

AS 2634—1983

Australian Standard[®]

**CHEMICAL PLANT EQUIPMENT
MADE FROM GLASS-FIBRE
REINFORCED PLASTICS (GRP) BASED
ON THERMOSETTING RESINS**

This Australian standard was prepared by Committee PL/44, Reinforced Plastics Process Equipment. It was approved on behalf of the Council of the Standards Association of Australia on 19 April 1983 and published on 8 August 1983.

The following interests are represented on Committee PL/44:

Confederation of Australian Industry
Melbourne and Metropolitan Board of Works
Plastics Institute of Australia Incorporated

Additionally the following participated actively in the preparation of this standard:

Consulting engineers
Fibreglass producers
Manufacturers of GRP equipment
Pulp and paper industry users of the equipment

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PREFACE

This standard was prepared by the Association's Committee on Reinforced Plastics Process Equipment under the direction of the Plastics Standards Board. The basis of the standard was an interim product specification supplied by the Fibre Glass Reinforced Plastics Division of the Plastics Institute of Australia Incorporated.

During the preparation of this standard, the committee gave consideration to the following standards and documents:

NBS	Voluntary Product Standard PS 15-69 Custom Contact-Moulded Reinforced-Polyester Chemical-Resistant Process Equipment
BS 4994	Vessels and Tanks in Reinforced Plastics
BS 5480	Specification for Glass Reinforced Plastics (GRP) Pipes and Fittings for Use for Water Supply or Sewerage Part 1 — Dimensions, Materials and Classification Part 2 — Performance Requirements*
	Draft British Standard (Doc. 76/50861 Dc) for Reinforced Plastics Pipes and Fittings for Process Plant
	Draft ASTM Specification (X-23-15-5-11), Contact Moulded Glass Fibre Reinforced Thermoset Resin Chemical Resistant Tanks

* In course of preparation —see BSI Doc. 77/53956 DC.

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STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard
for
CHEMICAL PLANT EQUIPMENT MADE FROM GLASS-FIBRE REINFORCED
PLASTICS (GRP) BASED ON THERMOSETTING RESINS

SECTION 1. SCOPE AND GENERAL

1.1 SCOPE. This standard specifies requirements for certain components of chemical processing equipment made from laminates constructed using glassfibre reinforced thermosetting resin systems. It specifies design, dimensional, constructional and installation requirements for ducting and fittings, pipes and fittings and for stationary cylindrical non-pressure tanks.

The components are covered in four Sections as follows:

- Section 2 — Laminates — Contact Moulded, Filament Wound and Centrifugal Cast
- Section 3 — Ducting and Fittings
- Section 4 — Pipes and Fittings
- Section 5 — Tanks (Stationary Non-pressure Vessels)

NOTES:

1. In Section 2, the requirements of the laminate made by means of contact moulding, filament winding or centrifugal casting are specified. Laminates so produced are intended to be used in the manufacture of tanks, pipes, ducts and other ancillary equipment which will be used primarily in contact with aggressive chemical environments. Dimensions and tolerances for ducting and fittings, pipes and fittings, and stationary non-pressure vessels are specified in their respective Sections, with the exception of dimensional requirements for rectangular tanks which are not embraced herein. To enable laminates to be produced for conditions and in dimensions outside of those specified in this standard, Appendix A providing design information has been included.
2. Because of the infinite range of chemical environments and operating conditions which may be encountered, no specific direction is given to material selection or test procedures which will ensure long-term resistance of the composite in service or non-contamination of the product being handled. Reference should be made to the chemical resistance test set out in AS XXXX, which provides guidelines to materials selection.
3. Requirements for jointing and installation are given in Appendix B and advice on the information to be sought or provided when making an enquiry or placing an order is given in Appendix C.

1.2 REFERENCED DOCUMENTS. The following documents are referred to in this standard:

- | | |
|------------|---|
| AS 1145 | Method for Determination of Tensile Properties of Plastics Materials |
| AS 1170 | SAA Loading Code
Part 1 — Dead and Live Loads
Part 2 — Wind Forces |
| AS 1358 | Bursting Discs |
| AS 1369 | Method for the Determination of the Deflection Temperature of Plastics Subjected to an Applied Stress |
| AS 1646 | Rubber Joint Rings for Water Supply, Sewerage and Drainage Purposes |
| AS 1657 | SAA Code for Fixed Platforms, Walkways, Stairways and Ladders |
| AS 1886 | Glossary of Terms Relating to Plastics |
| AS 2129 | Flanges for Pipes, Valves and Fittings |
| AS 2132 | Methods for the Determination of the Flexural Properties of Plastics |
| AS 2288 | Guide to the Selection and Use of Fire Tests for Plastics Materials and Products |
| AS 2484 | Glossary of Terms Relating to Fire Tests |
| AS XXXX | Test Methods for Glass-fibre Reinforced Plastics (GRP)* |
| BS 4994 | Vessels and Tanks in Reinforced Plastics |
| ASTM D2583 | Test for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor |

* In course of preparation.

SECTION 2. LAMINATES — CONTACT MOULDED, FILAMENT WOUND AND CENTRIFUGAL CAST

2.1 SCOPE OF SECTION. This Section specifies requirements for contact moulded, filament wound and centrifugal cast laminates made from glass-fibre reinforced thermosetting resin systems used to manufacture chemical processing equipment primarily intended for use in aggressive chemical environments.

NOTE: Information to be provided by a prospective purchaser when making an enquiry or by a manufacturer when applying for a tender, is given in Appendix C.

2.2 DEFINITIONS. For the purpose of this standard, the definitions given in AS 1886 and the following apply:

2.2.1 Contact moulding — the process of making reinforced plastics moulding in which minimal pressure is applied during the forming and curing operations.

2.2.2 Filament winding — a process used to manufacture tubular goods by winding continuous glassfibre strand roving or roving tape onto a contact moulded corrosion barrier which has previously been formed over a mandrel. The rovings are applied in a predetermined pattern, under controlled tension. The rovings may be saturated with liquid resin or preimpregnated with partially cured resin. The inside diameter (ID) of the finished product is fixed by the mandrel outside diameter (OD). The outside diameter (OD) of the finished product is determined by the amount of material that is wound on the mandrel.

2.2.3 Centrifugal casting — a manufacturing process used to produce tubular goods by applying resin and reinforcement to the inside of a rotating mould that may be heated. The outside diameter (OD) of the finished product is fixed by the inside diameter (ID) of the mould tube. The inside diameter of the product is determined by the amount of material introduced into the mould.

2.2.4 Chemical processing equipment — vessels, tanks, pipes, ducts stacks and other ancillary equipment used for the processing or conveyance of chemical products.

2.2.5 Laminate — the laminate consists of four or more layers, which can consist of a resin rich layer, a backing layer, a structural layer, an outer layer and combinations thereof.

2.2.6 Surfacing tissue — a very thin mat, composed of single continuous filaments of glass fibres bound together with a resinous binder.

2.2.7 'C' glass — calcium-aluminium-borosilicate glass with an alkali oxide content of approximately 8 percent.

2.2.8 'E' glass — a borosilicate glass with an alkali oxide content of less than 1 percent.

2.2.9 Chopped strands — short lengths of continuous filament strands.

2.2.10 Chopped strand mat — a random distribution of chopped strands of glass fibres bound together by a resinous binder.

2.2.11 Rovings — a collection of parallel strands or filaments assembled with or without intentional twist.

2.2.12 Woven roving — a heavy woven fabric constructed from rovings.

2.2.13 Woven cloth — a woven material constructed from continuous glass-fibre yarns.

2.2.14 Winding angle — the angle at which the continuous glass filaments are placed on the mandrel, measured from the axis of the mandrel.

2.2.15 Tex — the mass in grams of 1000 linear metres of continuous glass filament.

2.3 MATERIALS.

2.3.1 General. Materials shall be suitable for the chemical environment intended when tested in accordance with AS XXXX.2.

2.3.2 Resin. The resin component of all layers of the laminates shall be a commercial grade of polyester, epoxide, furane or vinylester type. When determined in accordance with AS 1369, the heat distortion temperature of the resin shall be not less than 20°C above the design temperature (see Appendix A).

2.3.3 Reinforcement. The reinforcing material shall be a commercial grade of 'E' glass fibre having a coupling agent which will provide a suitable bond between the glass reinforcement and the resin.

2.3.4 Other Materials. Unless otherwise specified, materials shall not differ from that required for each layer in Clause 2.4.

2.4 COMPOSITION AND STRUCTURE OF THE LAMINATE.

2.4.1 Laminate Construction (See Fig. 2.1). The laminate shall consist of a corrosion barrier, a structural layer and an outer surface layer.

NOTE: The structural layer for filament wound laminates differs from that of contact moulded and centrifugal cast laminates.

2.4.2 Corrosion Barrier. The corrosion barrier comprises a resin rich layer followed by a backing layer.

- (a) *Resin rich layer.* The resin rich layer shall be of thickness in the range 0.25 mm to 0.5 mm and shall contain 'C' glass surfacing tissue or synthetic fibres such as polyester or acrylic fibres of minimum dry thickness 0.25 mm.

The inclusion of surfacing tissue in the internal surface corrosion barrier of a centrifugal cast laminate is not necessary as the nature of the process ensures segregation of the resin rich layer from the glass strands of the backing layer.

- (b) *Backing layer.* The backing layer shall be of resin, reinforced with 'E' glass strands of length 10 mm to 50 mm. The minimum thickness of the backing layer shall be 2.5 mm. When determined in accordance with AS XXXX.3, the glass-fibre content shall be not less than 20 percent and not greater than 30 percent by mass.

NOTE: This can be achieved by 600 g/m² to 900 g/m² of glass.

2.4.3 Structural Layer.

2.4.3.1 Contact moulded and centrifugal cast laminates. The structural layer for contact moulded and centrifugal cast laminates shall be of resin, reinforced in layers with 'E' glass in the form of chopped strands, cloth or woven rovings. When determined in accordance with AS XXXX.3, the glass-fibre content of the structural layer shall be not less than 25 percent by mass.

If cloth or woven rovings are used, layers of chopped strand glass shall be placed as alternate layers. All layers of reinforcement shall be lapped at least 25 mm and laps shall be staggered as fully as practicable.

2.4.3.2 Filament wound laminates. The structural layer for filament wound laminates shall be of resin reinforced in layers with continuous glass rovings in a predetermined pattern, under controlled tension. The structural laminate shall consist of not less than two bidirectional layers of continuous filaments. Each bidirectional layer shall have a minimum glass content equal to three strands of 2400 tex rovings per centimetre width, measured at right angles to the direction of the fibres. Application of the continuous rovings shall be machine controlled to ensure uniformity so that, in each bidirectional layer, the adjacent bands of rovings abut or overlap to leave the structural layer free from unreinforced pockets.

NOTE: This requirement is best checked during manufacture.

The winding angle shall be selected to give the necessary hoop and longitudinal properties. The winding angle shall be uniform throughout the entire length of the pipe within ± 2 degrees of the designated angle. The winding pattern shall be regular and shall produce a dense laminate without unreinforced resin pockets, i.e. each layer shall be closed when winding the last filament of a layer.

When determined in accordance with AS XXXX.3, the glass-fibre content of the structural layer shall be not less than 50 percent by mass.

NOTE: If the glass content is greater than 75 percent, the integrity of the composite could be affected.

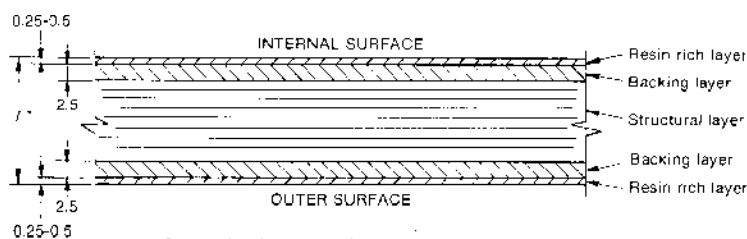
Before filament winding is applied, the corrosion barrier should be allowed to gel completely so that it will not be squeezed down to a thin layer with a glass content greater than 30 percent.

2.4.4 Outer Surface Layer (See Fig. 2.1).

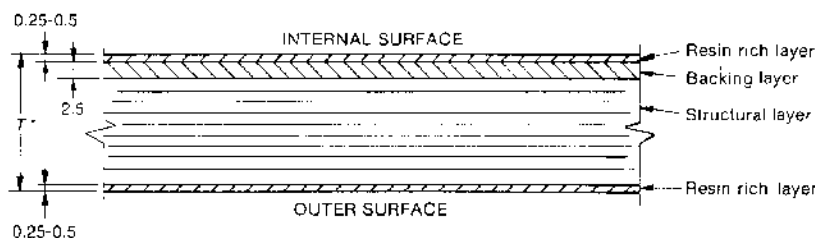
- Where the outer surface layer is exposed to a corrosive environment. The outer surface layer shall consist of a backing layer followed by a resin rich layer as specified in Clause 2.4.2. For centrifugal cast laminates, the outer surface resin rich layer shall include surfacing tissue.
- Where the outer surface layer is exposed to weathering. The outer surface layer shall consist of a resin rich layer as specified in Clause 2.4.2(a), which, in addition, shall be resistant to ultraviolet light. This layer may contain pigments, dyes and fillers as required. For contact moulded and filament wound laminates, such additions shall only be applied after visual inspection of the corrosion barrier and structural layers.

NOTE: The incorporation of ultraviolet stabilizers and the determination of ultraviolet light resistance is a matter for agreement between purchaser and supplier.

- Where the outer surface layer is decorative only. The outer surface layer shall be of resin and may be non-reinforced and may contain pigments, dyes, fillers and ultraviolet stabilizers as specified in Clause 2.4.4(b).



(a) Outer surface layer exposed to a corrosive environment



(b) Outer surface layer exposed to weathering

*T = thickness

DIMENSIONS IN MILLIMETRES

Fig. 2.1. STRUCTURE OF THE LAMINATES

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2.5 COMBUSTION CHARACTERISTICS. Where the combustion characteristics of laminates are to be determined, consideration should be given to the information contained in AS 2288 taking into account AS 2484.

NOTE: The need for the specification of fire tests is dependent on the final application of the laminate. For example, fire retardants may be required to be incorporated in the internal surface resin rich layer of ducting carrying flammable gases, whereas a tank exposed to potential combustion from external sources may have fire retardants in the outer surface layer.

Consequently this is a matter for arrangement between purchaser and supplier (see Appendix C).

2.6 CURING. Where laminates are to be post cured, this shall be carried out in accordance with the directions of the resin manufacturer.

2.7 MECHANICAL PROPERTIES OF THE LAMINATE.

2.7.1 Contact Moulded and Centrifugal Cast Laminates.

2.7.1.1 Tensile stress. When samples of laminate prepared in accordance with AS XXXX.1 are tested in accordance with AS 1145 using Speed B, the minimum tensile stress shall comply with the graph of Fig. 2.2 for the appropriate thickness of laminate.

2.7.1.2 Flexural stress and modulus of elasticity. When samples of laminate prepared in accordance with AS XXXX.1 are tested in accordance with AS 2132, the minimum flexural stress at rupture

shall comply with the graph of Fig. 2.2 and the minimum modulus of elasticity shall comply with the graph of Fig. 2.3, for the appropriate thickness of laminate.

2.7.1.3 Surface hardness. When determined in accordance with ASTM D2583, the minimum Barcol hardness of the corrosion barrier of the fabricated item (duct, pipe or tank, as applicable) shall be not less than 90 percent of the value specified by the resin manufacturer for cured resin.

NOTE: Where synthetic fibres are used in the resin rich layer, these may affect the values obtained for the Barcol hardness of the surface.

2.7.2 Filament Wound Laminates.

2.7.2.1 Hoop tensile stress. Hoop tensile stress shall be determined either in accordance with AS XXXX.5, or from Appendix A, Fig. A1(b).

2.7.2.2 Tensile modulus of elasticity. The tensile modulus of elasticity shall be determined in accordance with AS XXXX.6.

2.8 SURFACE FINISH.

NOTE: Surface finish and the acceptance of visual defects in glass-fibre reinforced plastics products are matters for agreement between the purchaser and supplier, including, if required, a representative laminate sample.

Appendix D defines defects in the corrosion barrier and outer layer and provides guidance on their limits.

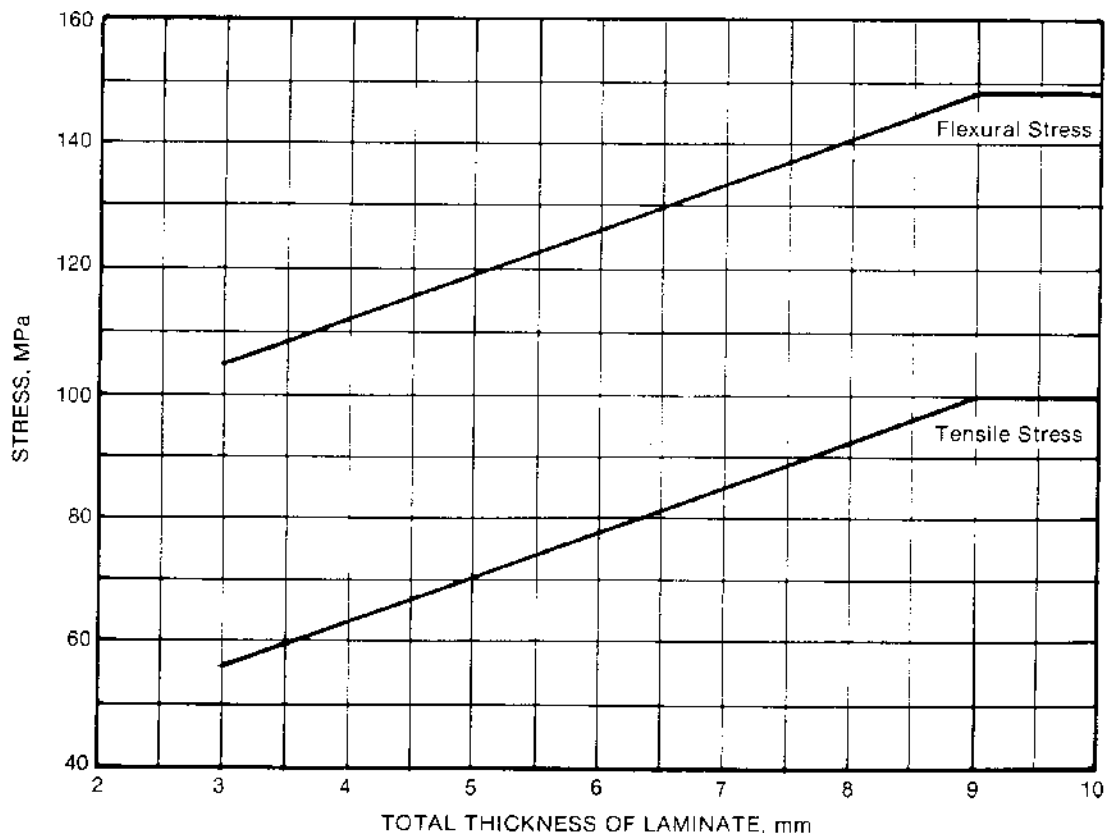


Fig. 2.2. GRAPH OF MINIMUM FLEXURAL STRESS AND MINIMUM TENSILE STRESS vs TOTAL LAMINATE THICKNESS (INCLUDING CORROSION BARRIER AND OUTER LAYER) FOR CONTACT MOULDED AND CENTRIFUGAL CAST LAMINATES

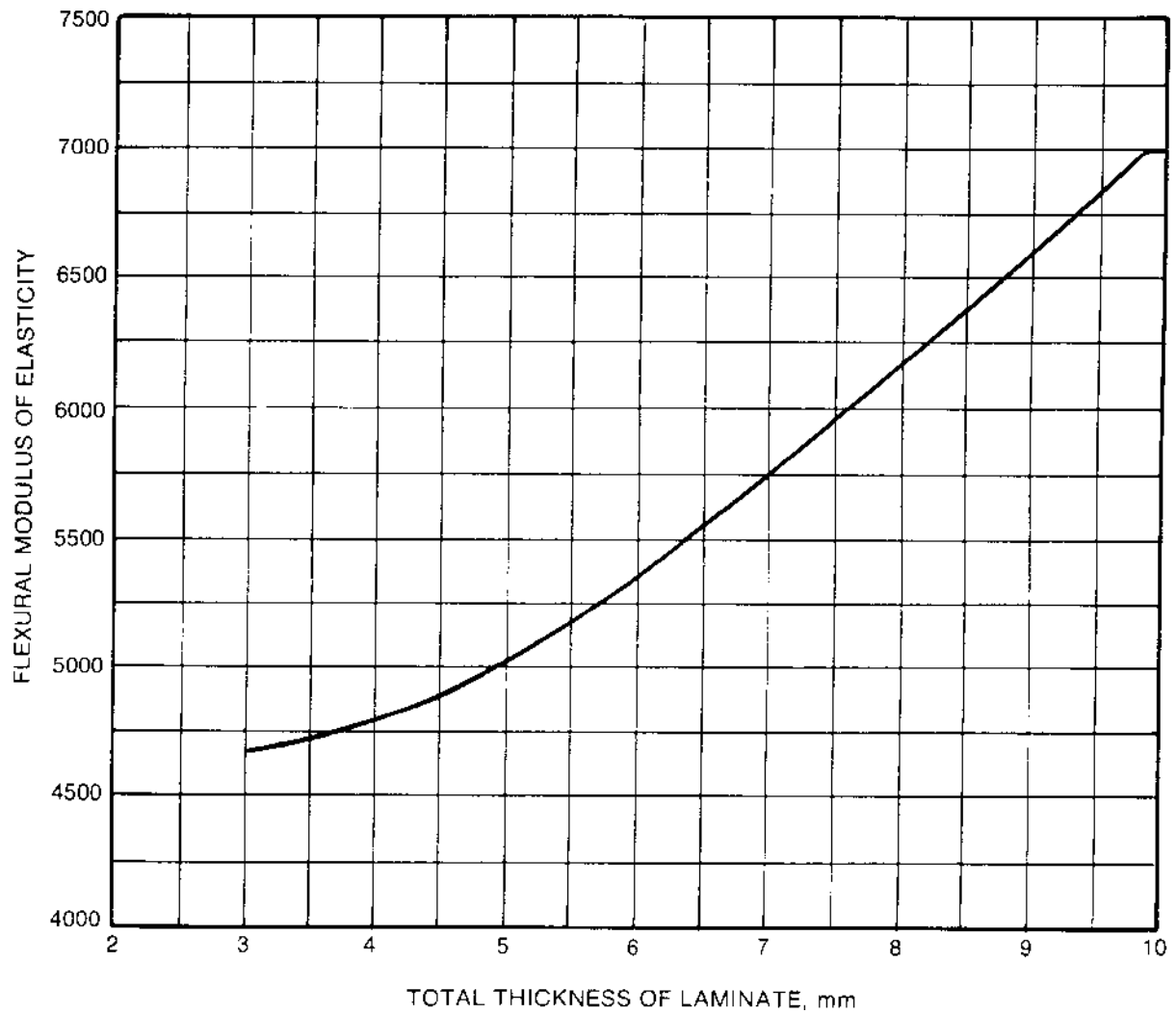


Fig. 2.3. GRAPH OF FLEXURAL MODULUS OF ELASTICITY vs LAMINATE THICKNESS FOR CONTACT MOULDED AND CENTRIFUGAL CAST LAMINATES

SECTION 3. DUCTING AND FITTINGS

3.1 SCOPE OF SECTION. This Section specifies requirements for round and rectangular ducting and ducting fittings made from laminate as specified in Section 2.

NOTES:

1. Rectangular ducting is normally only produced by contact moulded lay up.
2. Information to be provided by a prospective purchaser when making an enquiry or by a manufacturer when applying for a tender is given in Appendix C.

3.2 MATERIAL. The laminate used for the manufacture of ducting and ducting fittings shall comply with the requirements of Section 2 except that the backing layer may form part or all of the structural layer.

3.3 DIMENSIONS AND TOLERANCES OF DUCTING.

3.3.1 Length. Ducting shall be supplied in standard nominal lengths, exclusive of coupling, of 3, 5, 6, 10 or 12 m. Tolerance shall be ± 0.2 percent.

NOTE: All measurements should be adjusted to an equivalent length at 23°C using a coefficient of expansion agreed between purchaser and supplier.

3.3.2 Size.

- (a) *Round ducting.* The nominal diameter of round ducting shall be the internal diameter of the duct and shall be in accordance with the sizes indicated and the tolerances specified in Table 3.1.
- (b) *Rectangular ducting.* The size of rectangular ducting shall be the inside dimensions as determined at the mid-point of the sides. The tolerance on size shall be ± 5 mm for dimensions of 450 mm and less, and ± 1 percent for dimensions greater than 450 mm.

3.3.3 Wall Thickness.

- (a) *Round ducting.* The minimum wall thickness of round ducting shall be as given in Table 3.1.
- (b) *Rectangular ducting.* The minimum wall thickness of rectangular ducting shall be as given in Table 3.1 for the diameter corresponding to the dimension of the longer side of the rectangle.

3.3.4 Squareness of Ends. The ends of the ducting shall be to within the following tolerances:

- (a) For round ducting ≤ 600 mm nominal diameter and for rectangular ducting ≤ 1800 mm perimeter ± 3 mm.

- (b) For larger sizes of both round and rectangular ducting ± 6 mm.

3.4 DESIGN DIMENSIONS AND TOLERANCE OF DUCTING FITTINGS.

3.4.1 Wall Thickness. The minimum wall thickness at any point of a fitting shall be not less than that of ducting of the same nominal diameter.

3.4.2 Tolerance on Angles of Fittings. The tolerance on nominal angles in fittings shall be —

- (a) ≤ 1000 mm nominal diameter . . . ± 1 degree;
- (b) > 1000 mm nominal diameter . . . ± 0.5 degree.

3.4.3 Elbows. Elbows shall have a centreline radius of 1.5 times the duct nominal diameter. Bends may be lobsterbacked using two or more mitres.

3.4.4 Standard Laterals. Standard laterals shall have an angle of 45 degrees.

3.4.5 Reducers. The length of concentric and eccentric reducers shall be five times the difference between the larger and smaller diameters. The wall thickness shall be that of the larger diameter in accordance with Table 3.1.

3.5 JOINTING. The jointing of ducting shall be in accordance with the relevant portions of Paragraph B1 of Appendix B.

3.6 INSTALLATION. The installation of ducting shall be in accordance with the relevant portions of Paragraph B2 of Appendix B.

3.7 MARKING. All ducting and ducting fittings shall be permanently and indelibly marked with the following information:

- (a) The manufacturer's name and/or registered trademark.
- (b) Date of manufacture.
- (c) Nominal diameter.
- (d) Maximum allowable pressure/vacuum, as appropriate.

NOTE: Manufacturers who place the number of this Australian standard on ducting and ducting fittings, on packaging or on literature related thereto should ensure that the ducting and ducting fittings are manufactured to comply with the standard.

TABLE 3.1
TYPICAL DIMENSIONS OF ROUND DUCTING

Nominal diameter of ducting mm	Ducting			Flange				
	Minimum wall thickness mm	Maximum allowable vacuum kPa	Maximum allowable pressure kPa	Flange diameter (OD) mm	Minimum flange thickness mm	Bolt circle diameter mm	Bolt hole diameter mm	Number of bolt holes
50	3	100.0	1120	160	6	125	11	4
75	3	100.0	750	185	6	150	11	4
100	3	50.0	560	210	6	180	11	4
150	3	16.0	375	255	6	230	11	8
200	3	7.5	280	315	6	280	11	8
250	3	4.0	225	365	10	330	11	12
300	3	2.0	185	415	10	380	11	12
350	3	1.5	160	465	10	430	11	12
400	3	1.5	140	515	12	485	11	16
450	3	1.0	125	565	12	535	11	16
500	3	1.0	110	615	12	585	11	20
600	5	2.0	115	720	12	685	11	20
750	5	2.0	95	875	12	840	11	28
900	5	1.0	80	1025	12	990	11	32
1000	6	2.5	80	1180	16	1145	11	36
1200	6	2.0	65	1380	16	1320	14.5	44
1400	6	2.0	55	1535	16	1475	14.5	44
1500	6	1.5	50	1685	16	1625	14.5	52

NOTES:

- 10 to 1 design factor for pressure service and 5 to 1 design factor for vacuum service based on data in Figs 2.2 and 2.3. Also based on 3 m lengths between stiffener rings for vacuum service.
- These ratings are suitable for use up to 80°C in pressure service and ambient atmospheric temperature on vacuum service. For ratings at higher temperatures, consult the manufacturer.
- Nominal diameters are preferred metric dimensions. The fabricator is to nominate the actual internal diameter of the duct supplied and the tolerance on such a diameter is ± 2 mm for ducting up to and including 150 mm nominal diameter, or ± 3 mm or ± 1 percent, whichever is the greater, for ducting exceeding 150 mm nominal diameter. All measurements are to be made with ducting in the vertical position.
- The 3 mm wall thicknesses correspond to the conditions referred to in Clause 2.4.4(c). Increased wall thicknesses may be required for conditions specified in Clauses 2.4.4(a) and (b).