IS 3196-3 (2012): Welded low carbon steel gas cylinder exceeding 5 litre water capacity for low pressure liquefiable gases, Part 3: Methods of test [MED 16: Gas Cylinders]

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भारतीय मानक

अल्प दाब द्रवमाप गैसों के लिए 5 लिटर से अधिक जल क्षमता वाले वेल्डित अल्प कार्बन इस्पात के लिए सिलिंडर

भाग 3 परीक्षण पद्धतियाँ

(पांचवॉ पुनरीक्षण)

Indian Standard

WELDED LOW CARBON STEEL CYLINDERS EXCEEDING 5 LITRE WATER CAPACITY FOR LOW PRESSURE LIQUEFIABLE GASES

PART 3 METHODS OF TEST

(Fifth Revision)

ICS 23.060.40; 75.160.30

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May 2012 **Price Group 7**

Gas Cylinders Sectional Committee, MED 16

FOREWORD

This Indian Standard (Part 3) (Fifth 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 Division Council.

This standard was first published in 1965 and subsequently revised in 1968, 1974, 1982 and 1991. This standard is published in four parts. Other parts in this series are:

Part 1 Cylinders for liquefied petroleum gases (LPG)
Part 2 Cylinders for liquefiable non-toxic gases other than LPG
Part 4 Cylinders for toxic and corrosive gases

In the formulation of this standard considerable assistance has been taken from ISO 2291 : 2004 'Gas cylinders — Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) — Design and construction'.

In this revision all the amendments have been included. This revision incorporates the following major changes:

a) Macro-examination (*see* **5.5**).
b) A new clause on Fatigue/Cycle test has been added.
c) Results (*see* **5.7**).
d) Failure in burst test (*see* **9.2**).

Manufacture, possession and use of any gas, when contained in cylinders of more than 500 ml water capacity in a compressed or liquefied state, are regulated under the *Gas Cylinder Rules*, 2004, of the Government of India. This standard has been formulated in consultation and agreement with the statutory authorities under those rules.

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

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

WELDED LOW CARBON STEEL CYLINDERS EXCEEDING 5 LITRE WATER CAPACITY FOR LOW PRESSURE LIQUEFIABLE GASES

PART 3 METHODS OF TEST

(Fifth Revision)

1 SCOPE

This standard lays down methods of test for welded low carbon steel cylinders intended for storage and transportation of low pressure liquefiable gases, of nominal water capacity exceeding 5 litre and up to and including 250 litre nominal water capacity. This standard also lays down various tests carried out in the plant and laboratory and details of carrying out these tests.

2 REFERENCES

The standards listed in Annex A contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicted 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 in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 7241 shall apply.

4 TESTS

The details of the following tests specified in IS 3196 (Part 1), IS 3196 (Part 2), IS 3196 (Part 4) and IS 13258 have been stipulated in this standard:

a) Acceptance tests;
b) Burst and volumetric expansion test;
c) Hydrostatic stretch test;
d) Hydrostatic test;
e) Pneumatic leakage test;
f) Radiographic examination; and
g) Fatigue test/cycle test.

5 ACCEPTANCE TESTS

5.1 Number of Test Specimen

For every batch of 202 or less heat-treated cylinders, one cylinder shall be selected at random for these tests. The following test specimen shall be prepared from this cylinder as shown in Fig. 1.

a) *Test specimen for parent metal (P) tensile testing*:
   1) For two-piece cylinders, one tensile test specimen in the longitudinal direction and one tensile test specimen in the transverse direction shall be cut from the cylindrical portion of the cylinder. Alternatively, if sufficient cylindrical length is not available to permit cutting the cylindrical portion, then one tensile test specimen may be taken from the dished end (*see* Fig. 1A).
   2) For three-piece cylinders, one tensile test specimen in the longitudinal direction and one tensile test specimen in the transverse direction from the cylindrical portion and one tensile test specimen from one of the dished ends may be taken (*see* Fig. 1B).
b) *Test specimens from welds (W)*:
   1) For two-piece cylinders, one tensile test, one root bend test and one face bend test specimen may be taken across the circumferential weld (*see* Fig. 1A).
   2) For three-piece cylinders, one tensile test, one root bend test and one face bend test specimen may be taken across the longitudinal weld. In addition one tensile test, one root bend test and one face bend test specimen may be taken across one of the circumferential weld (*see* Fig. 1B). The specimen shall be taken alternately from the top and bottom circumferential welds on successive cylinders selected for the test.
c) Test specimen for minimum thickness test from knuckle radius portion for both two-piece and three-piece cylinders.

d) *Sample for macro-examination*:

1) For macro-examination in case of two-piece cylinders one specimen across circumferential seam and one from bung weld.

2) In case of three-piece cylinders one specimen across longitudinal weld and one on any one of the circumferential welds. The specimen shall be taken alternately from top and bottom circumferential welds on successive cylinders selected for test. In addition, one specimen from bung weld shall be taken.

3) Apart tfrom specimens from bung, circumferential and longitudinal seams, weld specimens from each of the non-pressure part attachments be drawn.

5.2 Parent Metal Tensile Tests

5.2.1 These test methods are based on IS 1608 which may be referred in case further references are required.

5.2.2 *Sample Preparation*

A typical layout of tensile test specimen is given in Fig. 2. The dimensions shall be as per Table 1 and tolerances on dimension shall be as per Table 2. The face and back of test specimen shall not be machined, but shall represent the surface of the cylinder as manufactured. lf individual measurements of the thickness of a test specimen, the two faces of which are formed by the surface of the cylinder wall, differ from one another, the minimum thickness of the test specimen shall be taken for calculation of the area. The test specimen may be carefully cold straightened sufficiently only to help gripping and placing them in the testing machine jaws.

For liquefied petroleum gases cylinders of 33.3 litre water capacity, the gauge width of 25 mm and gauge length of $5.65\sqrt{S_o}$ shall be taken (*see* Fig. 1A). The calculated value of the original gauge length may be rounded off to the nearest multiple of 5 mm provided the difference between the calculated and marked gauge length does not exceed 10 percent of the original gauge length. For steel other than IS 6240 specimens shall be prepared as per the relevant steel specification.

Table 1 Dimensions of Test Pieces Non-proportional

All dimensions in millimetres.

Sl No.	Width b	Gauge Length L_o	Minimum Transition Radius r	Approximate Total Length L_t
(1)	(2)	(3)	(4)	(5)
i)	40	200	25	450
ii)	30	200	25	375
iii)	25	100	25	300
iv)	12.5	50	25	200
v)	6	24	12	100
vi)	3	12	6	50

NOTES

1 Notwithstanding the above, test pieces having a gauge length equal to $5.65\sqrt{S_o}$ are permitted. Where '$\sqrt{S_o}$' is the original cross-sectional area of the test specimen.

2 For any width from 3 mm to 25 mm a gauge length of 50 mm may be used, the total length being adjusted accordingly.

3 A straight parallel test piece without enlarged ends is permissible for any size.

4 It is recommended that parallel length (L_c) of test piece shall be between $L_o + 1.5\sqrt{S_o}$ and $L_o + 2.5\sqrt{S_o}$.

5 Provided there is sufficient material, the parallel length (L_c) used for arbitration purposes shall be $L_o + 2\sqrt{S_o}$.

6 In case the gauge length is required to be proportional. Conversion to proportional length shall be done as per IS 3803 (Part 1).

Table 2 Tolerance on Dimensions of Test Pieces Machined on Two Opposite Faces
(*Clause* 5.2.2)

All dimensions in millimetres.

Sl No.	Nominal Dimension	Tolerance on Form Values
(1)	(2)	(3)
i)	3 to 6	0.18
ii)	Over 6 to 10	0.22
iii)	Over 10 to 18	0.27
iv)	Over 18 to 30	0.33
v)	Over 30 to 50	0.39

NOTE — Dimensions of the ends of the reduced section of test piece shall not differ in width by more than 0.1 mm.

5.2.3 Mark the axis on the test specimen and also mark over-lapping gauge length as shown in Fig. 2, in order to save the results of tensile test in case fracture occurs outside gauge length.

5.2.4 *Methods of Test*

5.2.4.1 *Principle of test*

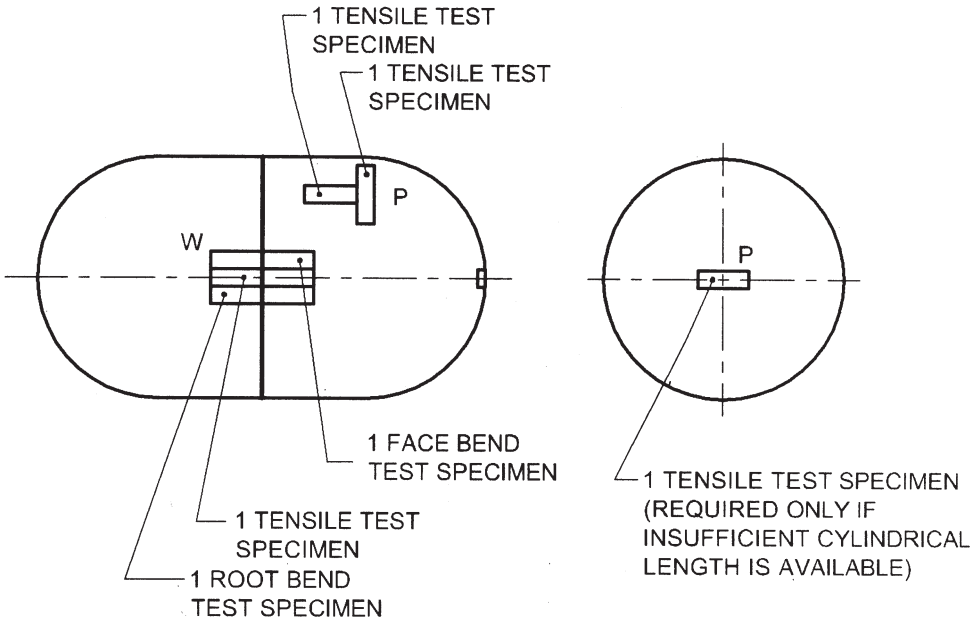
The test consists in straining a test piece by tensile stress, generally to fracture, with a view to determine the mechanical properties, that is, yield stress, tensile stress and percentage permanent elongation. The test shall be carried out at ambient temperature unless otherwise specified.

5.2.4.2 *Methods of gripping*

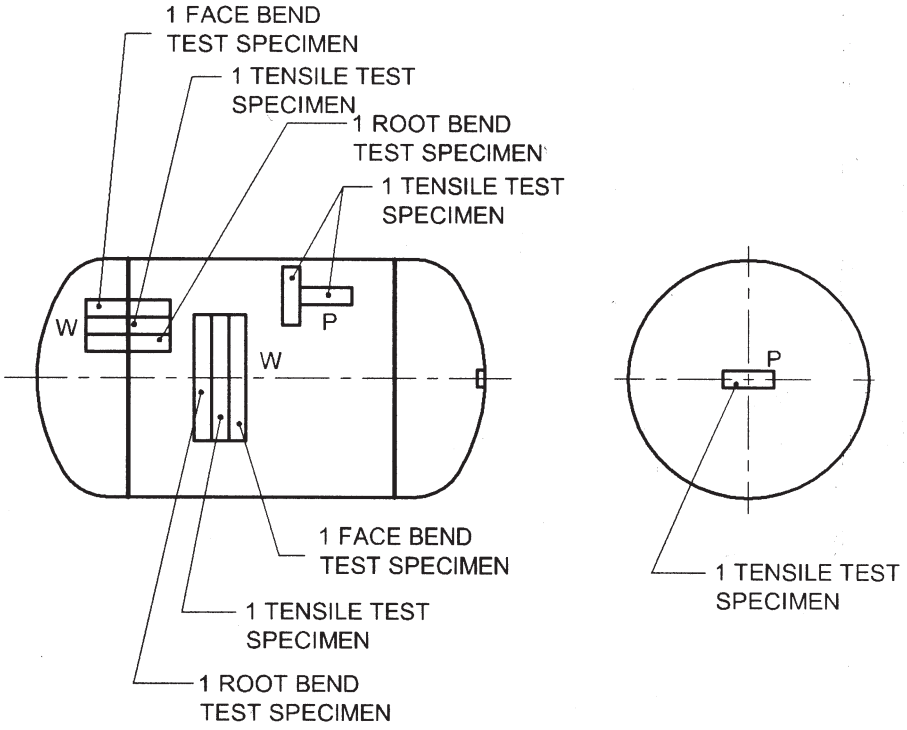
Test pieces should be held by suitable means, for example, wedges, screwed holders, shouldered holders, etc. Every endeavour should be made to ensure that test pieces are held in such a way that the load is applied as axially as possible.

5.2.4.3 *Accuracy of testing equipment*

The testing machine shall be calibrated in accordance



1A Two-Piece Cylinders



1B Three-Piece Cylinders

P DENOTES SPECIMEN FROM PARENT METAL
W DENOTES SPECIMEN FROM WELDED JOINT

FIG. 1 TENSILE SPECIMENS FOR ACCEPTANCE TEST

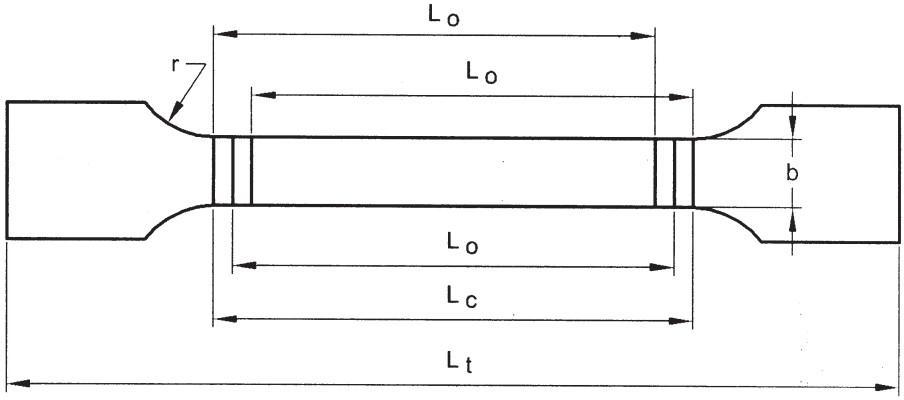


FIG. 2 TENSILE TEST SPECIMEN

with IS 1828 (Part 1) and should be maintained to Grade 1.0 except when Grade 0.5 is required by the standard of the material.

5.2.4.4 *Testing technique*

For most practical purposes the straining rate may be assessed in terms of loading rate, taking into account the following factors:

a) Apparent elastic compliance (k) of the testing machine and test assembly;
b) Area of cross-section of the test piece; and
c) Parallel length of the test piece.

For measurement of yield stress, a rate of strain during plastic deformation not exceeding 0.15/min is recommended which is normally obtained in number of testing machines in common use. In addition to the recommended rate of straining, the rate of stressing shall be between 20 to 30 $Nmm^{-2}\,s^{-1}$ in the elastic range, to avoid, amongst other things, errors due to inertia effects. The controls of the testing machine should not be adjusted after 90 percent of the expected yield force has been reached.

5.2.4.5 *Determination of yield stress*

The values of upper yield stress ($R_e H$) and lower yield stress ($R_e L$) can only be determined when a stress-strain diagram is obtained. For the purpose of this standard upper yield stress is to be determined.

Upper yield stress ($R_e H$) is the value of stress measured at the commencement of plastic deformation at yield (*see* Fig. 3A and 3B) or the value of stress measured at the first peak obtained during yield even when that peak is equal or less than any subsequent peaks observed during plastic deformation at yield.

In case yield point is not clear, a straight line shall be drawn on the curve as shown in Fig. 3C, and yield load taken at the point '*A*' from where the curve starts deflecting from straight line.

5.2.4.6 *Determination of tensile strength*

When determining tensile strength, the test piece shall be loaded so that in the plastic range, the rate of separation of the cross heads of the testing machine, expressed as a percentage of the parallel length per minute, shall at no moment, be not greater than twice the specified minimum elongation + 10.

The speed of testing should be as uniform as possible and the change of speed from one range to the other should be made gradually and without shock.

Tensile strength is determined as maximum load divided by the original cross sectional area of the test piece, that is, stress corresponding to the maximum load.

5.2.4.7 *Determination of percentage permanent elongation*

The percentage elongation after fracture shall be expressed to the nearest one percent. This is permanent elongation of the gauge length of the test piece after fracture, expressed as a percentage of the original gauge length.

Care shall be taken to place the broken parts of the test pieces along the axis and proper contact between the broken parts of the test piece ensured, when measuring the final length between gauge marks.

The test results are regarded as valid, irrespective of the position of the fracture, provided that the minimum elongation specified has been obtained. If the minimum elongation specified is not obtained, the results of a test shall be discarded, if the distance between the fracture and the nearer gauge mark is less than one-third of the gauge length. In case non-proportional gauge length has been used corrections shall be made for elongation according to IS 3803 (Part 1).

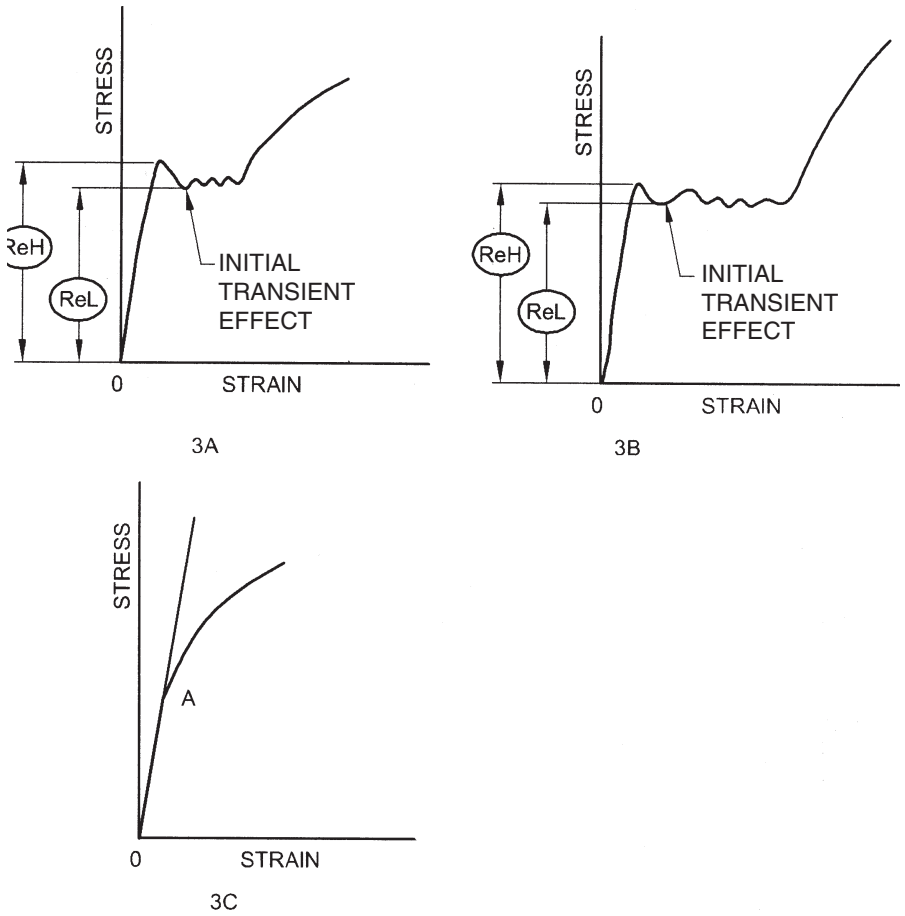


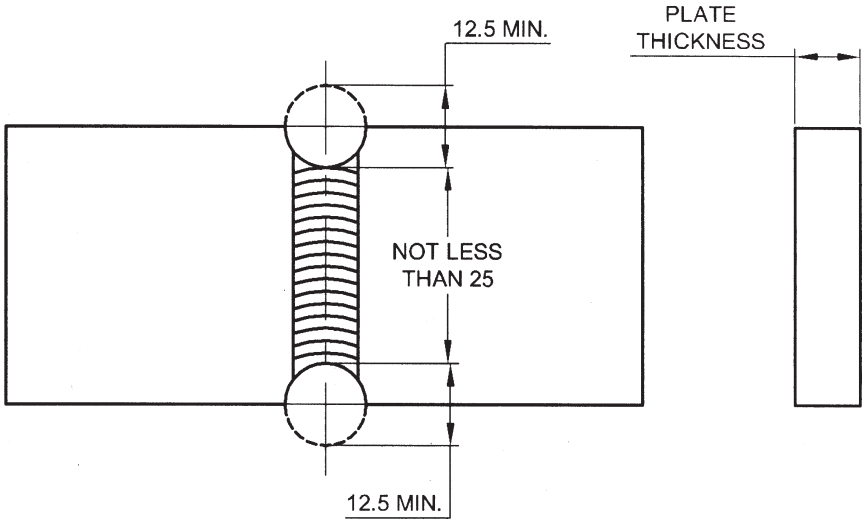
FIG. 3 STRESS STRAIN DIAGRAM

5.3 Tensile Test on Weld Joint

5.3.1 *Sample Preparation*

Test specimen cut from the cylinder across the weld shall be prepared with radius reduced dimension at the weld joints as shown in Fig. 4.

5.3.1.1 The test specimen shall be cut out transversely to the weld and shall be the full thickness of the material at the welded joint. In preparing the test specimen, the face and back shall be machined or ground to remove backing strip or joggling and the weld bead on the face and root side. The face and back



All dimensions in millimetres.

FIG. 4 RADIUS REDUCED TRANSVERSE TENSILE TEST SPECIMEN

of the test piece shall each represent the surface of the parent material.

5.3.2 *Test Method*

In weld joint tensile test, only tensile strength is to be determined, therefore, in this case the rate of loading within the elastic range may be as high as that permitted in the plastic range. Other details of test method would be as per **5.2.4.6**.

5.3.3 The tensile strength determined on test specimen shall also form a guide in selection of the size of the mandrel required for carrying out bend test across the weld as specified in **5.4**.

5.4 Bend Test Across Weld

5.4.1 *Sample Preparation*

The test specimen shall be cut transversely to the weld and shall be finished by machining or grinding, backing strip or joggling, if used to be removed. Weld bead shall be flushed with the parent metal on both sides. Further removal of material shall be done from the side being subjected to tension. Suitable precautions shall be taken to avoid superficial strain hardening or excessive heating of the material. The surfaces shall be free from scratches or notches transverse to the test piece direction.

5.4.2 The test piece shall have a rectangular cross-section practically constant for all its length, at any point of cross-section, the thickness shall not be less than the designed wall thickness of the cylinder. The cross-sectional shape shall conform to Fig. 5.

5.4.3 The weld portion, both in root and face shall be clearly identified by etching or using copper sulphate solution or any other method and marked.

5.4.4 The diameter of the mandrel shall be twice the plate thickness for specimen whose actual weld tensile strength is up to and including 420 N/mm^2 (43 kgf/mm^2) and thrice the plate thickness for specimen whose actual weld tensile strength is more than 420 N/mm^2 (43 kgf/mm^2). For the calculation of diameter of the mandrel, the thickness shall be taken at bend point of bend test specimen rounded off to the next 0.5 mm.

5.4.5 The corners/edges of the test piece shall be rounded off.

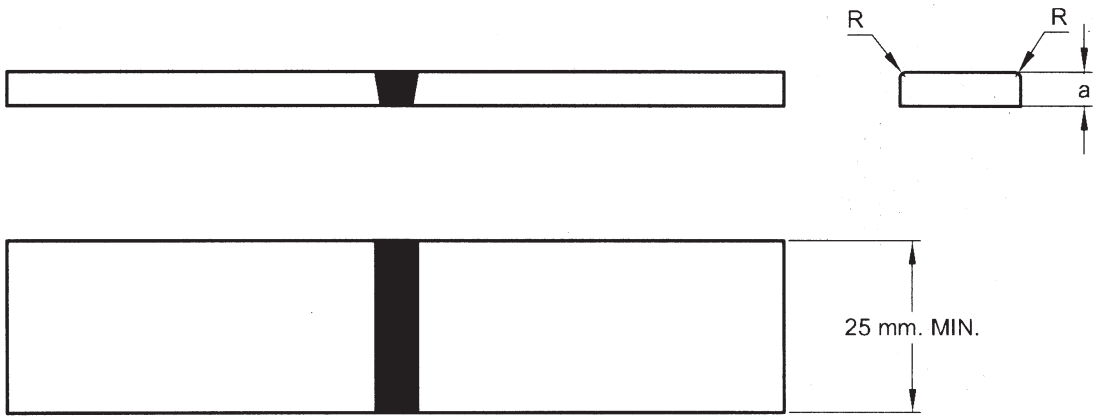
5.4.6 *Test Method*

5.4.6.1 The test shall be carried out by placing the test piece on two supports consisting of parallel rollers. The test piece shall be slowly and continuously bent by applying in the middle of the span, on the axis of the weld, a concentrated load perpendicularly to the test piece surface. The load shall be applied by means of a mandrel (*see* **5.4.4**). The test is completed when the bending angle (*see* Fig. 6) reaches 180° in case of face bend test and root bend test.

5.4.6.2 Alternatively, the test shall be carried out by firmly clamping one end of the test piece in a testing device. The test piece shall be slowly and continuously bent by applying pressure. The test is completed when the bending angle reaches 180° in case of face bend test and root bend test.

5.4.7 *Results*

On completion of the test, the convex surface of the specimen shall be examined for cracks or any other open defects. Premature crack or opening at the corner of the specimens shall not be considered as a failure, unless there is definite evidence that it has resulted from



'a' MINIMUM DESIGNED WALL THICKNESS
'R' ONLY ON THE FACE IN TENSION

FIG. 5 BEND TEST SPECIMEN

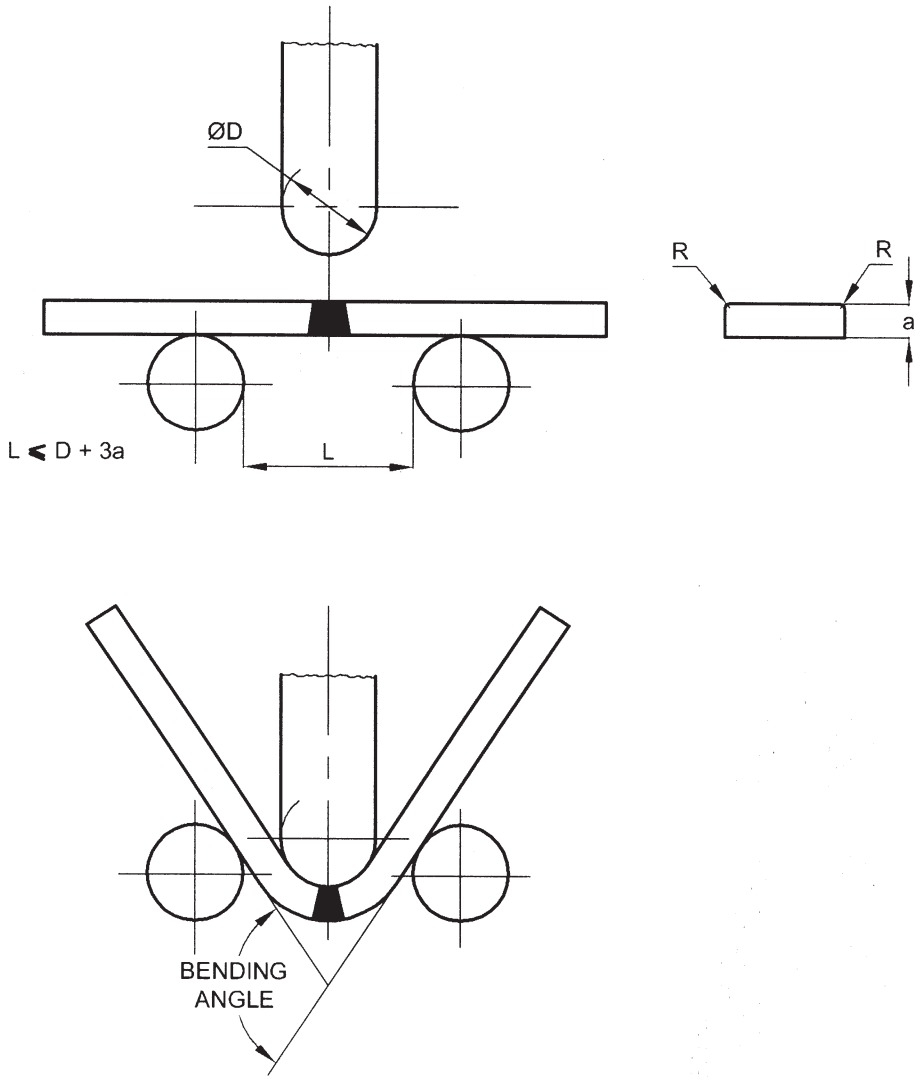


FIG. 6 BEND TEST

slag inclusions or other internal defects. The specimen showing shifting of the weld during the test shall be discarded.

5.5 Macro-examination

5.5.1 *Bung, Circumferential and Longitudinal Seams*

The macro-etching of a complete cross-section of the weld shall show a good penetration and absence of lack of fusion. Inclusions, porosities and other defects shall not exceed the limits specified for non-radiography, spot radiography and 100 percent radiography cylinders, as the case may be. The extent of permissible limits shall be as per **8.7.5.3** of IS 2825. In case the macro-examination is not acceptable, one more section on the same cylinder shall be examined and if it passes the test, the batch may be accepted. In case of failure, the weld of the entire batch shall be removed and cylinders re-welded. The re-welded cylinders are to be taken as a new batch and shall be tested accordingly.

5.5.2 *Non-pressure Parts Attachments*

The macro-etching of a complete cross-section of the welds of non-pressure part attachments shall be observed. The macro-examination of the weld metal shall,

a) show adequate penetration and fusion with the parent metal. In case the macro examination is not acceptable, one more section on the same cylinder should be examined and if it passes the test, the batch may be accepted. In case the weld of the attachment(s) is unacceptable, welds of such attachment(s) of the entire batch may be removed and re-welded. The re-welded cylinders shall be re-heat treated and shall be tested as a new batch.

b) not show penetration through the entire thickness of the pressure holding parent metal. In case the macro-examination is not acceptable, the inside of the cylinders of the entire batch shall be examined using a low voltage lamp and appropriate viewing arrangement for examination from the inside of the attachment's weld. Any cylinder found with weld metal having penetrated on the inside of the parent metal shall be rejected and de-shaped. The rest shall be accepted.

5.6 Minimum Thickness Test

A ring shall be cut from the knuckle portion of the cylinder used for the tensile test and examined for wall thickness the thickness shall not be less than the agreed finished thickness.

5.7 Results

5.7.1 If the sample fails in any of the tests given in **5.2** to **5.4** and if the inspecting authority considers that the failure was due to an error in carrying out the test, a fresh test shall be done on a test piece taken from the same cylinder. The defective test shall be ignored and one of the following procedures shall be adopted:

a) Test in which the failure occurred shall be repeated on the cylinder and in addition, all the tests given in **5** shall be carried out on another cylinder from the same batch manufactured from the same welding machine. If both the cylinders satisfy the test requirements, the batch shall be accepted. If the sample fails in any of the test carried out as per this clause, the method given in **5.7.1** (b) or **5.7.2** as applicable shall be adopted depending on the nature of failure.

b) Batch may be re-heat-treated and all the tests specified in **5** shall be carried out on two cylinders. If both the cylinders satisfy the test requirements, the batch may be accepted. If any of the tests specified in this clause fail, the batch may be re-heat-treated and offered for retest.

5.7.2 In the case of three-piece cylinders, or in the case of two-piece cylinders, if the failure is due to defect in the weld, the following procedure shall be followed:

a) Cylinders welded on the same welding machine to which failed sample belongs shall be segregated and procedure laid in **5.7.2.1** to **5.7.2.3** for repairing shall be followed.

b) The rest of the cylinders from the batch shall be segregated and one fresh cylinder shall be selected at random and tests given in **5.3** to **5.4** shall be repeated. If this fresh cylinder satisfies the test requirements, the rest of the batch shall be accepted. In case the cylinder fails, these segregated cylinders shall be rejected.

5.7.2.1 In the case of failure in the root bend test under **5.4** the weld shall be removed till the backing strip or the joggling lower plate is exposed or till the sound metal is reached.

5.7.2.2 In the case of failure in the face bend test under **5.4** the weld shall be removed flush with plate.

5.7.2.3 All such cylinders shall be re-welded and considered as a fresh batch. These cylinders shall be heat-treated and two cylinders shall be tested in accordance with all the tests specified in **5**.

5.7.2.4 lf any of the test specified in **5.7.2.3** fail, the entire batch shall be rejected.

5.7.3 In case the macro-examination is not acceptable, one more section on the same cylinder and one section from another cylinder shall be examined and if they pass the test the batch may be accepted. In case of failure the weld of the entire batch shall be removed and cylinders re-welded. The re-welded cylinders are to be taken as a new batch and shall be tested according to **5.7.1** (b).

5.7.4 In the case of failure in minimum thickness test, all the cylinders from acceptance test batch shall be segregated and inspecting authority shall give circumferential mark location at both the ends at every point at a distance of 50 mm of the cylinders on the circumferential marks. Ultrasonic prop testing shall be done at these points. In case of failure at any point on circumferential mark, the cylinder shall be rejected.

6 HYDROSTATIC STRETCH TEST

One cylinder taken at random from each batch of 403 or less shall be subjected to a hydrostatic stretch test by any of the following methods.

NOTE — This test method is based on IS 5844 which may be referred in case further references are required.

6.1 Water Jacket Method

6.1.1 *Apparatus*

A typical arrangement of apparatus for the test is shown in Fig. 7.

6.1.2 *Graduated Tube*

The graduated tube used for the measurement shall be of such diameter that a permanent change in volume of the cylinder of the order of 1/20 000 the total cylinder capacity can be observed. The length of tube shall be such that its capacity exceeds the total volumetric expansion of the cylinder under test. The diameter shall

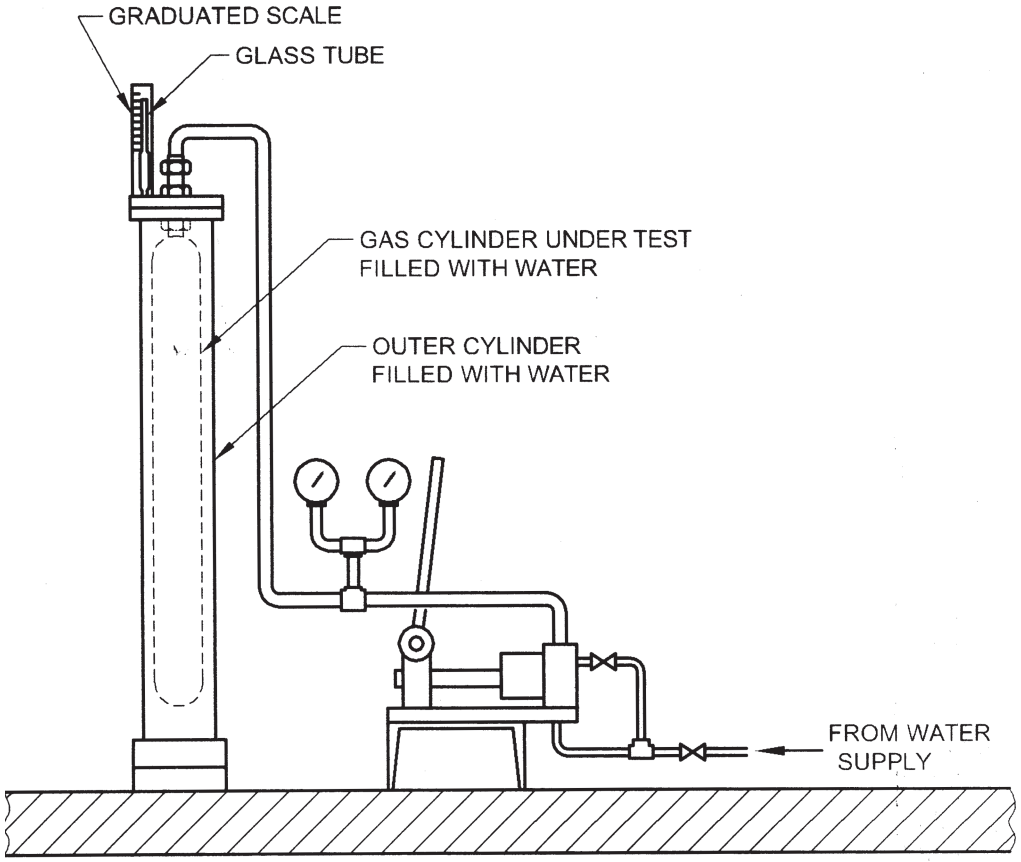


FIG. 7 WATER JACKET METHOD

be uniform and sufficiently small to permit an accurate reading of the expansion.

6.1.3 *Pressure Gauge*

Two pressure gauges or a duplicate gauge shall be used and shall be capable of reading to within 1 percent of the test pressure for pressures up to and including 15kgf/cm^2 and within 2 percent of pressures above 15 kgf/cm^2.

6.1.4 *Procedure Before Testing*

The water jacket shall be filled with water to a convenient level on the graduated glass tube. The cylinder shall be filled with water and assembled inside the jacket. Entrapped air from the water jacket shall be expelled.

6.1.5 *Precautions*

Care shall be taken to prevent any leakage through the joint between the cylinder neck and the water jacket cover. Change of temperature of the water in the jacket during the test shall be avoided.

6.1.6 *Readings*

Readings of the water level in the graduated tube shall be taken,

a) before the test pressure has been applied to the cylinder (C_1);
b) after the test pressure has been applied for 30 s (C_2); and
c) after the release of the test pressure (C_3).

The difference between C_1 and C_2 represents the total volumetric expansion and the difference between C_1 and C_3 represents the permanent expansion.

6.2 Non-jacket Method

6.2.1 *Apparatus*

A typical arrangement of apparatus for the test is shown in Fig. 8.

6.2.2 *Graduated Tube*

The graduated tube used for the measurement shall be of such diameter that a permanent change in volume of the cylinder of the order of l/20 000 the total cylinder capacity can be observed. The length of tube shall be such that its capacity exceeds the total volumetric expansion of the cylinder under test. The diameter shall be uniform and sufficiently small to permit an accurate reading of the expansion.

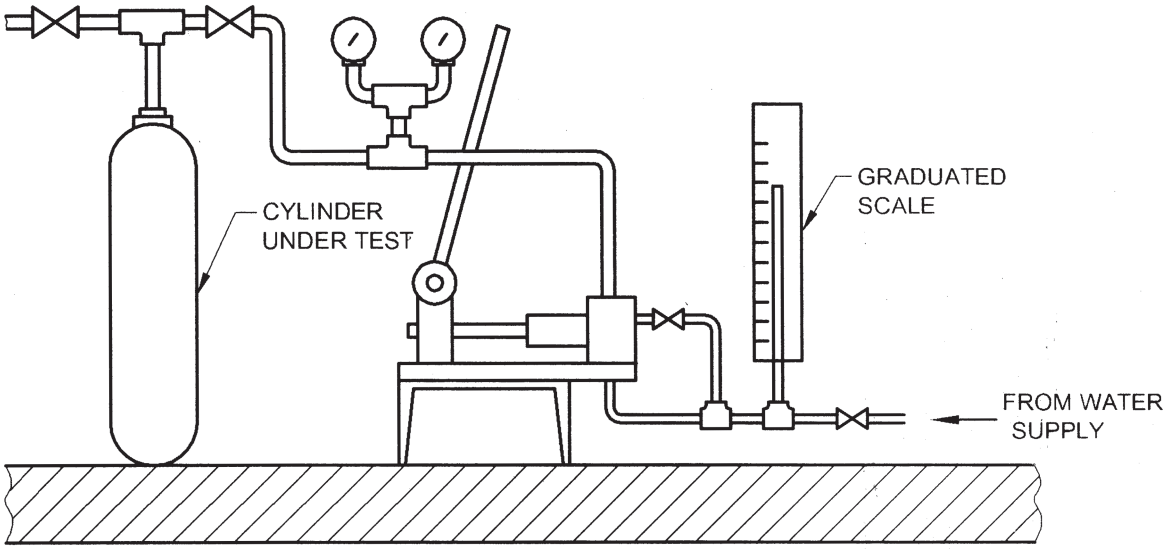


FIG. 8 NON-JACKET METHOD

6.2.3 *Pressure Gauge*

Two pressure gauges or a duplicate gauge shall be used and shall be capable of reading to within 1 percent of the test pressure for pressures up to and including 15 kgf/cm^2 and within 2 percent for pressures above 15 kgf/cm^2.

6.2.4 *Procedure Before Testing*

Before connections are made for testing, the cylinder shall be completely filled with water. Entrapped air from the cylinder shall be expelled.

6.2.5 *Connections*

All connections shall be air-free and water-tight.

6.3 During the tests, the pressure shall be increased gradually until the required test pressure is reached. After the test pressure is reached, it shall be maintained for at least 30 s to ensure complete expansion. Permanent stretch suffered by the cylinder due to application of test pressure shall not exceed the limits given in IS 3196 (Part 1), IS 3196 (Part 2) and IS 3196 (Part 4).

6.4 If in the hydrostatic stretch test the permanent stretch exceeds the limits given in **6.3** but the cylinder does not show visible local deformation the manufacturer may;

a) either subject the entire batch to the hydrostatic stretch test in accordance with **6.3** and reject those that fail in the test; or

b) re-heat-treat the batch and offer for re-test in accordance with **5** and **6**. In case of failure in the re-test the entire batch shall be rejected.

7 HYDROSTATIC TEST

7.1 Each heat-treated cylinder shall be subjected to hydrostatic test by filling the cylinder with water. During the hydrostatic test the pressure shall be increased gradually till the required test pressure is reached. After the test pressure is reached, and the external surfaces of the cylinder are dried, the pressure shall be retained for a period of not less than 30 s. The cylinder shall be thoroughly examined externally for all accessible surface of the cylinder. For this purpose the equipment used for hydrostatic test shall be either rotary type or invertible type. Any reduction in pressure noticed during this retention period or any leakage, or visible bulge of deformation shall be treated as a case of failure in the test.

7.2 Cylinders which have been rejected due to leaks for pin holes, blow holes, under cuts in weld during hydrostatic test may be repaired and re-offered for inspection and testing provided the following conditions are satisfied:

a) Defects have been removed by grinding, chipping, gauging or any other approved method;

b) Welding has been carried out by a qualified welder under the supervision of a competent person;

c) Repaired portion has been radiographed, if the cylinder was originally required to be radiographed after manufacture;

d) Cylinder has been re-heat-treated;

e) Cylinder has been subjected to prescribed hydrostatic test; and

f) Proper records of such repairs have been maintained.

7.3 Cylinders showing leaks in hydrostatic test at any

place other than the weld shall be rejected and rendered unserviceable. Further cylinders showing leakage after repairs as per the conditions mentioned in **7.2** and retested shall also be rejected.

8 PNEUMATIC LEAKAGE TEST

8.1 Each cylinder, after it has been dried, and fitted with valve, shall be tested for leakage by subjecting to air pressure of not less than 1 180 kPa (12 kgf/cm^2) for cylinders covered under IS 3196 (Part 1) and not less than 686 kPa (7 kgf/cm^2) for cylinder covered under IS 3196 (Part 2) and IS 3196 (Part 4). Proper adopter/ filling gun shall be used for air tilling to avoid damage to the valve.

8.2 The cylinder in horizontal position shall be immersed in water tank which shall be adequately illuminated with light both from outside and inside the tank. Suitable arrangement for revolving the cylinder inside the tank during the test shall be available in the water tank.

8.3 The pressure inside the cylinder shall be retained for a period of not less than 60 s and it shall be thoroughly checked for any leakage.

8.4 Cylinders which have been rejected because of leaks at the weld due to pin holes, blow holes or under cuts in welding may be repaired and re-offered for inspection and testing provided the condition laid down in **7.2** are satisfied. However, cylinders showing leaks at any place other than the weld shall be rejected.

9 FATIGUE/CYCLE TEST AND BURST TEST

9.1 Burst Test

9.1.1 One cylinder taken at random from each batch of 403 or less, which has already been subjected to hydrostatic stretch test, shall be subjected to an internal

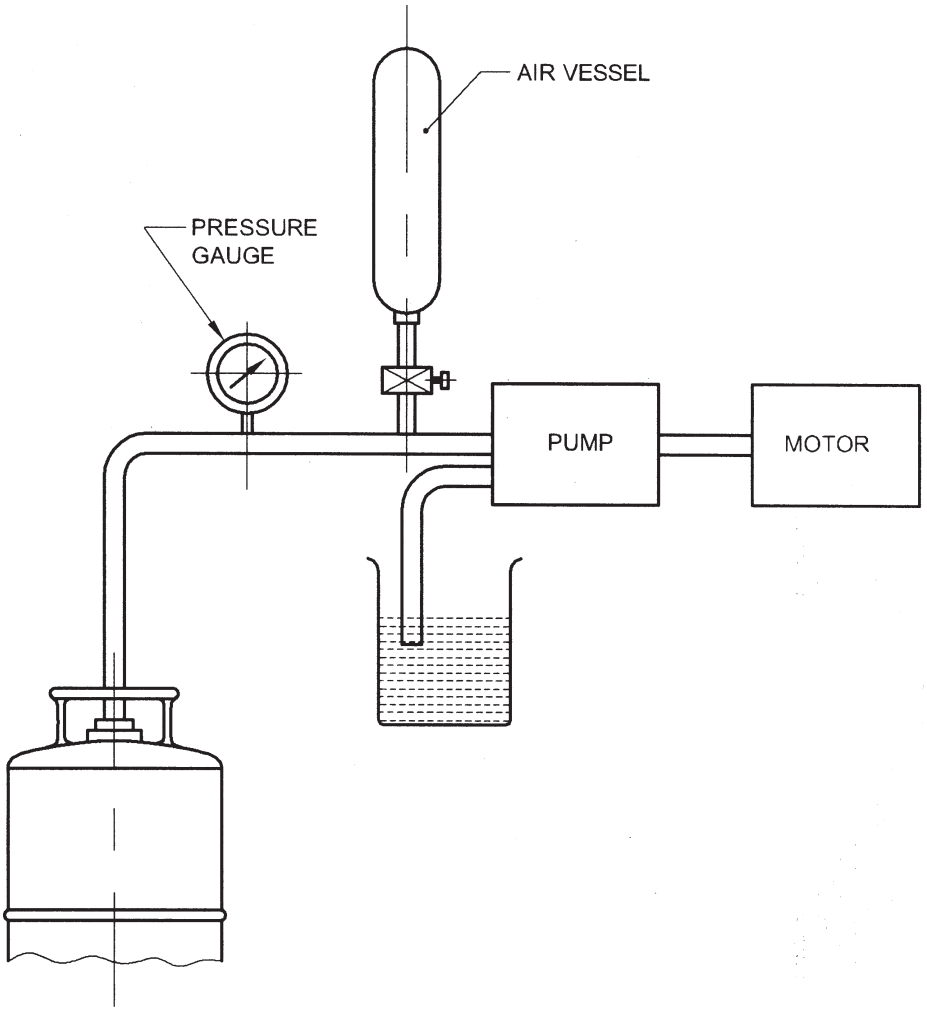


FIG. 9 BURST TEST APPARATUS (TYPICAL)

hydrostatic pressure till it bursts. The initial original volume and the expansion shall be noted by weight method, with provision for peak pressure and peak load indication facility, proper arrangement shall be provided to avoid pressure fluctuation during, the test. A typical sketch of such an arrangement is given in Fig. 9.

9.1.2 The nominal hoop stress corresponding to the pressure at which destruction occurs shall be calculated from the formula:

$$f_b = \frac{P_b \times D_i}{2\,t'}$$

where

f_b = nominal hoop stress at which destruction occurs, in MPa (N/mm^2);

P_b = internal hydrostatic pressure at which cylinder bursts, in MPa (N/mm^2);

D_i = nominal original internal dia of the cylinder, in mm; and

t' = minimum agreed finished thickness as specified on the drawing, in mm.

9.1.3 The value of 'f_b' shall be calculated and the fracture examined.

9.1.4 During burst test; in case leakage starts from any welding, the specimen shall be discarded. The cause of leakage to be identified and fresh test specimen shall be taken from the same welding machine to which the earlier sample belong.

9.2 Failure in Burst Test

If a cylinder fails due to non-compliance of the requirements of this test, the following procedure shall be adopted:

a) If failure can be attributed to a cause which is discernible even before the test, all cylinders with such defects shall be segregated and re-processed and considered as a new batch. After repair the procedure stated in (c) shall be adopted.

b) From the entire original batch or the rest of the sound cylinders after segregation as per (a), as the case may be, two more cylinders shall be selected at random and tested. If both cylinders meet the test requirement this batch shall be accepted. In case of failure of any one of the samples the procedure stated in (c) shall be adopted.

c) The re-processed new batch of cylinders as per (a) above or the failed batch after being tested as per (b) shall be re-heat treated and shall be tested in accordance with all the tests specified in **5**. Two cylinders shall be selected at random thereafter and subjected to burst test. In case of any failure the entire batch shall be rejected.

9.3 Fatigue/Cycle Test

9.3.1 For the purpose of this test, three cylinders which are guaranteed by the manufacturer to be representatives of the minimum end(s) thickness set by design and which shall include all markings, shall be filled with non-corrosive liquid and subjected to successive reversals of hydraulic pressure. This test shall be considered as type test.

9.3.2 The test shall be carried out at an upper cycle pressure, either,

a) equal to two-thirds of the test pressure in which case the cylinder shall be subjected to 80 000 cycles without failure; or

b) equal to the test pressure in which case the cylinder shall be subjected to 10 000 cycles without failure.

The values of the lower cyclic pressure shall not exceed 10 percent of the upper cycle pressure. The frequency of the reversal of pressure shall not exceed 0.25 Hz (15 cycles/min). In case of an interruption during the test, after rectification of the cause of interruption, the test shall be resumed from the point the interruption had occurred.

The temperature measured shall not exceed 50°C during the test. If the measured surface temperature of the cylinder exceeds the maximum permitted, the test shall be stopped and resumed after the temperature drops. External forced cooling is permitted.

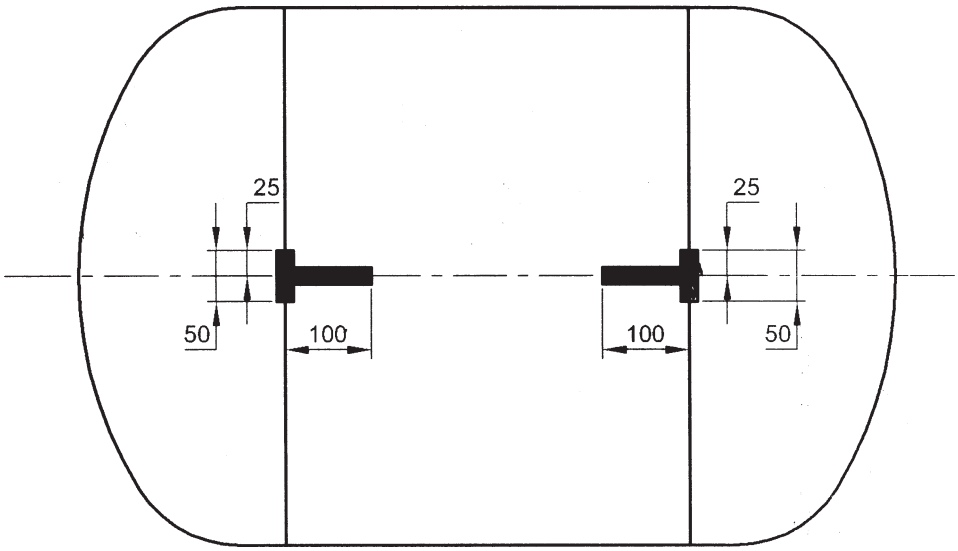
9.3.3 During fatigue test; in case leakage starts from any welding the specimen shall be discarded and fresh test specimen shall be taken and subjected to the required cycles for fatigue test.

9.3.4 The cylinders subject to fatigue test, shall be burst tested and shall meet the requirement of burst test.

9.3.5 Failure in burst test of cylinders subjected to fatigue test will be treated at par with failure in burst test and the retesting shall be in accordance with **9.2**.

10 RADIOGRAPHIC EXAMINATION

10.1 On each cylinder selected for radiographic examination, each weld intersection, 100 mm of the adjacent longitudinal weld and 50 mm (25 mm on each side of the intersection) of the adjacent circumferential weld shall be radiographed (*see* Fig. 10).



All dimensions in millimetres.

FIG. 10 EXTENT OF SPOT RADIOGRAPHY AT WELD INTERSECTIONS

10.2 Interpretation of Radiographs

For correct interpretation of radiographs, the film density shall preferably be between 2 and 3, but in no case less than 1.7. Any of the following imperfections shall be unacceptable:

a) Any type of crack or zone of incomplete fusion or penetration;

b) Any elongated slag inclusion which has a length greater than half the thickness with a maximum of 6 mm for thickness exceeding 12 mm.

c) Any group of inclusions of slag in weldment, the total length of which exceeds the thickness over a length of 12 times the thickness, except when the distance between successive defects exceeds 6 times the length of the longest defect in the group; and

d) Any porosity greater than given in Fig. 8.12A, 8.12B and 8.12C of IS 2825.

10.3 Defects in Radiography

When the cylinders are subjected to 100 percent radiography then the unacceptable defects shall be removed as per **7.2** and shall be repaired by welding. After re-welding, the repaired portion shall be radiographed again and checked as per the requirements given above. The accepted cylinders shall than be subjected to heat-treatment in accordance with the requirement of IS 3196 (Part 1) or IS 3196 (Part 2) as the case may be. The cylinders shall also be subjected to hydrostatic test and pneumatic leakage test. The cylinders shall be accepted if they pass these tests.

10.4 Re-tests

If the sample cylinder subjected to spot radiography is found defective, two more cylinders from the same batch manufactured from the same welding machine to which the failed sample belong shall be subjected to spot radiography. If both the cylinders meet the requirements of radiography then the batch shall be accepted. lf any one of the two cylinders does not meet the requirements of the radiography, then the entire batch shall be rejected. At the option of the manufacturer the entire batch of cylinders may be offered for spot radiography and carrying out tests as specified in **10** or the entire batch may be re-welded and offered for spot radiography examination as a new batch.

ANNEX A
(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
1608 : 2005	Metallic materials — Tensile testing at ambient temperature (*third revision*)
1828 (Part 1) : 2005/ISO 7500-1 : 1999	Metallic materials — Verification of static uniaxial testing machines: Part 1 Tension/compression testing machines — Verification and calibration of the force — Measuring systems (*third revision*)
2825 : 1969	Code for unfired pressure vessels
3196	Welded low carbon steel cylinders exceeding 5 litre water capacity for low pressure liquefiable gases:
(Part 1) : 2006	Cylinders for liquefied petroleum gas (LPG) — Specification (*fifth revision*)
(Part 2) : 2006	Cylinders for low pressure liquefiable gases other than LPG — Specification (*fifth revision*)
(Part 4) : 2001	Cylinders for toxic and corrosive gases
3803 (Part 1) : 1989/ISO 2566-1 : 1984	Steel — Conversion of elongation values: Part 1 Carbon and low alloy steels (*second revision*)
5844 : 1970	Recommendation for hydrostatic stretch testing of compressed gas cylinders
6240 : 2008	Hot rolled steel plate (up to 6 mm) sheet and strip for the manufacture of low pressure liquefiable gas cylinders (*fourth revision*)
7241 : 1981	Glossary of terms used in gas cylinder technology (*first revision*)
13258 : 1991	Welded low carbon steel cylinders exceeding 5 litre water capacity for low pressure liquefiable gases code of practice for inspection and reconditioning of used LPG cylinders

ANNEX B
(*Foreword*)

COMMITTEE COMPOSITION

Gas Cylinders Sectional Committee, MED 16

Organization	*Representative(s)*
Petroleum and Explosive Safety Organization, Nagpur	Shri P. B. Yedla (***Chairman***) Shri D. K. Gupta (*Alternate*)
All India Industrial Gases Manufacturers Association, New Delhi	Shri Karan Bhatia Shrimati Veena Peter (*Alternate*)
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Indian Oil Corporation Ltd, Mumbai	Shri Rabindra N. Ghosh Shri S. M. Rambhal (*Alternate*)

Organization	*Representative(s)*
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Shri Vishal Tomer
Scientist 'C' (MED), BIS

Composition of Low Pressure Gas Cylinders Sub-committee, MED 16 : 2

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All India Industrial Gases Manufacturers Association, New Delhi	Shri Karan Bhatia Shrimati Veena Peter (*Alternate*)
Bharat Petroleum Corporation Ltd, Mumbai	Shri J. Vedagiri Shri Sanjay Phulli (*Alternate*)
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