.1 The test device shall be calibrated by a calibrated gauge before use. The error of the displayed value of the pressure gauge shall not exceed ±2% of the displayed value of the calibrated gauge. The error of the displayed value of the pressure transmitter shall not exceed ±1% of the displayed value of the calibrated gauge.

7.3.2 Before the testing cylinder is pressurized, all the air in the cylinder and the pressure-bearing pipeline shall be exhausted.

7.3.3 When the pressure in the testing cylinder rises to the nominal working pressure of the gas cylinder, the pressurization can be suspended. Check system connections for leaks.

7.3.4 The pressure in the testing cylinder rises to the specified test pressure. Hold the pressure for at least 30s or specified time. The actual test pressure during the pressure holding period shall not be lower than the specified test pressure. At the end of the pressure holding time, the actual test pressure shall remain stable. If it is unstable, the pressure holding time shall be appropriately extended. Or after the reason for the suspension of the test is identified, repeat the test. If the testing cylinder is pressurized during the pressure holding time, restart the calculation of the pressure holding time. After the actual test pressure is stable at the end of the holding time, record the actual test pressure.

7.3.5 The error of the pressure value shall not exceed ±3% of the specified test pressure. Relevant standards for gas cylinders shall comply with the regulations.

7.3.6 The test pressure deviation shall not exceed +3% of the specified test pressure. Relevant standards for gas cylinders shall comply with the regulations.

7.3.7 The judgment of the test results shall be carried out in accordance with the relevant standards for gas cylinders.

7.4 Test records and reports

7.4.1 Test records

The test agency shall record the relevant information and data of the test process according to the actual situation of the gas cylinder pressure proof test. The test records shall be in a file format that cannot be changed, such as pictures, PDF. Test records shall be detailed, true, accurate and traceable.

7.4.2 Test reports

The test agency shall issue a test report of pressure proof test based on the test records.

In addition to recording the relevant information and main technical parameters of the testing cylinder, the test report shall at least include the following main contents:

a) Reference to this document;

ρ - The density of water, approximately 1, in grams per milliliter (g/mL);

η - The volume residual deformation rate of the testing cylinder;

M_0 - The indication value of the electronic balance before test, in grams (g).

The calculation result is expressed to one decimal place.

8.4 Test records and reports

8.4.1 Test records

The test agency shall record the relevant information and data of the test process according to the actual situation of the hydrostatic test by the water jacket method of the gas cylinder. The test records shall be in a file format that cannot be changed, such as pictures, PDF. Test records shall be detailed, true, accurate and traceable.

8.4.2 Test reports

The test agency shall issue a hydraulic test report based on the test records.

In addition to recording the relevant information and main technical parameters of the testing cylinder, the test report shall at least include the following main contents:

a) Reference to this document;

b) Test time;

c) Measured temperatures of test environment and test medium;

d) Actual test pressure;

e) Actual pressure holding time;

f) Total volumetric deformation value;

g) Volumetric elastic deformation value (if required);

h) Volumetric residual deformation value;

i) Volume residual deformation rate;

j) Description of the test situation of the testing cylinder;

k) Test conclusion.

The test report shall have the signatures and seals of the testers, auditors and the official seal (special seal) of the test agency.

9.2 Test steps

9.2.1 Use a calibrated gauge to verify the test devices before use. The displayed value of the pressure gauge shall not exceed ±1.5% of the displayed value of the calibrated gauge. The displayed value of the pressure transmitter shall not exceed ±1% of the displayed value of the calibrated gauge.

9.2.2 Before the test, select a measuring instrument with suitable range and accuracy level to accurately measure the actual volume of the testing cylinder and the water temperature in the testing cylinder, so as to avoid large errors.

9.2.3 Use a mallet or rubber mallet to tap the testing cylinder after being filled with water and standing still before the test. Expel air bubbles adhering to the inner wall of the cylinder. Use water to fulfill the cylinder. It is forbidden to pour the test water directly into the testing cylinder from the tap. The outer surface of the bottle shall be wiped dry.

9.2.4 Before the testing cylinder is pressurized, exhaust all the air in the cylinder and the pressure-bearing pipeline. It can be pressurized and relieved repeatedly within the nominal working pressure range until no air bubbles emerge in the water measuring instrument.

9.2.5 Before starting the test, close the water filling valve and the pressure relief valve. Keep the indication value of the initial value of the water measuring instrument stable for at least 5s.

9.2.6 When the pressure in the testing cylinder rises to the nominal working pressure, suspend the pressurization and inspect it. There shall be no leakage in the cylinder body and each connection joint. The indicated value of the pressure measuring instrument and the indicated value of the water volume measuring instrument shall be stable.

9.2.7 The pressure in the testing cylinder rises to the specified test pressure. Hold the pressure for at least 30s or specified time. During the pressure holding period, the actual test pressure shall not be lower than the specified test pressure. At the end of the holding time, the actual test pressure and the total volumetric deformation shall remain stable. If it is unstable, the holding time shall be appropriately extended. Or suspend the test to find out the reason, and then re-test. If the testing cylinder is pressurized during the pressure holding time, restart the calculation of the pressure holding time. After the actual test pressure and the total volumetric deformation are stable at the end of the holding time, record the actual test pressure and the total pressurized water volume or the indicated value of the electronic balance.

9.2.8 Open the relief valve. Depressurize to zero. After the testing cylinder is completely shrunk, record the volumetric residual deformation value of the testing cylinder or the value indicated by the electronic balance.

9.2.9 The error of the pressure value shall not exceed ±1% of the specified test pressure

V - The actual volume of the testing cylinder before the test, in milliliters (mL);

P_h - The hydraulic test pressure of the testing cylinder, in megapascals (MPa);

β_t - The average compressibility of water under test pressure and test water temperature. See Annex B for the calculation of β_t, in one-megapascal (MPa^{-1});

$\Delta V''$ - The volumetric residual deformation value of the testing cylinder, in milliliters (mL);

M' - The indication value of the electronic balance of the testing cylinder after pressure relief, in grams (g);

$\Delta V'$ - The volumetric elastic deformation value of the testing cylinder, in milliliters (mL);

η - The volume residual deformation rate of the testing cylinder.

The calculation result is expressed to one decimal place.

9.4 Test records and reports

9.4.1 Test records

The test agency shall record the relevant information and data of the test process according to the actual situation of the hydrostatic test of gas cylinders by direct expansion method. The test records shall be in a file format that cannot be changed, such as pictures, PDF. The test records shall be detailed, true, accurate and traceable.

9.4.2 Test reports

The test agency shall issue a hydraulic test report based on the test records.

In addition to recording the relevant information and main technical parameters of the testing cylinder, the test report shall at least include the following main contents:

a) Reference to this document;

b) Test time;

c) Actual volume V of the testing cylinder before the test;

d) Measured temperatures of test environment and test medium;

e) Actual test pressure;

f) Actual pressure holding time;

g) Total pressurized water volume A or M value of the test system under test pressure;

h) Pressurized water volume B value of the pressure-bearing pipeline under test pressure;

i) Indicated value ΔV" or M' of the water measuring instrument after pressure relief;

j) Total volumetric deformation value;

k) Volumetric elastic deformation value (if required);

l) Volumetric residual deformation value;

m) Volumetric residual deformation rate;

n) Description of the test situation of the test cylinder;

o) Test conclusion.

The test report shall have the signatures and seals of the testers, the auditors and the official seal (special seal) of the test agency.

10 Rounding rules for calculated values

The calculation results of formula (1) to formula (7) in this document and formula (A.1), formula (A.2) and formula (A.3) in Annex A are rounded according to the following rules.

Round to one decimal place according to rounding rules. However, when the second decimal place is "5" and the number after it is "0", then, if the decimal number to the left of "5" is an odd number, round-up "1". If it is an even number, discard it.

11 Precautions in the test

11.1 When installing the pressure measuring instrument, pay attention to the air in the pressure measuring instrument and its connecting pipe.

11.2 The shockproof ring shall be removed before the hydrostatic test. Loosen the clamp for clamping the gas cylinder.

11.3 In the process of pressurization, if the pressurization speed is obviously increased or slowed down, the hydraulic pump shall be stopped immediately. Find the cause of the abnormal pressurization speed and deal with it.

11.4 During the pressure test, especially after the pressure in the testing cylinder exceeds the nominal working pressure, the testing cylinder shall not be impacted or collided.

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