HOME OFFICE

SPECIFICATION FOR SEAMLESS ALLOY STEEL CYLINDERS FOR THE CONVEYANCE OF COMPRESSED GASES

HOT

Cylinders manufactured to these specifications shall be manufactured by a cylinder manufacturer on the Home Office list of recognised manufacturers of alloy steel cylinders. The steel from which the cylinders are made shall have been manufactured by a steel manufacturer on the Home Office list of recognised manufacturers of steel for cylinders. The method of manufacture and the testing of the cylinders at the works of the cylinder manufacturer shall be carried out to the satisfaction of an inspecting authority on the Home Office list of recognised inspecting authorities.

The cylinders shall only be made by a process which has been shown to produce cylinders free from cracks.

Cylinders shall not be filled with gas unless steps have been taken to ensure that, at the time of filling, the gas is as far as is reasonably practicable, free from moisture.

Cylinders shall not be filled with carbon monoxide, coal gas, hydrogen or methane unless steps have been taken to ensure that, at the time of filling, the gas is free from hydrogen sulphide and is, as far as is reasonably practicable, free from organic sulphur impurities.

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Scope

1. Cylinders manufactured in accordance with this specification shall not exceed a capacity of 25 lbs of water and may only be used in aircraft, for portable resuscitation apparatus, for breathing apparatus used for rescue purposes or for portable fire extinguishers.

Quality of Material

2. The steel used in the manufacture of the cylinders shall have been made by the acid or basic open-hearth process or in an electric furnace, by a steel manufacturer who affords to the cylinder manufacturer facilities for inspection of the steel at the steel manufacturer's works.

Chemical Composition

3. The steel used in the manufacture of the cylinders shall on analysis give one of the following results:

(i) *Manganese Molybdenum Steel**

Carbon	not less than 0.25 per cent and not more than 0.40 per cent
Silicon	not less than 0.10 per cent and not more than 0.35 per cent
Manganese	not less than 1.30 per cent and

. . . . .	not more than 1.80 per cent
Molybdenum	not less than 0.20 per cent and not more than 0.40 per cent
Sulphur	not more than 0.05 per cent
Phosphorus	not more than 0.05 per cent

(ii) *Chromium Molybdenum Steel*

Carbon	not more than 0.37 per cent
Silicon	not less than 0.10 per cent and not more than 0.35 per cent
Manganese	not less than 0.40 per cent and not more than 0.90 per cent
Nickel (residual)	not more than 0.50 per cent
Chromium	not less than 0.80 per cent and not more than 1.20 per cent
Molybdenum	not less than 0.15 per cent and not more than 0.25 per cent
Sulphur	not more than 0.05 per cent
Phosphorus	not more than 0.05 per cent

(iii) *Nickel Chromium Molybdenum Steel*

Carbon	not less than 0.27 per cent and not more than 0.35 per cent
Silicon	not less than 0.10 per cent and not more than 0.35 per cent
Manganese	not less than 0.50 per cent and not more than 0.70 per cent
Nickel	not less than 2.30 per cent and not more than 2.80 per cent
Chromium	not less than 0.50 per cent and not more than 0.80 per cent
Molybdenum	not less than 0.40 per cent and not more than 0.70 per cent
Sulphur	not more than 0.05 per cent
Phosphorus	not more than 0.05 per cent

* Manganese molybdenum steel in accordance with BS. 970:1955, EN 16 conforms with these requirements except that this specification restricts the carbon content to a minimum of 0.30 per cent, and the maximum molybdenum content to 0.35 per cent.

Chromium molybdenum steel in accordance with BS T.59: 1948 conforms with these requirements except that this specification restricts the carbon to a maximum of 0.26 per cent.

Nickel chromium molybdenum steel in accordance with BS 970: 1955, EN 25 conforms with these requirements.

Steel Maker's Certificate

4. The cylinder manufacturer shall have obtained from the steel manufacturer a certificate that the material from which the billets specified in the certificate have been produced has been made by one of the processes specified in paragraph 2 and giving details of the chemical analysis.

Marking of Steel

5. The steel shall be marked and records shall be kept so as to enable the material from which any cylinder is made to be identified.

Manufacture of Cylinders

6. The cylinders shall be of an approved shape and shall be solidly drawn or made from seamless steel tube.

Thickness of Cylinder Walls

7. The thickness of the cylinder wall shall be not less than the value of t (in inches) given by the following formulae whichever is the greater:-

$$t = \frac{pDi}{2f - p} \quad * \qquad t = 0.027 \surd Di$$

where p = the maximum working pressure in lbs per square inch
f = the maximum stress of 56,000 lbs per square inch
Di = internal diameter in inches.

For cylinders liable to external corrosion during use an appropriate margin shall be added to the value of t to obtain the nominal wall thickness of the cylinder, that is the design value shown on the drawing.

External corrosion protection in accordance with P D 420: 1953 Grade 1 but with a metallic zinc coating not less than 0.005 in. thickness may be used as an alternative to the recommended increase in wall thickness, provided that the thicknesses of the metal and paint coatings are each checked instrumentally for minimum and even thickness and the results recorded.

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* Alternatively the formula $t = \frac{pDe}{2f + p}$ may be used in which De refers to the external diameter of the cylinder in inches.

For air, nitrogen and oxygen the maximum working pressure shall be the pressure to which it is intended to fill the cylinder at 60°F.

For carbon dioxide a nominal pressure of 1980 lbs per square inch shall be assumed for the maximum working pressure.

Examination of Cylinder before Closing-in

8. Each cylinder shall be examined before the closing-in operations for maximum and minimum thickness and for external and internal surface defects. The wall thickness shall be not less than the design thickness at any point.

Heat Treatment

9. Each cylinder after manufacture shall be hardened by cooling in air or in oil from the appropriate temperature as stated in BS 970: 1955 or BS T.59 : 1948. Each cylinder after hardening shall be tempered at a temperature not exceeding 660°C and shall then be cooled in air The method of cooling shall be chosen by means of hardenability tests so as to ensure that a cylinder is adequately hardened throughout.

Examination for Internal Folds in the Neck

10. One finished cylinder in every batch constructed or, when the number in any batch exceeds 100, one cylinder in every 100 shall be examined for the presence of internal folding in the neck. Cylinders shall not be regarded as in a single batch unless they are of similar analysis and heat-treated in the same manner at the same temperature $\pm$ 20°C. The cylinder selected for examination may be used for the tensile test (paragraph 12), the impact test (paragraph 13 and the bend test (paragraph 14).

A thin sheet ring of internal diameter equal to two thirds of the outside diameter of the parallel portion of the cylinder shall be placed over the cylinder neck which shall be sectioned at right angles to the longitudinal axis of the cylinder at the position where the ring rests on the neck. The depth of folds in the section shall be measured by an approved method (eg magnetic crack detection). The maximum depth of any fold in the section shall not exceed 7 per cent of the cylinder wall thickness in the section in cases where the minimum design thickness of the parallel portion of the cylinder does not exceed 0.3 inch. For cylinders of minimum design thickness of the parallel portion of the cylinder does not exceed 0.3 inch. For cylinders of minimum design thickness t greater than 0.3 inch the maximum depth of fold in the section shall not exceed 7 x 0.3 per cent of the cylinder wall thickness t in the section. In no case shall the wall thickness at the section, after deduction of the permissible depth of fold stated, be less than the design thickness of the parallel portion of the cylinder.

Where the cylinder fails to pass the test, the batch shall be rejected and no further production batches shall be made until the process of manufacture has been examined and corrected to the satisfaction of the inspecting authority.

Hardness Test

11. Each cylinder after final heat treatment shall be subjected to a Brinell hardness test complying with BS 240, 'Method for Brinell hardness test', Part I, 'Testing of Metals'. The diameter of the ball and load shall be such as not to damage the cylinder and shall be in the relationship of $\frac{\text{LOAD}}{(\text{BALL DIA.})^2} = 30$. The impression shall be placed on the body of the cylinder. The surface of the cylinder may be prepared by lightly polishing with abrasive paper where the impression is to be placed, but the thickness of the wall must not thereby be reduced below the minimum value given under paragraph 7. The Brinell hardness number shall be not less than 245 and not more than 308.

Tensile Tests

12. Tensile tests shall be made on the material of one finished cylinder in every batch constructed or when the number in any batch exceeds 100 on the material of at least one finished cylinder in every 100. Cylinders shall not be regarded as in a single batch unless they are of similar analysis heat-treated in the same manner and at the same temperature $\pm$ 20°C.

The tests shall be made on a strip, cut longitudinally from the finished cylinder or ring of the form shown in Fig. 1.

In preparing the test piece, only the edges shall be machined; the face and back of the test piece shall each represent the surface of the cylinder as manufactured.

The results of the tensile test shall conform to the following conditions:-

(a) Yield Stress: Not less than 44 tons per square inch.

(b) Tensile Strength: Not less than 55 tons per square inch and not more than 65 tons per square inch.

(c) Elongation:

on eight inches, Test Piece A, ¾ inch wide according to BS 18: Not less than 7 per cent.

on 5.65√ area, Test Piece A, according to BS 18: Not less than 13 per cent.

on 4√ area, Test Piece A, according to BS 18: Not less than 16 per cent.

Notched Bar Impact Test

13. Notched bar impact test pieces shall be cut from the same cylinder as that used for the tensile test (paragraph 12). The test shall only be made on the material of cylinders where the plate thickness permits of the requisite test pieces being obtained.

Six test pieces shall be cut - three in a longitudinal and three in a circumferential direction - and machined to the dimensions shown in Fig. 2.

The mean energy required for fracture shall be not less than 4.5 ft lbs for the circumferential test pieces and 10 ft lbs for the longitudinal test pieces[1].

Bend Test

14. Cold bend tests shall be made on four strips cut from the same cylinder as that used for the tensile test (paragraph 10) the impact test (paragraph 11). A ring one inch in width shall be cut from the cylinder and be divided into four strips of equal length. Each strip shall be machined on the edges only. Each strip shall remain uncracked when bent inwards round a former of diameter equal to six times the thickness of the strip until the interior edges are at a distance apart not greater than the diameter of the former.

Hydraulic Stretch Test

15. Each completed cylinder shall be subjected to a hydraulic stretch test, preferably by the 'water-jacket'[2] method. The proof pressure applied internally in this test shall be 1 1/3 times the working pressure for cylinders designed in accordance with the first formula in paragraph 7 and shall be equal to $\frac{4{,}000}{\sqrt{Di}}$ lbs per square inch (Di = internal diameter of cylinder in inches) for cylinders designed in accordance with the second formula in paragraph 7. If a cylinder has been designed with a corrosion allowance then the test pressure shall be increased by that percentage by which the design thickness exceeds the thickness required by paragraph 7. Except in a case where under hydraulic stretch test the test pressure has not been reached owing to a fault of the instrument, and the inspecting authority is satisfied that in the process no permanent set has been taken up by the cylinder, no pressure greater than the working pressure shall have been applied to the cylinder before the test. The cylinder shall be deemed to have passed the test if the permanent stretch is not greater than 10 per cent of the total stretch under the proof pressure. Should any cylinder fail to meet the requirements of the hardness test described in paragraph 11, or should its permanent stretch exceed 10 per cent of the total stretch under the proof pressure, it may be re-heat treated in accordance with the method described in paragraph 9, and again subjected to the hardness test and the hydraulic stretch test; if it then passes those tests it may be released for service.

Results of Tests

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1 Until further notice a mean energy of fracture of 3 ft lbs may be accepted for circumferential test pieces taken from cylinders manufactured from manganese molybdenum steel.

2 The 'water-jacket' method is that in which the cylinder is enclosed in a vessel which is filled with water and which is fitted with a gauge glass projecting from its upper cover The changes in volume of the cylinder on applying and after removal of the internal hydraulic pressure are measured by the changes in level of the water in the gauge glass.
An alternative method is the non-jacket method, in which the cylinder is not enclosed. The changes in volume are determined (subject to certain corrections) by the movement of the water level in a gauge glass from which the water is drawn by the pump in applying the internal hydraulic pressure.

16. A record shall be kept by the cylinder manufacturer of all tests specified to be made in this specification and of their results, and copies of such records shall be forwarded to the purchasers of the cylinders.

If any of the tests specified in this specification results in a cylinder or batch of cylinders failing to pass the test, the cylinder or batch as the case may be shall be rendered unserviceable for the conveyance of any compressed gas.

Re-heat Treatment

17. If, for any reason, the re-heat treatment of any cylinder is considered desirable, the treatment specified in paragraph 9 shall be applied. After any such re-heat treatment the cylinder shall be thoroughly examined and subjected to the hydraulic stretch test specified in paragraph 15.

Marking

18. Each cylinder shall be permanently and visibly marked with:-

(a) Manufacturer's and owner's identification marks and rotation number.

(b) The maximum working pressure and the test pressure.

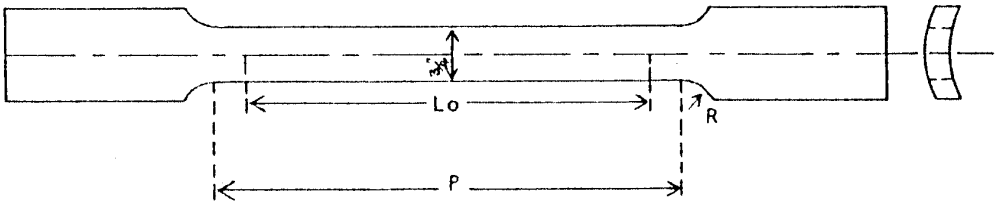
(c) Date of last hydraulic test. This may be indicated by the month and year or by the year with a symbol to denote the quarter of the year.

(d) A mark indicating this specification, that is to say HOT. Or the mark may be that of the equivalent British Standards.

Fig. 1

LONGITUDINAL TENSILTE TEST PIECE

Ends may be flattened for grips



This portion must not be flattened.

DIMENSIONS OF TENSILE TEST PIECE

GAUGE LENGTH Lo	MINIMUM PARALLEL LENGTH P	MINIMUM RADIUS AT SHOULDER R	APPROXIMATE TOTAL LENGTH
5 in.	9 in.	3 in.	15 in.
5.65√ area	Lo + ½ in.	1 in.	p + 6 in.
or 4√ area			

Fig. 2

CANTILEVER TYPE IMPACT TEST PIECES