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Gas cylinders — Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles

Bouteilles à gaz — Inspection de l'installation des bouteilles, et requalification des bouteilles haute pression pour le stockage du gaz naturel, utilisé comme carburant, à bord des véhicules automobiles

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19078 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders*.

Introduction

This International Standard provides information and procedures for the periodic visual examination and inspection of natural gas fuel cylinders and the condition of the installation. These cylinders, installed in vehicles, are certified by the manufacturer to meet the requirements of ISO 11439, and are designed to store natural gas at high pressures. This International Standard requires that appropriate information, such as an installation and maintenance manual from the cylinder manufacturer, be reviewed and used during the inspection, together with all the cylinder manufacturer's current recommendations and guidance documents.

Gas cylinders — Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles

1 Scope

This International Standard specifies the requirements for the inspection of the cylinder installation and the requalification of high pressure cylinders, designed and manufactured in accordance with ISO 11439, for the on-board storage of natural gas as a fuel for automotive vehicles. The purpose of this International Standard is to provide guidance for the inspection of these cylinders in accordance with the manufacturer's recommendations, and to provide criteria for acceptance or rejection in the absence of guidance from the manufacturer, with subsequent disposition as necessary.

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.

ISO 11439:2000, *Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
abrasion
damage to cylinder or equipment caused by wearing, grinding or rubbing away of material by friction

NOTE Abrasion can be the result of many cycles of something rubbing lightly on the surface of the cylinder or equipment, or due to a few cycles, perhaps only one, of heavy rubbing.

3.2
impact
forceful blow to the surface of the cylinder that can cut, gouge or significantly indent the surface

NOTE Impact can also induce such damage as delaminations, which are not readily apparent through visual examination.

3.3
condemned
⟨cylinder or piece of equipment⟩ in a state no longer fit for service and for which repair is not allowed

3.4
crazing
hairline cracking of the resin, giving it an opaque, frosty appearance

3.5
cut
damage caused by a sharp object coming into contact with the cylinder's surface

3.6
delamination
form of composite damage, in which a separation develops between layers of the composite

NOTE Delaminations usually result from excessive localized loading normal to the surface of the laminate.

3.7
destroyed
⟨fuel cylinder or piece of equipment⟩ in a state of alteration which makes it physically unusable

3.8
domes
curved end portions of the fuel cylinder

3.9
external coating
clear or coloured surface treatment applied to the cylinder for environmental protection and/or improved appearance

3.10
helical
winding in the longitudinal circumferential direction for both the cylindrical and dome regions of the cylinder

NOTE The strands of reinforcing fibres are oriented at an angle to the longitudinal axis of the cylinder.

3.11
hoop direction
hoop pattern
winding in the cylindrical region of the cylinder

NOTE The strands of reinforcing fibres are oriented at an angle of nearly 90 degrees to the longitudinal axis of the cylinder.

3.12
inspection body
individual or organization that performs the visual inspection of compressed natural gas (CNG) cylinders used in natural gas vehicles (NGVs)

3.13
inspection mark
mark, label or tag placed by an inspector on the cylinder indicating acceptance of the cylinder

3.14
Level 1 damage
Level 1 condition
minor damage that can occur during normal use

NOTE Such damage normally has no adverse effects on the safety of the cylinder and its continued use. Scratched paint or nicks that have no appreciable depth in metal, or similar damage in the composite cylinder paint or resin where there are no visible frayed fibres, are considered to be of this level of damage.

See Table 1.

3.15
Level 2 damage
Level 2 condition
damage that is more severe than Level 1, but where possibilities of repair subsist, or where the cylinder can be returned to service, or where the cylinder is classified as Level 1 or Level 3 based upon the recommendations of the manufacturer

See 7.4.3 and Table 1.

3.16
Level 3 damage
Level 3 condition
damage that requires a cylinder to be condemned

NOTE A Level 3 condition is such that the cylinder must be rendered unfit for continued service and cannot be repaired.

See Table 1.

3.17
liner
internal component of the cylinder that prevents leakage of gas through the composite cylinder structure

3.18
manufacturer
cylinder manufacturer, unless otherwise stated

3.19
marking(s)
information permanently applied to the fuel cylinder, which is required by the fuel cylinder standard, including stamping and permanent labels

3.20
mounting brackets and/or straps
devices used to secure fuel cylinders in a vehicle

3.21
overpressurization
pressurization in the cylinder at 15 °C which is higher than the working pressure in the cylinder, as specified in ISO 11439

3.22
pressure relief device
PRD
device that releases the contained gas in specific emergency conditions

NOTE The PRD can be activated by excessive temperature, excessive internal pressure, or both.

3.23
regulatory authority
national entity, or entities, that have the jurisdiction to specify requirements for the cylinders and equipment addressed in this International Standard

3.24
reinforcing fibres
continuous fibrous strands in the composite, such as carbon, aramid and glass, which withstand loads caused by pressurization

See Annex F.

3.25
rejected cylinder
cylinder or equipment that needs to be removed from service, i.e. deinstalled from the vehicle

NOTE For Level 2 damage, the cylinder is evaluated further before repairing or condemning. For Level 3 damage, the cylinder or equipment is subsequently condemned.

3.26
repair
action, including rework, to return a cylinder to an acceptable Level 1 condition

3.27
resin
material that is used to bind and hold the fibres in place

NOTE The resin is usually thermoplastic or thermosetting.

3.28
working pressure
settled pressure, at a uniform temperature of 15 °C, marked on the cylinder

3.29
stress corrosion cracking
SCC
phenomenon resulting in a split or rift in the materials, caused by a combination of load and aggressive environment

NOTE Such cracks in composite materials are typically sharply defined and perpendicular to the fibre direction. They can appear as a family of cracks or as a single crack.

3.30
valve
device installed in one of the threaded openings of the cylinder that is used to regulate gas flow into or from the cylinder

NOTE A manual valve is turned on or off with a handle. A solenoid valve is turned on or off electronically. Some solenoid valves can be operated manually with special tools.

3.31
vent line
high-pressure line used to conduct gas from a pressure relief device to a location outside the vehicle, where gas can be discharged safely

4 Background information

4.1 General

NGV fuel cylinders inspected in accordance with this International Standard are designed and qualified in accordance with ISO 11439. These cylinders have markings that identify the ISO 11439 type of construction.

4.2 Cylinder types and descriptions

4.2.1 CNG-1 metal

CNG-1 cylinders are all metallic and can be made of any alloy of steel or aluminium that meets the qualification requirements outlined in the design standard.

4.2.2 CNG-2 metal liner partially reinforced with resin-impregnated continuous filament (hoop-wrapped)

CNG-2 cylinders have a metallic liner with sufficient strength and thickness to carry the entire longitudinal load at the required burst pressure, and to withstand the standard-specified factor of the nominal working pressure without rupture. Metal liner materials are those identified under CNG-1 cylinders (see 4.2.1). They are reinforced with fibres wound only in the hoop (circumferential) direction. Reinforcing fibres are carbon, aramid, glass, or combinations thereof.

4.2.3 CNG-3 metal liner totally reinforced with resin-impregnated continuous filament (fully wrapped)

CNG-3 cylinders have a metallic liner that is generally load carrying, but they do not have sufficient strength and thickness to carry the longitudinal load at the burst pressure. They are reinforced with fibres wound in both a helical (polar) and hoop pattern. Reinforcing fibres are carbon, aramid, glass, or combinations thereof. Metal liner materials are those identified under CNG-1 cylinders (see 4.2.1).

4.2.4 CNG-4 non-metallic liner totally reinforced with resin-impregnated continuous filament (all composite)

CNG-4 cylinders have a non-metallic liner that does not carry load. The liner is typically a thermoplastic material. Reinforcing fibres are carbon, aramid, glass, or combinations thereof. They are reinforced with fibres wound in both a helical (polar) pattern and hoop direction. Metallic bosses are used to accept valves or PRDs. Boss materials are typically aluminium or stainless steel.

NOTE Annex F provides background information on the composite matrix.

4.3 Required marking information

The design standard shall be reviewed to verify the exact wording, lettering size and required content.

The following marking information, required in ISO 11439, shall be verified:

a) “CNG ONLY”;

b) “DO NOT USE AFTER XX/XXXX” (providing the month and year of expiry);

c) the manufacturer’s identification;

d) the cylinder identification (a unique serial number for every cylinder);

e) the working pressure and the specified temperature;

f) the ISO standard, along with cylinder type and certification registration number (if applicable);

g) the approved PRD type;

h) the date of manufacture (month and year);

i) any additional markings, as required by the regulatory authority of the country (or countries) of use.

When labels are used, all cylinders shall have a unique identification number and the manufacturer's name stamped on an exposed metal surface, to permit tracing in the event of the label being destroyed.

4.4 Additional marking

The following additional information may be included:

a) specific PRDs and valves approved for use with the cylinder;

b) the operating temperature range;

c) the nominal water capacity;

d) the initial pressure test date;

e) the inspector's mark.

5 Inspection body and inspectors

The inspection body shall be certified in the country of use. See Annex A for an example of minimum inspector qualifications.

In order to guarantee that the cylinders are fit for continued safe use, the inspection shall be carried out exclusively by persons competent to do so (see Annex A). The inspector shall have available and within easy access during the inspection the equipment described in Clause 6 and the documentation referenced in 7.3.2. The vehicle to be inspected shall be positioned in such a way that the inspector has unimpeded access to the surface of the cylinder, or else in accordance with the vehicle manufacturer's recommendations (see 7.3.5). If the inspector finds areas, such as those described in Clause 7, that require additional inspection or testing, the cylinder shall be depressurized in accordance with the recommendations in Annex B and with the manufacturer's instructions, and then removed from the vehicle. If the inspector determines that the cylinder needs to be permanently removed from service, this shall be done in accordance with Clause 9.

6 Inspection equipment

6.1 Adequate light, sufficient to illuminate all surfaces clearly, in order to examine properly the external surfaces of cylinders, mounting brackets, valves, vent lines, etc.

CAUTION — To avoid combustion or fire, either use explosion-proof lights or ensure that the area is well ventilated.

6.2 Angled inspection mirrors, or other suitable devices, to aid in the examination of cylinder surfaces that are partially concealed by the installation.

6.3 Various hand tools, to remove covers, shields or other installed equipment, such that the external cylinder surfaces, brackets, valves, PRDs and other components can be viewed.

6.4 Torque wrench, to verify that the mounting bracket bolts are tightened properly.

6.5 Depth gauge, to determine the depth of cuts, pits and abrasions. It is recommended that a commercial type pit or depth gauge be used for this purpose; alternatively, the use of other equipment to estimate imperfection depths is acceptable.

6.6 Rule and straightedge, in combination, to evaluate indentations and bulges.

6.7 Rule or tape measure, to determine the length of noted cuts and the general area of abrasion.

6.8 Commercial-type leak test fluid, which does NOT contain ammonia, harsh corrosives or chemicals incompatible with the system materials (the fluid is usually a mild soap solution that meets these criteria). A methane gas detector may also be used to test for leakage. Additional information is provided in 7.6.4.

7 Cylinder, valve and pressure relief device inspection

7.1 Inspection interval

CAUTION — Failure to perform diligent and accurate inspections on a regular basis, or promptly (in the case of a potentially damaging incident or unusual behaviour), can result in a serious accident causing severe damage or injury, or both.

NGV fuel storage systems shall be visually inspected by a qualified inspection body (see Clause 5), at intervals of 36 months or less. The country of use can require more frequent visual inspections. Annex C specifies typical conditions and usage that may warrant more frequent inspections, whilst Annex E outlines specific considerations relating to internal inspections.

7.2 Conditions requiring immediate inspection

An inspection shall be performed on a depressurized CNG cylinder, prior to filling or returning it to service, if

a) the fuel cylinder or vehicle in which it is installed is involved in a fire,

b) the fuel cylinder is exposed to excessive heat,

c) the fuel cylinder is dropped or subjected to impact,

d) the NGV is in a collision,

e) the cylinder is suspected to have damage from cargo, vehicle and/or environmental conditions,

f) the cylinder is believed to have been damaged by any means,

g) there is unusual behaviour including, but not limited to:

   1) the presence of any odour added to natural gas (indicating a possible leaking cylinder or fuel system);

   2) unexpected loss of gas pressure;

   3) rattling or other indications of looseness;

   4) unusual snapping or hissing sounds,

NOTE Some minor noise is not unusual for composite materials when cylinders are being pressurized or depressurized.

h) the cylinder is reinstalled after removal from the vehicle,

i) the cylinder installation is changed significantly,

j) the fuel cylinder is transferred to another vehicle, or

k) the cylinder has been overpressurized, not in accordance with the limits of its design.

7.3 Preparation for inspection — all cylinder types

7.3.1 Background vehicle information

CAUTION — A cylinder shall not be pressurized with air or an oxidizing gas mixture prior to use or inspection. This can create a reactive mixture and be very dangerous.