



SPECIFICATION FOR SEAMLESS STEEL

TRANSPORTABLE PRESSURE

RECEPTACLES

DOT - 3B (HSE)

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1. SCOPE

This specification details the requirements for the material, design, construction and testing of seamless steel transportable pressure receptacles, ie gas cylinders, over 0.5 kg but not over 450 kg water capacity and service pressure of at least 10 bar but not exceeding 35 bar and a diameter not exceeding 127 mm. Gas cylinders manufactured to this specification shall not be used for the carriage of Hydrogen.

2. CERTIFICATE OF COMPLIANCE

The Approved Verification (Inspection) Body shall certify that the manufacture, inspection and testing of the cylinders was carried out in compliance with the requirements of this specification.

Note: A suitable form of certificate is shown in Appendix 1.

3. REFERENCES

ASTM Standard E8 - American Society for Testing and Materials (tensile testing).

CGA-C-1 - Compressed Gas Association - Hydrostatic Testing.

4. PERMITTED STEEL

Open-hearth or electric steel of uniform quality. The content percentage may not exceed the following :-

Carbon 0.55%

Phosphorous 0.045%

Sulphur 0.05%

5. IDENTIFICATION OF MATERIAL

The material of construction shall be identified by a suitable method and plates and billets for hot-drawn cylinders shall be marked with the heat number.

6. DEFECTS

Materials with seams, cracks, laminations, or other injurious defects, are not permitted.

7. MANUFACTURE

7.1 Cylinders must be manufactured using equipment and processes adequate to ensure that each cylinder produced conforms to the requirements of this specification. No fissure or other defect is permitted that is likely to weaken the finished cylinder appreciably. A reasonably smooth and uniform surface finish is required. If not originally free from such defects, the surface may be machined or otherwise treated to eliminate these defects. Dirt and scale shall be removed as necessary to afford proper inspection.

7.2 The thickness of the bottoms of cylinders welded or formed by spinning is, under no condition, to be less than two times the minimum wall thickness of the cylindrical shell; such bottom thicknesses to be measured within an area bounded by a line representing the points of contact between the cylinder and floor when the cylinder is in a vertical position.

8. WELDING OR BRAZING

Welding or brazing for any purpose whatsoever is prohibited except as follows :-

a) Welding or brazing is authorised for the attachment of neckrings and footrings which are non-pressure parts, and only to the tops and bottoms of cylinders having a service pressure of 35 bar or less. Cylinders, neckrings and footrings must be made of weldable steel, carbon content of which must not exceed 0.25 percent except in the case of 4130X steel which may be used with proper welding procedure.

b) As permitted by section 7 of this specification.

9. WALL THICKNESS

9.1 The thickness of each cylinder shall conform to the following:-

9.1.1 The wall stress may not exceed 166MPa.

9.1.2 The wall thickness shall be a minimum of 2.286 mm

9.2 Calculation shall be by the formula:

$$S = [P/10 (1.3D^2 + 0.4d^2)] / (D^2 - d^2)$$

where S = wall stress in Mpa

P = minimum test pressure prescribed for water jacket test in bar

D = outside diameter in mm

d = inside diameter in mm

10. HEAT TREATMENT

10.1 The completed cylinders must be uniformly and properly heat treated to a procedure agreed with the Approved Verification Body prior to tests.

11. THREADED OPENINGS

11.1 All threads are required to be clean cut, even, without cutting tool marks and to gauge.

11.2 Taper threads, when used, are to be of length not less than as specified for American Standard taper pipe threads.

11.3 Straight threads having at least 4 engaged threads are permitted and shall have a tight fit. The calculated shear strength shall be at least 10 times the test pressure of the cylinder. Gaskets, adequate to prevent leakage, are required.

12. PRESSURE RELIEF DEVICES

12.1. General Requirements

No pressure relief device shall be fitted to a cylinder intended for the conveyance of toxic gases. However, a pressure relief device may be fitted to a cylinder intended for the conveyance of non-toxic gases.

The materials of construction for all pressure relief devices shall be compatible with the gas to be conveyed and other service conditions.

All pressure relief devices shall be so designed and fitted as to ensure that the cooling effect of the contents of the cylinder during discharge shall not prevent the effective operation of the devices.

The outlets from all pressure relief devices shall be so sited that free discharge from the devices is not impaired.

The outlets from all pressure relief devices shall be so designed and constructed as to prevent the collection of moisture or other foreign matter that could adversely affect the performance of the devices.

12.2. Pressure Relief Valves

If a pressure relief valve is fitted to a cylinder, it shall be of the spring-loaded type. Where practicable the pressure at which the relief valve is designed to start lifting shall be marked on the relief valve or the outlet valve body where the relief valve forms part of the outlet valve.

Discharge from the pressure relief valve shall be obtained at a pressure not greater than the test pressure of the container, except in the case of liquefied petroleum gas cylinders for service in Great Britain.

Where liquefied petroleum gas cylinders for service in Great Britain are fitted with pressure relief valves they shall be set as follows:

- (a) Propane: 26 bar;
- (b) Butane: 21 bar.

12.3. Bursting discs

Bursting discs if fitted, shall be constructed in accordance with BS 2915 and shall be so designed as to ensure that rupture occurs at a pressure not greater than the test pressure of the cylinder except in the case of cylinders for halons and nitrogen.

Note. A bursting disc may be fitted to any cylinder intended for the conveyance of non-toxic and non-flammable gases. The pressure at which the the bursting disc is designed to rupture shall, where practicable, be stamped on the bursting disc holder.

If a cylinder is liable to be subjected to vacuum conditions during service, the bursting disc shall be resistant to vacuum or be fitted with a vacuum support.

12.4. Cylinder valve protection.

Cylinders charged with flammable, corrosive, or noxious gases, shall have their valves protected by one of the following methods.

12.4.1. By equipping the cylinders with securely attached metal caps of sufficient strength to protect the valves from damage during transit.

12.4.2. By boxing or crating the cylinders so as to give proper protection to the valves.

12.4.3. By so constructing the cylinders that the valve is recessed into the cylinder or otherwise protected so that it will not be subjected to a blow when the cylinder is dropped on a flat surface.

12.4.4. By loading the cylinders compactly in an upright position and securely bracing them in cars or motor vehicles, when loaded by the consignor and to be unloaded by the consignee.

12.4.6. By equipping with valves strong enough to avoid damage during transit for cylinders containing non-liquefied gas under pressure not exceeding 20.7 bar at 21°C.

12.5. The protective collar or neck ring must provide protection for the valve and any other fittings against accidental functioning and damage.

13. HYDROSTATIC TEST

13.1 The hydrostatic test shall be by the water jacket method, or other suitable methods, see CGA-C-1, and operated so as to obtain accurate data. Pressure gauge must permit reading to an accuracy of 1 percent. The calibrated expansion gauge must permit reading of total expansion to an accuracy of either 1 percent or 0.1 ml.

13.2 Pressure must be maintained for at least 30 seconds and sufficiently longer to ensure complete expansion. Any internal pressure applied after heat treatment and previous to the official test must not exceed 90 percent of the test pressure.

If, due to failure of the test apparatus, the test pressure cannot be maintained, the test may be repeated at a pressure increased by 10 percent or 7 bar, whichever is the lower.

13.3 Permanent volumetric expansion must not exceed 10 percent of total volumetric expansion at test pressure.

13.4 Each cylinder must be tested as follows :

- (i) at least two times service pressure; and
- (ii) One cylinder out of each lot of 200 or less to 3 times service pressure.

14 PRESSURE CYCLING TEST

14.1 Pressure cycling tests must be performed for each new design on three cylinders. The cylinders shall carry stamp marking in accordance with Section 21. The test shall be carried out using a non-corrosive pressurising fluid. The maximum pressure in the cycle shall either be the design test pressure of the cylinder, or 67% of this value. The minimum test pressure in the cycle shall not exceed 10% of the maximum pressure. The frequency of cycling shall not exceed 15 cycles/minute, and the temperature measured on the outside of the cylinder during the test shall not exceed 50°C.

14.2 Acceptance values for the test are:

- 12,000 cycles without failure when the maximum cycle pressure is the design pressure; or,
- 80,000 cycles without failure when the maximum cycle pressure is 67% of the design test pressure;

Failure shall be construed as leakage from any part of the cylinder other than from the neck/pipe joint.

14.3 Following attainment of the required number of cycles:

One of the three cylinders shall continue to be pressure cycled to destruction under the same cycle conditions. The number of cycles to destruction and mode of failure recorded;

Two of the three cylinders shall be subjected to the hydraulic burst test of Section 15.

15 HYDRAULIC BURST TEST

15.1 Two cylinders from each lot of 200 or less shall be subjected to a hydraulic burst test. The cylinders shall carry stamp marking in accordance with Section 21. The rate of pressurisation shall not exceed 5 bar/second. In the course of the test, the yield pressure, burst pressure, burst mode and volumetric expansion shall be recorded.

15.2 Test acceptance criteria are:

1. The yield pressure shall be equal to or greater than $\frac{4}{3}$ times design test pressure.
2. The burst pressure shall be equal to or greater than 1.6 times design test pressure.
3. The cylinder shall burst from a point within the sidewall.
4. The cylinder shall remain in one piece after bursting.

16. FLATTENING TEST

A flattening test must be performed on each cylinder taken at random out of each lot of 200 or less, by placing the cylinder between wedge shaped knife edges having 60° included angle, rounded to 13mm radius. The longitudinal axis of the cylinder must be at a 90° angle to knife edges during the test. For lots of 30 or less, flattening tests are authorised to be made on a ring at least 203mm long cut from each cylinder and subjected to the same heat treatment as the finished cylinder.

17. PHYSICAL TEST

To determine yield strength, tensile strength, elongation and reduction of area of material.

Required on 2 specimens cut from 1 cylinder taken at random out of each lot of 200 or less. For lots of 30 or less, flattening tests are authorised to be made on a ring at least 203mm long cut from each cylinder and subjected to the same heat treatment as the finished cylinder.

Specimens must be: Gauge length 203mm with width not over 38mm; or, gauge length 50.4mm with width not over 38mm or a gauge length at least 24 times thickness with width not over 6 times thickness is authorised when cylinder wall is not over 4.8mm. The specimen, exclusive of grip ends, must not be flattened. Grip ends may be flattened to within 25.4mm of each end of the reduced section. When the size of the cylinder does not permit securing straight specimens, the specimens may be taken in any location or direction and may be straightened or flattened cold, by pressure only, not by blows; when specimens are so taken and prepared, the Inspector's report must show, in connection with the record of physical tests, detailed information in regard to such specimens. Heating of the specimen for any purpose is not authorised.

The yield strength in tension shall be the stress corresponding to a permanent strain of 0.2 percent of the gauge length. The following conditions apply :

- (1) The yield strength shall be determined by either the 'offset' method or the 'extension under load' method as prescribed in ASTM Standard E8-78.
- (2) In using the 'extension under load' method, the total strain (or 'extension under load') corresponding to the stress at which the 0.2 percent permanent strain occurs may be determined with sufficient accuracy by calculating the elastic extension of the gauge length under appropriate load and adding thereto 0.2 percent of the gauge length. Elastic extension calculations shall be based on an elastic modulus of 30,000,000. In the event of controversy, the entire stress-strain diagram shall be plotted and the yield strength determined from the 0.2 percent offset.

- (3) For the purpose of strain measurement, the initial strain shall be set while the specimen is under a stress of 83 Mpa, the strain indicator reading being set at the calculated corresponding strain.
- (4) Cross-head speed of the testing machine shall not exceed 3mm per minute during yield strength determination.

18. ACCEPTANCE CRITERIA FOR PHYSICAL AND FLATTENING TESTS

Acceptable results for physical and flattening tests;

- a) elongation at least 40% for 50mm gauge length or at least 20% in other cases and yield strength not over 73% of tensile strength. In this instance, the flattening test is not required.
- b) elongation test at least 20% for a 50mm gauge length or 10% in other cases and a yield strength not over 73% of tensile strength. In this instance a flattening test is required without cracking to 6 times the wall thickness.

19. LEAKAGE TEST

- (a) All spun cylinders and plugged cylinders (see notes 1 and 2) must be tested for leakage by gas or air pressure after the bottom has been cleaned and is free from all moisture. Pressure, approximately the same as but no less than service pressure, must be applied to one side of the finished bottom over an area of at least 6.25% of the total area of the bottom but not less than 19mm in diameter, including the closure, for at least one minute, during which time the other side of the bottom exposed to pressure must be covered with water and closely examined for indications of leakage. Any cylinders exhibiting leakage must be rejected.

Note 1: A spun cylinder is one in which an end closure in the finished cylinder has been welded by the spinning process.

Note 2: A plugged cylinder is one in which a permanent closure in the bottom of a finished cylinder has been effected by a plug.

Note 3: As a safety precaution, if the manufacturer elects to make this test before the hydrostatic test, he should design his apparatus so that the pressure is applied to the smallest area practicable, around the point of closure, and so as to use the smallest possible volume of air or gas.

20. REJECTED CYLINDERS

(a) Reheat treatment of rejected cylinders is allowed. Subsequent thereto, acceptable cylinders must pass all prescribed tests. Repair by welding or spinning is not authorised.

Note 1: Spun cylinders rejected under the provision of Section 19 may be removed from the spun cylinder category by drilling to remove defective material, tapping and plugging.

21. MARKING

21.1 Each cylinder which complies with the requirements of this specification shall be permanently and legibly marked on the side walls adjacent to the top head with the following:

- (a) **DOT - 3B (HSE)** followed by the service pressure in bar at 15°C.
- (b) Cylinder serial number.
- (c) Manufacturer's mark or registration number.
- (d) The identification mark(s) of the Approved Verification Body.
- (e) Hydrostatic Test Pressure in bar.
- (f) The date of the hydrostatic test so placed that dates of subsequent tests can be easily added.
- (g) The design water capacity as specified in the design drawing.

- (h) The weight of the cylinder in kgs.
- (i) The words 'Spun' or 'Plug' must be placed near to the HSE specification number when an end closure in the finished cylinder has been welded by the spinning process or effected by plugging.

21.2 The marks shall be at least 6 mm in height.

21.3 The depth of stamping must be no greater than 15% of the minimum wall thickness, but may not exceed 0.38 mm

21.4 If steel carbon content exceeds 0.25%, the complete cylinder must be normalised after stamping.

22 PERIODIC INSPECTION AND TESTING

In-service inspection and testing may be carried out in accordance with the basic requirements of British Standard BS5430 : Part 1 "*Periodic inspection testing and maintenance of transportable gas containers for seamless steel containers.*" The duties concerning the in-service inspection of cylinders is covered under the requirements of Part 3 of "*The Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996*". (SI 2092).

APPENDIX 1

INSPECTORS REPORT

Manufacturing Location

Consigned to

Address

Quantity

Size mm outside diameter by mm long

Marks Stamped into the shoulder of the cylinder are:

Specification

Serial numbers to inclusive

Inspector's mark

Identifying Symbol (registered)

Test Date

Tare Weights

Other Marks (if any)

These cylinders were made by process of

.....

The cylinders were heat treated by the process of

.....

The material used was identified by the following

(heat-purchase order) numbers

The material used was verified as to chemical analysis and record thereof is attached hereto. The heat numbers

(were - were not) marked on the material.

All material, such as seamless tubing, was inspected and each cylinder was inspected both before and after closing the ends; all that was accepted was found free from seams, cracks, laminations and other defects which might prove injurious to the strength of the cylinder. The processes of manufacture and heat treatment of cylinders were supervised and found to be efficient and satisfactory. The cylinder walls were measured and the minimum thickness noted was mm. The outside diameter was determined by a close approximation to be mm. The wall stress was calculated to be N/mm² under an internal pressure bar.

Hydrostatic tests, bend tests, tensile tests of material, and other tests, as prescribed in this specification made in the presence of the inspector and all material and cylinders accepted were found to be in compliance with the requirements of this specification. Records thereof are attached hereto. I hereby certify that all of these cylinders proved satisfactory in every way and comply with the requirements of specification No: DOT - 3B (HSE).

Signed:

(Approved Verification Body)

(Place)

(Date)