DRAFT AMENDMENT

ISO 11439:2013/DAM 1

ISO/TC **58**/SC **3**

Secretariat: **BSI**

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2020-12-24

Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles

AMENDMENT 1

Bouteilles à gaz — Bouteilles haute pression pour le stockage de gaz naturel utilisé comme carburant à bord des véhicules automobiles

AMENDEMENT 1

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Foreword

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This document was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles

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2 Normative references

Eliminating dates on standards so that latest versions are required:

ASTM D522, Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

ASTM D1308, Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes

ASTM D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)

ASTM D3170, Standard Test Method for Chipping Resistance of Coatings

ASTM G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

NACE/TM 0177, Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H2S Environments

7.5.2.2 Material tests for steel cylinders

a) *Tensile test*

Steel from a finished cylinder shall meet the requirements of the tensile test in A.1.

b) *Impact test*

Steel from a finished cylinder shall meet the requirements of the impact test in A.2.

c) *Sulfide stress cracking resistance test*

If the upper limit of the specified tensile strength for the steel exceeds 950 MPa, the steel from a finished cylinder shall meet the requirements of the sulfide stress cracking resistance test in A.3. The actual tensile strength of the steel according to A.1, shall not exceed the value obtained by more than 5%, on the samples tested for SSC resistance.

7.6.2.1 Batch tests

Tests shall be carried out on each batch of cylinders:

a) *on one cylinder, one hydrostatic pressure burst test in accordance with A.12.*

b) *on a further cylinder, or a heat treated witness sample representative of a finished cylinder:*

   1) *a check of the critical dimensions against the design (see 6.4.1);*

2) *one tensile test in accordance with A.1; the test results shall satisfy the requirements of the design (see 6.4.1);*

3) *for steel cylinders, three impact tests in accordance with A.2; the test results shall satisfy the requirements specified in A.2;*

4) *when a protective coating is a part of the design, a coating batch test in accordance with A.24. Where the coating fails to meet the requirements of A.24, the batch shall be 100 % inspected to remove cylinders with similar defective coatings. The coating on all defectively coated cylinders may be stripped and recoated. The coating batch test shall then be repeated.*

8.2.3.1 Resins

The material for impregnation may be thermosetting or thermoplastic resins. Examples of suitable matrix materials are epoxy, modified epoxy, polyester and vinyl ester thermosetting plastics, and polyethylene and polyamide thermoplastic material.

The glass transition temperature of the resin material shall be determined in accordance with ASTM D3418, and shall not be less than 102 °C.

8.5.2.2 Material tests for steel liners

a) *Tensile test*

Steel from a finished liner shall meet the requirements of the tensile test in A.1.

b) *Impact test*

Steel from a finished liner shall meet the requirements of the impact test in A.2.

c) *Sulfide stress cracking resistance test*

If the upper limit of the specified tensile strength for the steel exceeds 950 MPa, the steel from a finished liner shall meet the requirements of the sulfide stress cracking resistance test in A.3. The actual tensile strength of the steel according to A.1, shall not exceed the value obtained by more than 5%, on the samples tested for SSC resistance.

8.5.2.11 High temperature creep test

In designs where glass or aramid fibre has a load sharing application, one cylinder shall be tested in accordance with A.18.

8.6.3.1 Liner tests

d) *on one liner, one hydrostatic pressure burst test in accordance with A.12.*

e) *on a further liner, or heat treated sample representative of a liner:*

1) *a check of the critical dimensions against the design (see 6.1.3.1);*

2) *one tensile test in accordance with A.1; the test results shall satisfy the requirements of the design (see 6.1.3.1);*

3) *three impact tests in accordance with A.2; the test results shall satisfy the requirements specified in A.2;*

All liners represented by a batch test that fails to meet the specified requirements shall follow the procedures specified in 8.9.

9.2.3.1 Resins

The material for impregnation may be thermosetting or thermoplastic resins. Examples of suitable matrix materials are epoxy, modified epoxy, polyester and vinyl ester thermosetting plastics, and polyethylene and polyamide thermoplastic material. The glass transition temperature of the resin material shall be determined in accordance with ASTM D3418, and shall not be less than 102 °C.

9.5.2.2 Material tests for steel liners

a) *Tensile test*

Steel from a finished cylinder or liner shall meet the requirements of the tensile test in A.1.

b) *Impact test*

Steel from a finished liner shall meet the requirements of the impact test in A.2.

c) *Sulfide stress cracking resistance test*

If the upper limit of the specified tensile strength for the steel exceeds 950 MPa, the steel from a finished liner shall meet the requirements in A.3. The actual tensile strength of the steel according to A.1, shall not exceed the value obtained by more than 5 %, on the samples tested for SSC resistance.

9.5.2.11 High temperature creep test

In designs where glass or aramid fibre has a load sharing application, one cylinder shall be tested in accordance with A.18.

9.6.2 Liner tests

On a liner, or heat treated sample representative of a finished liner:

a) *a check of the critical dimensions against the design (see 6.1.3.1);*

b) *one tensile test in accordance with A.1; the test results shall satisfy the requirements of the design (see 6.1.3.1);*

c) *for steel liners, three impact tests in accordance with A.2; the test results shall satisfy the requirements specified in A.2;*

All liners represented by a batch test that fails to meet the requirements specified shall follow the procedures specified in 9.9.

10.2.2 Resins

The material for impregnation may be thermosetting or thermoplastic resins. Examples of suitable matrix materials are epoxy, modified epoxy, polyester and vinyl ester thermosetting plastics, and polyethylene and polyamide thermoplastic material.

The glass transition temperature of the resin material shall be determined in accordance with ASTM D 3418, and shall not be less than 102 °C.

10.5.2.10 High temperature creep test

In designs where glass or aramid fibre has a load sharing application, one cylinder shall be tested in accordance with A.18.

A.6 Leak-before-break (LBB) test

Three finished cylinders shall be pressure cycled between less than or equal to 20 bar and greater than or equal to 1.5 × working pressure, at a rate not exceeding 10 cycles per minute in accordance with A.13.

All cylinders shall either fail by leakage or exceed 45 000 pressure cycles.

A.7 Extreme temperature pressure cycling

Finished cylinders, with the composite wrapping free of any protective coating, shall be cycle tested:

a) *condition for more than 48 h at zero pressure, 65 °C or higher, and 95 % or greater relative humidity. The intent of this relative humidity requirement shall be deemed met by spraying with a fine spray or mist of water in a chamber held at a minimum 65 °C;*

b) *hydrostatically pressurize for 500 cycles multiplied by the specified service life in years between less than or equal to 20 bar and greater than or equal to 260 bar at 65 °C or higher, and 95 % or greater relative humidity;*

c) *condition the cylinder and fluid at – 40 °C or lower as measured in the fluid and on the cylinder surface;*

d) *pressurize from less than or equal to 20 bar to greater than or equal to 200 bar for 500 cycles multiplied by the specified service life in years at – 40 °C or lower. Adequate recording instrumentation shall be provided to ensure the minimum temperature of the fluid is maintained during the low temperature cycling. At no time during the pressure cycling shall the fluid be warmer than – 40 °C.*

The pressure cycling rate of b) shall not exceed 10 cycles per minute. The pressure cycling rate of d) shall not exceed 3 cycles per minute unless a pressure transducer is installed directly within the cylinder. All temperature, pressure, and relative humidity values shall be recorded at least every 6 seconds. Cycles that fall outside the limits of the pressure, humidity and temperature values, shall be discounted from the total requirement.

During this pressure cycling, the cylinder shall show no evidence of rupture, leakage or fibre unravelling.

Following pressure cycling at extreme temperatures, cylinders shall be hydrostatically pressured to failure in accordance with A.12, and achieve a minimum burst pressure of 85 % of the minimum design burst pressure. For type 4 designs, prior to the hydrostatic burst test the cylinder shall be leak tested in accordance with A.10.

A.9 Coating tests

These tests are intended to validate a coating system that can be used for the same coating on other designs. An alternative corrosion test for severe exposure conditions is provided in Annex H.

Coatings shall be evaluated using:

f) *Adhesion testing, in accordance with ASTM D3359, using method A or B, as appropriate. The coating shall exhibit an adhesion rating of either 4A or 4B, as appropriate.*

g) *Flexibility, in accordance with ASTM D522-93, using test method B with a 12,7 mm (0,5 in) mandrel at the specified thickness at - 20 °C. Samples for the flexibility test shall be prepared in accordance with ASTMD522-93. There shall be no visually apparent cracks.*

h) *Impact resistance, in accordance with ASTM D2794-93. The coating at room temperature shall pass a forward impact test of 18 J (13,3 ft lbs).*

i) *Chemical resistance, in accordance with ASTM D1308-87, except that the tests shall be conducted using the open spot test method and 100 h exposure to a 30 % sulfuric acid solution (battery acid with a specific gravity of 1,219) and 24 h exposure to a polyalkalene glycol (e.g. brake fluid). There shall be no evidence of lifting, blistering or softening of the coating. The adhesion shall meet a rating of 3 when tested in accordance with ASTM D3359.*

j) *Minimum 1 000 h exposure, using a UVA lamp in accordance with ASTM G154-2006. There shall be no evidence of blistering and adhesion shall meet a rating of 3 when tested in accordance with ASTM D3359. The maximum gloss loss shall be 20 %.*

k) *Minimum 500 h exposure in accordance with ISO 9227. Undercutting shall not exceed 2 mm at the scribe mark, there shall be no evidence of blistering and adhesion shall meet a rating of 3 when tested in accordance with ASTM D3359.*

l) *Resistance to chipping at room temperature, in accordance with ASTM D3170-87. The coating shall have a rating of 7A or better, and there shall be no exposure of the substrate.*

A.10 Leak test

This test is for the design qualification and production testing of cylinders only. It is not for the purpose of in-service inspection. Type 4 designs shall be leak tested by:

a) *thoroughly drying the cylinders;*

b) *pressurizing the cylinders to working pressure with compressed natural gas, or nitrogen containing a detectable gas such as helium.*

Any leakage detected shall be cause for rejection.

Leakage is the release of gas through a crack, pore, un-bond or similar defect. Permeation through the wall in conformance to A.21 is not considered to be leakage.

A.13 Ambient temperature pressure cycling

Pressure cycling shall be performed by:

a) *filling the cylinder to be tested with a non-corrosive fluid such as oil, inhibited water or glycol;*

b) *cycling the pressure in the cylinder from less than or equal to 20 bar and greater than or equal to 1,3 times working pressure at a rate not exceeding 10 cycles per minute.*

The number of cycles to failure shall be reported, along with the location and description of the failure initiation, if applicable.

A.14 Environmental test

A.14.5 Pressure cycle and pressure hold

The cylinder shall be hydraulically pressure cycled between less than or equal to 20 bar and greater than or equal to 260 bar for a total of 3 000 cycles. The maximum pressurization rate shall be 27,5 bar per