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Compressed natural gas cylinder valve for vehicle

车用压缩天然气瓶阀

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Compressed natural gas cylinder valve for vehicle

1 Scope

This Standard specifies the basic types, technical requirements, inspection and test methods, inspection rules and signs, packaging, storage and transportation of compressed natural gas cylinder valves for vehicles.

This Standard is applicable to the compressed natural gas cylinder valve for vehicles (hereinafter referred to as the valve) whose working environment temperature is -40℃~+85℃ and whose nominal working pressure is not more than 25MPa.

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 197, *General purpose metric screw threads - Tolerances*

GB/T 228.1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature*

GB/T 1173, *Casting aluminium alloys*

GB/T 3512, *Rubber, vulcanized or thermoplastic - Accelerated ageing and heat resistance tests - Air-oven method*

GB/T 3934, *Specification of gauges for general purpose screw threads*

GB/T 4423, *Copper and copper alloy cold-drawn rod and bar*

GB/T 5121.1, *Methods for chemical analysis of copper – Part 1: The electrolytic method for the determination of copper content*

GB/T 5121.3, *Methods for chemical analysis of copper and copper alloys - Part 3: Determination of lead content*

GB/T 5121.9, *Methods for chemical analysis of copper and copper alloys - Part 9: Determination of iron content*

GB/T 5231, *Designation and chemical composition of wrought copper and copper alloys*

5.2 Material requirements

5.2.1 Metal part material

5.2.1.1 The main metal parts of the valve (valve body, valve stem, valve, pressure cap, safety cap) shall be made of HPb59-1 bar. Its mechanical properties and chemical composition shall meet the requirements of GB/T 4423 and GB/T 5231. If other materials are used, their mechanical properties shall not be lower than those specified in HPb59-1.

5.2.1.2 The handwheel material shall be ZL 102, which shall meet the requirements of GB/T 1173.

5.2.1.3 The bursting disc material shall comply with the provisions of GB/T 16918.

5.2.1.4 Fusible alloy materials shall comply with the provisions of GB/T 8337.

5.2.2 Non-metallic seal material

5.2.2.1 Oxygen aging resistance

The non-metallic seals shall be kept for 96h continuously in oxygen with a temperature of 70℃±5℃, a test pressure of 2MPa and a purity of ≥99.5%, and there shall be no visible cracks and damages.

5.2.2.2 Ozone aging resistance

Under the elongation of 20%, the rubber seal material shall be placed in the air at a temperature of 40℃ ± 2℃ and an ozone concentration of $(50 \pm 5) \times 10^{-8}$ for 72 hours, and there shall be no cracks.

5.2.2.3 Dry heat resistance

After the rubber seal material is placed in the air at a temperature of 85℃ for 168 hours, the change in tensile strength shall not exceed 25%, and the change in elongation shall range from -30% to +10%.

5.2.2.4 Medium compatibility

5.2.2.4.1 After the non-metallic seals are soaked in natural gas of not less than 0.95 times the nominal working pressure for 70h, there shall be no tearing or cracking. Its volume expansion rate shall not exceed 25% or shrinkage rate shall not exceed 1%. The mass loss rate does not exceed 10%.

5.2.2.4.2 Immerse non-metallic seals in n-pentane at a temperature of 23℃±2℃ for 72 hours. The volume change rate shall not exceed 20%. Then place in the air at 40℃ for 48 hours. The mass loss rate shall not exceed 5%.

and 1.2 times the nominal working pressure respectively, and there shall be no air bubbles.

5.4.1.5 Vibration resistance

At the nominal working pressure, the valve is subjected to vibration tests for 30 minutes each at the resonance frequency or 500 Hz along the three orthogonal axes. After the test, there shall be no damage and no loosening of the threaded connection, and shall meet the requirements of 5.4.1.4.1, 5.4.2.2, 5.4.2.1, 5.4.2.7c) and 5.4.1.6.

5.4.1.6 Pressure resistance

When the valve is kept at 2.5 times the nominal working pressure for 3 minutes, there shall be no leakage and other abnormal phenomena.

5.4.1.7 Stress corrosion resistance

The valve shall have no cracks after ammonia fumigation in the container box of ammonia water-air mixture at a temperature of 34℃±2℃ and a time of 240h.

5.4.1.8 Salt spray corrosion resistance

The valve is placed in a salt spray chamber with a temperature of 33℃~36℃. The valve must be subjected to a 500h salt spray test, which shall comply with 5.4.1.4.1, 5.4.2.1, 5.4.2.2, 5.4.2.7c) and 5.4.1.6.

5.4.1.9 Surface liquid resistance

Immerse the valve in the following three liquids for 24h. There shall be no cracks, softening or expansion and other damage and phenomena to affect its performance. It shall meet the requirements of 5.4.1.4.1, 5.4.2.2, 5.4.2.1 and 5.4.1.6.

Liquid used in the test:

a) Sulfuric acid aqueous solution: a solution of sulfuric acid and water with a volume ratio of 19:81;

b) Ethanol/gasoline: E10 fuel with a volume ratio of 10:90 that meets the requirements of GB 18351;

c) Windshield washer fluid: a 1:1 volume ratio of methanol and water washer fluid.

5.4.1.10 Durability

The valve shall comply with the provisions of 5.4.1.4.1, 5.4.1.1 and 5.4.1.6 under the following conditions:

a) When the temperature is 15°C~30°C and it is the nominal working pressure, the full stroke can be opened and closed 1920 times;

b) When the temperature is 85°C and it is the nominal working pressure, the full stroke can be opened and closed 40 times;

c) When the temperature is -40°C and it is the nominal working pressure, the full stroke is opened and closed 40 times.

5.4.2 Safety pressure relief device performance

5.4.2.1 Extrusion resistance

After holding the pressure for 30 minutes at 1.2 times the nominal working pressure, increase the pressure to 2.25 times the nominal working pressure at a rate of 0.5MPa/s, and the fusible alloy of PRD shall not be extruded.

5.4.2.2 Air tightness

PRD shall be free of bubbles under the following conditions. If bubbles are found, the leak rate needs to be measured by an appropriate method. The leakage rate shall be less than $2cm^3/h$ (under standard conditions):

a) Under the condition of -40°C, the test pressure of PRD shall be maintained for at least 2min at 0.75 times the nominal working pressure;

b) Under the condition of 85°C, the test pressure of PRD shall be maintained for at least 2min at 1.3 times the nominal working pressure.

5.4.2.3 Durability

PRD shall meet the requirements of 5.4.2.2 and 5.4.2.7c) under the following conditions:

a) Under the high temperature condition of 85°C, cycle 2000 times within the range of 10%~100% nominal working pressure;

b) Under the condition of 57℃±2℃, cycle 18000 times within the range of 10%~100% of the nominal working pressure.

5.4.2.4 Accelerated life

PRD accelerated life shall meet the following requirements:

a) Under the conditions of maximum burst pressure and fusible alloy flow temperature, PRD operates within 10 hours;

b) Under the conditions of nominal working pressure and accelerated life test temperature (T_L), PRD does not operate within 500h.

Accelerated life test temperature (T_L), is expressed as:

$$T_L = 12.88 \times T_f^{0.420}$$

Where: T_f is the flow temperature in degrees Celsius (°C).

5.4.2.5 Temperature cycle

PRD temperature cycling shall meet the following requirements:

a) Incubate at -40°C and 85°C for at least 2h each and complete 15 temperature cycles;

b) Incubate at -40°C for at least 2h. Complete another 100 pressure cycles under the (10%~100%) nominal working pressure, which meets the requirements of 5.4.2.2 and 5.4.2.7c).

5.4.2.6 Condensation corrosion resistance

Under the temperature condition of 21℃±2℃, soak PRD in the prepared test solution for 100h and then take it out. When it is heated to 85℃, place for 100h, which shall meet the requirements of 5.4.2.2 and 5.4.2.7c).

5.4.2.7 Pressure relief

PRD pressure relief shall meet the following requirements:

a) The burst pressure of PRD is the hydraulic test pressure of the matching gas cylinder, and the allowable deviation is $^{+10\%}_{0}$;

b) The flow temperature of fusible alloy is 110℃±5℃;

c) After PRD is tested for durability, temperature cycling, condensation corrosion resistance, salt spray corrosion resistance and vibration resistance respectively, under the condition of 11℃±1℃ above the flow temperature of fusible alloy, the operating pressure is within the range of 75% to 105% of the PRD reference operating pressure.

NOTE: The reference operating pressure of PRD is the average value of burst pressure measured in a).

5.4.2.8 Flowability

Under the pressure state of 0.8MPa~0.9MPa, the difference between the maximum flow rate and the minimum flow rate of PRD shall be within 10% of the maximum flow rate.

5.4.3 Performance of excess flow device

5.4.3.1 Durability

6.2 Mechanical properties test and chemical composition analysis of metal parts materials

The test methods for material mechanical properties of main metal parts of the valve (valve body, valve stem, valve, pressure cap, safety cap) are according to the provisions of GB/T 228.1. The chemical composition analysis method shall comply with the provisions of GB/T 5121.1, GB/T 5121.3, GB/T 5121.9 and the provisions of 5.2.1.1.

NOTE: In the case of non-arbitration, the chemical composition analysis methods of metal materials can choose electrolysis method, atomic absorption method, volume method and spectroscopic method.

6.3 Material performance test of non-metallic seals

6.3.1 Oxygen aging resistance test

Place 3 non-metallic seal test pieces in the aging test device. Remove air from the device. Fill with oxygen with a purity of ≥99.5%. Make the pressure reach 2MPa. Warm up to 70℃±5℃. Keep 96h and take out. Visually inspect its changes, which shall meet the requirements of 5.2.2.1.

6.3.2 Ozone aging resistance test

According to the test method specified in GB/T 13642, put 3 rubber seal material test pieces at 20% elongation. Put them in an air ozone box with a temperature of 40℃ ± 2℃ and an ozone concentration of (50±5) $\times 10^{-8}$. Keep it for 72h and take it out. Check its changes with a 25x magnifying glass, which shall meet the requirements of 5.2.2.2.

6.3.3 Dry heat resistance test

According to the test method specified in GB/T 3512, place 3 rubber seal material test pieces in an air box with a temperature of 85℃ for 168h dry heat resistance test, which shall meet the requirements of 5.2.2.3.

6.3.4 Medium compatibility test

6.3.4.1 The medium used in this test is compressed natural gas for vehicles. Carry out at room temperature. Use three samples for each test. Each sample shall be placed on a small diameter wire loop. Determination of its volume: first weigh in air (M_1) and then in water (M_2). Dry the sample. Place it in a test device for compressed natural gas for vehicles with a working pressure of not less than 0.95 times the nominal working pressure. After 70h, the samples shall be taken out of the device one by one without cracks and weighed in the air on the same wire ring (M_3). This mass shall be weighed within 3 minutes after it leaves the test medium. Determine the final mass in water immediately afterwards (M_4). Each sample shall be immersed in ethanol and then in

6.6.1.1 Opening-closing test at room temperature

Install the valve on the test special device. Keep the valve closed. Charge the air source from the valve air inlet to the nominal working pressure. Block the air outlet. Open the valve according to the torque specified in Table 1. The valve shall be able to open fully. Then close the valve according to the torque specified in Table 1. The valve shall be able to close and comply with the provisions of 5.4.1.1.

6.6.1.2 Opening-closing test at low temperature

Install the valve on the test special device. Place in a temperature-controlled box at -40°C. Keep the valve closed. Charge the air source from the valve air inlet to the nominal working pressure. Block the air outlet. Open the valve according to the torque specified in Table 1. The valve shall be able to open fully. Then close the valve according to the torque specified in Table 1. The valve shall be able to close and comply with the provisions of 5.4.1.1.

6.6.2 Excess torque resistance test

Use a nut or plug to screw the air outlet of the valve. Then tighten the nut or plug with 150% of the installation torque, respectively. The applied torque shall be maintained for more than 15min. Then remove the nut or plug. Visually inspect the valve that shall not be deformed or damaged. Carry out the test according to the provisions of 6.6.4.1 and 6.6.6, which shall comply with the provisions of 5.4.1.4.1 and 5.4.1.6.

Install the air inlet of the valve on the test special device. Use a torque wrench to tighten according to the installation torque specified in Table 2. Carry out the test according to the provisions of 6.6.4.1 and 6.6.6, which shall comply with the provisions of 5.4.1.4.1 and 5.4.1.6.

6.6.3 Bending moment test

Fix the air inlet of the valve to the test rig (see Figure 1). Connect a pipe longer than 300mm to the outlet of the valve. Fill the pipeline with 0.05MPa air and follow the steps below:

a) Apply the force specified in Table 3 in any direction of the vertical (up and down) and horizontal (left and right) directions of the force point. Keep it for at least 15min. Use leak detection fluid to coat valve outlet threaded connections without removing force. Visually inspect it and there shall be no leakage;

b) Follow step a) to complete the other three direction tests;

c) After completing the above test steps, remove the valve. Visually inspect the valve and there shall be no deformation. Carry out the test according to the provisions of 6.6.4.1 and 6.6.6, which shall comply with the provisions of 5.4.1.4.1 and 5.4.1.6.

pressure. Immerse the valve in water to maintain pressure for at least 2min, which shall meet the requirements of 5.4.1.4.1b).

6.6.4.1.3 High temperature test

Install the valve on the test special device. Keep the valve in any open state. Block the air outlet and place in water. Put it in the thermostat. Through the external pipeline, fill the air source into the valve to 0.05 times and 1.5 times the nominal working pressure, respectively. Keep this pressure. Then gradually increase the temperature to 85°C ± 2°C while the initial temperature is room temperature. When the specimen valve reaches this temperature, visually inspect the valve for at least 2 minutes, which shall meet the requirements of 5.4.1.4.1c).

Install the valve on the test special device. Close the valve and place in water. Put it in the thermostat. Through the external pipeline, fill the air source into the valve to 0.05 times and 1.5 times the nominal working pressure, respectively. Keep this pressure. Then gradually increase the temperature to 85°C ± 2°C while the initial temperature is room temperature. When the specimen valve reaches this temperature, visually inspect the valve for at least 2 minutes, which shall meet the requirements of 5.4.1.4.1c).

6.6.4.2 Exit-factory inspection air tightness

At room temperature, according to the test method specified in 6.6.4.1.2, fill the valve with 0.025 times and 1.2 times the nominal working pressure respectively for air tightness test. Keep it for 1min, which shall comply with 5.4.1.4.2.

6.6.5 Vibration resistance test

Install the valve on the test special device. Block the air outlet. Open the valve. Fill the valve with air source to the nominal working pressure. Mount the device on a vibration test bench. In the sinusoidal range of 10Hz to 500Hz, conduct sweep vibration at an acceleration of 1.5g for 10min. Find the resonant frequency of the valve. At this frequency, the valve is subjected to vibration tests for 30 minutes along the three orthogonal axes, respectively. If no resonance frequency is found, the valve shall be subjected to vibration tests for 30 minutes respectively along the three orthogonal axes at a frequency of 500Hz. After the test, there shall be no damage and no loosening of the threaded connections. Then carry out the test according to the provisions of 6.6.4.1, 6.7.2, 6.7.1, 6.7.7.3 and 6.6.6, which shall comply with 5.4.1.4.1, 5.4.2.2, 5.4.2.1, 5.4.2.7c) and 5.4.1.6.

6.6.6 Pressure resistance test

Remove safety relief from valve. Block each vent between the valve and the outside world (except the air inlet connected to the gas cylinder). Open the valve. Connect the air inlet of the valve to the water pressure pump. Fill the valve with clean water. Boost to 2.5 times the nominal working pressure. Keep this pressure for 3min, which shall comply with the provisions of 5.4.1.6.

6.6.7 Stress corrosion resistance test

Pour ammonia water with a relative density of 0.94 (specific gravity) into a glass container with a lid. The ratio of the added ammonia water to the container volume is 21.2 ml/L (for example, 636mL of ammonia water is added to a 30L glass container). Use a torque specified by the manufacturer to screw the air inlet and outlet of the valve on the plug. No fillers such as Teflon are allowed to be attached to the thread. The valve is then placed in a lidded glass container with ammonia water. The valve shall be placed 40mm above the ammonia water level. Cover with glass cover. Put the glass container in a temperature-controlled box. The set temperature is 34℃±2℃. After 240h of heat preservation, the valve shall be inspected under a magnifying glass of 25 times, which shall meet the requirements of 5.4.1.7.

6.6.8 Salt spray corrosion resistance test

Place the valve in a salt spray chamber between 33°C and 36°C. Block the air inlet and outlet. Without any cover, use a salt solution composed of 5% sodium chloride and 95% distilled water (by weight), to continuously carry out the salt spray test to the valve for 500h. Then take out. Immediately rinse the test piece with clean water. Gently wipe away salt deposits. Carry out the test according to the provisions of 6.6.4.1, 6.7.2, 6.7.1, 6.7.7.3 and 6.6.6, which shall comply with 5.4.1.4.1, 5.4.2.2, 5.4.2.1, 5.4.2.7c) and 5.4.1.6.

6.6.9 Surface liquid resistance test

Block the valve inlet and outlet. Carry out the test as follows:

a) Soak the valve in a solution of sulfuric acid and water in a volume ratio of 19:81. After soaking for 24 hours, rinse and wipe the valve with clean water. It shall meet the requirements of 5.4.1.9, that is, there is no cracks, softening or expansion and other damages that affect its performance;

b) Immerse the valve in a mixed solution of E10 fuel ethanol and gasoline with a concentration of 10:90 by volume. After soaking for 24 hours, rinse the wipe valve with clean water. It shall meet the requirements of 5.4.1.9, that is, there is no cracks, softening or expansion and other damages that affect its performance;

c) Soak the valve in a 1:1 volume ratio of methanol and water in a windshield washer solution. After soaking for 24 hours, rinse the wipe valve with clean water. It shall meet the requirements of 5.4.1.9, that is, there is no cracks, softening or expansion and other damages that affect its performance;

d) After immersion in three liquids, the test shall be carried out according to the provisions of 6.6.4.1, 6.7.2, 6.7.1 and 6.6.6, which shall meet the provisions of 5.4.1.4.1, 5.4.2.2, 5.4.2.1 and 5.4.1.6.

6.6.10 Durability test

times/min. Complete 18000 cycles at 57°C ± 2°C. The fusible alloy shall be free of extrusion after the specified number of cycles.

After completing the above test, carry out the test according to the provisions of 6.7.2 and 6.7.7.3, which shall meet the provisions of 5.4.2.2 and 5.4.2.7c).

6.7.4 Accelerated life test

Install the valve with PRD on the test special device. Keep the valve closed. Place in a high and low temperature box or a liquid bath. Gradually increase the temperature, so that the temperature of the PRD is controlled within the range of ±1°C of the flow temperature. Charge the air source to the air inlet of the valve through the external pipeline to the maximum burst pressure. It shall act within 10h under this pressure and temperature and meet the requirements of 5.4.2.4a).

Install the valve with PRD on the test special device. Keep the valve closed. Place in a high and low temperature box or a liquid bath. Gradually increase the temperature, so that the temperature of PRD is controlled at the accelerated life test temperature T_L. Fill the air source from the valve air inlet through the external pipeline to the nominal working pressure (tolerance is ±0.7MPa). Keep at this pressure and temperature for more than 500h, which shall comply with the provisions of 5.4.2.4b).

6.7.5 Temperature cycle test

PRD is tested according to the following steps:

a) Put the valve with PRD in the liquid tank or high and low temperature box at -40°C for at least 2h. Take out the valve. Within 5min, place it in a liquid tank or a high and low temperature box with a temperature of 85°C for at least 2h;

b) Take out the valve that has been placed in the liquid tank or high and low temperature box at a temperature of 85°C for at least 2h. Within 5min, place the valve in a liquid tank or a high and low temperature box with a temperature of -40°C for at least 2h;

c) Above-mentioned a), b) step is a temperature cycle. Repeat steps a) and b). Complete 15 temperature cycles;

d) Put the valve that has completed the temperature cycle in a liquid tank or a high and low temperature box with a temperature of -40°C for at least 2h. Charge the air source to the air inlet of the valve through the external pipeline to the nominal working pressure. Then reduce from nominal working pressure to below 10% nominal working pressure. This boost-to-buck process is a pressure cycle. PRD completes 100 pressure cycles at a cycle frequency of no more than 10 cycles/min.

After the above tests are completed, the test shall be carried out according to the provisions of 6.7.2 and 6.7.7.3, which shall comply with the provisions of 5.4.2.2 and

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