

Australian Standard[®]

**Steel cylinders for compressed gases—
Welded—150 kg to 500 kg**



This Australian Standard® was prepared by Committee ME-002, Gas Cylinders. It was approved on behalf of the Council of Standards Australia on 13 October 2006. This Standard was published on 6 November 2006.

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- Air Conditioning and Refrigeration Wholesalers Association
 - Australasian Institute of Engineer Surveyors
 - Australia New Zealand Industrial Gas Association
 - Australian Chamber of Commerce and Industry
 - Australian Industry Group
 - Australian Liquefied Petroleum Gas Association
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 - Institute of Materials Engineering Australasia
 - International Association for Natural Gas Vehicles
 - Pressure Equipment Association Incorporated
 - The Australian Gas Association
 - Victorian WorkCover Authority
 - Welding Technology Institute of Australia
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-

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Steel cylinders for compressed gases— Welded—150 kg to 500 kg

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-002, Gas Cylinders, to supersede AS 3577—1999. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to provide manufacturers of gas cylinders with a specification for the design, manufacture, inspection and testing of welded steel cylinders in the water capacity range of 150 to 500 kg.

The objective of this revision is to include stainless steel as a construction material, and to more closely align the radiographic inspection requirements with those of ISO 4706, *Refillable welded steel gas cylinders*.

This Standard is one of a suite of three Standards for welded and brazed cylinders for compressed gases, the other Standards being as follows:

AS

- | | |
|------|--|
| 2469 | Steel cylinders for compressed gases—Welded two-piece construction—0.1 kg to 150 kg |
| 2470 | Steel cylinders for compressed gases—Welded three-piece construction with longitudinal joint—11 kg to 150 kg |

This Standard provides for gas cylinders produced in large quantities. Users of this Standard should note that the relevant Inspection Body will require either quality control procedures to be employed at the point of manufacture in Australia, or sampling testing at the point of entry into Australia. It should also be noted that before a gas cylinder can be first filled in Australia, it must be stamped with a Gas Cylinder Test Station registered mark in accordance with the relevant Standard of the AS 2030 series.

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STANDARDS AUSTRALIA

Australian Standard**Steel cylinders for compressed gases—Welded—150 kg to 500 kg****1 SCOPE**

This Standard specifies requirements for welded carbon and stainless steel cylinders with one longitudinal joint, and two circumferential joints, of water capacity not less than 150 kg nor more than 500 kg, which have test pressures from 1750 kPa to 7000 kPa, and are intended for the storage and transport of compressed gases in accordance with AS 2030.1.

NOTES:

- 1 A gas cylinder manufactured by welding but which includes any brazing of or on the pressure-retaining portions is for the purpose of this Standard considered to be a brazed gas cylinder.
- 2 Other Australian Standards for brazed and welded gas cylinders are AS 2469 and AS 2470.
- 3 Appendix A lists the suggested minimum information that should be supplied by the purchaser when ordering gas cylinders to this Standard.

2 REFERENCED DOCUMENTS

A list of documents referred to in this Standard is given in Appendix B.

3 DEFINITIONS

For the purpose of this Standard the definitions given in AS 2030.1 and those below apply.

3.1 Attachment

Any fitting attached to the pressure-retaining sections of the cylinder by welding, including bosses, pads, valve protection rings, and footrings.

3.2 Competent person

A person who has acquired, through training, qualification or experience, or a combination of these, the knowledge and skills enabling that person to perform the task required.

3.3 Inspection Body

A body responsible for inspection which may cover one or more of the following:

- (a) Design verification.
- (b) Fabrication inspection.
- (c) In-service inspection.

3.4 Inspector

A person, able to inspect pressure equipment for the purposes of conformity with the specified requirements.

4 STEEL

4.1 Steelmaking process

The steel shall be made by the open hearth, basic oxygen, or an electric process and shall be continuously cast. Production by the use of ingots is acceptable provided the steel is fully killed. Rimmed steels shall not be used for arc welded components.

NOTE: Rimmed steels are considered not suitable for arc-welded components because of problems associated with welding of the slit edge due to the possibility of lamination and segregation problems.

4.2 Carbon steel

4.2.1 Cylindrical section and ends

4.2.1.1 Cast analysis

The cast analysis shall conform to Table 1, except that where resistance-welded attachments are to be added to the cylinder the maximum carbon content of the pressure-retaining portion of the joint shall be 0.15%.

TABLE 1
CAST ANALYSIS

Elements (other than iron)	Cast analysis (max.), percent
Carbon	0.25
Manganese	1.70
Silicon	0.40
Micro-alloying elements (total)	0.15
Sulphur	0.040
Phosphorus	0.040

NOTES:

- Grain-refining elements, i.e. titanium (up to 0.040%) and aluminium (up to 0.1%), may be added.
- Examples of micro-alloying elements are titanium (where greater than 0.040%), niobium, and vanadium.
- AS/NZS 1594 and equivalent overseas Standards specify some acceptable grade of steel with conforming cast analyses.
- Residual elements up to the following individual amounts or a sum of 0.7% of all listed elements are considered to be incidental:

Chromium	0.30%
Copper	0.35%
Molybdenum	0.10%
Nickel	0.35%

4.2.1.2 Residual elements

Elements not shown in Table 1 shall not be intentionally added to the steel, other than for the purpose of finishing the heat.

All reasonable precautions shall be taken to prevent the addition of such elements during manufacture, and the quantities present shall not be detrimental to the application of steel for a welded gas cylinder.

4.2.1.3 Weldability

The steel shall be of a weldable quality.

4.2.1.4 *Mechanical properties*

When a completed gas cylinder is tested in accordance with Clause 9.3, the yield and tensile strength values obtained shall be not less than the values used in the equations in Clause 5.1.1.

When determined in accordance with Clause 9.3, the elongation shall be not less than 20% minus one percentage unit for each increment of 50 MPa by which the measured tensile strength exceeds 350 MPa, but in any case not less than 16%.

4.2.2 *Attachments*

Attachments shall be of steel complying with the requirements of Clause 4.1, except that for resistance-welded attachments the steel of both components of the joint shall be weldable and be subject to a maximum carbon content of 0.15%.

4.3 **Stainless steel**

4.3.1 *Cylindrical section and ends*

4.3.1.1 *Cast analysis*

The cast analysis shall comply with the cast analysis shall comply with the chemical composition requirements of grades 304/304 L or 316/316 L as specified in ASTM A240/A240M and ASTM A480/A480M, except that the maximum carbon content shall not exceed 0.05%.

4.3.1.2 *Test certificates*

Test certificates shall be provided by the stainless steel supplier, with each completed order to indicate the material and mechanical properties of the stainless steel supplied.

For temper rolled stainless steel, tensile specimens shall be taken from both ends of each coil. For test certificate purposes, all specimens shall be taken at a sufficient distance from the coil ends in order to be fully representative of the coil.

4.3.1.3 *Mechanical properties*

All tests specified in Section 9 are required. When a completed cylinder is tested in accordance with Clause 9.3, the yield and tensile strength values obtained shall not be less than those values used in the equation in Clause 5.1.1.

When determined in accordance with Clause 9.3, the elongation shall be not less than 20% minus one percentage unit for each increment of 50 MPa by which the measured tensile strength exceeds 350 MPa, but in any case is not less than 16%.

4.3.1.4 *Intergranular corrosion tests*

These intergranular corrosion tests shall comply with the requirements of AS 2038. For welded variables, materials and welding procedures shall be qualified by testing a specimen from at least one cylinder randomly selected from each batch of 200 cylinders or part batch thereof.

Test pieces shall be prepared to provide representative weld metal and heat affected parent metal for each of the following:

- (a) T-joint of the longitudinal and circumferential joint.
- (b) Longitudinal joint.
- (c) Pad or boss attachment weld.
- (d) Representative attachment welds of any attachment described in Clause 4.3.2.

At least one of the test pieces shall be taken from the position of maximum heat input and maximum number of runs.

Test pieces may be taken from cylinders used for other tests provided these other tests on the cylinder have been completed with successful results.

4.3.2 Attachments

Attachments, including fittings, data plates, lugs, handles, valve guards and footings, shall be of stainless steel complying with grades 304/304L or 316/316L of ASTM A240/240M, ASTM A276 and ASTM A480/A480M.

5 DESIGN AND CONSTRUCTION

5.1 Minimum thickness

5.1.1 Cylindrical portions of shell (not including any part of the ends)

The thickness of the cylindrical portion shall be not less than 1.75 mm for carbon steel and not less than 1.5 mm for stainless steel, nor less than the greater of those calculated from the following equations:

$$t = 2.5 \left(\frac{D_i}{R_m} \right)^{1/2} \quad \dots 5.1.1(1)$$

$$\text{and } t = \frac{p_h D_o}{2f\eta + p_h} \quad \dots 5.1.1(2)$$

where

- t = minimum finished thickness of the cylinder, in millimetres
- D_i = nominal internal diameter, in millimetres
- D_o = nominal outside diameter of cylindrical section, in millimetres
- p_h = test pressure (the design test pressure specified in AS 2030.1), in megapascals
- f = for carbon steel maximum permissible stress, to be taken as 90% of the minimum yield strength of the steel, but not exceeding 60% of the minimum tensile strength of the steel, in megapascals. For calculation purposes, a maximum value for f of 320 MPa shall apply for carbon steel
- = for stainless steel maximum permissible stress, to be taken as 90% of the minimum yield strength of the steel (taken as the 0.2% proof stress), but not exceeding 53% of the minimum tensile strength of the steel, in megapascals. For calculation purposes, a maximum value for f of 360 MPa shall apply for stainless steel

R_m = minimum tensile strength of the steel, in megapascals

NOTE: Minimum yield strength and minimum tensile strength are those values determined in accordance with Clause 9.3, i.e. following the heat treatment.

- η = efficiency of the welded joint
- = 0.8, where cylinders are constructed with a longitudinal joint, and no radiography is carried out
- = 0.9, where sample/s are selected from each batch for spot radiography as specified in Clause 7.1.2(b)
- = 1.0, where the longitudinal weld and T-joint are fully radiographed for every cylinder as specified in Clause 7.1.2(a)

5.1.2 Ends

The minimum thickness of ends after forming shall be as follows:

- (a) Other than where thinning has occurred in the forming operation(s), the greater of the thickness given in Items (i) and (ii) as follows:
 - (i) Calculated from the equations of Clause 5.1.1, where the factor η is taken to equal 1.0.
 - (ii) Not less than 1.75 mm for carbon steel and not less than 1.5 mm for stainless steel.
- (b) Where thinning has occurred in the formed portion of the end owing to the forming operation(s), the minimum thickness at that thinned section shall be not less than 90% of the thickness established in Item (a).

5.2 Form of ends

Ends shall be concave to pressure, and shall have either spherical form or ellipsoidal form. See Figure 1.

The ends shall have a cylindrical portion of length not less than four times the minimum thickness.

The ellipsoidal form shall be of not more than 2 to 1 ratio at the internal surface, i.e. the internal height of the end is 25% of the internal diameter. A template of true form shall be used internally or externally to check the deviation from the true form. Any deviation measured perpendicular to the surface shall not exceed 1.25% of the nominal external diameter of the cylinder (see Figure 1).

5.3 Footring

A cylinder intended to be freestanding and upright in service shall be fitted with a footring which shall be clear of, and in such position that will not obstruct the inspection of, any circumferential joint. The footring shall not entrap liquid when the cylinder is in the standing position, and the space enclosed by the footring shall be suitably ventilated.

Where a cylinder is intended for other than vertical application, the means of support shall be approved by the Inspector.

NOTE: Clause 5.6.4 gives requirements for footring attachment.

5.4 Length to outside diameter ratio

The ratio of length over the ends to the outside diameter of the cylinder shall be not greater than 4.0 to 1, except where calculation or test shows to the satisfaction of a competent person that a greater ratio is suitable.

5.5 Valve protection

Valve protection shall be provided in accordance with AS 2030.1.

5.6 Pressure-retaining joints

5.6.1 General

There shall be one longitudinal joint and two circumferential joints. The main longitudinal joint and circumferential joints shall be of a quality not inferior to that produced by electric arc welding by a machine process using automatic feed and guidance mechanisms. Other equivalent automatic processes, with the exception of resistance welding, may be used.

The longitudinal joint and circumferential joints shall be made with weld variables verified by type testing in accordance with Clause 11, and, where welding procedures are changed, these shall be re-verified by further type testing in accordance with Clause 11.

Misalignment of mating butt edges shall not exceed the following percentages of the thicker nominal material thickness of the joint components:

- (a) Square butt joint 15%.
- (b) Joggle-butt joint 25%.

5.6.2 Longitudinal joint

The longitudinal joint shall be a full penetration butt weld. There shall be not more than one main longitudinal joint. Acceptable longitudinal butt joints are as follows:

- (a) Double welded, close square (see Figure 2(a)).
- (b) Single welded, close square (see Figure 2(b)).
- (c) Single welded, open square, with removable backing strip (see Figure 2(c)).

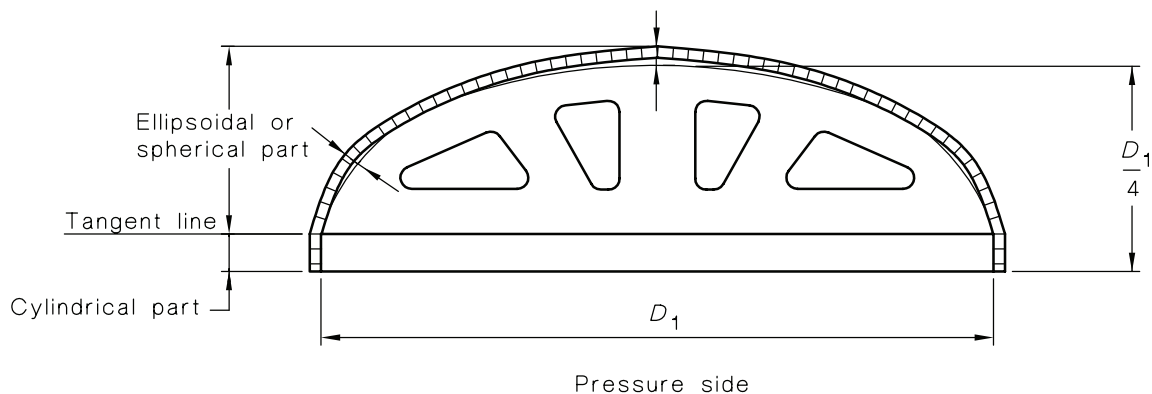
Where a backing strip is used, it shall be non-ferrous, and shall be removed after welding.

5.6.3 Circumferential joints

There shall be not more than two circumferential joints in the cylinder shell. Some acceptable circumferential joints are as follows:

- (a) Butt joint (full penetration) as shown in Figure 2, or with a removable backing bar or a retained backing strip.
- (b) Joggle-butt joint (full penetration) of the proportions shown in Figure 3, with one member offset to form an integral internal backing strip.

Welded circumferential joggle-butt joint members shall be made with a uniform press fit at the weld root, and the offset shall be smooth and symmetrical without notches at position 'X' shown in Figure 3. The weld shall penetrate the root.



NOTE: This Figure illustrates a true ellipsoidal internal templates of 2 to 1 ratio at the surface position.

FIGURE 1 TRUE ELLIPSOIDAL INTERNAL TEMPLATE

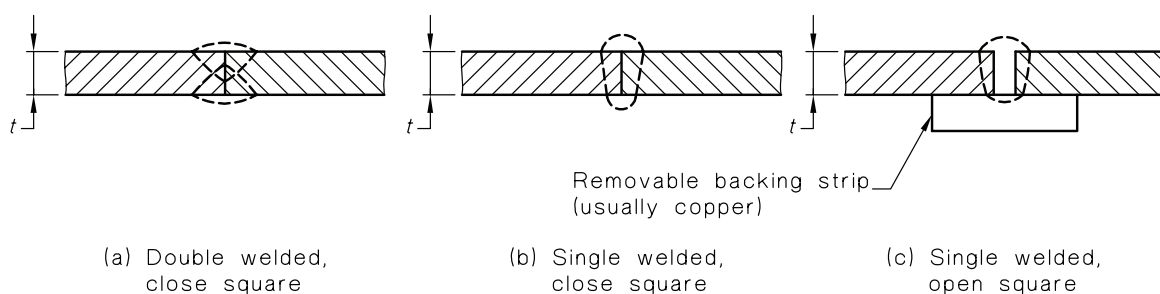


FIGURE 2 ACCEPTABLE TYPES OF LONGITUDINAL BUTT JOINT

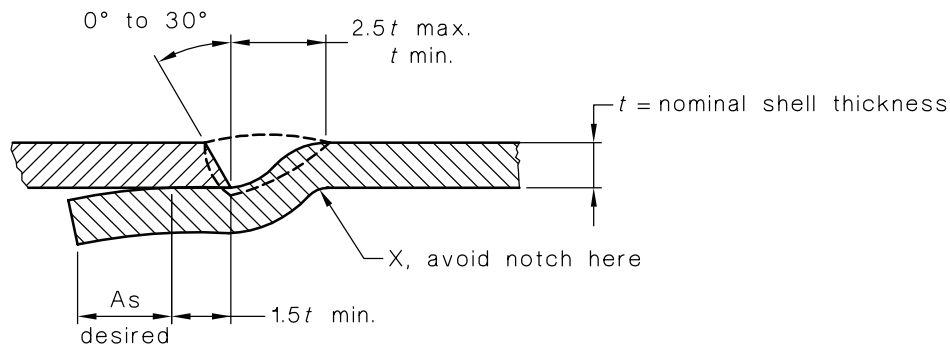


FIGURE 3 CIRCUMFERENTIAL JOGGLE-BUTT JOINT

5.6.4 Non-pressure-retaining joints

Non-pressure-retaining joints for joining of attachments directly to pressure-retaining part shall be designed to prevent crevice corrosion. They may have intermittent contact such as scalloping or attachment by ears. However they shall be continuously welded at all points of contact with the pressure retaining member. Welding shall be achieved by means of one of the following:

- (a) Resistance welding by seam welding in accordance with ISO 16433.
- (b) Spot welding in accordance with Appendix C.

NOTE: Spot weld joining of a non-pressure-retaining attachment is deemed to comply with the requirement for continuous welding, provided that the joint is sealed to prevent corrosion within the joint.

- (c) Arc welding.

5.7 Openings in cylinders

5.7.1 Location

Openings shall be in only the ends of the cylinder.

5.7.2 Size, proportions, and construction

The diameter of an opening shall not exceed 50% of the outside diameter of the cylinder. Multiple openings are permitted, but shall all lie within a diameter not exceeding 80% of the outside diameter of the cylinder, and the design shall take into account ligament efficiency. The edge of any reinforced opening or the edge of any reinforcement or welding thereto shall be not closer to the outside circumference of an end than 10% of the outside diameter of the cylinder, when measured perpendicularly to the axis of the end.

Where an external pad similar to that shown in Figure 4(a) is used, a seal weld shall be made on the inside of the end to attach the pad to the end; however, where this is impracticable, the pad shall be not less than twice the thickness of the end, and shall be fillet welded on the outside by a weld of not less than the proportions shown in Figure 4(a).

NOTE: Figure 4 shows some acceptable opening constructions.

Where a boss is used, it shall project at least 3 mm clear of the outside weld metal. All bosses used for threaded attachments shall have a diameter of not less than the greater of—

- (a) 1.3 times the maximum major diameter of the thread; and
- (b) 6 mm plus the major diameter of the thread.

5.7.3 Cylinder neck thread

Any cylinder neck thread shall permit the fitting of a valve in accordance with AS 2030.1, or shall have one of the following threads: