



**SPECIFICATION FOR WELDED STEEL**

**NON REFILLABLE**

**TRANSPORTABLE PRESSURE**

**RECEPTACLES**

**DOT - 39 (HSE)**

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## 1. SCOPE

This specification details the requirements for the material, design, construction and testing of welded steel gas cylinders over 1.4 kg but not over 4.55 kg water capacity and service pressure not exceeding 155 bar.

For cylinders intended to contain toxic gases or toxic gas mixtures the water capacity shall not exceed 2 kg.

A 'transportable pressure receptacle' has the same meaning as that given in "*The Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996*". In this specification, it is referred to as a 'cylinder'.

## 2. CERTIFICATE OF COMPLIANCE

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

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

## 3. REFERENCES

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

## 4. PERMITTED STEEL

AISI 1010 or 1020 aluminium killed steel with the following composition:-

	Ladle analysis	Check analysis
Carbon, maximum percentage	0.12	0.15
Phosphorous, maximum percentage	0.04	0.05
Sulphur, maximum percentage	0.05	0.06

## **5. IDENTIFICATION OF MATERIAL**

The material of construction shall be identified by a suitable method agreed with the Approved Verification Body.

## **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.

## **8. WELDING OR BRAZING**

Brazing for any purpose whatsoever is prohibited.

8.1 Welded seams must be properly aligned and welded by a method that provides clean, uniform joints with adequate penetration.

8.2 Welded joints must have a strength equal to or greater than the minimum strength of the shell material in the finished cylinder.

8.3 Attachments to the cylinder are permitted by any means that will not be detrimental to the integrity of the cylinder as agreed with the Approved Verification Body.

8.4 All welding must be completed prior to any pressure testing.

8.5 Welding procedures and operators used for each cylinder must be qualified by the Approved Verification Body.

## 9. WALL THICKNESS

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

9.1.1 The minimum wall thickness must be such that the wall stress at the test pressure does not exceed the yield strength of the material of the finished cylinder wall.

9.1.2 The service pressure does not exceed 80% of the test pressure.

9.1.3 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 - bar

D = outside diameter in mm

d = inside diameter in mm

## 10. OPENINGS AND ATTACHMENTS

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

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

10.3 Parallel threads having at least 6 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.

10.4 Openings and attachments are permitted on heads only.

10.5 All openings and their reinforcements must be within an imaginary circle, concentric to the axis of the cylinder. The diameter of the circle may not exceed 80% of the outside diameter of the cylinder. The plane of the circle must be parallel to the plane of the circumferential weld and normal to the longitudinal axis of the cylinder.

10.6 Area replacement calculations must be carried out on each opening and where the head has insufficient thickness, each opening must be reinforced by a securely attached fitting, boss, pad, collar or other suitable means.

10.7 Material used for welded openings and attachments must be of weldable quality and compatible with the material of the cylinder.

## **11. PRESSURE RELIEF DEVICES**

### **11.1. 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 or heating effects of the contents of the cylinder during discharge shall not prevent the effective operation of the relief 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.

### **11.2. 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 liquefiable petroleum gas cylinders for service in Great Britain.

Where liquefiable 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.

### **11.3. 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 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.

#### **11.4. Cylinder valve protection.**

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

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

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

11.4.3. 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.

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

11.4.6. By equipping with valves strong enough to avoid damage during transit for cylinders containing non liquefied gas under pressure not exceeding 20.7 bar (300 p.s.i.) at 21°C (70°F).

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

#### **12. HYDROSTATIC TEST**

12.1 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 gauges must permit reading to an accuracy of 1 percent.

12.2 Each cylinder must be tested. Pressure must be maintained for at least 30 seconds.

12.4 Each cylinder must be tested to at least the greater of the maximum developed pressure of the contents at 54.5 °C or 12.7 bar.

12.5 Following the hydrostatic test, each cylinder must be dried out using a method that is approved by the Approved Verification Body.

### **13 LEAKAGE TEST**

13.1 Each cylinder must be subjected to a leakage test.

13.2 The leakage test must be conducted by submersion under water or by some other equally effective measure.

13.3 If the cylinder leaks, evidences visible distortion, or any other defect, whilst under test, it must be rejected.

### **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:

- 10,000 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 pressure;

Failure shall be construed as leakage from any part of the cylinder other than at 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 and the number of cycles causing destruction and the mode of failure recorded;

Two of the three cylinders shall be subjected to the hydraulic burst test of section 16.

## 15 NEW DESIGN

A previously approved cylinder shall be considered to be of a new design when any of the following conditions apply:

- a) It is manufactured in a different factory (see Note 1).
- b) It is manufactured by a significantly different process. A significant change is regarded as a change that would have a measurable change in the performance of the finished cylinder. The Approved Verification Body shall determine when a change in process or design or manufacture is significantly different from the original qualified design.
- c) The hydraulic test pressure has changed by more than 60% (see Note 2).
- d) The cylinder diameter has changed by more than 50%.

Note 1: Where a factory moves to a different location with the same equipment, a reduced testing programme may be agreed with the Approved Verification Body.

Note 2: A cylinder may be used and marked for a lower test pressure than stated in the original type approval without additional testing.

## 16 HYDRAULIC BURST TEST

16.1 Cylinders from each lot shall be subjected to a hydraulic burst test in accordance with the table 16.1 below. 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 burst pressure and burst mode shall be recorded.

Maximum Service Pressure x Volume of cylinder	Minimum sampling frequency
0 to 50	1/1000
51 to 300	1/750
301 to 600	1/500
601 to 1000	1/200

Table 16.1 Minimum sampling frequency for the lot tests.

16.2 Test acceptance criteria are:

1. The burst pressure shall be equal to or greater than 2 times the design test pressure.
2. The cylinder shall burst from a point within the sidewall along the longitudinal axis.
3. The cylinder shall remain in one piece after bursting
4. The burst is not within the heat effected zone of any weld.

**NB** A lot is defined as the quantity of cylinders successively produced per production shift (not exceeding 10 hours) having identical size, design, construction, material, heat treatment, finish and quality.

## **17. DROP TEST**

17.1 Drop tests shall be carried out on a minimum of three cylinders from each new design.

17.2 The impact surface shall be concrete block 1m by 1m by 0.1m thick, from a single cast composed of cement, sand and gravel. It shall be protected by a sheet of 10mm thick steel. The flatness of the protective sheet shall be such that the difference in level of any two points on its surface shall not exceed 2mm. It must be changed when significantly damaged.

17.3 Cylinders for use with liquefiable gases shall be filled to the maximum water capacity of the cylinder. Cylinders used for permanent gases shall be filled with water to 40% of the water capacity of the cylinder.

17.4 No cylinder shall be pressurised for the drop test.

17.5 The drop test procedure shall be :

i) One cylinder shall be dropped from a height of 1.2m with the bottom of the cylinder striking the impact surface of 17.2.

ii) One cylinder shall be dropped from a height of 1.2m with its sidewall striking the impact surface of 17.2

iii) One cylinder shall be dropped from a height of 1.2m with the cylinder cap, collar, guard or other valve protection striking the impact surface at a 45 ° degree angle.

17.6 The acceptance criteria for the drop tests shall be :-

i) For cylinders test to 17.5 i) and ii), the cylinder shall exhibit no leakage, and then the cylinder shall pass the burst test of section 16.

ii) For cylinders tested to 17.5 iii), the cylinder shall exhibit no leakage, the valve shall remain operational and the cylinder shall pass the burst test of section 16.

## **18. FLATTENING TEST**

18.1 Cylinders from each lot shall be subjected to a flattening test in accordance with table 16.1 after the cylinders have been hydrostatically tested.

18.2 A ring taken from the cylinder may be flattened as a alternative to a test on a complete cylinder. The test ring must include the heat affected zone.

18.3 The flattening must be 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.

18.4 Cylinders and test rings may not crack when flattened so that their outer surfaces are not more than six times wall thickness apart.

18.5 If any cylinder or test ring cracks when subjected to the flattening test, the lot of cylinders represented by the test must be rejected.

## **19. DIMENSIONAL CHECKS**

19.1 Cylinders from each lot in accordance with table 16.1 shall be subject to dimensional checks.

19.2 The cylinder shall be longitudinally sectioned into sufficient pieces to determine the minimum thickness in the cylinder shell. Alternatively ultrasonic measurement or any other equally sensitive method, as approved by the Approved Verification Body, may be used.

19.3 The minimum thickness shall not be less than the minimum thickness calculated in section 9.

19.4 The nominal outside diameter, length and head radii shall be measured and be in accordance with the design drawings.

19.5 Each completed cylinder shall be placed on a scale to determine the cylinder tare weight. Each cylinder shall then be filled with liquid to the maximum volume of the cylinder to determine the water capacity. The cylinder tare weight and water capacity shall be recorded.

19.6 Cylinders not meeting the design tare weight or water capacity must be rejected.

## **20. REJECTED CYLINDERS**

Rejected cylinders must conform to the following requirements :-

i) If the cause for the rejection of the lot is determinable, and if by test or inspection defective cylinders are eliminated from the lot, the remaining cylinders, with written agreement from the Approved Verification Body, must be qualified as a new lot.

ii) Repairs to welds are permitted. Following repair, a cylinder must pass the pressure test specified in section 12.

iii) If a cylinder made from seamless steel tubing fails the flattening test describe in section 18, heat treatment shall be performed to a procedure agreed in writing with the Approved Verification Body on each cylinder in the lot. All tests must be performed subsequent to this heat treatment.

## **21. MARKING**

21.1 Each cylinder which complies with the requirements of this specification shall be marked in a durable and waterproof manner on the shoulder, top head or neck, with the following:



- (a) DOT - 39(HSE)
- (b) NRC
- (c) The service pressure in bar
- (d) The identification mark(s) of the approved Inspection Body.
- (e) Hydrostatic Test Pressure in bar.
- (f) The date of the hydrostatic test in bar.
- (g) The design water capacity as specified in the design drawing in kg.
- (h) *“This cylinder must not be refilled.”*

21.2 The marks shall be at least 3 mm in height and displayed sequentially.

**APPENDIX 1**

**INSPECTOR'S REPORT**

Manufacturing Location .....

Consigned to .....

Address .....

Quantity .....

Size ..... mm outside diameter by ..... mm long

Marks on the cylinder are:

Specification .....

Serial numbers ..... to ..... inclusive

Inspector's mark .....

Identifying Symbol (registered) .....

Test Date .....

Capacity .....

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/mm<sup>2</sup> under an internal pressure of ..... bar.

Hydrostatic tests, flattening tests, and other tests, as prescribed in this specification made in the presence of the Approved Verification Body 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 - 39 (HSE).

Signed: .....

(Approved Verification Body)

(Place) .....

(Date) .....