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Periodic inspection and evaluation of hoop wrapped fibre reinforced composite gas cylinders with metal liners of compressed natural gas for automotive vehicles

汽车用压缩天然气金属内胆纤维环缠绕气瓶定期检验与评定

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1 Scope

This document specifies the basic methods and technical requirements for periodic inspection and evaluation of hoop wrapped fibre reinforced composite gas cylinders with metal liners of compressed natural gas for automotive vehicles (hereinafter referred to as "the cylinder").

This document applies to refillable gas cylinders of which the nominal working pressure is 20MPa, 25MPa and 30MPa, the nominal volume is 30L~450L, the storage medium is compressed natural gas, the working temperature is -40℃~65℃, and it is fixed on the automotive vehicle as a fuel tank.

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 8335, *Special threads for gas cylinders*

GB/T 8336, *Special thread gauges for gas cylinders*

GB/T 9251, *Methods for hydrostatic test of gas cylinders*

GB/T 10878, *Special taps of taper threads for gas cylinders*

GB/T 12137, *Methods for leakage test of gas cylinders*

GB/T 13005, *Terminology of gas cylinders*

TSG 23, *Regulation on Safety Technology for Gas Cylinder*

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.

4 Inspection tools, devices, inspection cycles and inspection items

4.1 Inspection tools and devices

The inspection agency shall have the following tools and devices (but not limited to these):

a) Lamp: It can clearly illuminate the inner and outer surfaces of the gas cylinder to be inspected and the surface of its accessories. It shall use an explosion-proof lamp not exceeding 24V;

b) Special tools such as torque wrench: For the removal and installation of gas cylinders, cylinder valves or PRD end plugs;

c) Depth gauge: Used to measure the depth of damage such as scratches, dents and abrasions;

d) Length measuring tools (including rulers, squares and tapes): Used to determine the length of damage;

e) Ultrasonic thickness gauge: Used to measure the wall thickness of the metal part of the gas cylinder;

f) Weighing apparatus: Used to measure the weight and volume of gas cylinders;

g) Hydrostatic test device by external test method: Used for hydrostatic test of gas cylinders;

h) Air tightness test device: Used for air tightness test of gas cylinders;

i) Natural gas recovery unit: Used for the recovery of natural gas;

j) Cleaning device: Used to clean the dirt, corrosion products and contaminants on the inner and outer surfaces of gas cylinders;

k) Thread gauges and taps: Used for inspection and repair of bottle threads.

4.2 Inspection cycles

4.2.1 The periodic inspection cycle of gas cylinders shall comply with the relevant provisions of TSG 23.

4.2.2 In the process of use, if in the following situations, it shall check in advance:

a) Gas cylinder or car fire;

b) Gas cylinders are exposed to ambient temperatures higher than 65°C for a long time;

c) Gas cylinders are impacted or dropped during installation;

d) The car suffered a collision;

e) Cylinder exposure to chemicals;

f) Abnormal sound occurs during use;

g) Be sure that the cylinder has been damaged in some way;

h) Doubt about the safety of gas cylinders.

4.2.3 Cylinders in stock or out of service for more than one inspection period shall be inspected before being put into use.

4.3 Inspection items

The periodic inspection items of gas cylinders include: internal appearance inspection, bottle thread inspection, hydraulic pressure test, cylinder valve inspection and assembly, and air tightness test.

5 Inspection preparation

5.1 Records

5.1.1 Check and record the manufacturing marks and inspection marks of gas cylinders one by one. The contents of the record include at least manufacturer license number or agency code, gas cylinder manufacturing standard, gas cylinder number, year and month of manufacture, nominal working pressure, hydraulic test pressure, design wall thickness of inner tank, nominal volume, presence or absence of "TAXI" mark, cylinder valve, manufacturer and model of PRD end plug (if any, the same below), previous inspection date (year, month), and name or code of the inspection agency. Country shall be recorded for imported gas cylinders.

5.1.2 For gas cylinders produced by manufacturers that have not obtained a special equipment manufacturing license, gas cylinders with unclear manufacturing marks or incomplete items without evidence, and gas cylinders that are not allowed to be reused according to the safety technical specifications for special equipment, they shall not be inspected after they are registered. They shall be judged scrapped.

5.1.3 Cylinders whose service life exceeds the design service life from the date of manufacture shall not be inspected after they are registered. They shall be judged scrapped. For the gas cylinders used in taxis, if they have been used for more than 8 years, they will not be inspected after registration. They shall be judged scrapped.

5.2 In-cylinder medium handling

Appropriate methods (such as vacuuming or nitrogen replacement) shall be taken to discharge and properly handle the medium in the cylinder under the conditions of safety, hygiene and no environmental pollution.

5.3 Bottle valve disassembly and surface cleaning

5.3.1 After confirming that the pressure inside the cylinder is consistent with atmospheric pressure, remove the cylinder valve and PRD end plug.

5.3.2 For gas cylinders whose valve cannot be opened or removed, they shall be stored separately from other gas cylinders to be tested. Label them for proper disposal.

5.3.3 Use an appropriate method that does not damage the bottle metal and the wrapping layer to clean the dirt, corrosion products, contaminants and other debris on the inner and outer surfaces of the gas cylinder that hinder the appearance inspection, as well as the loose coating on the outer surface.

6 Internal and external appearance inspection and evaluation

6.1 Damage type

Visual inspection is the primary way to determine cylinder damage. Types of damage include: corrosion, scratches, bruises, gouges, abrasions, dents, bulges, exposed fibers, fiber breaks, loose or separated fibers, material loss, delamination, cracks, discoloration of the cylinder surface (such as carbon deposits, carbonization, chemical attack), traces of exposure to thermal environments, impact, deterioration of surface materials.

6.2 Damage level

According to the degree of damage, the damage is divided into level 1 damage, level 2 damage and level 3 damage. Level 1 damage does not require repair and can continue to be used. Level 2 damage can be repaired or consulted with the manufacturer for disposal advice or judged as scrapped. Level 3 damage cannot be repaired, and the cylinder shall be judged as scrapped. The damage found in the wrapping layer of the gas cylinder shall be inspected and evaluated according to Table 1. The damage found on the metal part of the cylinder shall be inspected and evaluated in accordance with

Cylinders with gas leakage from the cylinder body shall be judged as level 3 damage.

6.3.5 Chemical corrosion

The damage on the cylinder surface caused by chemical product erosion. This damage may manifest as corrosion, discoloration, pitting, pitting, spotting, blistering, softening, stress corrosion cracking and resin peeling. In severe cases, the fibers of the cylinder will be broken or loose.

When it is confirmed that the known chemical contaminated by the gas cylinder will not cause damage to the gas cylinder, it shall be judged as a level 1 damage. Spotting, blistering, softening, resin peeling, fiber breakage, or loosening caused by chemical product erosion on cylinders shall be judged as level 3 damages. When the chemical product cannot be determined, or the impact on the cylinder material cannot be confirmed, it shall also be judged as a level 3 damage.

6.3.6 Ageing

If the cylinder is exposed to sunlight, rain and atmospheric environment for a long time, the wrapping layer on the outer surface of the cylinder will age. As a result, discoloration or degradation of the outer surface material may occur. If there is no fiber breakage or collapse of the wrapping layer, it shall be judged as level 1 or level 2 damage. If the fiber loosens or breaks, it shall be judged as a level 3 damage.

6.3.7 Impact damage

Impact damage is caused by a strong impact on the surface of the cylinder. Impact damage can cause fiber breakage and delamination of the wrapping layer. Surface damage associated with impact damage is dents, scratches, grooves, scratches, bruises, peeling, punctures, broken or loose fibers, cracked resin, discoloration, or deformation of the cylinder. Cylinder surfaces shall be carefully inspected in the presence of such damage.

The known impacted areas, areas of surface damage, and the inner wall of the cylinder shall be inspected, so as to determine if the inner wall has been damaged. Damage to the inner wall can cause permanent deformation of the cylinder. A dent is a more serious sign of damage. Cylinders showing signs of such damage shall be carefully inspected. It shall be judged as a level 2 or level 3 damage. Any bulge in the cylinder wall shall be judged as a level 3 damage.

There is a local change in the color of the cylinder. A local change in color may appear on the surface of the cylinder that has been impacted. This change is caused by delamination, cracks or crazes in the wrapping material, and scratches on the outer surface. Cylinders showing signs of such damage shall be carefully inspected and judged as a level 2 or level 3 damage.

Local surface cracking of gas cylinder. The impacted cylinders may develop circular,

oval or linear cracks on the surface of the wrapping material. This cracking can also cause color changes. Cylinders showing signs of such damage shall be carefully inspected and judged as a level 2 or level 3 damage.

Cylinders can be tested for impact damage by tapping with a coin. Use a one-yuan coin to test areas that may have been damaged by impact. Hold the coin with hand. Tap the surface of the wrapping layer with the edge of the coin. Listen carefully to the sound. The sound produced by the impact-damaged area will be significantly different from the sound produced by the non-damaged area.

6.3.8 Stress corrosion cracking

Stress corrosion cracking is the cracking or fracture of materials caused by a combination of loads and harsh environments. Stress corrosion cracking in gas cylinders can be caused by environmental induced erosion (such as carbonic acid or acid leaking from auto parts). For gas cylinders using glass fiber as reinforcement fiber, stress corrosion cracking shall be paid attention to.

Stress corrosion cracking on the wrapping layer appear as cracks or groups of cracks perpendicular to the fiber direction. Cracks or groups of cracks perpendicular to the fiber direction shall be judged as level 3 damages.

6.3.9 Crazing

Crazing is generally linear. Usually, crack occurs along the fiber direction, or crack occurs in multiple directions on the resin on the surface of the wrapping layer. It can occur after a cylinder has been pressurized a few times.

The crazing that the crack width along the fiber direction is less than 1.0mm, and there is no corrosion of the metal material precipitated in the liner at the crack shall be judged as a level 1 damage. The crazing that the crack width along the fiber direction is greater than or equal to 1.0mm, or the corrosion of the metal material of the liner is precipitated at the crack shall be judged as a level 3 damage.

6.4 Inspection and evaluation of metal part damage

6.4.1 Scratches, bruises, gouges and abrasions

The metal parts with scratch, bruise, gouge and abrasion marks shall be carefully inspected to confirm that the residual wall thickness at the damage is not less than the design wall thickness, otherwise it shall be judged as level 3 damage.

6.4.2 Bulge

A bulge is a serious damage. All cylinders showing signs of such damage shall be classified as level 3 damage.

6.4.4 Concave

Small, shallow concaves are more of a concern than large, shallow concaves. Sharp concaves can create stress concentrations and reduce the safety of the cylinder. A concave with a depth greater than or equal to 1.6mm, or a maximum diameter or length of less than or equal to 50mm, shall be judged as a level 3 damage.

7 Inspection and evaluation of cylinder thread

7.1 Visually inspect or use a low magnification magnifying glass to check the threads one by one for cracks, deformation, corrosion or other mechanical damage.

7.2 There shall be no cracking defects in the thread of the cylinder mouth. However, slight damage to the thread of the cylinder mouth that does not affect the use is allowed, that is, not more than 2 teeth are allowed, and the length of the notch does not exceed 1/6 of the circumference, and the depth of the notch does not exceed 1/3 of the height of the teeth.

7.3 For mild corrosion, abrasion or other damage to the cone thread of the cylinder mouth, it can be repaired with a tap that meets the requirements of GB/T 10878. Use the gauge that meets GB/T 8336 to inspect after repair. When the inspection result does not meet the requirements of GB/T 8335, the gas cylinder shall be judged to be scrapped.

7.4 For mild corrosion, abrasion or other damage of the straight thread of the cylinder mouth, it can be repaired with a tap that meets its corresponding standard. After repair, use a gauge that meets its corresponding standard to inspect. When the inspection result does not meet the requirements, the gas cylinder shall be judged to be scrapped.

8 Hydrostatic test

8.1 The hydrostatic test by external measurement method shall be carried out one by one in accordance with GB/T 9251.

8.2 The test pressure is the water pressure test pressure in the cylinder mark.

8.3 The holding time of the gas cylinder under the hydrostatic test pressure shall not be less than 2min.

8.4 During the hydrostatic test, the cylinders whose wrapping layer defects expand, the cylinder body leaks, are obviously deformed, or the pressure drops back during the pressure holding period (not caused by the leakage of the test device or the cylinder mouth) shall be judged to be scrapped.

8.5 During the hydrostatic test, the volume residual deformation rate shall be measured at the same time. Cylinders with a residual volumetric deformation rate exceeding 10%

shall be deemed to be scrapped.

8.6 During the hydrostatic test, when the pressure rises to 90% or more of the test pressure, if the test cannot be continued for some reason, the test pressure shall be increased by 0.7MPa during the test again but shall not exceed the self-tightening pressure. At this time, the calculation of the residual deformation rate of the cylinder volume shall be calculated according to the increased pressure. Retest only for once.

9 Internal drying

9.1 Drying method and requirements

9.1.1 Cylinders that have passed the hydrostatic test shall be internally dried one by one.

9.1.2 Hold the cylinder upside down for a while. After the remaining water in the cylinder is drained, use dry air blowing, internal heating or other appropriate methods for internal drying.

9.1.3 When drying inside, the temperature shall not exceed 65℃. The time shall be long enough to keep the inside of the cylinder completely dry.

9.2 Drying condition inspection

Observe the dryness of the cylinder with the help of an endoscope or a small light bulb. If the inner wall is completely dry, the cylinder valve and PRD end plug can be installed.

10 Cylinder valve inspection and assembly

10.1 The cylinder valve and PRD end plug shall be visually inspected one by one. All parts of the cylinder valve and PRD end plug (bursting disc and fusible plug and so on) shall be complete. There shall be no deformation. The thread shall not be damaged.

10.2 The cylinder valve and PRD end plug shall be firmly assembled and shall ensure the effective thread number and sealing performance of their connection. A new seal shall also be used when assembling straight-threaded cylinder valves and PRD end plugs.

NOTE: The recommended upper valve torque of PZ27.8 taper thread is 200N·m~300N·m. The recommended upper valve torque of M25×2.0-6H straight thread is 100N·m~130N·m.

10.3 When the cylinder valve or PRD end plug is damaged or cannot be used safely until the next inspection cycle, the cylinder valve and PRD end plug shall be replaced with a new one. The products of the same manufacturer and the same model as the

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