

Proposal for amendments to UN Regulation No. 110 (CNG/LNG vehicles)

Uniform provisions concerning the approval of:

- I. Specific components of motor vehicles using compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion system;
- II. Vehicles with regard to the installation of specific components of an approved type for the use of compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion system.

A. Proposal for amendments to permit use of Conformable container type

The aim of this proposal is to allow the use Conformable container type in vehicles equipped with CNG. All adaptations are based on UN Regulation No. 110.01

Paragraph 4.13.1 add new type of containers:

- Type A** Pressure vessel or assembly consisting of a non-cylindrical or non-spherical (i.e. irregular) shape.
- Type B** Pressure vessel or assembly of possible regular shape contained within a conformable protective shell that is not under any stress associated with the application of gas pressure.
- Type C** Pressure vessel or assembly of possible irregular shape contained within a conformable protective shell that is under stress associated with the application of gas pressure.

Paragraph 4.54 add new paragraph.

- 4.54** “Conformable container types” means Pressure vessel or assembly consisting of a non-cylindrical or non-spherical (i.e. irregular) shape.

Paragraphs 4.54. to 4.74., renumber as paragraphs 4.55. to 4.75

Annex 3

Paragraph 1.1 amend to read:

1.1. Annex 3A sets out minimum requirements for light-weight refillable gas cylinders. The cylinders are intended only for the on-board storage of high pressure compressed natural gas as a fuel for automotive vehicles to which the cylinders are to be fixed. Cylinders may be of any steel, aluminium or non-metallic material, design or method of manufacture suitable for the specified service conditions. This annex also covers stainless steel metal liners of seamless or welded construction **and conformable containers.**

Annex 3A

Paragraph 1. add new type of containers:

- Type A** Pressure vessel or assembly consisting of a non-cylindrical or non-spherical (i.e. irregular) shape.
- Type B** Pressure vessel or assembly of possible irregular shape contained within a conformable protective shell that is not under any stress associated with the application of gas pressure.

Type C Pressure vessel or assembly of possible irregular shape contained within a conformable protective shell that is under stress associated with the application of gas pressure.

Paragraph 7.5.3. amend to read:

Ambient temperature pressure cycling test.

Two finished cylinders shall be pressure cycled at ambient temperature in accordance with paragraph A.13. (Appendix A to this annex) to failure, or to a minimum of 45,000 cycles. The cylinders shall not fail before reaching the specified service life in years times 1,000 cycles. Cylinders exceeding 1,000 cycles times the specified service life in years shall fail by leakage and not by rupture. Cylinders which do not fail within 45,000 cycles shall be destroyed either by continuing the cycling until failure occurs, or by hydrostatically pressurising to burst. The number of cycles to failure and the location of the failure initiation shall be recorded.

For Type B conformable containers, if pressure cycling causes damage to the protective shell, then this is considered a test failure. A shell failure is defined as cracks or fractures in the shell, or if shell dimensions are deformed outside the limits of the design. Cycle testing requires a minimum 2 second hold at the maximum and minimum pressure of each cycle, to ensure pressure equalizes in the pressure containing elements.

For Type C conformable containers, cycle testing requires a minimum 2 second hold at the maximum and minimum pressure of each cycle, to ensure pressure equalizes in the pressure containing elements.

Paragraph A.7. amend to read:

Extreme temperature pressure cycling

Finished cylinders, with the composite wrapping free of any protective coating, shall be cycle tested, without showing evidence of rupture, leakage, or fibre unravelling, as follows:

- (a) Condition for 48 hours at zero pressure, 65 °C or higher, and 95 per cent or greater relative humidity. The intent of this requirement shall be deemed met by spraying with a fine spray or mist of water in a chamber held at 65 °C;
- (b) Hydrostatically pressurized for 500 cycles times the specified service life in years between not more than 2 MPa and not less than 26 MPa at 65 °C or higher and 95 per cent humidity;
- (c) Stabilize at zero pressure and ambient temperature;
- (d) Then pressurize from not more than 2 MPa to not less than 20 MPa for 500 cycles times the specified service life in years at -40 °C or lower;

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. Adequate recording instrumentation shall be provided to ensure the minimum temperature of the fluid is maintained during the low temperature cycling.

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

For Type B conformable containers, if pressure cycling causes damage to the protective shell, then this is considered a test failure. A shell failure is defined as cracks or fractures in the shell, or if shell dimensions are deformed outside the limits of the design.

For Types B and C conformable containers, the pressure shall be measured at opposite end of vessel from where pressure is being applied or shall hold at minimum design burst pressure for 1 min to verify pressure dispersed throughout pressure vessel.

Paragraph A.16. Penetration tests amend to read:

A cylinder pressurised to 20 MPa \pm 1 MPa with compressed gas shall be penetrated by an armour piercing bullet with a diameter of 7.62 mm or greater. The bullet shall completely penetrate at least one side wall of the cylinder. For type CNG-2, CNG-3 and CNG-4 designs, the projectile shall impact the side wall at an approximate angle of 90°. The cylinder shall reveal no evidence of fragmentation failure. Loss of small pieces of material, each not weighing more than 45 grams, shall not constitute failure of the test. The approximate size of entrance and exit openings and their locations shall be recorded. **For containers with diameter less than 100 mm or a targeting profile of less than 200 mm, it is acceptable to penetrate the fuel container using a 5.56 mm or 5.6 mm armor piercing bullet.**

Paragraph A.17 Composite flaw tolerance tests amend to read:

For type CNG-2, CNG-3 and CNG-4 designs only, one finished cylinder, complete with protective coating, shall have flaws in the longitudinal direction cut into the composite. The flaws shall be greater than the visual inspection limits as specified by the manufacturer.

The flawed cylinder shall then be pressure cycled from not more than 2 MPa to not less than 26 MPa for 3,000 cycles, followed by an additional 12,000 cycles at ambient temperature; The cylinder shall not leak or rupture within the first 3,000 cycles, but may fail by leakage during the last 12,000 cycles. All cylinders which complete this test shall be destroyed.

For Type A and C conformable containers, the flaws shall be made at exposed (external) locations where the highest stress location exists. Flaws shall be oriented perpendicular to the maximum stress direction.

This test is not required for Type B conformable containers with outer shell thickness greater than 1 mm.

Paragraph A.21. Permeation test amend to read:

This test is only required on type CNG-4 designs. One finished cylinder shall be filled with compressed natural gas or a 90 per cent nitrogen/10 per cent helium mixture to working pressure, placed in an enclosed sealed chamber at ambient temperature, and monitored for leakage for a time sufficient to establish a steady state permeation rate. The permeation rate shall be less than 0.25 ml of natural gas or helium per hour per litre water capacity of the cylinder. **For Type A conformable containers, the permeation test is only required if the tank liner is plastic. For Type B and C, the permeation test is only required if pressurized elements have plastic liners. The entire conformable tank unit must meet the permeation criteria. If protective shell is gas-tight (i.e. able to hold 50 psi), measurement samples shall be taken from annular space within shell. There shall be no CNG build-up within the sealed shell.**

Paragraph A.25. Boss torque test amend to read:

The body of the cylinder shall be restrained against rotation and a torque of 500 Nm shall be applied to each end boss of the cylinder, first in the direction to tighten a threaded connection, then in the untightening direction, and finally again in the tightening direction.

For conformable tanks the torque shall be 2 times the torque recommended by manufacturer.

A.27. Natural gas cycling test amend to read

One finished cylinder shall be pressure cycled using compressed natural gas from less than 2 MPa to working pressure for 300 cycles. Each cycle, consisting of the filling and venting of the cylinder, shall not exceed 1 hour. The cylinder shall be leak tested in accordance with paragraph A.10. above and meet the requirements therein. Following the completion of the natural gas cycling the cylinder shall be sectioned and the liner/end boss interface inspected for evidence of any deterioration, such as fatigue cracking or electrostatic discharge.

Note - Special consideration shall be given to safety when conducting this test. Prior to conducting this test, cylinders of this design shall have successfully passed the test requirements of paragraph A.12. above (hydrostatic pressure burst test), paragraph 8.6.3. of Annex 3A (ambient temperature pressure cycling test) and paragraph A.21. above (permeation test). Prior to conducting this test, the specific cylinders to be tested shall pass the test requirements of paragraph A.10. above (leak test).

For Type A conformable containers, the natural gas cycling test is only required if the tank liner is plastic.

For Type B and C, the natural gas cycling test is only required if pressurized elements have plastic liners.

H.4. Preconditioning apparatus amend to read

The following apparatus are needed for preconditioning the test cylinder by pendulum and gravel impact.

(a) Pendulum impact

The impact body shall be of steel and have the shape of a pyramid with equilateral triangle faces and a square base, the summit and the edges being rounded to a radius of 3 mm. The centre of percussion of the pendulum shall coincide with the centre of gravity of the pyramid; its distance from the axis of rotation of the pendulum shall be 1 m. The total mass of the pendulum referred to its centre of percussion shall be 15 kg. The energy of the pendulum at the moment of impact shall be not less than 30 Nm and as close to that value as possible.

During pendulum impact, the cylinder shall be held in position by the end bosses or by the intended mounting brackets.

For Type B conformable containers, if the outer shell is not gas-tight (i.e. unable to hold 50 psi), then apply environmental fluids for exposure onto internal elements. The pendulum impact test is not required on outer shell for this design.

B. Justification

1. The above-mentioned proposals are made upon the request of the CNG market to have new cylinder shape and concept.
2. The Regulation has been modified to enable the approval of a new product also for paragraph A.25. on Boss torque, in conformable tanks small thread shall be used; in this case 500 Nm values is too high for the application.
3. In paragraph A.16. on Penetration tests, the severity of the test is proportional to the ratio of the bullet diameter to tank diameter. For small tanks, application of the larger bullet would require excessive wall thickness to survive this test.
4. Change of penetration angle. This is to reduce the chance of ricochet during the test.