भारतीय मानक
*Indian Standard*

**IS 7285 (Part 1) : 2018**

# फिर से भरे जा सकने वाले निर्बाध इस्पात के गैस सिलेंडर — विशिष्टि

भाग 1 सामान्यीकृत इस्पात सिलेंडर

*(चौथा पुनरीक्षण)*

# Refillable Seamless Steel Gas Cylinders — Specification

Part 1 Normalized Steel Cylinders

*( Fourth Revision )*

ICS 23.020.30



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FOREWORD

This Indian Standard (Part 1) (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Gas Cylinders Sectional Committee had been approved by the Mechanical Engineering Divisional Council.

This standard was first published in 1974 as IS 7285 'Specification for seamless steel cylinders for permanent and high pressure liquefiable gases', when the manufacture of seamless steel gas cylinders had not started in our country and subsequently revised in 1982, 1988 due to technological development made by the gas cylinder industry. Subsequently, this Part of standard was published together with Part 2 'Quenched and tempered steel cylinder with tensile strength less than 1 100 MPa (112 kgf/mm$^2$)' superseding IS 7285 : 1988. Further this standard (Part 1) was revised in 2004. In this revision efforts have been made to align with ISO 9809-3:2010 'Gas cylinder – Refillable seamless steel gas cylinders – Design, construction and testing – Part 3 Normalized steel cylinders'. However, considering the prevailing practices of cylinder manufacturing in the country, necessary additions are made wherever necessary.

Assistance has also been taken from ISO 13769 : 2007 'Gas cylinders — Stamp-marking'

The purpose of this standard is to provide a specification for the design, manufacture, inspection and testing of a cylinder for worldwide usage. The objective is to balance design and economic efficiency against International acceptance and universal utility.

Cylinders for on-board storage of compressed natural gas (CNG) as fuel for automobile vehicles application covered in IS 15490 : 2004 'Cylinders for on-board storage of compressed natural gas as a fuel for automotive vehicles — Specification'. Periodic inspection and testing of high pressure gas cylinders is covered in IS 8541 : 2009 'Periodic inspection and testing of high pressure gas cylinders — Code of practice'.

While implementing this standard, the manufacturer and the inspection agency shall ensure compliance with statutory regulations. It is the responsibility of the owners and the users to ensure that the cylinders are periodically tested as per norms laid down in *Gas Cylinder Rules,* 2004 as amended from time to time and as enforced by statutory authorities under the rules.

The relevant SI units and corresponding conversion factors are given below for guidance:

Pressure 1Pa (Pascal) = 1 N/m$^2$

1 kgf/mm$^2$ = 9.806 65 MPa

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard*

# REFILLABLE SEAMLESS STEEL GAS CYLINDERS — SPECIFICATION

## PART 1 NORMALIZED STEEL CYLINDERS

*( Fourth Revision )*

### 1 SCOPE

This standard specifies minimum requirements for the material, design, construction and workmanship, manufacturing processes and tests at manufacture of refillable normalized or normalized and tempered seamless steel gas cylinders of water capacities from 0.5 litre upto and including 400 litres for compressed, liquefied and dissolved gases.

NOTES

**1** If so desired, cylinders of water capacity less than 0.5 litre may be manufactured and certified according to this standard.

**2** If so desired, cylinders of water capacity greater than 400 litres may be manufactured and certified according to this standard. The number of cylinders to be subjected to pressure cycling test and sampling method for mechanical tests shall be decided in consultation with the statutory authority.

### 2 REFERENCES

The standards listed below contain provisions which, through reference in this text constitute provisions of this standard. At the time of publication, the editions were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

| *IS No.* | *Title* |
|---|---|
| 1500 : 2005 | Method for brinell hardness test for metallic materials (*third revision*) |
| 1586 : 2000 | Method for Rockwell hardness test for metallic materials (scales A-B-C-D-E-F-G-H-K 15N, 30N, 45N, 15T, 30T and 45T) (*third revision*) |
| 1608 : 2005 | Mechanical testing of metals tensile testing (*second revision*) |
| 1757 (Part 1) : 2014 | Metallic materials — Charpy pendulum impact test: Part 1 Test method (*third revision*) |
| 2878 : 2004 | Fire extinguisher, carbon dioxide type (portable and trolley mounted) — Specification (*third revision*) |
| 3224 : 2002 | Valve fittings for compressed gas cylinders excluding liquefied petroleum gas LPG) cylinders — Specification (*fourth revision*) |
| 3745 : 2006 | Yoke type valve connections for small medical gas cylinders — Specification (*second revision*) |
| 3933 : 1966 | Colour identification of gas cylinders and related equipment intended for medical use |
| 4218 | ISO Metric screw threads: |
| (Part 1) : 2001 | Basic and design profiles (*second revision*) |
| (Part 2) : 2001 | General plan (*second revision*) |
| (Part 3) : 1999 | Basic dimensions (*second revision*) |
| (Part 4) : 2001 | Selected sizes for screws, bolts and nuts (*second revision*) |
| 14962 | ISO general purpose metric screw threads — Tolerances: |
| (Part 2) : 2001 | Limits of sizes for general purpose external and internal screw threads – Medium quality |
| (Part 3) : 2001 | Deviations for constructional screw threads |
| 4258 : 2011 | Metallic materials — Conversion of hardness values (*second revision*) |
| 4379 : 1981 | Identification of the contents of industrial gas cylinder (*first revision*) |
| 5844 : 2014 | Hydrostatic stretch testing of compressed gas cylinders — Recommendations (*first revision*) |
| 7241 : 1981 | Glossary of terms used in gas cylinder technology (*first revision*) |
| 15683 : 2006 | Portable fire extinguishers — Performance and construction — Specification |
| IS/ISO 11114-1 : 2012 | Gas cylinders — Compatibility of cylinder and valve materials with gas contents : Part 1 Metallic materials |

### 3 TERMINOLOGY

In addition to the definitions given in IS 7241, the following definitions shall apply:

**3.1 Yield Stress ($R_e$)** — Value corresponding to the lower yield stress $R_e$ or for steels that do not exhibit a defined yield, the 0.2 percent proof stress (non-proportional elongation) $R_{p02.}$

**3.2 Normalizing —** Heat treatment in which a cylinder is heated to a uniform temperature above the upper critical point ($Ac_3$) of the steel and then cooled in still air.

**3.3 Tempering —** Softening heat treatment which follows normalizing, in which the cylinder is heated to a uniform temperature below the lower critical point ($Ac_1$) of the steel.

**3.4 Batch —** A quantity of up to 200 cylinders plus cylinder for destructive testing of the same nominal diameter, thickness and design made, successively from the same steel and subjected to the same heat treatment for the same duration of time.

**3.5 Working Pressure ($P_w$)/Service Pressure —** Working pressure for permanent gas means the settled internal pressure of the gas in the cylinder at a temperature of 15°C.

**3.6 Test Pressure ($P_h$) —** Test pressure means the internal pressure required for the hydrostatic test or the hydrostatic stretch test of the cylinders.

NOTE — It is used for cylinder wall thickness calculation.

**3.7 Burst Pressure ($P_b$) —** Highest pressure reached in a cylinder during a burst test.

## 4 SYMBOLS

$a$ = calculated minimum thickness, in millimetres, of the cylindrical shell;

$a'$ = guaranteed minimum thickness, in millimetres, of the cylindrical shell (*see* Fig. 1);

$a_1$ = guaranteed minimum thickness, in millimetres, of a concave base at the knuckle (*see* Fig. 2);

$a_2$ = guaranteed minimum thickness, in millimetres, at the centre of a concave base (*see* Fig. 2);

$A$ = percentage elongation on gauge length $5.65\sqrt{S_o}$;

$b$ = guaranteed minimum thickness, in millimetres, at the centre of a convex base (*see* Fig. 1);

$d_2$ = maximum permissible deviation of burst profile, in millimetres (*see* Fig. 5);

$D_o$ = nominal design outside diameter of the cylinder, in millimetres, (*see* Fig. 1);

$D_i$ = nominal inside diameter of the cylinder, in millimetres;

$D_F$ = diameter, in millimetres, of former (*see* Fig. 9);

$h$ = outside depth (concave base end), in millimetres (*see* Fig. 2);

$H$ = outside height, in millimetres, of domed part (convex head or base end) (*see* Fig. 1);

$l$ = length of cylindrical part of the cylinder, in millimetres (*see* Fig. 3);

$L_o$ = original gauge length, in millimetres;

$n$ = ratio of diameter of bend test former to actual thickness of test piece ($t$);

$P_b$ = measured burst pressure, in bar or kgf/cm$^2$;

$P_h$ = hydraulic test pressure, in bar or kgf/cm$^2$, above atmospheric pressure;

$P_w$ = working pressure/Service pressure, in bar or kgf/cm$^2$, above atmospheric pressure;

$P_y$ = observed pressure when cylinder starts yielding during hydraulic bursting test, in bar or kgf/cm$^2$;

$r$ = inside knuckle radius, in millimetres (*see* Fig.1 and Fig. 2);

$R_e$ = minimum guaranteed value of yield strength (*see* **3.1**) in MPa or kgf/mm$^2$;

$R_{ea}$ = value of the actual yield strength, in MPa or kgf/mm$^2$, as determined by the tensile test;

$R_g$ = minimum guaranteed value of tensile strength, in MPa or kgf/mm$^2$;

$R_m$ = actual value of tensile strength, in MPa or kgf/mm$^2$, as determined by the tensile test;

$R_{m\,Max}$ = maximum guaranteed value of tensile strength, in MPa or kgf/mm$^2$;

$S_o$ = original cross-sectional area of tensile test piece, in square millimetres according to IS 1608;

$t$ = actual thickness of the test specimen, in millimetres;

$u$ = ratio of distance between knife edges or platens in the flattening test to average cylinder wall thickness at the position of test;

$V$ = water capacity of cylinder, in litres; and

$w$ = width, in millimetres, of the tensile test piece.

## 5 MATERIALS

### 5.1 General Requirements

**5.1.1** The steel used shall be such that its properties met the requirements of the finished product. The steel shall be aluminium or silicon killed with non-aging properties, other than rimming qualities. The chemical composition of all steels shall be declared and defined at least by:

a) carbon, manganese and silicon content in all cases;

b) chromium, nickel, molybdenum, vanadium and that of any other alloying elements intentionally added; and

c) maximum sulphur and phosphorus contents in all cases.

NOTES

**1** When aluminium or a combination of aluminium and silicon is used for killing the steel, the requirement regarding minimum silicon content does not apply.

**2** When steel is aluminium killed, nitrogen content shall be limited to 0.01 percent.

**3** When steel is aluminium killed by aluminium alone, nitrogen content is limited to 0.007 percent.

**5.1.2** The cylinder manufacturer shall establish means to identify the cylinders with the cast of steel from which they are made.

**5.1.3** Grades of steel used for cylinder manufacture shall be compatible with the intended gas service, for example corrosive gases, embrittling gases (*see* IS/ ISO 11114-1).

### 5.2 Controls on Chemical Composition

**5.2.1** The steel used in the manufacture of gas cylinder shall be as per chemical composition specified in Table 1, unless otherwise permitted by the statutory authority.

The actual content of any element deliberately added shall be reported and their maximum content shall be representative of good steel making practice.

**Table 1 Chemical Composition of Steel (cast analyses) in Percentage**
(*Clauses* 5.2.1 and 5.4)

| Sl No. (1) | Element (2) | Contents (3) |
|---|---|---|
| i) | Carbon | 0.45, *Max* |
| ii) | Manganese | 1.20 – 1.70 |
| iii) | Silicon | 0.10 – 0.35 |
| iv) | Chromium | 0.20, *Max* |
| v) | Nickel | 0.20, *Max* |
| vi) | Copper | 0.20, *Max* |
| vii) | Combined value of micro alloyingelements: that is, V, Nb, Ti, B, Zr, Sn | 0.15, *Max* |
| viii) | Sulphur | 0.015, *Max* |
| ix) | Phosphorus | 0.02, *Max* |
| x) | Sulphur + Phosphorus | 0.03, *Max* |

NOTE — Actual cast analysis shall comply with **5.2.2**.

**5.2.2** The carbon, manganese silicon and molybdenum contents shall be given, with tolerances, such that the differences between the maximum and minimum values of the cast do not exceed the values given in col 5 of Table 2.

**Table 2 Chemical Composition Tolerances**
(*Clauses* 5.2.2 and 5.2.3)

| Sl No. | Element | Maximum Content in Percentage | Maximum Permissible Deviation in Percentage | Maximum Permissible Range in Percentage |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| i) | Carbon | < 0.30 | 0.06 | 0.06 |
| | | ≥ 0.30 | 0.07 | 0.07 |
| ii) | Manganese | All values | 0.30 | 0.30 |
| iii) | Silicon | All values | 0.30 | 0.30 |
| iv) | Molybdenum | All values | 0.15 | 0.15 |

**5.2.3** The cylinder manufacturer shall obtain and provide certificates of cast (heat) analysis of the steels supplied for the construction of gas cylinders. If check analysis is required, they shall be carried out either on specimen taken during manufacture from the material in the form as supplied by the steel maker to the cylinder manufacturer, or from finished cylinders. In any check analysis, the maximum permissible deviation from the values obtained for the cast analysis of that particular heat/cast, shall conform to the values specified in col 4 of Table 2.

### 5.3 Heat Treatment

The heat treatment process applied to the finished cylinder shall be either normalizing or normalizing and tempering. The cylinder manufacturer shall certify the heat treatment process applied and shall be in conformity with material standard and or as recommended by steel maker. The heat treatment process shall achieve the required mechanical properties. The actual temperature to which a type of steel if subjected for a given tensile strength shall not deviate by more than 30°C from the temperature specified by the cylinder manufacturer. When the hardness check is specified, the hardness value shall be within the band related to the range of declared values of tensile strength.

### 5.4 Mechanical Properties

The steel conforming to the composition specified in Table 1 after manufacture of the cylinders the normalized or normalized and tempered, should meet the mechanical properties given in Table 3.

**5.4.1** Suitable steel other than above may be used with the prior approval of the statutory authority. In such a case, minimum specified value of the yield strength of the steel shall be taken for the purpose of calculating the wall thickness of the cylinder.

**Table 3 Mechanical Properties**
(*Clause* 5.4)

| Sl No. | Properties | Heat Treatment Condition Normalized or Normalized and Tempered |
|---|---|---|
| (1) | (2) | (3) |
| i) | Tensile strength ($R_g$) kgf/mm$^2$ (MPa), *Min* | 68 (670) |
| ii) | Yield strength ($R_e$) kgf/mm$^2$ (MPa), *Min* | 44 (430) |
| iii) | Elongation percent *Min* on gauge length = 5.65 $\sqrt{S_o}$ | 18 |

NOTE — Alternatively, yield strength shall be 0.2 percent of proof stress.

## 6 DESIGN

### 6.1 General Requirements

For design purpose, the value of $R_e$ shall not exceed 0.75 $R_g$.

### 6.2 Limitation on Tensile Strength

**6.2.1** Where there is no risk of hydrogen embrittlement the maximum value of the tensile strength is limited by the ability of the steel to qualify the requirements of **9** and **10**, but in no case shall the actual maximum tensile strength $R_m$ exceed 1 100 MPa for chrome-molybdenum steel or 1 030 MPa for carbon manganese steels.

**6.2.2** Where there is a risk of hydrogen embrittlement the maximum value of the tensile strength as determined as per **10.2** shall either be 880 MPa or, where the ratio $R_{ea}/R_m$ does not exceed 0.9, shall be 950 MPa. The hardness obtained on each cylinder shall be within the band related to the range of declared values of tensile strength.

**6.2.3** In case of cylinders for compressed natural gas or any embrittling gas or embrittling gas mixtures as specified in IS/ISO 11114-1 or by statutory authority, the maximum value of the tensile strength ($R_{m\ max}$) as determined as per **10.2** shall either be 880 MPa or where the ratio $R_{ea}/R_m$ does not exceed 0.9 shall be 950 MPa. The minimum guaranteed value of tensile strength in MPa ($R_g$) shall be less than or equal to $R_{m\ max}$ minus 120 MPa. The hardness obtained on each cylinder shall be within the band related to the range of declared values of tensile strength.

### 6.3 Calculation of Cylindrical Shell Thickness

**6.3.1** The wall thickness of the cylindrical shell of the cylinder may be calculated by the following formulae:

$$f = \frac{P_h\left(1.0D_o^{\ 2} + 0.4D_i^2\right)}{100\left(D_o^2\right)} \quad \text{..... 1}$$

$$a \le \left(D_o / 250\right) + 1 \quad \text{..... 2}$$

with absolute minimum of $a$ = 1.5 mm

where

$f$ = maximum allowable wall stress at hydrostatic test pressure in kgf/mm²;

= 5/6 $R_e$, $R_e$ being the minimum value of the yield strength in kgf/mm²;

$D_o$ = nominal outer diameter of cylinder in mm;

$D_i$ = nominal inner diameter of cylinder in mm;

$a$ = calculated minimum wall thickness of cylindrical shell in mm, excluding additional allowances to resist influences other than those of internal pressure and of external forces due to normal handling; and

$P_h$ = 5/3 × service pressure for permanent gases, in kgf/cm$^2$.

NOTES

1 In case of liquefiable gases, $P_h \ge 1.5 \times$ developed pressure at 65°C (for the filling ratio under consideration);

2 For dissolved acetylene $P_h \ge 60$ kgf/cm$^2$;

3 The value of $R_e$ itself is limited to 75 percent of the minimum value of the tensile strength of the material.

**6.3.2** The value of the wall thickness as calculated from above formula shall however, be not less than 0.136 $\sqrt{D_o}$.

### 6.4 Calculation of Convex Ends (Heads and Bases)

**6.4.1** The thickness, $b$, at the centre of a convex end shall not be less than that required by the following criteria:

$$b \ge 1.5\ a' \text{ for } H/D_o \ge 0.25$$

$$b \ge 2\ a' \text{ for } 0.25 > H/D_o \ge 0.2$$

where the inside knuckle radius, $r$, is not less than 0.075 $D_o$.

NOTE — $H / D_o \le 0.20$ is not recommended.

**6.4.1.1** For cylinders manufactured from plate, the thickness, $b$, at the centre of a convex end shall be not less than that required by the following criteria:

$$b \ge 1.5a' \text{ for } 0.4 > H/D_o \ge 0.20$$

$$b \ge a' \text{ for } H/D_o \ge 0.40$$

where the inside knuckle radius, $r$ is not less than 0.075 $D_o$.

**6.4.1.2** In order to obtain a satisfactory stress distribution in the region where the end joins the shell, any thickening of the end that is required shall be gradual from the point of juncture, particularly at the base. For the application of this rule the point of juncture between the shell and the end is defined by

the horizontal line indicating dimension *H* in Fig. 1.

**6.4.2** The cylinder manufacturer shall prove by the pressure cycling test as detailed in **9.2.4** that the design is satisfactory. The shapes shown in Fig.1 are typical convex heads and base ends. Shapes A, B, D and E are base ends and shapes C and F are heads.

**6.4.3** The cylinder may be designed with one or two openings along the central axis.

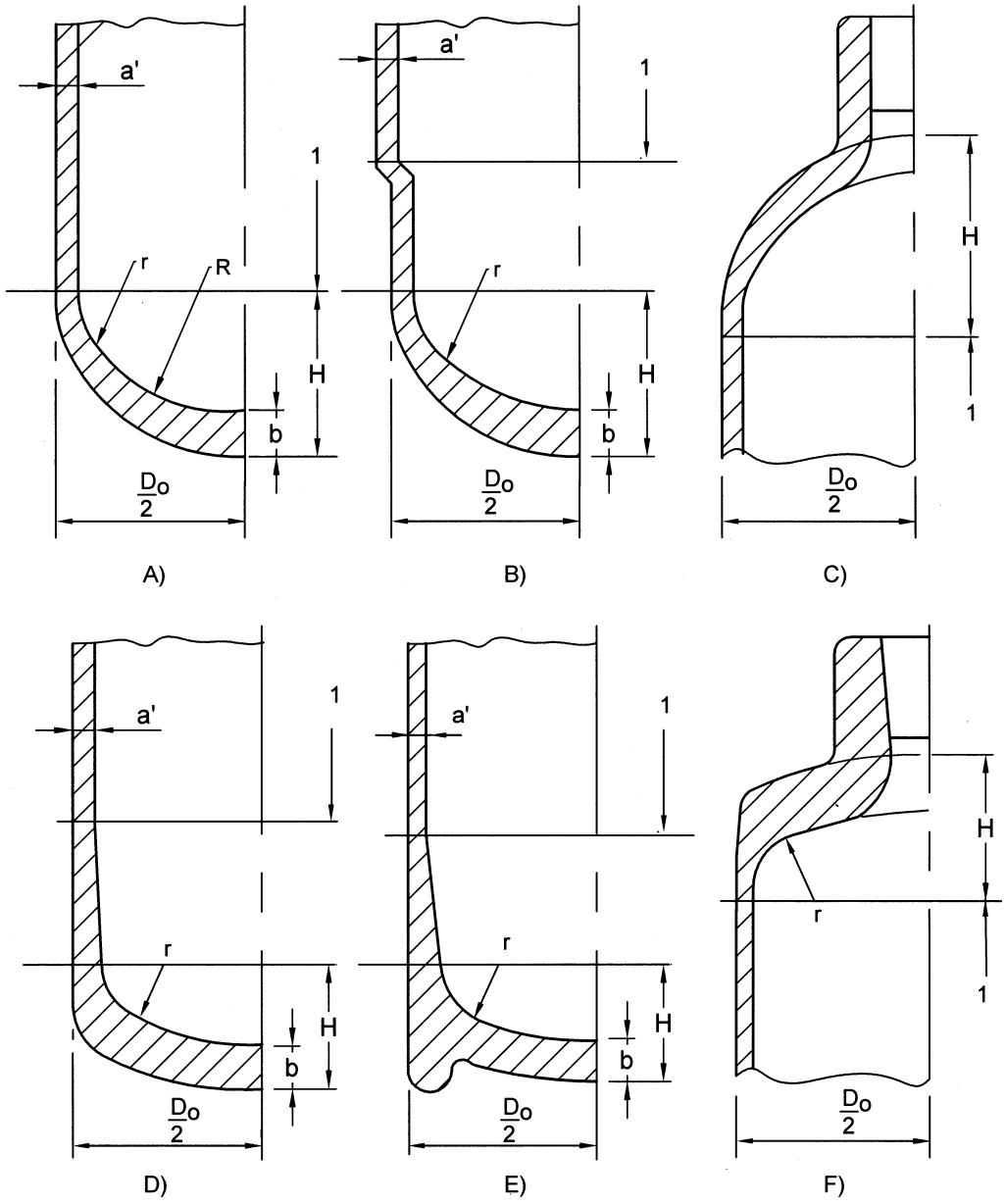
**6.5 Calculation of Concave Base Ends**

When concave base ends (*see* Fig. 2) are used the following design values are recommended:

$a_1 \geq 2\ a'$
$a_2 \geq 2\ a'$
$h \geq 0.10\ D_o$
$r \geq 0.075\ D_o$

The design drawing shall at least show values for $a_1$, $a_2$, $h$ and $r$.

**6.5.1** In order to obtain a satisfactory stress distribution,




**Key**

1 Cylinderical Part

NOTE — Shape B shall not be excluded from this requirement.

FIG. 1 TYPICAL CONVEX ENDS

the thickness of the cylinder shall increase progressively in the transition region between the cylindrical part and the base.

**6.5.2** The cylinder manufacturer shall in any case prove by the pressure cycling test as detailed in **9.2.4** that the design is satisfactory.

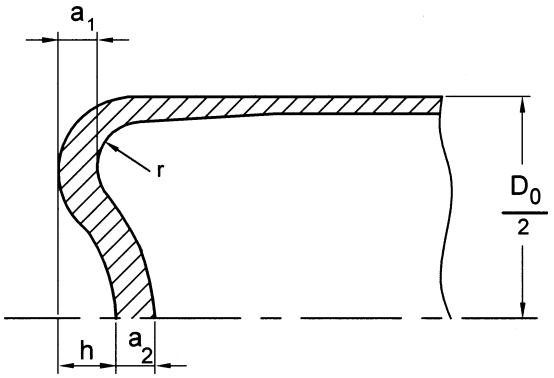



FIG. 2 CONCAVE BASE ENDS

### 6.6 Neck Design

**6.6.1** The external diameter and thickness of the formed neck end of the cylinder shall be adequate for the torque applied in fitting the valve to the cylinder. The torque may vary according to the diameter of thread, the form of thread and the sealant used in the fitting of the valve (for guidance on torque, *see* IS 3224 and IS 3745).

**6.6.2** In establishing the minimum thickness, consideration shall be given to obtain a thickness of wall in the cylinder neck which will prevent permanent expansion of the neck during the initial and subsequent fittings of the valve into the cylinder without support of an attachment such as a neck ring. Where the cylinder is specifically designed to be fitted with neck reinforcement, such as neck ring or shrunk-on collar, the same shall be taken into account.

**6.6.3** *Valve Fittings*

The cylinder neck shall be threaded to suit the type of valves specified in IS 3224 or IS 3745 or to any other specification approved by the statutory authority. The threads shall be full form, clean cut, even, and without chatter, tapped into gauges, and concentric with axis of the cylinder.

NOTE — For special application parallel threads suitable for pressure retaining as per IS 4218 (Part 1 to Part 4), IS 14962 (Part 2) and IS 14962 (Part 3) may be acceptable with the approval of the statutory authority.

### 6.7 Foot Rings

When a foot ring is provided, it shall be sufficiently strong and made of material compatible with that of the cylinder. The shape should preferably be cylindrical and shall give the cylinder sufficient stability. The foot ring shall be secured to the cylinder by a method other than welding, brazing or soldering. Any gaps which may form water traps shall be sealed by a method other than welding, brazing or soldering.

### 6.8 Neck Rings

**6.8.1** The valve shall be protected against damage by the provision of a stout cap of thickness not less than 2.5 mm. Cylinder for non-toxic gases of nominal water capacity upto 5 litres shall be exempted from this provision. Cylinder for non-toxic gases of nominal water capacity above 5 litres and up to 10.5 litres may not be provided with valve protection cap, if approved by the statutory authority. The cap shall be of such a shape that it is nowhere in actual contact with any part of the valve or the valve body. The cap shall be provided with vent of adequate size so as to avoid any gas pressure accumulation inside cap in case of leak. However, in case of highly toxic gases, the cap shall be gas tight, capable of withstanding maximum developed pressure of contained gas at 65°C.

**6.8.2** When a neck ring is provided, it shall be sufficiently strong and made of material compatible with that of the cylinder and shall be securely attached by a method other than welding, brazing or soldering. The manufacturer shall ensure that the torque to turn the neck ring is greater than100 Nm.

### 6.9 Design Drawing

A fully dimensioned drawing shall be prepared which includes the specification of the material (cast analyses), neck threads, working pressure, test pressure, mechanical properties selected for calculating the wall thickness, heat treatment parameters and hardness range.

## 7 MANUFACTURE

### 7.1 General

The cylinder shall be produced by:

a) forging or drop forging from a solid ingot or billet; or

b) manufacturing from seamless tube (hot/cold finish, flow formed); or Pressing from a flat plate;

c) closing of the open ends may be done by any hot working processes such as spinning, forging, etc; and

e) cylinders may be designed with one or two openings along the central cylinder axis. Metal shall not be added in the process of closure of the end. Plugging to correct manufacturing defects in cylinder bases is not permitted.

### 7.2 Wall Thickness

During production each cylinder or semi-finished shell shall be examined for thickness. The wall thickness at any point shall be not less than the minimum thickness specified. If required by the purchaser, suitable allowances to cover corrosion, manufacturing tolerances, stresses due to horizontal acceleration and retardation during transportation may also be provided. The amount of these allowances shall be as agreed to between the manufacturer and the purchaser.

### 7.3 Surface Defects

The internal and external surfaces of the finished cylinder shall be free from defects which would adversely affect the safe working of the cylinder (*see* Annex A for examples of defects and guidance on their evaluation).

### 7.4 Out-of-Roundness

The out-of-roundness of the cylindrical shell that is the difference between the maximum and minimum outside diameters at the same cross-section shall not exceed 2 percent of the mean of these diameters.

### 7.5 Mean Diameter

The mean external diameter of the cylindrical part outside the transition zones on a cross-section shall not deviate more than ±1 percent from the nominal design diameter.

### 7.6 Straightness

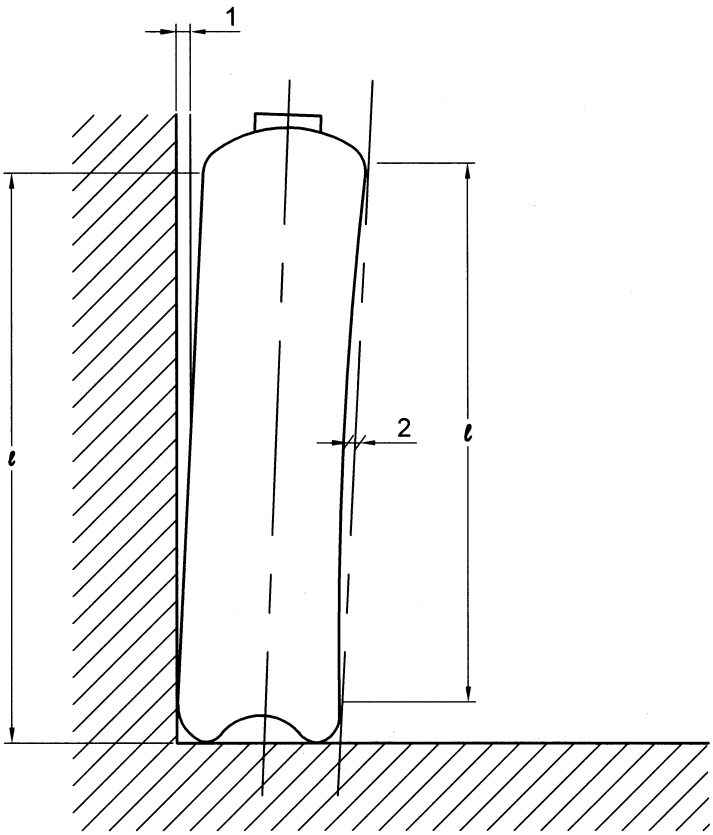
The maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 3 mm/m length (*see* Fig. 3).

### 7.7 Verticality

Deviation from vertical shall not exceed 10 mm/m length (*see* Fig. 3).

### 7.8 Stability

The outer diameter of the surface in contact with the




Key
1 Maximum 0.01 × *l* (*see* **7.7**)
2 Maximum 0.003 × *l* (*see* **7.6**)

FIG. 3 ILLUSTRATION OF DEVIATION OF CYLINDRICAL PART OF SHELL FROM A STRAIGHT LINE AND FROM VERTICAL

ground shall be greater than 65 percent of the nominal outside diameter of the concave base cylinder.

**7.9 Testing Requirements** The material of the finished cylinders shall satisfy the requirements given in **9** (type approval test), **10** (batch test) and **11** (test on every cylinder).

**7.9.1** In the event of failure to meet test requirements, retesting or reheat treatment and retesting shall be carried out as follows:

**7.9.1.1** If the sample fails in any of the test specified in **10.2**, **10.3** and **10.4** and if the inspecting authority considers that failure was due to an error in carrying out the test, a fresh test shall be made on a test piece taken from the same cylinder. The defective test shall be ignored but otherwise, at the cylinder makers' discretion, one of the following procedures shall be adopted:

a) The test in which the failure occurred shall be repeated on the cylinder or test ring originally tested and, in addition, the test specified in **10.2**, **10.3** and **10.4** shall be carried out on another cylinder or test rings from the same batch of the cylinders. If both test samples comply with the test requirements of **10.2**, **10.3** and **10.4** the batch shall be accepted.

b) The batch may be reheat-treated as given in **5.3** and the tests specified in **10.2, 10.3** and **10.4** shall be carried out on two cylinders or test rings at the discretion of inspecting authority, which have not been previously tested. If both the cylinders or both test rings satisfy the test requirements, the batch shall be accepted.

**7.9.2** If any of the tests specified in **10.2**, **10.3** and **10.4** fail, the batch may be reheat-treated as given in **7.10** and retested as given in **7.10.1.1** (b). If both cylinders or both test rings satisfy the test requirements, the batch shall be accepted.

**7.9.3** No cylinder shall, however, be heat-treated more than three times. Also, if more than five cylinders in a batch are reheat-treated, they shall constitute a new batch for the purposes of **10.2**, **10.3** and **10.4**.

**7.9.4** Not more than five cylinders or test rings from batch shall be submitted to the test and the limitations on reheat-treatment given in **7.9.3** shall be complied with.

**7.9.5** If after the permitted number of retests and reheat-treatments the tests requirements have not been complied with, the cylinders in the batch shall be rendered unserviceable for holding the gas under pressure.

NOTE — If any cylinders fail to meet the requirements of hydrostatic stretch test in terms of stretch, or burst test, no further cylinders conforming to that drawing shall be accepted from the manufacturer until it has been demonstrated to the satisfaction of the inspector that the cause of the failure has been identified and corrected. Also, for the batch under consideration, each of the remaining cylinders should be demonstrated to the satisfaction of the inspector, to be free from the defect which caused the failure.

**7.10 Water Capacity**

The manufacturer shall check and record the water capacity of each cylinder in order to ensure compliance as per following tolerance:

a) For cylinders of water capacity up to and including 20 litres = +10/–0 percent subject to a maximum of 1 litre; and

b) For cylinders of water capacity exceeding 20 litres = +5/–0 percent.

**7.11 Neck Thread**

Neck threads shall meet the requirements of **6.8**.

## 8 INSPECTION AND TESTING

In order to ensure that the cylinders are in compliance with this standard they shall be subject to inspection and testing in accordance with **9** (type approval test), **10** (batch test) and **11** (test on every cylinder) by an authorized inspection body (hereafter referred to as 'the inspector') recognized by the statutory authority.

## 9 TYPE APPROVAL PROCEDURE

**9.1 General Requirements —** A technical specification of each new design of cylinders (or cylinder family as given in **9.1** (f) including design drawing, design calculations, steel details and heat treatment, shall be submitted by the manufacturer to the inspecting authority, for scrutiny and further recommendations to statutory authority. The type approval tests detailed given in **9.2** shall be carried out on each new design under the supervision of the inspector. A cylinder shall be considered to be of a new design, compared with an existing approved design when:

a) it is manufactured in a different factory; or

b) it is manufactured by a different process; or

c) it is manufactured from a steel of different specified chemical composition range as defined in **5.2.1**; or

d) it is given a different heat treatment beyond the limits stipulated in **5.3**; or

e) base/neck profile has changed, for example concave, convex, hemispherical or also if there is a change in base thickness/cylinder diameter ratio; or

f) overall length of the cylinder has increased by more than 50 percent (cylinders with a length to diameter ratio less than 3 shall not be used as reference cylinders for any new design with this ratio greater than 3); or

g) nominal outside diameter has changed; or

h) design wall thickness has changed; or

j) hydraulic test pressure has been increased (where a cylinder is to be used for lower pressure duty than that for which design approval has been given, it shall not be deemed to be a new design); or

k) guaranteed minimum yield stress ($R_e$) and/or the guaranteed minimum tensile strength ($R_g$) have changed.

**9.2 Prototype Tests**

**9.2.1** A minimum of 50 cylinders, which shall be guaranteed by the manufacturer to be representative of the new design, shall be made available for prototype testing. However, if for special applications the total production if less than 50 cylinders, enough cylinders shall be made to complete the prototype tests required, in addition to the production quantity.

**9.2.2** In the course of the type approval process, the inspector shall select the cylinders for test and

a) Verify that:

1. Design conforms to the requirements of **6** (design);
2. Requirements of **5** (materials) are complied with;
3. Thickness of the wall of the ends on one cylinder (that taken for mechanical testing) meet the requirements of **6.3**. The measurements being taken at least at three transverse sections of the cylindrical part and on a longitudinal section of the base and head;
4. Requirements of **6.5** to **6.8** and **7.5** to **7.8**, are complied with for all cylinders selected by the inspector; and
5. Internal and external surfaces of the cylinders are free of any defect which might make them unsafe for use (*see* Annex A).

b) Supervise the following tests on the cylinders selected:

1. tests specified in **9.2.3** (hydraulic burst test) on one cylinder, the cylinder bearing representative tamp markings;
2. tests specified in **10.1.3** (mechanical testing) on one cylinder, the test piece being identifiable with the batch;
3. tests specified in **9.2.4** (pressure cycling test) on two cylinders, the cylinders bearing representative stamp marking;
4. for cylinders made from seamless tube, the test specified in **9.2.5** (base check) shall be performed on one cylinder selected for mechanical testing.

NOTES

**1** In case of cylinders having diameter exceeding 300 mm for test **9.2.2** (b) (**2**), a sample cut from a tube of same heat number in the form of a ring of sufficient length to provide requisite test piece may be taken and subjected to the same heat treatment, so that its mechanical properties are representative of the cylinders in the batch.

**2** Cylinders selected for pressure cycling test may be used for hydraulic burst test.

**9.2.3** *Hydraulic Bursting Test*

**9.2.3.1** *Test installation*

The test equipment shall be capable of operation in accordance with the test conditions specified in **9.2.3.2** and producing accurately the information required by **9.2.3.3**. A typical hydraulic burst test installation is illustrated in Fig. 4.

**9.2.3.2** *Test conditions*

As the cylinder and test equipment are being filled with water, care shall be taken to ensure that no air is trapped in the circuit by operating the hydraulic pump until water is discharged from the vent or air release valve. During the test, pressurization shall be carried out in two successive stages:

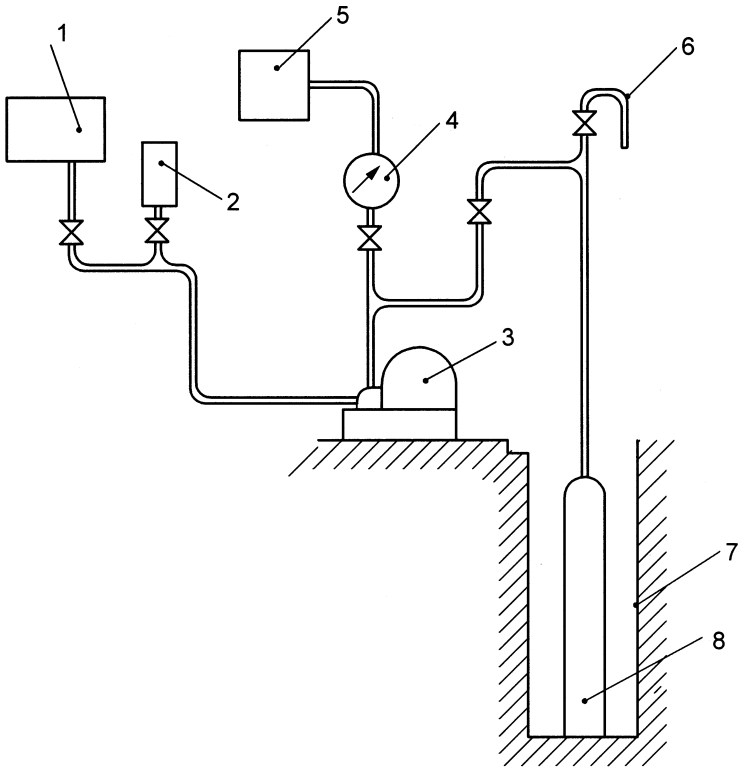
a) In the first stage, the pressure shall be increased at a rate of not more than 0.5 MPa/s (5 bar/s) up to a pressure value corresponding to the initiation of plastic deformation; and

b) In the second stage, the pump discharge rate shall be maintained at as constant a level as is possible until the cylinder bursts.

**9.2.3.3** *Interpretation of test*

a) The interpretation of the burst test shall involve:

1 Examination of the pressure/time curve or pressure/volume of water used curve, to permit determination of the pressure ($P_y$) at which plastic deformation of the cylinder commences, together with the bursting pressure ($P_b$); and
2. Examination of the burst tear and of the shape of its edges.




**Key**

1 Test fluid reservoir
2 Tank for measurement of test fluid (the feed tank may also be used as a measuring tank)
3 Pump
4 Pressure gauge
5 Pressure/time curve recorder
6 Vent or air release valve
7 Test well
8 Cylinder

FIG. 4 TYPICAL HYDRAULIC BURST TEST INSTALLATION

For the result of a bursting test to be considered satisfactory, the following requirements shall be met:

1. Observed yield pressure ($P_y$) shall be greater than or equal to 1.2 times of test pressure ($P_h$).
2. Actual burst pressure ($P_b$) shall be greater than or equal to 2.25 times of working pressure ($P_w$).

b) The cylinder shall remain in one piece and shall not fragment;

c) The main fracture shall be in the cylindrical portion and shall not be brittle, that is the fracture edges shall be inclined with respect to the wall. The tear shall not reveal a significant defect in the metal;

d) For cylinder with wall thickness less than 7.5 mm, the fracture shall be acceptable only if it conforms to one of the following descriptions:

1. Longitudinal, without branching (*see* Fig. 5a);
2. Longitudinal, with a side branching at each end which in no case extends $d_2$ beyond the longitudinal plane normal to the fracture plane (*see* Fig. 5b) or with fishtail branching at one end (*see* Fig. 5c) or at both ends (*see* Fig. 5d).

e) Cylinder having diameter exceeding 300 mm and water capacity exceeding 150 litres shall be subjected to hydraulic pressure not less than calculated burst pressure as per formula given below. During pressurization, if no visible permanent deformation is observed, the cylinder shall be considered to have passed the burst test.

$$R_g \times 0.95 = \frac{P_b\left(D_o - 2a'\right)}{200a'}$$

**9.2.3.4** *Acceptance criteria*

Figure 5 illustrate satisfactory burst test profiles and batches represented by such results shall be accepted. If the configuration of the fracture does not conform to Fig. 5 but other material and mechanical tests are satisfactory, investigation of the cause of the non-conformity shall be undertaken prior to acceptance or rejection of the batch.

**9.2.4** *Pressure Cycling Test*

This test shall be carried out on cylinders bearing representative markings with a non-corrosive liquid subjecting the cylinders to successive reversals at an Upper Cyclic Pressure (UCP) which is equal to the hydraulic test pressure ($P_h$). The cylinders shall withstand 12 000 cycles without failure. For cylinders with hydraulic test pressure ($P_h$) > 450 bar, the upper cyclic pressure may be reduced to two-third of this test pressure. In this case the cylinders shall withstand 80 000 cycles without failure. The value of the lower cyclic pressure shall not exceed 10 percent of the upper cyclic pressure, but shall have an absolute maximum of 30 bar. The cylinder shall actually experience the maximum and minimum cyclic pressures during the test. The frequency of reversals of pressure shall not exceed 0.25 Hz (15 cycles/min). The temperature measured on the outside surface of the cylinder shall not exceed 50°C during the test. After the test the cylinder bases shall be sectioned in order to measure the thickness and to ensure that this thickness is greater than the minimum designed thickness. The test shall be considered satisfactory if the cylinders attain the required number of cycles without developing a leak.

**9.2.5** *Base Check* (*for cylinder made from tube only*)

A meridian section with offset equal to saw blade thickness shall be made in the base of the cylinder and one of the surfaces thus obtained polished for examination under a magnification of between 5 X and 10 X. The cylinder shall be regarded as defective if the presence of cracks is detected. It shall also be regarded as defective, if the dimensions of any pores or inclusions present reach values considered to pose a threat to safety. In no case shall the sound thickness (that is the thickness with no defects) in the base center be less than the specified shell thickness as per **6.3** and **6.4**.

### 9.3 Type Approval Certificate

If the results of the checks according to **9.2** are satisfactory, the inspector shall issue a type approval certificate. A typical proforma for type approval certificate is given in Annex B.

## 10 BATCH TESTS

### 10.1 General Requirements

**10.1.1** All tests given at **10.1.3** for checking the quality of the gas cylinder material shall be carried out on material from finished cylinders. For the purpose of

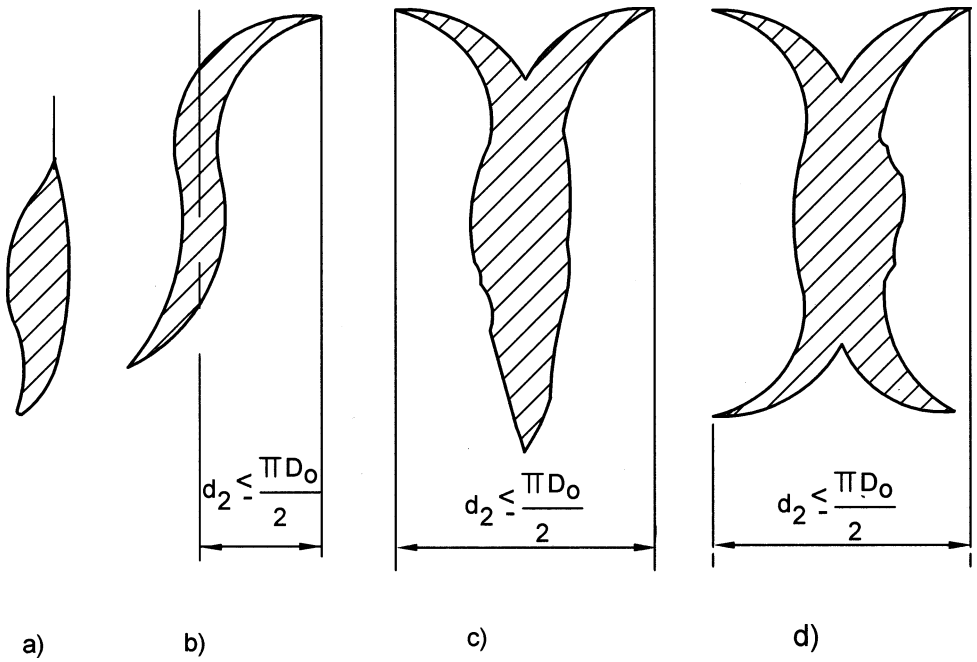



FIG. 5 ACCEPTABLE BURST PROFILES

batch testing the manufacturer shall provide the inspector with:

a) type approval certificate;
b) certificates from material manufacturer stating the cast analysis of the steel supplied for the manufacture of the cylinders, and heat-wise verification by test laboratory;
c) evidence that appropriate heat treatment has been performed;
d) a list of the cylinders, stating serial numbers and stamp markings as required; and
e) confirmation that threads are checked properly in accordance with gauging requirements. The gauges to be used shall be specified.

**10.1.2** During batch testing, the inspector shall:

a) ascertain that the type approval certificate has been obtained and the cylinders confirm to it;
b) check whether the requirements set out in **5**, **6** and **7** have met and in particular check by an external and, if physically possible, internal visual examination of the cylinders whether their construction and checks carried out by the manufacturer in accordance with **7.2**, **7.3**, **7.4**, **7.5**, **7.6**, **7.7** and **7.8** are satisfactory. The visual examination shall cover at least 10 percent of the cylinders manufactured;
c) check whether the information supplied by the manufacturer referred to in **10.1.1** is correct;
d) select the necessary cylinders per batch for destructive testing and carry out the tests specified in **10.2**, **10.3** and **10.4**. Where alternative tests are permitted, the purchaser and manufacturer shall agree which tests are to be carried out; and
e) assess the results of hardness testing specified in **11.3**.

**10.1.3** *Mechanical Test*

The following tests shall be carried out on one cylinder of each batch:

a) one tensile test in the longitudinal direction (*see* **10.2**);
b) either two bend tests (*see* **10.4.1**) in a circumferential direction or a flattening test (*see* **10.4.2**) or one ring flattening test (*see* **10.4.3**); and
c) three impact tests in transverse or longitudinal direction as required in **10.3** when the thickness of the cylinder permits the machining of a test piece at least 3 mm thick.

NOTE — For location of test pieces, *see* Fig 6.

**10.2 Tensile Test**

**10.2.1** A tensile test shall be carried out on material taken from the cylindrical part of the cylinder by adopting either of the following procedures:

a) Rectangular specimens shall be prepared in accordance with Fig. 6 and with a gauge length $L_o$ equal to $5.65\sqrt{S_o}$. The two faces of the test piece representing the inside and the outside surfaces of the cylinder shall not be machined. The elongation ($A$) shall not be less than 18 percent.

b) Machined round specimens having the maximum diameter practicable, the elongation ($A$) measured on a gauge length of 5 times the specimen's diameter being not less than the value calculated by the formula in **10.2.1 (a)** increased by elongation as 20 percent. It is recommended that machined round test pieces are not used for wall thickness less than 3 mm.

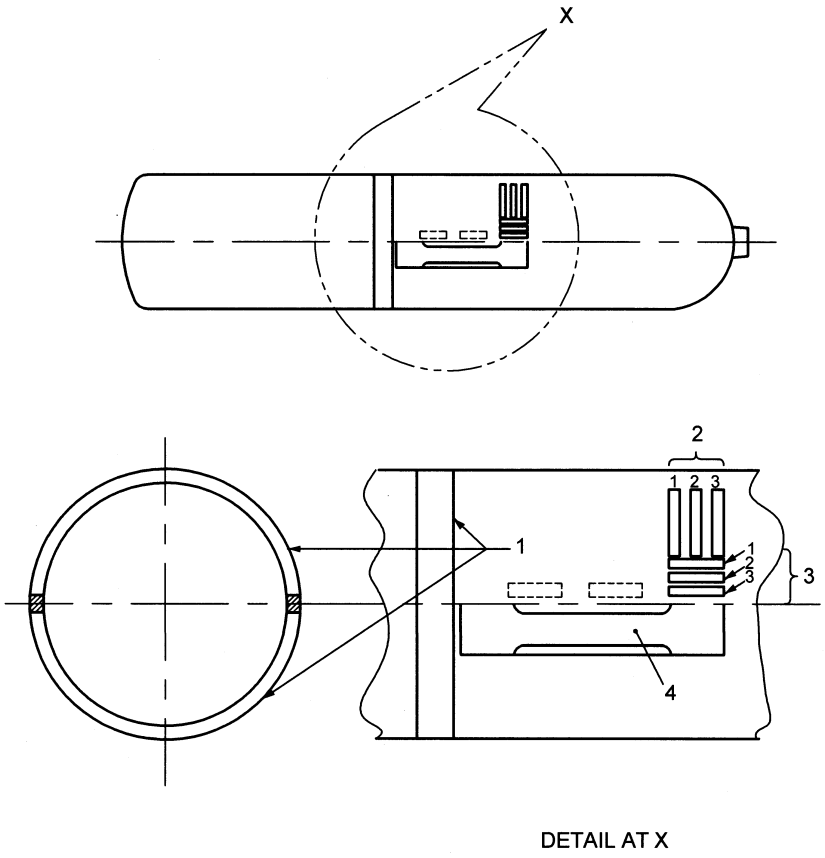
**10.2.2** The tensile test shall be carried out in accordance with IS 1608.

**10.3 Impact Test**

**10.3.1** Except for the requirement set out below, the test shall be carried out in accordance with IS 1757 (Part 1). The impact test pieces three numbers shall be taken in the direction either transverse or longitudinal as required in Table 4 from the wall of the cylinder. The notch shall be perpendicular to the face of the cylinder wall (*see* Fig. 7). For longitudinal tests the test piece shall be machined all over (on six faces), if the wall thickness does not permit a final test piece width of 10 mm, the width shall be near as practicable to the nominal thickness of the cylinder wall. The test pieces taken in the transverse direction shall be machined on four faces only, the inner and outer faces of the cylinder wall shall be un-machined (*see* Fig. 8). Minimum acceptance values are given in Table 4.

**Table 4 Impact Test Acceptance Values**
(*Clauses* 6.8 *and* 10.3.1)

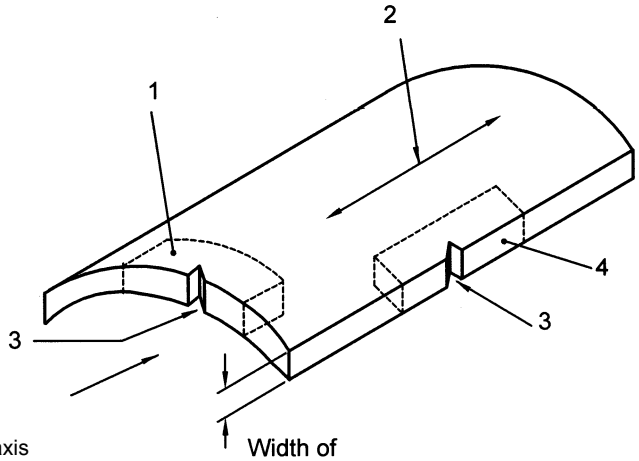
| Sl No. | Cylinder Diameter $D_o$, in mm | > 140 | ≤ 140 |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Direction of testing | Transverse | Longitudinal |
| ii) | Test temperature, in °C | –20 | –20 |
| iii) | Impact strength in J/cm$^2$, Minimum for mean of 3 specimens | 20 | 40 |
| iv) | Impact strength in J/cm$^2$, Minimum for individual specimen | 16 | 32 |




**Key**

1 Bend test pieces
2 Transverse impact test pieces
3 Longitudinal impact test pieces (alternative positions shown dotted)
4 Tensile test piece

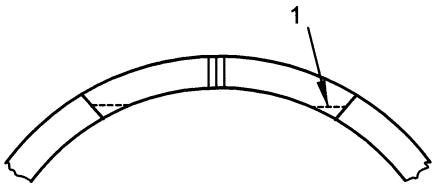
FIG. 6 TYPICAL LOCATION OF TEST PIECES



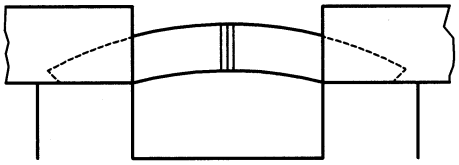

Key

1 Transverse specimen
2 Cylinder longitudinal – axis
3 Charpy-V – notch perpendicular to wall
4 Longitudinal specimen

FIG 7 DESCRIPTION OF TRANSVERSE AND LONGITUDINAL IMPACT TEST PIECES

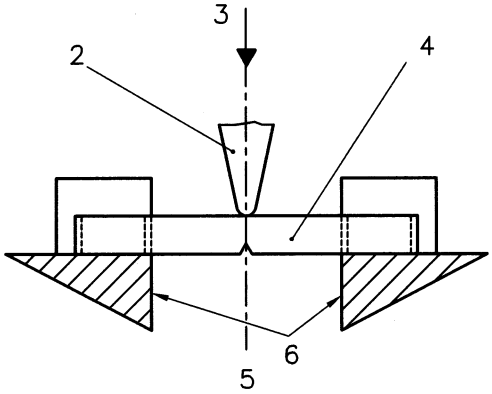



8A TEST PIECE TAKEN FROM CYLINDER WALL



8B FRONT VIEW OF TEST PIECE IN IMPACT TESTER

Key
1 Machining optional
2 Striker
3 Direction of strike
4 Test piece
5 Centre of strike
6 Anvils




8C TOP VIEW OF TEST PIECE IN IMPACT TESTER

FIG. 8 DESCRIPTION OF TRANSVERSE IMPACT TESTING

**10.4 Bend Test and Flattening Test**

**10.4.1** *Bend Test*

**10.4.1.1** The bend test shall be carried out on two test pieces obtained by cutting either one or two rings of width 25 mm or 4 times the minimum agreed finished thickness, whichever is the greater, into equal parts. Each test piece shall be of sufficient length to permit the bend test to be carried out correctly. Only the edges of each strip may be machined.

**10.4.1.2** The test piece shall not crack when bent inwards around the former until the inside surfaces are not further apart than the diameter of the former (*see* Fig. 9).

**10.4.1.3** The maximum diameter of the former ($D_F$) shall be established form Table 5. For the actual tensile strength ($R_m$) given in Table 5; $D_F = n \times t$ where $t$ is the test piece thickness.

**10.4.2** *Flattening Test*

**10.4.2.1** The flattening test shall be performed on one cylinder selected from each batch after heat treatment.

**10.4.2.2** The test cylinder shall be flattened between wedge-shaped knife edges with a 60° included angle, the edges being rounded to a nominal radius of 13 mm. The length of the wedges shall not be less than the width of the flattened cylinder. The longitudinal axis of the cylinder shall be at an angle of approximately 90° to the knife edges.

**Table 5 Bend Test and Flattening Test Requirements**
(*Clauses* 10.4.1.3, 10.4.2.3 and 10.4.3)

| Sl No. | Actual Tensile Strength $R_m$, MPa | Bend Test Value of $n$ | Flattening Test (Cylinder or Ring) Value of $u$[1)] |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | $R_m \leq 500$ | 2 | 4 |
| ii) | $500 < R_m \leq 670$ | 3 | 5 |
| iii) | $670 < R_m \leq 800$ | 4 | 6 |
| iv) | $800 < R_m < 950$ | 6 | 8 |

[1)] Maximum distance between knife edges or platens = $u \times t_m$, where $t_m$ is the average cylinder wall thickness at the position of testing.

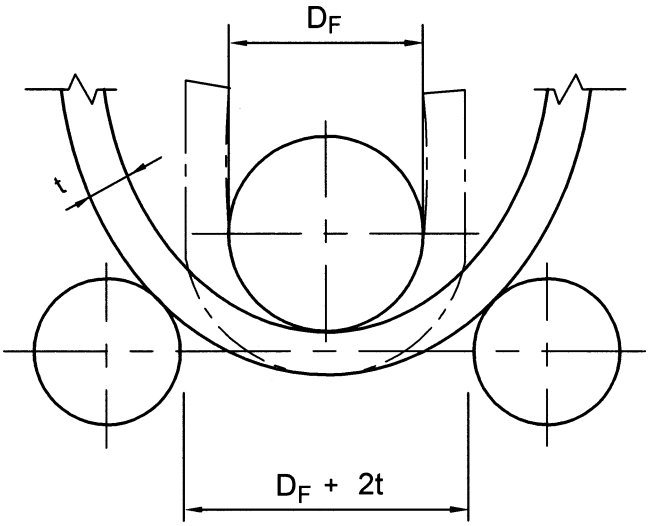



FIG. 9 ILLUSTRATION OF BEND TEST

**10.4.2.3** The test cylinder shall be flattened until the distance between the knife edges is in accordance with Table 5. The flattened cylinder shall remain visually intact.

**10.4.3** *Ring-Flattening Test*

The ring-flattening test shall be carried out on one ring of width 25 mm or 4 times the minimum agreed finished thickness, whichever is greater, taken from the cylinder body. Only the edges of the ring may be machined. The ring shall be flattened between platens until the distance between platens is in accordance with Table 5. The flattened ring shall remain visually uncracked.

## 11 TESTS ON EVERY CYLINDER

### 11.1 General

Following heat treatment, all cylinders except those selected for testing under **10**, shall be subjected to the following tests:

a) Hydrostatic stretch test in accordance with **11.2**;
b) Cylinders manufactured from chromium, molybdenum and nickel chromium molybdenum steel shall be tested for hardness in accordance with **11.3**;
c) Leakage test in accordance with **11.4**;
d) Water capacity check in accordance with **11.5**; and
e) Neck thread, shall meet the requirements of **6.6**.

If there is an evidence of failure of test apparatus, the test shall be repeated.

### 11.2 Hydrostatic Stretch Test

The water pressure in the cylinder shall be increased at a controlled rate until the test pressure, $P_h$, is reached. The cylinder shall remain under pressure $P_h$ for at least 30 s and the total volumetric expansion measured. The pressure shall be released, and the volumetric expansion re-measured (*see* IS 5844). The cylinder shall be rejected, if it shows a permanent expansion (that is volumetric expansion after the pressure has been released) in excess of 10 percent of the total volumetric expansion measured at the test pressure $P_h$. The total and permanent expansion readings shall be recorded together with the corresponding serial number of each cylinder tested, so that the elastic expansion (that is total expansion less permanent expansion) under the test pressure can be established for each cylinder.

### 11.3 Hardness Test

If required, a hardness test [*see* **11.1** (b)] in accordance with IS 1500 (Brinell), or IS 1586 (Rockwell) or other equivalent methods shall be carried out by the manufacturer after the final heat treatment of the cylinder. The hardness values thus determined according to IS 4258, shall be within the limits specified by the cylinder manufacturer for the material, dependent upon the heat treatment used for the production of the cylinder.

NOTES

**1** Methods for measuring the surface indentation, other than given in IS 1500 or IS 1586 may be used subject to agreement between the parties concerned.

**2** Cylinders made from carbon manganese steel shall not be subjected to this test, except those having a hydraulic test pressure ≥ 260 bar.

### 11.4 Leakage Test

The manufacturer shall employ such manufacturing techniques and apply such tests as will demonstrate to

the satisfaction of the inspector that the cylinders do not leak. This test shall be conducted at a pressure not lower than 0.6 × test pressure ($P_h$).

### 11.5 Capacity Check

The manufacturer shall verify that water capacity of each cylinder conforms to **7.10**.

## 12 CERTIFICATION

Each batch of cylinders shall be covered by a certificate signed by the inspecting authority's representative to the effect that the cylinders meet the requirements of this standard in all respects. An example of a suitable worded certificate is given in Annex C. Copies of the certificate shall be issued to the manufacturer. The original certificate shall be retained by the inspector and the copies by the manufacturer in accordance with the regulations of the relevant statutory authority.

## 13 COLOUR IDENTIFICATION

The cylinder shall be painted externally in accordance with the colour scheme specified in IS 3933 or IS 4379. The cylinders used for fire extinguisher or used in fire fighting service, in accordance to IS 15683 or IS 2878 shall be painted externally to the requirements of respective standard.

## 14 CYLINDER MARKING

**14.1** Each cylinder shall be permanently stamped with the following:

a) Serial number and identification of manufacturer and year of manufacture;
b) Number of this standard IS 7285 (Part 1);
c) Test pressure and date of the hydraulic test (such as 4/15 for April 2015);
d) Tare weight, in kg (except in case of dissolved gas);
e) Design minimum water capacity of the cylinder, in litres;
f) Inspector's official mark;
g) A whole number, indicating the value of yield stress, $R_e$, in MPa, on which the calculation of wall thickness was based;
h) Symbol for heat treatment, N;
j) Filling pressure in bar or kgf/cm$^2$ at 15° C in the case of permanent gases and filling ratio in the case of liquefiable gases;
k) Name or chemical symbol of the gas for which cylinder is to be used; and
m) Identification of cylinder thread, for example:
    1) T1S1 for Type 1 Size 1 threads mark,
    2) T1S2 for Type 1 Size 2 threads mark,
    3) T1S3 for Type 1 Size 3 threads mark,
    4) T3 for Type 2 threads mark,
    5) T4S1 for Type 4 Size 1 threads mark,
    6) T4S2 for Type 4 Size 2 threads mark,
    7) T4S3 for Type 4 Size 3 threads mark,

**14.2** The marking shall not be made on the body of the cylinder but shall be at areas in the formed neck where the thickness of metal is greater than the design minimum and where it is adequate for marking to be carried out.

**14.3** The characters in marking shall be 6 mm in height. On cylinders below 140 mm diameter, the height may be reduced, but in no case shall the characters be less than 3 mm in height. The indentation shall not be excessive depth.

**14.4** The stamps used for marking shall have small radii at changes of section to avoid the formation of sharp edges in the stamped marking.

### 14.5 Export Market/Defence Services

Cylinders manufactured for export/defense services use, shall be marked as agreed to between the purchaser and the manufacturer.

## 15 BIS CERTIFICATION MARKING

**15.1** Each cylinder may also be marked with the Standard Mark.

**15.2** The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the license for the use of the Standard Mark may be granted to the manufacturers or producers may be obtained from the Bureau of Indian Standards.

## 16 RECORDS

Records shall be kept of all the tests made at the cylinder manufacturer's works and copies shall be forwarded to the purchase of the cylinder and the inspecting authority.

## 17 PREPARATION FOR DESPATCH

Before being despatched from the manufacturer's works, all cylinder shall be thoroughly cleaned and all particles of grit, filings or other matter which may have collected inside the cylinder during the course of manufacture, heat treatment and testing shall be removed completely and the cylinder dried internally. If cylinder is heated for drying the temperature shall not exceed 200°C. Cylinders not immediately closed by fitting of a valve and safety devices if applicable, shall have plugs suitably designed to prevent ingress of moisture and to protect threads, fitted to all the openings. The outside of the cylinder shall be given a suitable protective coating before despatch.

# ANNEX A

[*Clauses* 7.3 *and* 9.2.2 (a)]

## DESCRIPTION, EVALUATION OF MANUFACTURING DEFECTS AND CONDITIONS FOR REJECTION OF SEAMLESS STEEL GAS CYLINDERS AT TIME OF FINAL VISUAL INSPECTION BY THE MANUFACTURER

### A-1 INTRODUCTION

Several types of defects can occur during the manufacturing of seamless steel gas cylinders. Such defects can be mechanical or material. They can be due to the basic material used, the manufacturing process, heat treatments, manipulation, neck-ring, machining or marking operations and other occurrences during manufacture. The aim of this Annex is to identify the manufacturing defects most commonly met and to provide rejection criteria to the inspectors that perform the visual inspection. Nevertheless extensive field experience and good judgement and independence from production are necessary by the inspector to detect and to be able to evaluate and judge a defect at the time of the visual inspection.

### A-2 GENERAL

**A-2.1** It is essential to perform the visual internal and external inspection in good conditions. The surface of the metal and particularly the inner wall should be completely clean, dry and reasonably free from oxidation products, corrosion, scale, etc, since these could obscure other more serious defects. Where necessary, the surface should be cleaned under closely controlled conditions by suitable methods before further inspection. Appropriate sources of illumination with sufficient intensity should be used. After the cylinders have been closed and the threads have been cut, the internal neck area should be examined by means of an introscope, dental-mirror or other suitable appliance.

**A-2.2** Small defects may be removed by local dressing, grinding, machining, or other appropriate methods. Great care should be taken to avoid introducing new injurious defects. After such a repair the cylinders should be re-examined.

### A-3 MANUFACTURING DEFECTS

The most commonly found manufacturing defects and their definitions are listed in Table 6. Rejection limits for repair or reject are also included in Table 6. These rejections limits are established following considerable field experience. They apply to all sizes and types of cylinders and service conditions. Nevertheless, some customer specifications, some types of cylinder or some special service conditions can require stringent conditions.

### A-4 REJECTED CYLINDERS

a) All rejected cylinders should be rendered unserviceable for their original application, and

b) It may be possible to produce cylinders for different service conditions from rejected cylinders.

**Table 6 Manufacturing Defects**

(*Clause* A-3)

| Sl No | Defect | Description | Conditions for Rejection and/or Actions | Repair/ Reject |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| i) | Bulge | Visible swelling of the wall | All cylinders with such a defect | Reject |
| ii) | Dent (flats) | A depression in the wall that has neither penetrated nor removed metal (*see* Fig. 10) (*see also* 'excessive grinding or machining' below). | a) When the depth of the dent exceeds 2 percent of the external diameter of the cylinder<br>b) When the depth of the dent is greater than 1 mm and when the diameter of the dent is less than 30 times its depth.<br>NOTE — On small diameter cylinders these general limits may have to be adjusted. Consideration of appearance also plays a part in the evaluation of dents, especially in the case of small cylinders. | Reject<br>Permit repair |
| iii) | Cut, gouge, metallic or scale impression | An impression in the wall where metal has been removed or redistributed (due basically to the introduction of foreign bodies on the mandrel or matrix during extrusion or drawing operations) | a) *Inside defect* : If not superficial with sharp notches more than 5 percent of wall thickness<br>NOTE — Consideration of appearance and localization (in thicker part with lower stresses) can be taken into account.<br>b) *Outside defect* : When the depth exceeds 5 percent of the wall thickness | Reject<br>Repair (*see* **A - 2.2**) |

**Table 6 —** (*Concluded*)

| Sl No | Defect | Description | Conditions for Rejection and/or Actions | Repair/ Reject |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| iv) | Dent containing cut or gouge | A depression in the wall which contains a cut or gouge (*see* Fig.11) | All cylinders with such defects | Reject |
| v) | Excessive grinding or machining | Local reduction of wall thickness by grinding or machining. | a) When the wall thickness is reduced to below the minimum drawing thickness; and<br>b) When it results in the formation of a dent. | Reject<br>*See* 'dent' above |
| vi) | Rib | A longitudinal raised surface with sharp corners (*see* Fig. 12) | *Inside defect* : If height or depth exceeds 5 percent of wall thickness or if the length exceeds 10 percent of the length of the cylinders | Repair if possible or reject |
| vii) | Groove | A longitudinal notch (*see* Fig. 13) | *Outside defect* : when the height or depth exceeds 5 percent of the wall thickness or when the length exceeds 5 × the thickness of the cylinders | Repair if possible (*see* **A-2.2**) |
| viii) | Crack | Split, material separation | a) When not removable within thickness tolerance; and<br>b) When removable within thickness tolerance | Reject<br>Repair |
| ix) | Neck cracks | Appear as lines, which run vertically down the thread and across the thread faces. (They should not be confused with tap marks or thread machining marks.) (*see* Fig. 14) | All cylinders with such defects | Reject |
| x) | Shoulder folds and/or shoulder cracks | Folding with peaks and troughs situated in the internal shoulder area, which can propagate into the threaded area of the shoulder (*see* Fig. 15)<br>Cracks can start from folds in the internal shoulder area and propagate into the cylindrical machined or threaded area of the shoulder (*see* Fig. 16 shows exactly where shoulder cracks start and how they propagate). | a) Folds or cracks that are visible as a line of oxide running into the threaded portion should be removed by a machining operation until the lines of oxide are no longer visible. After machining, the whole area should be re-inspected carefully and the wall thickness verified<br>b) If folding or lines of oxide have not been removed by machining, if cracks are still visible or if wall thickness is unsatisfactory; and<br>c) Folds which extend beyond the machined area and are clearly visible as open depressions where no oxides have been trapped in the metal, should be accepted provided that the peaks are smooth and the root of the depression is rounded | Repair, if possible<br>Reject<br>Acceptable |
| xi) | Internal cracks in base | Splits in the metal of the bottom of the cylinder in star form | a) When not removable within thickness tolerance; and<br>b) When removable within thickness tolerance. | Reject<br>Repair |
| xii) | Orange peel surface | Orange peel appearance due to discontinuous metal flow | If sharp cracks are visible in the orange peel surface | Acceptable for non-aggressive gases |
| xiii) | Internal neck threads damaged or out of tolerance | Neck threads damaged, with dents, cuts, burrs or out of tolerance | a) When the design permits it, threads may be retapped and re-checked by the appropriate thread gauge and carefully visually re-examined. The appropriate number of effective threads shall be guaranteed; and<br>b) If not repairable. | Repair<br>Reject |
| xiv) | Pitting | Severe surface corrosion | All cylinders with such defects visible after shot blasting | Reject |
| xv) | Non-conformity with design drawing | — | All cylinders presenting such a defect | Repair if possible or reject |
| xvi) | Neck ring not secure | Neck ring turns under application of low torque, or pulls off under low axial load (*see* **6.7.2)** | All cylinders presenting such a defect | Repair possible according to approved method only |
| xvii) | Arc or torch burns | Partial burning of the cylinder metal, the addition of weld metal or the removal of metal by scarfing or cratering | All cylinders presenting such a defect | Reject |

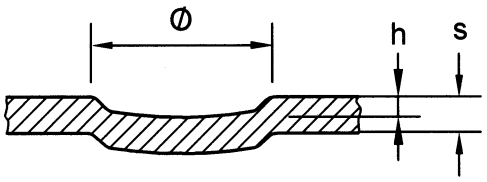



FIG. 10 DENT

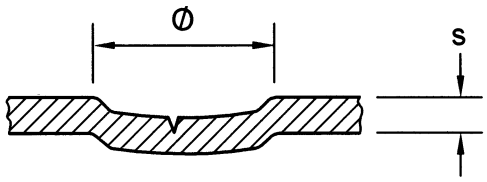



FIG. 11 DENT CONTAINING CUT OR GOUGE

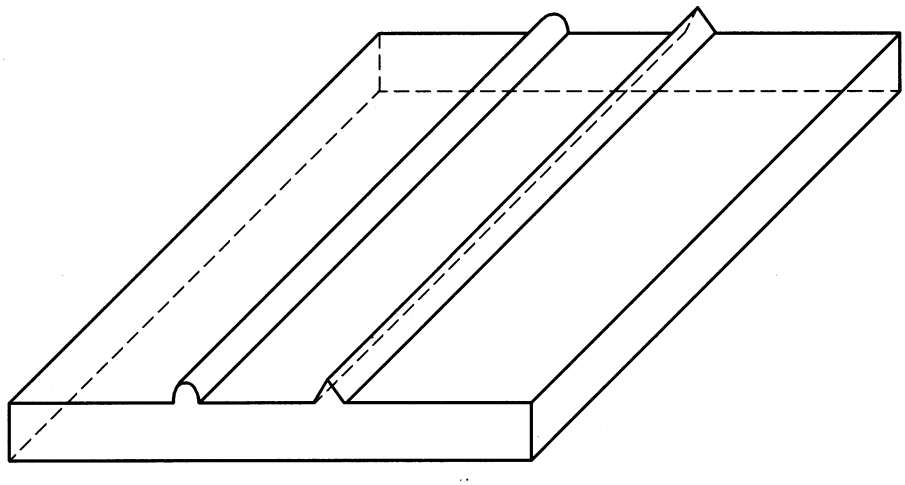


FIG. 12 RIB

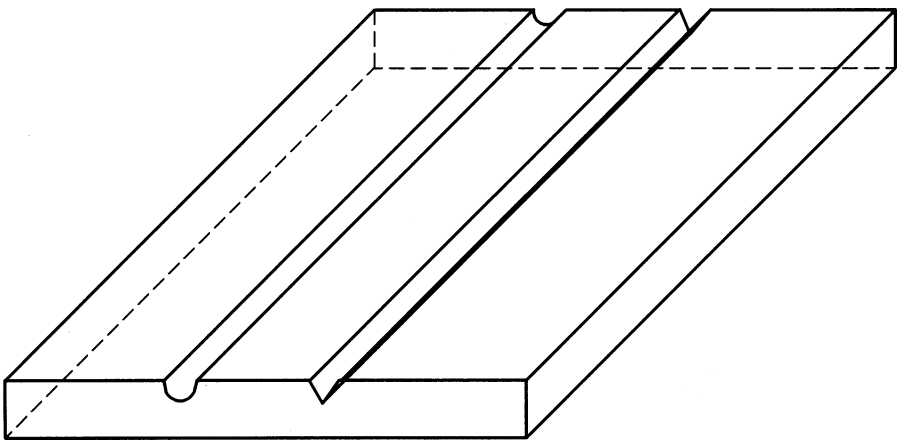
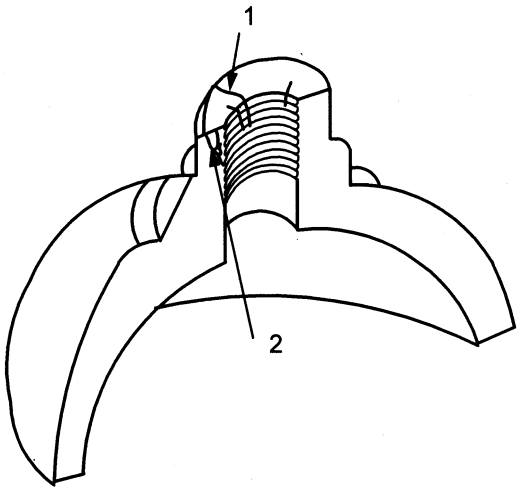
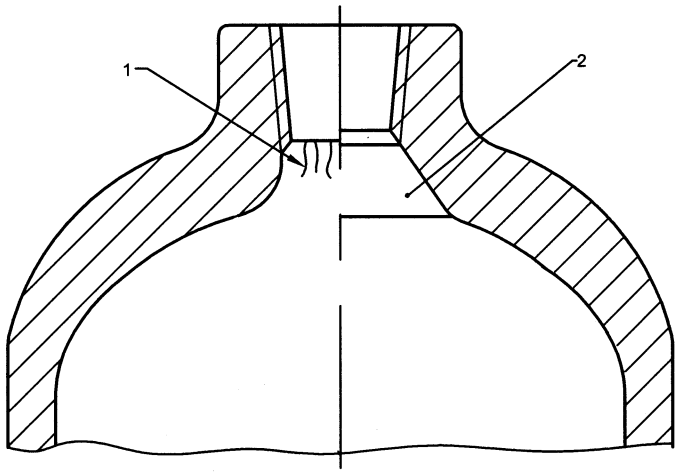


FIG. 13 GROOVE



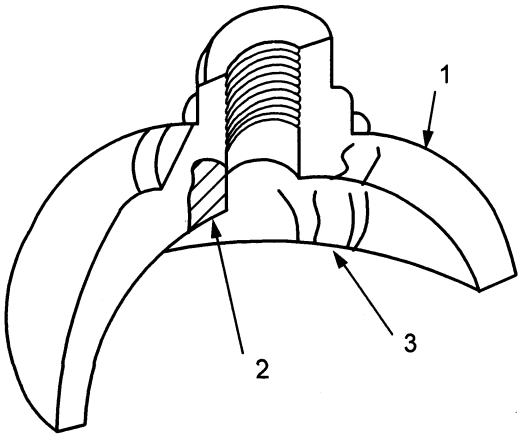

**Key**
1 Neck cracks
2 Propagated crack in the neck

FIG. 14 NECK CRACKS




**Key**
1 Folds or cracks
2 After machining

FIG. 15 CYLINDER SHOULDER FOLDS OR CRACKS BEFORE AND AFTER MACHININS




**Key**
1 Shoulder cracks
2 Propagated crack in the shoulder
3 Folds

FIG. 16 SHOULDER CRACKS

# ANNEX B

(*Clause* 9.3)

**TYPE APPROVAL CERTIFICATE**

This Annex provides an example of a suitable form of a type approval certificate. Other formats also acceptable.

## TYPE APPROVAL CERTIFICATE

Issued by …….....

(Authorized Inspection Authority)

…….....

applying IS Standard …….....

concerning

SEAMLESS STEEL GAS CYLINDERS

---

Approval No…….....…. Date …….....…….…..

Type of cylinder: …….....…….

(Description of the family of cylinders (Drawing No.) which has received type approval)

$P_h$……..bar, $D_{Min}$ ……. mm, $D_{Max}$…….....mm, $a'$ .....…….mm

Shape of base…….....…..., $b$ ……... mm

$L_{Min}$…….mm, $L_{Max}$…....…….mm, $V_{Min}$…….....…litre, $V_{Max}$…....…….…..litre

Material and heat treatment: …….....

Material and characteristics: Material: ……..... $R_e$…….....…..MPa, $R_g$…….....…….…MPa

Manufacturer or agent…….....….....

(Name and address of manufacturer or its agent)

…… .....

All information may be obtained from

…….....

(Name and address of approving body)

…….....

Date: ..…….....

Place: …….....

……..

(Signature of Inspector)

# ANNEX C

(*Clause* 12)

## ACCEPTANCE CERTIFICATE

This Annex provides an example of a suitable form of an acceptance certificate. Other formats are also acceptable.

## ACCEPTANCE CERTIFICATE

Acceptance certificate for seamless steel cylinders No…….....

A consignment of …….....…cylinders consisting of …… test batches have been inspected and tested for …….....…. according to IS 7285 (Part 1).

(Designation or type of gas)…….....…

Manufacturer's Nos ……..…….. to ……..……

Owner's Nos. [1] : ……..…… to ……..……

Manufacturer : ……..…… Manufacturer order No.…….....

Address : ……..……..

Country : ……..…… Date : ……

Owner/Customer [2] : ……..…… Purchase Order No.:……..……

Address : ……..

Country : ……..……. Date : ……

## TECHNICAL DATA

Water capacity *V*: Nominal [1] …..... Litre
Minimum [1]….....Litre

Test pressure $P_h$: …. ..... bar

Working Pressure [1] at 15°C $P_w$: ……..... bar

Maximum Filling Charge [1] ……..... kg

Nominal length:……...…….. mm
(without cap and without valve)

Outside diameter *D*: ….....…… mm

Min. wall thickness *a*: ….. .....… mm

Drawing No.: ……....…. Approved vide
CCE letter No……....… dt……..…….

Material: Manufacturer's name, Specification, designation and grade:

| Specified analysis [3]: | C% | Si% | Mn% | P% | S% | (P + S)% |
|---|---|---|---|---|---|---|
| | | | | | | |
| % maximum : | | | | | | |
| % minimum : | | | | | | |

Heat treatment:

Stamp markings: [3]

…….. Date

…… Manufacturer

**ACCEPTANCE TESTS**

1. Measurements taken on one representative cylinder of the batch [4)]

| Test No. | Covering Serial | Water | Mass | Minimum measured | |
|---|---|---|---|---|---|
| or Batch No. | No.…… to | capacity | empty | Thickness (mm) | |
| or Cylinder No. | …….. | litre | kg | Wallbase | |
| | | | | | |
| | | | | | |

2. Mechanical tests [1)]

| | | Tensile Test | | | Hardness | Impact test | | Bend or |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | flattening test |
| Test | Cast | Yield | Tensile | Elong- | | Charpy (V) | | 180° |
| No. | No. | Stress | Strength | ation | | ……. °C | | without |
| | | ($R_{ea}$) | ($R_m$) | ($A$) | | …….direction | | cracking |
| | | MPa | MPa | % | HB | Average | Minimum | |
| | | | | | | J/cm$^2$ | J/cm$^2$ | |
| Minimum Values : | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

This is to certify that the cylinders covered by this Acceptance Certificate have passed the hydraulic pressure test and all the other tests as required in **10** of IS 7285 (Part 1) and they are in accordance with this Indian Standard.

Special remarks: ……..……..

…….....

On behalf of :

…….....

……. …….....

Date (Signature of Inspector)

[1)] If required by customer.

[2)] Delete as applicable.

[3)] To be quoted or drawing to be attached.

[4)] Need not be filled in if test reports are attached.

# ANNEX D

(*Foreword*)

## COMMITTEE COMPOSITION

Gas Cylinders Sectional Committee, MED 16

| *Organization* | *Representative*(*s*) |
|---|---|
| Petroleum and Explosive Safety Organization, Nagpur | Dr Sudarshan Kamal (***Chairman***)<br>Shri Ashendra Singh (*Alternate*) |
| All India Industrial Gases Manufacturers Association, New Delhi | Shri Saket Tiku<br>Shrimati Veena Peter (*Alternate*) |
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| Indian Oil Corporation Ltd, Mumbai | Shri Ashutosh Tiwari<br>Shri S. M. Rambhal (*Alternate*) |
| Indraprastha Gas Limited, Delhi | Shri Praveen K. Pandey<br>Shri Alok Sharma (*Alternate*) |
| International Industrial Gases Ltd, Kolkata | Shri Devendra K. Garg<br>Shri Nikhilesh K. Garg (*Alternate*) |
| Inox India Limited, Vadodara | Shri Deepak V. Patwardhan<br>Shri Deepak V. Acharya (*Alternate*) |
| Kabsons Gas Equipments Ltd, Hyderabad | Shri Satish Kabra<br>Shri. S. Gopalaiah (*Alternate*) |
| Kosan Industries Ltd, Mumbai/Surat | Shri Sunil K. Dey<br>Shri S. B. Bolmal (*Alternate*) |
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| LPG Equipment Research Centre, Bangalore | Shri P. Krishnan Kutty<br>Dr. A. Krishna (*Alternate*) |
| Mahanagar Gas Limited, Mumbai | Shri S. Murali<br>Shri Arun Nayak (*Alternate*) |
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| Research & Development Estt (Engineers), Pune | Shri P. K. Chattopadhyay<br>Shri A. Basu (*Alternate*) |
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| Society of Indian Automobile Manufacturers (SIAM), New Delhi | Shri K. K. Gandhi<br>Shri Pankaj K. Karn (*Alternate*) |
| Steel Authority of India Ltd, Ranchi | Shri Debashis Karmakar<br>Dr Anjana Deva (*Alternate*) |

| *Organization* | *Representative*(*s*) |
|---|---|
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| Tata Motors Ltd, Pune | Shri P. K. Banerjee<br>Shri Amul Verma (*Alternate*) |
| Tekno Valves, Kolkata | Shri Y. K. Behani<br>Shri R. Behani (*Alternate*) |
| The Automotive Research Association of India, Pune | Dr S. S. Thipse<br>Shri S. D. Rairikar (*Alternate*) |
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Scientist 'B' (MED), BIS

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| Maruti Koatsu Cylinders Limited, Mumbai | Shri Nitin J. Thakkar<br>Shri A. S. Saran (*Alternate*) |
| Ministry of Defence (DGQA), Pune | Shri J. P. Tiwari<br>Shri K. Sudhakaran (*Alternate*) |
| Petroleum and Explosive Safety Organization, Nagpur | Shri Ashendra Singh |
| Rama Cylinders Private Limited, Mumbai | Shri Sanjay Mande<br>Shri Pramod W. Sangwai (*Alternate*) |
| Sahuwala High Pressure Cylinder (P) Limited, Visakhapatnam | Shri P. K. Gupta<br>Shri Srinivas Rao (*Alternate*) |

| *Organization* | *Representative*(*s*) |
|---|---|
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| Society of Indian Automobile Manufacturers (ARAI), New Delhi | SHRI K. K. GANDHI<br>SHRI PANKAJ KUMAR KARN (*Alternate*) |
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| The Automotive Research Association of India, Pune | DR S. S. THIPSE<br>SHRI M. K. CHOUDHARI (*Alternate*) |

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