

Australian Standard™

**Fibre reinforced plastics (FRP)  
aluminium alloy gas cylinders—  
Hoop overwrapped**



This Australian Standard was prepared by Committee ME-002, Gas Cylinders. It was approved on behalf of the Council of Standards Australia on 31 July 2002 and published on 20 August 2002.

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Australian Gas Association  
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Hoop overwrapped**

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## PREFACE

This Standard was prepared by the Australian members of Joint Standards Australia/Standards New Zealand Committee ME-002, Gas Cylinders, to supersede AS 2764—1985, *Fibre reinforced plastic (FRP) aluminium alloy gas cylinders—Hoop overwrapped*. 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 specify the limitations of design and manufacture of FRP aluminium alloy gas cylinders as these offer higher stored capacity to mass ratios than available with conventionally manufactured cylinders, and are expected to have application in portable breathing apparatus and where mass is critical. The technology was developed for the United States space program.

The Standard provides for hoop overwrapped construction only, and not for totally overwrapped construction.

This Standard specifies a bonfire test to establish the performance of the complete cylinder system. Performance in this test depends on the valve and safety relief device (if fitted) as well as the cylinder and the cylinder lading. It is therefore necessary for the purchaser to specify any required departures from the method given in this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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## STANDARDS AUSTRALIA

## Australian Standard

**Fibre reinforced plastics (FRP) aluminium alloy gas cylinders—  
Hoop overwrapped**
**1 SCOPE**

This Standard specifies requirements for the materials, design, manufacture, inspection, pressure tests and markings of aluminium alloy gas cylinders reinforced by hoop overwrapping with fibre reinforced plastics (FRP), intended for storage and transport of compressed gases, and of water capacity exceeding 0.10 kg but not exceeding 130 kg.

NOTE: Appendix A lists the suggested minimum information that should be supplied by the purchaser when ordering gas cylinders covered by this Standard.

**2 REFERENCED DOCUMENTS**

The following documents are referred to in this Standard:

|                              |                                                                                                                           |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| AS                           |                                                                                                                           |
| 1391                         | Methods for tensile testing metals                                                                                        |
| 1777                         | Aluminium cylinders for compressed gases—Seamless—0.1 kg to 130 kg                                                        |
| 2030                         | The verification, filling, inspection, testing and maintenance of cylinders for storage and transport of compressed gases |
| 2030.1                       | Part 1: Cylinders for compressed gases other than acetylene                                                               |
| 2337                         | Gas cylinder test stations                                                                                                |
| 2337.1                       | Part 1: General requirements, inspections and tests—Gas cylinders                                                         |
| 2473                         | Valves for compressed gas cylinders (threaded outlet)                                                                     |
| 3635                         | Unified (ISO inch) screw threads, associated gauges and gauging practice                                                  |
| ISO                          |                                                                                                                           |
| 11439                        | Gas cylinders—High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles           |
| ANSI                         |                                                                                                                           |
| B1.20.3                      | Dryseal pipe threads (inch)                                                                                               |
| B1.20.5                      | Gauging for dryseal pipe threads (inch)                                                                                   |
| B57.1                        | Compressed gas cylinder valve outlet and inlet connections (identical with CGA V-1 and CSA B96)                           |
| ASTM                         |                                                                                                                           |
| D 2343                       | Test method for tensile properties of glass fibre strands, yarns and rovings used in reinforced plastics                  |
| D 2344                       | Test method for short-beam strength of polymer matrix composite materials and their laminates                             |
| DIN                          |                                                                                                                           |
| 477                          | Gas cylinder valves                                                                                                       |
| MIL-R-60346B<br>4 April 1975 | Military specifications, roving, glass, fibrous (for filament winding applications)                                       |

### 3 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 2030.1 and the following apply:

#### 3.1 Autofrettage pressure

The pressure within the overwrapped cylinder at which the required distribution of stresses between the liner and the overwrap is established.

#### 3.2 Competent person or body

A person or body who, through training, qualification or practical experience or a combination of these, and understanding of the equipment and processes, is able to verify compliance with this Standard.

#### 3.3 Design verifier

A competent person or body, who can verify that the design complies with all the required performance and safety criteria of the cylinder specified in this Standard.

#### 3.4 Filling pressure

The settled filling pressure at 15°C, which does not exceed 60% of the test pressure.

#### 3.5 Hoop wrap

Winding of filament in a substantially circumferential pattern over the cylindrical portion of the liner so that the filament does not transmit any significant stresses in a direction parallel to the cylinder longitudinal axis.

#### 3.6 Liner

The seamless aluminium alloy gas cylinder to which the overwrap is applied.

#### 3.7 Overwrap

The reinforcement of filament and resin system applied over the liner.

### 4 OVERWRAP MATERIALS

#### 4.1 Filament

The filament shall be glass fibre filament commercially known as Type S2 or Type E Fibreglass, or any other fibre sufficient to meet the requirements of this Standard.

NOTE: Typical properties for Type S2 and Type E fibreglass are given in Appendix B.

When determined in accordance with ASTM D 2343, the filament tensile strength shall be not less than—

- (a) for Type S2 Fibreglass ..... 2760 MPa; or
- (b) for Type E Fibreglass ..... 1380 MPa.

#### 4.2 Resin

The resin shall be epoxy with amide or anhydride curing agent, or any material otherwise sufficient to meet the requirements of this Standard. The resin shall be translucent to facilitate inspection.

#### 4.3 Fibre reinforced plastics specimen

When determined in accordance with ASTM D 2344, the shear strength of a specimen constructed of the filament and resin specified in Clauses 4.1 and 4.2 shall be not less than 35 MPa.

## 5 DESIGN OF LINER

The design of the liner shall be in accordance with AS 1777, with the following additional requirements:

- (a) The design test pressure of the liner shall be not less than 50 percent of the design test pressure of the overwrapped cylinder.
- (b) The liner design burst pressure shall be not less than 80 percent of the design test pressure of the overwrapped cylinder.
- (c) The design of the liner shall ensure that the overwrapped cylinder complies with Clause 9.3.2.
- (d) The design of the liner shall ensure that the liner, after autofrettage, will not buckle owing to compressive forces induced by the overwrap when the internal and external pressures are equalized at atmospheric pressure.
- (e) The design of the liner ends shall ensure that the stress intensity (Von Mises) in the liner ends is less than the stress intensity in the liner cylindrical portion, at the design test pressure.
- (f) The inside knuckle radius of liner ends of torispherical form shall be not less than 12.5 percent of the inside diameter of the liner.
- (g) The neck thread shall provide for fitting of a valve complying with one of the following items, as appropriate:
  - (i) AS 2473 and AS 3635.
  - (ii) ANSI B57.1 (identical with CGA V-1 and CSA B96).
  - (iii) ANSI B1.20.3; and  
ANSI B1.20.5.
  - (iv) DIN 477.

## 6 DESIGN OF OVERWRAPPED CYLINDER

### 6.1 General

The design of a composite gas cylinder is not conducive to explicit solution, and therefore cannot be reduced to such simple formulas as conventional design equations. This Standard does not provide design formulas, but specifies maximum stress levels at critical conditions of pressurization. The manufacturer shall provide design computations when requested.

NOTE: A suggested form for stress analysis values is given in Appendix C.

Adequacy of the design shall be demonstrated by satisfactory performance of the tests specified in Clause 9.

### 6.2 Design burst pressure

The design burst pressure shall be not less than 1.5 times the test pressure.

### 6.3 Maximum stress levels

The maximum stress levels after autofrettage shall be confirmed by the appropriate finite element stress analysis or other stress analysis programs to be as follows:

- (a) The maximum compressive stress in the liner while the cylinder is subjected to equalized internal and external atmospheric pressure shall be less than 95 percent of the 0.2 percent proof stress value of the aluminium alloy. (See Note.)
- (b) The maximum stress intensity (Von Mises) in the liner while the cylinder is subjected to 60 percent of the test pressure shall be not more than 60 percent of the 0.2 percent proof stress of the aluminium alloy. (See Note.)