

AS/NZS 2208:1996

Australian/New Zealand Standard[®]

Safety glazing materials in buildings

AS/NZS 2208:1996

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee BD/7, Glazing and Fixing of Glass. It was approved on behalf of the Council of Standards Australia on 4 October 1996 and on behalf of the Council of Standards New Zealand on 4 October 1996. It was published on 5 December 1996.

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Architectural Aluminium Association of New Zealand
Architectural Aluminium Fabricators Association, Australia
Australian Association of Certification Bodies
Australian Building Codes Board
Australian Chamber of Commerce and Industry
Australian Chamber of Manufactures
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STANDARDS AUSTRALIA
1 The Crescent,
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PREFACE

This Joint Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee BD/7 on Glazing and Fixing of Glass to supersede AS 2208—1978, *Safety glazing materials for use in buildings (human impact considerations)*.

This Standard covers tests to be carried out for the different types of safety glazing material such as laminated, toughened, heat strengthened, toughened laminated, liquid laminated, safety wired, organic-coated, plastic and organic-backed safety mirrors.

This edition incorporates the following major changes from the previous edition:

- (a) The methods of test that were in Appendices B to H have been replaced by Appendices C to I.
- (b) Sampling and acceptance procedures that were in Appendices J and K and compliance verification given in Appendix P have been deleted and replaced by Appendix A.
- (c) Additional impact levels have been added to the impact test.

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.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

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CONTENTS

	<i>Page</i>
FOREWORD	4
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	5
1.2 APPLICATION	5
1.3 REFERENCED DOCUMENTS	5
1.4 DEFINITIONS	6
1.5 TESTING	7
1.6 CLASSIFICATION	7
1.7 MARKING	7
1.8 VENTS	8
SECTION 2 DIMENSIONAL SPECIFICATIONS	
2.1 GENERAL	9
2.2 THICKNESS REQUIREMENTS	9
2.3 SIZE TOLERANCE REQUIREMENTS	11
2.4 SQUARENESS OF RECTANGULAR PANELS—REQUIREMENTS	11
2.5 FLATNESS REQUIREMENTS	12
2.6 EDGEWORK	12
SECTION 3 TEST REQUIREMENTS	
3.1 GENERAL	13
3.2 IMPACT TEST	13
3.3 FRAGMENTATION TEST	14
3.4 BOIL TEST	14
3.5 WEATHERING TEST	15
3.6 AGEING TEST	15
APPENDICES	
A MEANS FOR DEMONSTRATING COMPLIANCE WITH THIS STANDARD	16
B NOTES ON SAFE PERFORMANCE CRITERIA AND HUMAN DYNAMICS DATA	18
C DETERMINATION OF THICKNESS	20
D IMPACT TEST	21
E FRAGMENTATION TEST	28
F BOIL TEST	30
G WEATHERING TEST	31
H AGEING TEST	33
I UNIFORMITY/SURFACE COMPRESSION	34

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FOREWORD

Where glazing material is so situated that accidental breakage is reasonably foreseeable, the glazing materials and thicknesses required for wind loading may not be adequate. While the accident rate through breakage of glazing material glazed at low level is significant among most age groups, it is particularly high in the age groups up to 19 years. Research in the United Kingdom, New Zealand and Australia has shown that a high proportion of all reported accidents with glazing material involve glazed doors and side panels in all types of buildings. In certain specialized rooms, such as gymnasiums, breakage of glazing material located at high level is also a potential danger. In these and other similar danger areas, safety glazing materials meeting the requirements of this specification will reduce the risk of injury.

Although these safety glazing materials will break under sufficient impact their fracture characteristics are such that if broken the likelihood of cutting and piercing injuries will be minimized.

The aim of the impact test is to assess the fracture characteristics of a safety glazing material which has been broken at some predetermined minimum impact energy level dependent upon the intended application of the material. If the safety glazing material does not fracture at this minimum energy level, it must again be tested at higher energy levels until it is fractured, in order that the fracture characteristics can be assessed.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Safety glazing materials in buildings

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard sets out test requirements for classification of safety glazing materials for use in buildings. The test requirements for the different glazing materials are designed to promote safety and to reduce or minimize the likelihood of cutting and piercing injuries from human impact.

NOTES:

- 1 Alternative methods for determining compliance with this Standard are given in Appendix A.
- 2 This Standard is not intended to restrict the use of materials or methods of test not specified herein where such materials or methods of test can be demonstrated to be the equal of, or superior to, those specified.
- 3 Notes on safe performance criteria and human dynamics data are given in Appendix B.
- 4 This Standard identifies safety glazing marking requirements.

1.2 APPLICATION This Standard applies to all safety glazing materials for use as required by AS 1288.

1.3 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

- | | |
|------|--|
| 1199 | Sampling procedures and tables for inspection by attributes* |
| 1288 | Glass in buildings—Selection and installation |
| 1399 | Guide to AS 1199—Sampling procedures and tables for inspection by attributes* |
| 1599 | Pressure sensitive adhesive packaging tapes |
| 2193 | Methods for calibrating and grading of force-measuring systems of testing machines |

AS/NZS

- | | |
|------------|--|
| ISO 9000 | Quality management and quality assurance standards |
| ISO 9000.1 | Part 1: Guidelines for selection and use |
| ISO 9004 | Quality management and quality system elements |
| ISO 9004.1 | Part 1: Guidelines |

SAA/SANZ

- | | |
|---------|--|
| HB18 | Guidelines for third-party certification and accreditation |
| HB18.28 | Guide 28—General rules for a model third-party certification scheme for products |

* Standard endorsed by Standards New Zealand as suitable for use in New Zealand.

ANSI Z97.1	Glazing materials used in buildings—Safety performance specification and methods of test
ASTM C1279	Test method for non-destructive photoelastic measurement of edge and surface stresses in annealed, heat-strengthened, and fully tempered flat glass
D756	Practice for determination of weight and shape changes of plastics under accelerated service conditions
D1499	Recommended practice for operating light- and water-exposure apparatus (carbon-arc type) for exposure of plastics
G26	Practice for operating light-exposure apparatus (Xenon-arc type) with and without water for exposure of nonmetallic materials
DIN 50 017	Condensation water test atmospheres
NZS 6507	Materials testing machines and force verification equipment

1.4 DEFINITIONS For the purpose of this Standard the definitions given below apply.

1.4.1 Drop height—the vertical distance from the horizontal centre-line of the maximum diameter of the impacting object when it is released relative to the horizontal centre-line of the impacting object when it is at rest (see Figure D1).

1.4.2 Heat-strengthened glass—Glass which has been subjected to a special heat treatment, so that the residual surface compression stresses lies between 24 MPa and 45 MPa.

1.4.3 Heat-strengthened laminated safety glass—laminated safety glass utilizing two or more panels of heat-strengthened glass in the make-up.

1.4.4 Laminated safety glass—a glass consisting of two or more sheets of glass permanently bonded together by one or more sheets of plastic interlayer.

1.4.5 Liquid-laminated safety glass—a glass consisting of two or more sheets of glass permanently bonded together by liquid chemicals that cure to form a plastic-type interlayer.

1.4.6 Safety double (or multiple) glazing unit—a double (or multiple) glazing unit in which all panels are of safety glazing material and are separated by airspaces.

1.4.7 Safety glazing materials—materials constructed, treated or permanently combined with other materials as to reduce the likelihood of cutting and piercing injuries resulting from human impact with them. All safety glazing materials are classified as either Grade A or Grade B according to the performance requirements in Section 3.

1.4.8 Safety organic-backed mirror—a glazing material consisting of a piece of mirror with a sheet of organic material permanently bonded to one side.

1.4.9 Safety organic-coated glass—a glazing material consisting of a piece of glass coated and permanently bonded on one or both sides with a continuous polymeric coating, sheet or film.

1.4.10 Safety plastic glazing material—a glazing material which contains as an essential ingredient an organic substance of large molecular mass, is solid in its finished state and at some stage in its manufacture or processing into finished articles can be shaped by flow. Plastic may consist of a single sheet of plastic material, a combination of two or more such sheets laminated together, or a combination of plastic material and reinforcement material in the form of fibres or flakes.

1.4.11 Safety wired glass—a single sheet of glass with wire completely embedded in the glass.

1.4.12 Toughened laminated safety glass—laminated safety glass utilizing two panels of toughened safety glass in the make-up.

1.4.13 Toughened safety glass—a glass which has been converted to a safety glass by subjection to a process of prestressing so that, if fractured, the entire piece disintegrates into small, relatively harmless particles. The residual surface compression is a minimum of 69 MPa.

1.5 TESTING Testing shall be carried out to ensure compliance of safety glazing materials with this Standard. Separate testing shall be carried out for different glazing materials, or for differences within a type of glazing material that could noticeably affect performance in the impact, fragmentation or environmental durability tests. Such differences may include, but are not limited to, nominal thickness or thicknesses, method of manufacture, types and amounts of additives and composition of base materials and adhesives.

1.6 CLASSIFICATION All safety glazing materials shall be classified as either Grade A or Grade B according to the performance requirements in Section 3.

1.7 MARKING Glazing material complying with this Standard shall be legibly marked with the following:

- (a) The name or registered trademark of the manufacturer or supplier.
- (b) The number of this Australian/New Zealand Standard, i.e. AS/NZS 2208.
- (c) A letter or other code to indicate plant of manufacture or supply.
- (d) Grade A or Grade B to indicate the grade of the material.
- (e) A number to indicate the nominal thickness for standard glazing material (see Table 2.1) in millimetres, or a number to indicate the minimum thickness for non-standard glazing material to the nearest tenth of a millimetre.
- (f) A letter or word or combinations thereof to indicate type of glazing material used in the product, as follows:
 - (i) The letter 'T' or word 'toughened', indicating a toughened safety glass.
 - (ii) The letter 'L' or the word 'laminated' indicating a laminated safety glass.
 - (iii) The letters 'TL' indicating that the material is toughened laminated safety glass.
 - (iv) The letters 'HSL' indicating that the material is heat-strengthened laminated safety glass.
 - (v) The letters 'LL' indicating that the material is liquid-laminated safety glass.
 - (vi) The letter 'W' or the word 'wired' indicating safety wired glass.
 - (vii) The letter 'F' or the word 'float' indicating that the component or components are float glass.
 - (viii) The letter 'P' or the word 'patterned' indicating that the component or components are patterned glass.
 - (ix) The letter 'S' or the word 'sheet' indicating that the component or components are made from sheet glass.
 - (x) The letters 'SP' indicating that the material is safety plastics for external and internal applications.

- (xi) The letters 'SPI' indicating that the material is safety plastics for internal applications only.
- (xii) The letters 'OC IN' indicating organic-coated glass. The marking shall be on the organic coating, the letters 'IN' indicating the side of the material which is not to be exposed to the elements.
- (xiii) Any combinations of the above letters, e.g. 'LWF' indicating laminated wired float.

Where non-permanent marking is used it shall be of a type that remains legible until examined by the appropriate authorities, that can be removed and that will self-destruct when removed.

NOTES:

- 1 An example of a trademark for a 6 mm thick laminated float glass, Grade A safety glazing material by ABC company is as follows:

LF



To AS/NZS 2208—GRADE A—6

- 2 Manufacturers making a statement of compliance with this Australian/New Zealand Standard on a product, or on packaging or promotional material related to that product, are advised to ensure that such compliance is capable of being verified.

1.8 VENTS Toughened safety glass shall be free from vents exceeding 2 mm in length and any cracks or vents extending from tong marks towards the interior of the glass.

NOTES:

- 1 A vent is a minute crack which may be induced during the toughening process.
- 2 The production of small indentations (tong marks) close to the edge of sheets of toughened safety glass is a feature inherent in some manufacturing processes and the presence of such marks is permissible except as given above.

SECTION 2 DIMENSIONAL SPECIFICATIONS

2.1 GENERAL This Section sets out the required thickness, size tolerance, squareness of rectangular panels and flatness of panels for safety glass in order to comply with this Standard.

NOTES:

- 1 For safety material other than safety glass (i.e. plastic), the manufacturer's recommendation should be followed.
- 2 Prior to furnacing, toughened safety glass should be finished to a minimum standard whereby all edges are arrised. Arrised edges are formed by grinding a chamfer or bevel approximately 1 mm wide on all sharp edges and corners.

2.2 THICKNESS REQUIREMENTS

2.2.1 General The thickness obtained shall be within the limits provided in Table 2.1, measured in accordance with Appendix C.

2.2.2 Standard nominal thickness of safety glass Safety glass, as specified in this Standard, refers to safety glass having a standard nominal thickness. Limits on the standard nominal thickness of various types of glass are given in Table 2.1.

2.2.3 Non-standard thickness of glazing material Thicknesses of safety glass other than those specified in Table 2.1 may be utilized and shall not be a cause for rejection provided that the product meets all other appropriate test requirements of this Standard.

NOTE: The use of non-standard thickness will require interpolation to satisfy the requirements of AS 1288.

TABLE 2.1
THICKNESS LIMITS FOR STANDARD
NOMINAL THICKNESS OF GLASS

millimetres

Type of glass	Standard nominal thickness	Glass thickness limits	
		Minimum	Maximum
Toughened glass, and heat-strengthened glass	3	2.8	3.2
	4	3.8	4.2
	5	4.8	5.2
	6	5.8	6.2
	8	7.7	8.3
	10	9.7	10.3
	12	11.7	12.3
	15	14.5	15.5
	19	18.0	20.0
Laminated glass	25	23.5	26.5
	5.38	4.6	5.4
	6.38	5.6	6.4
	8.38	7.6	8.4
	10.38	9.6	10.4
	12.38	11.6	12.4
	16.38	15.4	16.6
Toughened laminated glass, and heat-strengthened laminated glass	6.38	5.6	6.4
	8.38	7.6	8.4
	10.38	9.6	10.4
	12.38	11.6	12.4
Patterned glass, toughened patterned glass, and heat-strengthened patterned glass	3	2.5	3.9
	4	3.5	4.5
	5	4.5	5.5
	6	5.5	7.0
	10	9.0	10.8
	12	11.0	13.5
Wired glass	6	5.0	6.8

NOTES:

- 1 For glass that does not satisfy the thickness tolerances for the standard nominal thickness specified above, the minimum glass thickness shall be marked.
- 2 Linear interpolation as defined in AS 1288 shall apply for non-standard thickness.
- 3 Glass thickness limits specified for laminated glass exclude interlayer thickness.

2.3 SIZE TOLERANCE REQUIREMENTS Tolerance on sizes for all safety glass shall be as specified in Table 2.2.

TABLE 2.2
SIZE TOLERANCE FOR GLASS OF STANDARD NOMINAL THICKNESS

millimetres

Standard nominal thickness	Tolerance limits			
	Non-patterned		Patterned	
	< 1200	≥ 1200	< 1200	≥ 1200
3	±2	±2	±3	±4
4	±2	±2	±3	±4
5	±2	±2	±3	±4
6	±2	±2	±3	±4
8	±2	±2	±4	±5
10	±2	±3	±4	±5
12	±2	±3	±4	±5
15	±2	±3	—	—
19	±2	±3	—	—
25	±2	±3	—	—

NOTE: For non-standard glass thicknesses, interpolation will be required.

2.4 SQUARENESS OF RECTANGULAR PANELS—REQUIREMENTS The squareness of rectangular panels shall be such that the difference between the two diagonals does not exceed 5 mm for panels where the largest dimension is less than 1200 mm and 10 mm for all other panels.

2.5 FLATNESS REQUIREMENTS The flatness of panels shall be within the following limits:

- (a) Localized warp 1.0 mm over any 200 mm span.
- (b) Overall bow and warpage as given in Table 2.3.

TABLE 2.3
FLATNESS LIMITS FOR GLASS OF STANDARD NOMINAL THICKNESS

Standard nominal thickness	Bow		
	0 to 1500	1501 to 3000	3001 to 5000
3	1 in 200	1 in 150	—
4	1 in 200	1 in 150	—
5	1 in 300	1 in 200	1 in 200
6	1 in 350	1 in 250	1 in 200
8	1 in 400	1 in 300	1 in 250
10	1 in 400	1 in 300	1 in 250
12	1 in 400	1 in 300	1 in 250
15	1 in 400	1 in 300	1 in 250
19	1 in 400	1 in 300	1 in 250
25	1 in 400	1 in 300	1 in 250

NOTES:

- 1 Flatness measurements shall be checked against a straightedge with the panel standing within 5° of vertical and measurement taken horizontally.
- 2 For non-standard glass thicknesses, interpolation will be required.

2.6 EDGEWORK Prior to heat treatment, glass shall be arrised on all edges.

NOTES:

- 1 Arrised edges are formed by grinding a chamfer or bevel of approximately 1 mm wide on all sharp edges and corners.
- 2 Care should be exercised when handling glass to prevent edge damage and subsequent fracture. Particular care is required when handling toughened safety glass as damaged edges may result in spontaneous glass fracture.

SECTION 3 TEST REQUIREMENTS

3.1 GENERAL Glazing materials shall be classified as Grade A or Grade B safety glazing materials if it is shown that they satisfy the relevant impact (or fragmentation test for toughened glass) test performance requirements in addition to all other appropriate tests to be carried out as listed in Table 3.1.

**TABLE 3.1
TESTING FOR SAFETY GLAZING MATERIALS**

Test	Glazing type							
	Laminated safety glass	Toughened safety glass*	Heat-strengthened and toughened laminated safety glass	Liquid-laminated safety glass	Safety wired glass	Organic-coated safety glass	Safety plastics	Organic-backed safety mirror
Impact (see Clause 3.2)	X	X	X	X	X	X	X	X
Fragmentation (see Clause 3.3)	—	X	—	—	—	—	—	—
Boil (see Clause 3.4)	X	—	X	X	—	—	—	—
Weathering (see Clause 3.5)	—	—	—	—	—	X	X	—
Ageing (see Clause 3.6)	—	—	—	—	—	—	X	X

X indicates test to be conducted.

* For toughened safety glass an impact or fragmentation test shall be carried out.

NOTE: Boil test for heat-strengthened and toughened laminated glass can use laminates from ordinary annealed glass manufactured simultaneously.

3.2 IMPACT TEST

3.2.1 Test specimens Test specimens shall be prepared in a manner representative of normal installation practice. For example, if a safety organic-coated glass is used, the coating shall be applied to the test specimen in a manner that is representative of normal application (normally confined within the visible sight lines only).

3.2.2 Orientation of test specimens For a symmetric material (any material symmetric about the geometric centre plane through its thickness, including toughened glass and some laminated glass) the impact test shall be carried out by impacting on either face.

For an asymmetric material (any material not symmetric about the geometric centre plane through its thickness, including patterned wired glass and laminated glass with mixed glass types or thicknesses) the classification shall be based on impact test results for impact on the face that is shown to give the worst performance.

3.2.3 Testing and classification Grade A glazing material tested in accordance with Appendix D (see also Table 3.2), at a drop height of 300 mm, shall not break or shall comply with the requirements for breakage given in Appendix D. If breakage does not occur at 300 mm then the drop height is progressively increased to 450 mm, 600 mm, 750 mm, 900 mm, 1200 mm and 1500 mm until breakage occurs. When breakage occurs it shall comply with the requirements for breakage as given in Appendix D.

Grade B glazing material, when tested in accordance with Appendix D (see also Table 3.2), at a drop height of 200 mm, shall not break or shall comply with the requirements for breakage given in Appendix D. If breakage does not occur at 200 mm, then the drop height is progressively increased to 300 mm, 450 mm, 600 mm, 750 mm, 900 mm, 1200 mm and 1500 mm until breakage occurs. When breakage occurs it shall comply with the requirements for breakage given in Appendix D.

TABLE 3.2
CLASSIFICATION OF GLAZING MATERIAL ACCORDING
TO BEHAVIOUR WHEN SUBJECTED TO THE IMPACT TEST

Class	Drop height 200 mm nominal	Drop height 300 mm to 1500 mm nominal	Drop height greater than 1500 mm or by a centre punch
A	No requirement	No breakage, or breaks safely	Breaks safely or deforms
B	No breakage, or breaks safely	No breakage, or breaks safely	No requirement

3.3 FRAGMENTATION TEST When samples of safety glazing material are tested in accordance with Appendix E, a sample which complies with the minimum particle count specified in Table 3.3 shall be deemed to comply with the requirements for Grade A safety glazing materials specified in Clause 3.2.

TABLE 3.3
FRAGMENTATION TEST—
MINIMUM PARTICLE COUNT

Nominal glazing material thickness mm	Minimum number of particles per square of 50 mm side
3	30
4	30
5	40
6	40
8	40
10	40
12	40

NOTE: There is no reference to particle count for 15 mm, 19 mm and 25 mm due to the lack of scientific data.

3.4 BOIL TEST When tested in accordance with Appendix F the glazing material itself might crack, but no bubbles or other defects shall develop more than 12 mm from the edge of the test specimen or from any cracks that have developed.

Any test specimen which cracks to an extent that the results are confused shall be discarded without prejudice and another specimen shall be tested in its stead.

3.5 WEATHERING TEST

3.5.1 Safety organic-coated glass Safety organic-coated glass, when tested in accordance with Appendix G, shall have—

- (a) an adhesion value, when exposed to weathering, of not less than 90 percent of the adhesion value when not exposed to weathering; and
- (b) a tensile strength, when exposed to weathering, of not less than 75 percent of the tensile strength when not exposed to weathering.

3.5.2 Safety plastics Safety plastics glazing materials intended for use in all applications when tested in accordance with Appendix G shall have the impact resistance when exposed to weathering of not less than 75 percent of the impact strength when not exposed to weathering. When exposed to weathering the safety plastics glazing material may show some discolouration, but no bubbles or other noticeable decomposition shall develop in the irradiated portion.

In addition, for safety plastics the modulus of elasticity shall be not less than 5170 MPa and a Rockwell hardness shall be not less than M140 or R140.

3.6 AGEING TEST Safety glazing materials intended for use in all applications after ageing in accordance with Appendix H shall comply with the requirements for Grade A safety glazing materials in Clause 3.2.

After ageing, some discolouration or milkiness may develop and is allowable but defects other than these shall not be permitted.

APPENDIX A
MEANS FOR DEMONSTRATING COMPLIANCE WITH THIS STANDARD
(Informative)

A1 SCOPE This Appendix sets out the following different means by which compliance with this Standard can be demonstrated by the manufacturer or supplier:

- (a) Evaluation by means of statistical sampling.
- (b) The use of a product certification scheme.
- (c) Assurance using the acceptability of the supplier's quality system.
- (d) Other such means proposed by the manufacturer or supplier and acceptable to the customer.

A2 STATISTICAL SAMPLING Statistical sampling is a procedure which enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

- (a) The sample shall be drawn randomly from a population of product of known history. The history shall enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.
- (b) For each different situation, a suitable sampling plan needs to be defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199, guidance to which is given in AS 1399.

A3 PRODUCT CERTIFICATION The purpose of product certification is to provide independent assurance of the claim by the manufacturer that products comply with the stated Standard.

The certification scheme should meet the criteria described in SAA HB18.28 (SANZ HB18.28) in that, as well as full type testing from independently sampled production and subsequent verification of conformance, it requires the manufacturer to maintain effective quality planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of the Standard.

A4 SUPPLIER'S QUALITY SYSTEM Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or international Standard for a supplier's quality system or systems, this may provide the necessary confidence that the specified requirements will be met. The quality assurance requirements need to be agreed between the customer and supplier and should include a quality or inspection and test plan to ensure product conformity.

Guidance in determining the appropriate quality management system is given in AS/NZS ISO 9000.1:1994 and AS/NZS ISO 9004.1:1994.

A5 OTHER MEANS OF ASSESSMENT If the above methods are considered inappropriate, determination of compliance with the requirements of this Standard may be assessed by being based on the results of testing coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform with the full requirements of the Standard.

APPENDIX B
NOTES ON SAFE PERFORMANCE CRITERIA AND
HUMAN DYNAMICS DATA

(Informative)

B1 SAFE PERFORMANCE CRITERIA The performance criteria specified are directly related to the reduction of cutting and piercing injuries to persons who impact the glazing used in buildings.

The 90 J energy level was established as being practically related to those situations where the glazing is around a confined space and there is a limited acceleration path available for the building user to develop much kinetic energy.

The 135 J and 203 J energy levels were established as practically related to those situations in which the limited acceleration path precluded, in most cases, the possibility of an individual developing his or her full kinetic energy potential.

The 541 J impact level was established for relatively unlimited acceleration paths in which it might be reasonable to expect that an energetic teenager might develop something approaching his or her full impact velocity.

As Paragraph B2 and Figure B1 indicate, independent safety experts in the USA who considered the matter judged that these values were realistic.

B2 DEVELOPMENT OF HUMAN DYNAMICS DATA CHART Safety experts in the USA indicate that a 46 kg person is representative of glazing material breakage accident victims. From the chart (Figure B1) it is apparent that a 46 kg person running at the rate of 6.7 m/s (equivalent to the 4-minute mile) has about 1034 J of kinetic energy. The amount of this energy he might deliver to a glazed opening would depend upon the way he hit the glazed surface; a 'straight arm' would transmit more energy to the glazing material than an arm which flexes with the impact.

For test purposes, ANSI* decided after extensive evaluation to use a readily available standard punching bag filled with 46 kg of lead shot to simulate the running person. The test impact values 135 J, 203 J and 541 J were selected as representative of energy levels likely to be delivered by humans in situations involving interior doors and patio doors. These test levels were set considerably below the 1034 J kinetic energy of the typical victim, since the impact energy delivered to the glazing materials perhaps first by the hands, then by the head, and then by the knees is much less than the kinetic energy of the running person. Also the incident angle of impact will be less than normal in most cases.

In Australia and New Zealand the test impact value of 90 J was selected as representative of energy levels likely to be delivered by humans in situations involving glazing around confined spaces, e.g. shower screens.

* See ANSI Z97.1.

Figure B1 was developed to assist in the establishment of performance criteria for safety glazing materials subject to human impact. The chart is based on the kinetic energy formula—

$$T = 0.5 mv^2$$

where

T = kinetic energy, in joules

m = mass of missile, in kilograms

v = velocity of missile, in metres per second.

Maximum impact energy equals the kinetic energy of the person in motion at the moment of impact. Actual impact energy (that which the person delivers) will always be considerably less, except perhaps in the case of a person falling on a skylight.

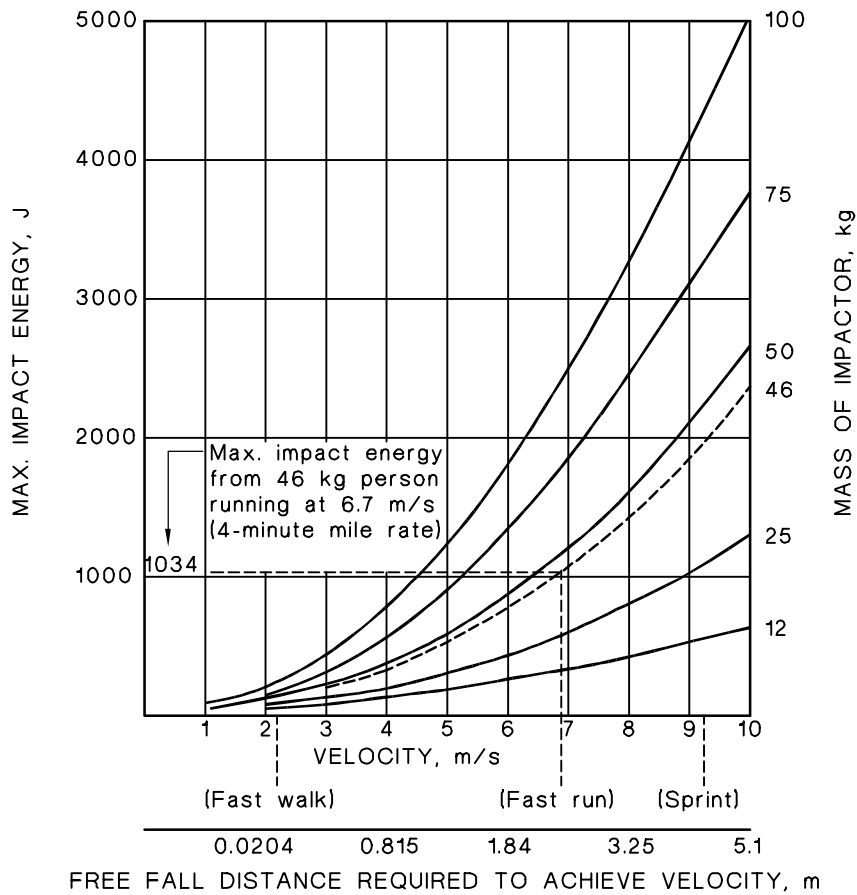


FIGURE B1 HUMAN DYNAMICS DATA

APPENDIX C
DETERMINATION OF THICKNESS
(Normative)

C1 SCOPE This Appendix sets out the method for determining the thickness of a glazing material.

C2 PRINCIPLE The glazing material is measured at specified locations with a vernier calliper or micrometer (patterned glass is also measured using a point micrometer).

C3 APPARATUS The following apparatus is required:

- (a) For flat glazing material a vernier calliper or micrometer graduated to 0.01 mm.
- (b) For patterned glazing material—
 - (i) a point micrometer graduated to 0.01 mm; and
 - (ii) a 55 mm anvil micrometer or flanged dial indicator graduated to 0.01 mm.

C4 PROCEDURE The procedure for flat glazing material shall be to measure the thickness at two locations approximately equally spaced along each of two adjacent edges (a total of four measurements) using either a vernier calliper or a 55 mm anvil micrometer.

The procedure for patterned glazing material shall be to measure the thickness at two locations on each of two adjacent edges. The locations shall be spaced at least half the respective edge length apart, using both a 55 mm anvil micrometer or flanged dial indicator and a point micrometer to measure the thickest and thinnest glass points at each location (a total of eight measurements).

C5 TEST REPORT The following information shall be reported:

- (a) Identification of the glazing material.
- (b) Values of the individual readings.
- (c) For flat glazing material, the mean of the four readings taken.
- (d) For patterned glazing material, the mean of the four readings taken of the thickest sections and the mean of the four readings taken of the thinnest sections.
- (e) Location of testing facility.
- (f) Date and time of the test.
- (g) Names, positions and relevant qualifications of personnel carrying out or supervising the test.
- (h) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

C6 INTERPRETATION The interpretation shall be as follows:

- (a) For flat glazing material, the mean of the measurements taken shall be within the thickness limits specified in Table 2.1.
- (b) For patterned glazing material, the mean of the measurements shall be as follows:
 - (i) Equal to or less than the maximum thickness limit specified in Table 2.1, for measurements taken over the thickest sections.
 - (ii) Equal to or greater than the minimum thickness limit specified in Table 2.1, for measurements taken at the thinnest sections.

APPENDIX D
IMPACT TEST
(Normative)

D1 SCOPE This Appendix sets out the method for determining the resistance of glazing material to impact by the penetration method.

D2 PRINCIPLE The specimen is supported vertically in a steel frame and an impact shot bag is released from a pre-determined height to strike the specimen at the centre. The height is progressively increased until fracture occurs.

D3 APPARATUS The following apparatus is required:

- (a) A steel frame to support the sample in a vertical plane. The frame is to be securely bolted to the floor and have edge clamps to hold the glazing material in position (see Figure D1).
- (b) An impacting shot bag as shown in Figure 2. The impacting shot bag is a reinforced leather bag filled with No. 7½ chilled lead shot, providing a total mass of 46 ± 0.1 kg. The bag is constructed either of 1.6 mm thick pliable leather with canvas laminated to the inside surface making a wall thickness of 2.4 mm, or of thick pliable vinyl. A rubber bladder of 0.6 mm wall thickness is contained within the leather or vinyl outer shell and is filled with lead shot through a small hole in the upper portion. After filling, the rubber bladder is closed by tying with a cord or leather thong.

NOTE: Commercial punching bags meeting this specification may be available.

A method for attaching the shot bag to the test frame and for swinging the test bag from the height required needs to be devised.

D4 SAMPLES AND SAMPLE PREPARATION

D4.1 Sampling A minimum of four test specimens shall be tested.

D4.2 Specimen size Each specimen shall be 1900 mm \pm 3 mm high by 860 mm \pm 3 mm wide, or the maximum size available if that is smaller.

D4.3 Conditioning Immediately prior to testing specimens shall be conditioned for a minimum of 4 h at a temperature of $23 \pm 5^\circ\text{C}$ with the test surfaces exposed to full air at that temperature. Toughened glass does not require conditioning.

D6 PROCEDURE The procedure shall be as follows:

- (a) Place the test specimen in the test frame.
- (b) Suspend the impacting shot bag from an overhead support so located that the impacting object when at rest will, at its maximum diameter, be not more than 12 mm from the surface of the test specimen and not more than 50 mm from the centre of the specimen (see Figure D1).
- (c) Raise the shot bag by the bridle to a drop height of 300 mm for Grade A or 200 mm for Grade B safety glazing.
- (d) Stabilize the shot bag before release.
- (e) Release the shot bag, allowing it to swing smoothly through a pendulum arc and strike the specimen once at the centre.

- (f) In the event of the test specimen coming out of the frame, disregard the sample.
- (g) Inspect the test specimen and determine if it complies with any of the following requirements after impact and record—
 - (i) it has remained unbroken; or
 - (ii) it has broken and numerous cracks or fissures appear but no shear or opening develops within the body of the glazing material through which a 76 mm diameter sphere can be passed freely; additionally, if fragments are detached from the test piece up to 3 min after impact, they shall, in total, weigh no more than the mass equivalent to 10 000 mm² of the original test piece and the largest single fragment shall weigh less than the mass equivalent to 4400 mm² of the original test piece; or
 - (iii) it has broken and disintegration occurs but the 10 largest crack-free fragments selected 3 min after impact, together weigh no more than the mass equivalent to 6500 mm² of the original test piece; or
 - (iv) it has broken and the breakage results in several separate pieces, which may or may not be retained in the frame. Those pieces that are exposed after the impact shall be in accordance with one or both of the following:
 - (A) The perimeter shall not be sharp.
 - (B) Where any pointed protrusion occurs in any perimeter, the length of the chord between the two points which are established when an arc of radius 25 mm, whose centre is at the apex of the protrusion, crosses the perimeter on each side of the apex shall be not less than 25 mm (see Figure D3).
- (h) If any one of the test specimens which break do not comply with the requirements of Step (g), terminate the procedure, the product has failed.
- (i) If the test specimen does not break and remains intact within the frame, progressively increase the drop height as follows:
 - Grade A: 450 mm, 600 mm, 750 mm, 900 mm, 1200 mm and 1500 mm.
 - Grade B: 300 mm, 450 mm, 600 mm, 750 mm, 900 mm, 1200 mm and 1500 mm.
- (j) Inspect the test specimen in accordance with Step (g) for each drop height.

Interpretation: In the event of the glazing material not breaking after being impacted from a drop height of 1500 mm, use a centre-punch with sufficient force to deform or break the glazing material and examine the fracture pattern as follows:

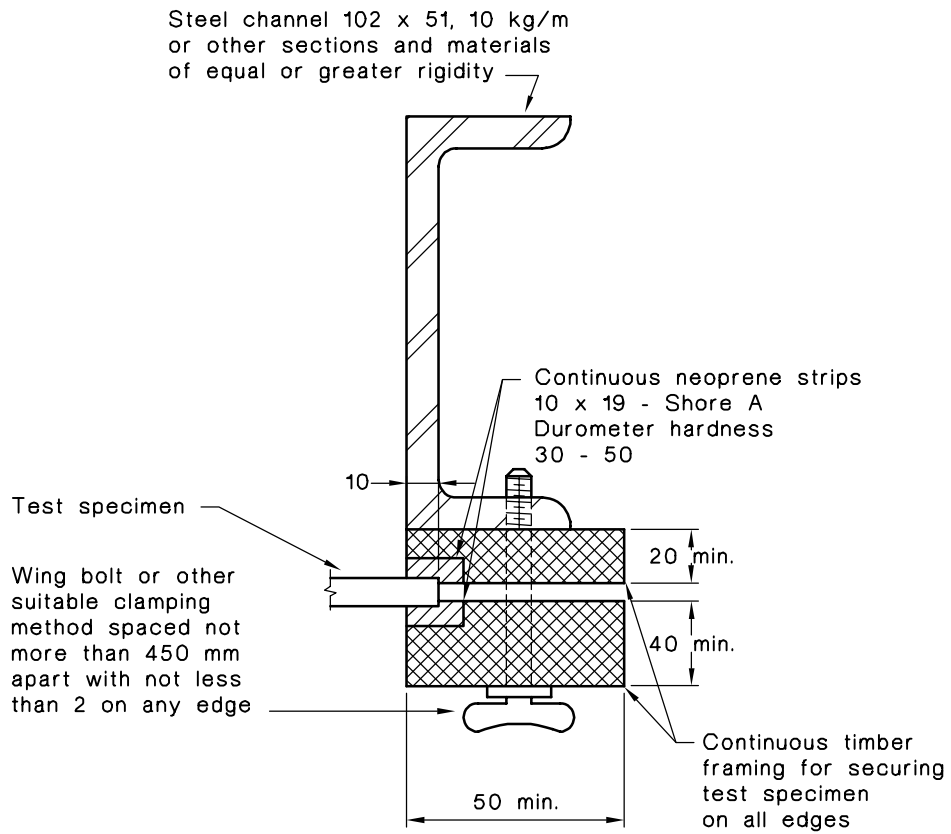
 - (i) If the glazing material disintegrates into small fragments as defined in Step (g) above, it is considered a pass.
 - (ii) If the panel cracks or deforms but is held together in a safe manner, it passes.
 - (iii) If it breaks in large pieces and can be pushed out of the frame, it fails.
- (k) Repeat Steps (a) to (h) for the other three test specimens.

D7 REPORT The following information shall be reported:

- (a) Identification of the test specimen.
- (b) For each drop height, whether the test specimen remained unbroken. If not, whether it broke and complied with the requirements of Paragraph D6(g)(ii) to (iv), or broke and did not comply with the requirements of Paragraph D6(g)(ii) to (iv).
- (c) Grade of pass or fail.

- (d) Location of testing facility.
- (e) Date and time of the test.
- (f) Names, positions and relevant qualifications of personnel carrying out or supervising the test.
- (g) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

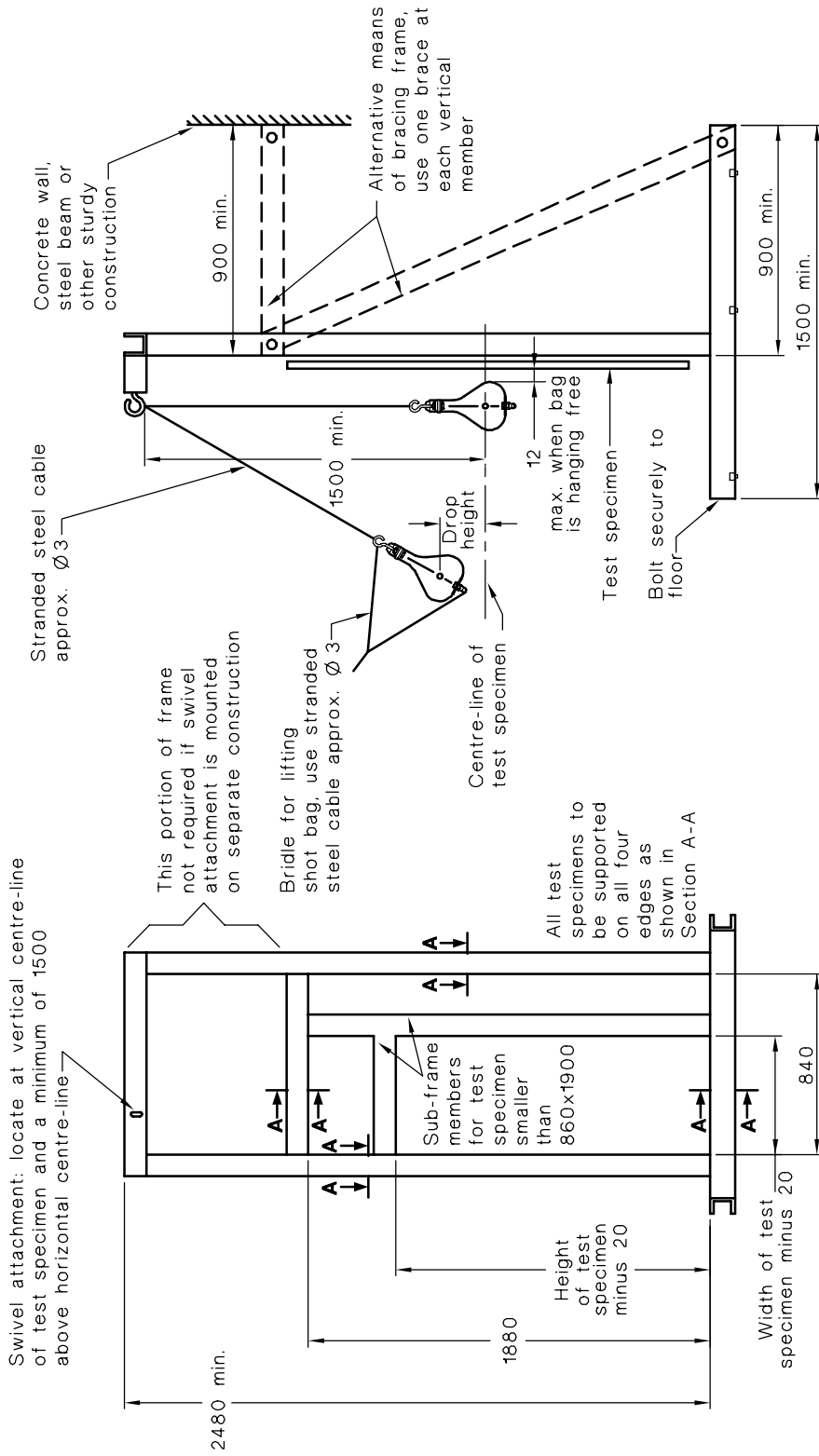


SECTION A-A OF TEST FRAME

NOTE: Sub-frame for holding test specimen not shown.

DIMENSIONS IN MILLIMETRES

FIGURE D1 (in part) TEST FRAME



NOTE: Sub-frame for holding test specimen not shown.
DIMENSIONS IN MILLIMETRES

FIGURE D1 (in part) TEST FRAME

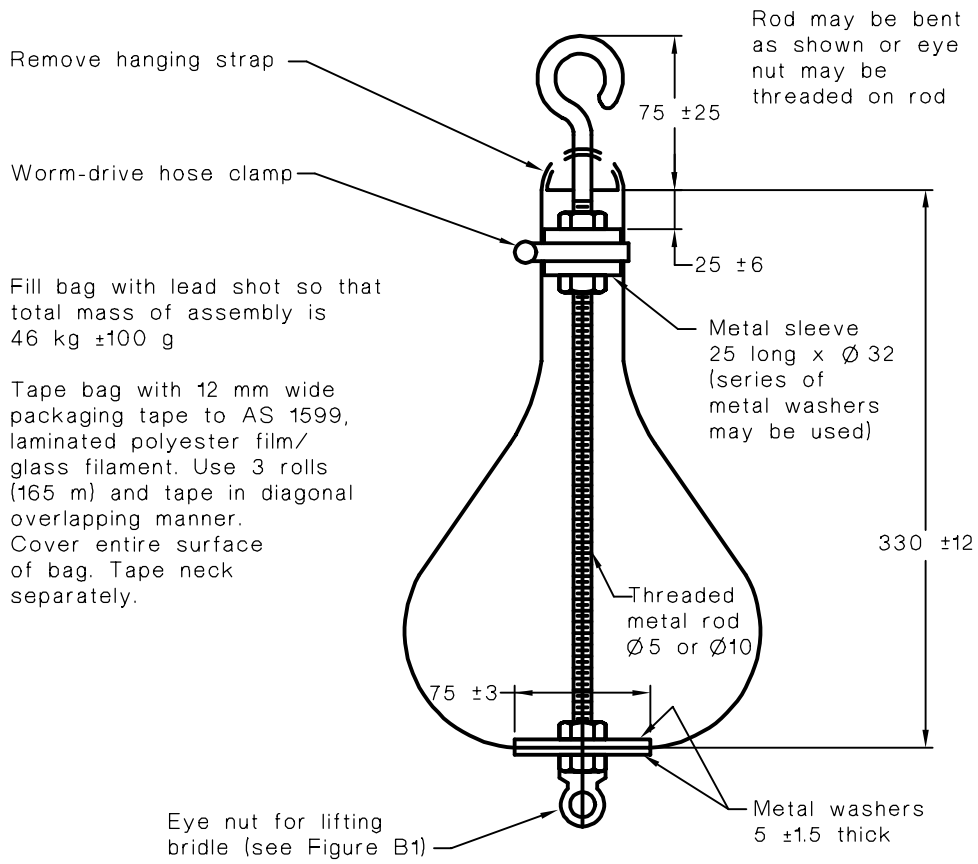


FIGURE D2 SHOT BAG

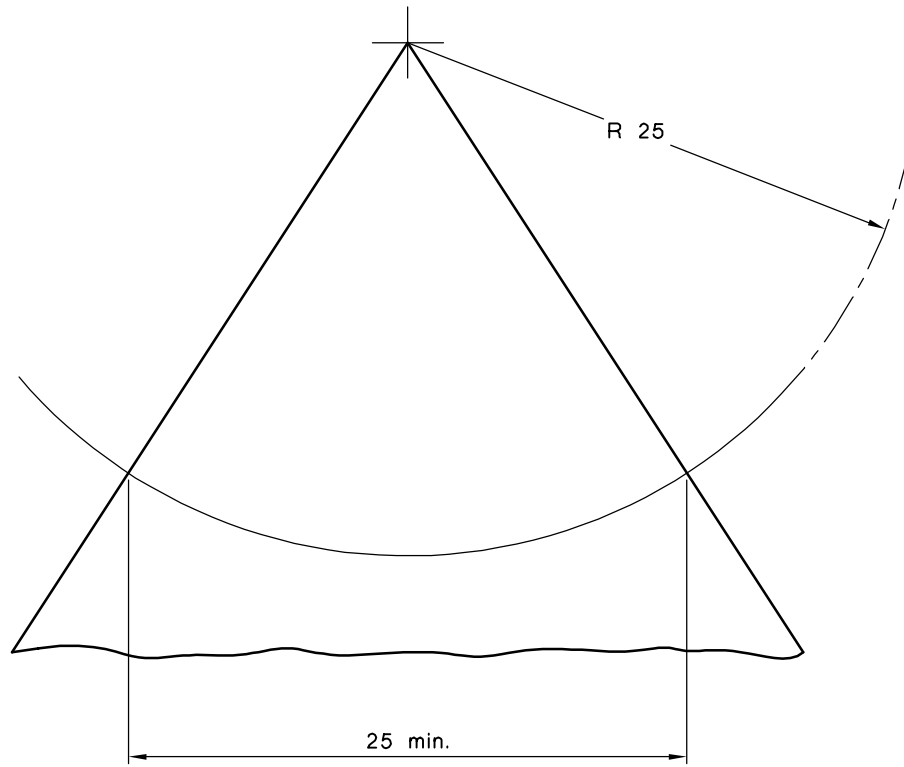


FIGURE D3 POINTED PROTRUSIONS

APPENDIX E
FRAGMENTATION TEST
(Normative)

E1 SCOPE This Appendix sets out the method for determining the fracture characteristics of toughened safety glass or other glazing materials.

E2 APPARATUS The following apparatus is required:

- (a) A flat wooden platform, if floor is unsuitable (see Paragraph E5(a)).
- (b) A spring-loaded carbide-tipped centre-punch or similar manual-type centre-punch.

E3 PRINCIPLE The specimen is laid horizontally on a surface that supports it over its entire area, and is broken by a punch applied at a predetermined location. The number of particles of broken glazing material within a given area are counted.

E4 SAMPLES Each specimen shall be taken from the production run.

E5 PROCEDURE The procedure shall be as follows:

- (a) Place the specimen horizontally upon a flat wooden platform or floor that will support the test specimen on its entire surface. Provide a means to prevent any substantial spreading of the fragments.
- (b) Break the test specimen by means of a spring-loaded carbide-tipped centre-punch, or similar manual-type centre-punch struck with a hammer. The punch blow shall be applied 13 mm inboard from and at the midpoint of the longest edge of the specimen.
- (c) Make a count of the particles of broken glazing material within 5 min of the fracture of the glazing material. The particle count shall be made in the region of the coarsest fracture, excluding a segment of radius 75 mm centred on the point of impact of the centre-punch and two further segments (S) of radius 75 mm centred as shown in Figure E1. The particle count shall be made in a square of side 50 mm. In the particle count, all particles wholly contained within the square and all the particles only partially contained by two adjacent edges of the square shall be counted. All particles only partially contained by the other two adjacent edges of the square shall not be counted. Only particles containing both original faces shall be counted.

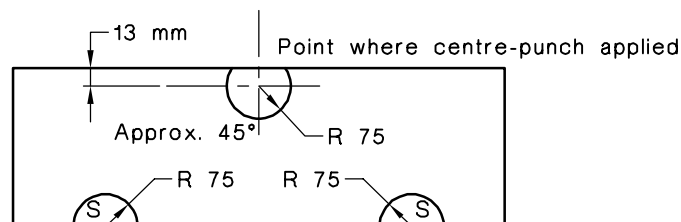


FIGURE E1 AREAS TO BE EXCLUDED IN PARTICLE COUNT DETERMINATION

E6 TEST REPORT The following information shall be reported:

- (a) Identification of the test specimen.
- (b) Particle count of the fractured test specimen.
- (c) Location of testing facility.
- (d) Date and time of the test.
- (e) Names, positions and relevant qualifications of personnel carrying out or supervising the test.
- (f) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

APPENDIX F
BOIL TEST
(Normative)

F1 SCOPE This Appendix sets out the method for determining the effect of exposure of safety glazing material to temperature and humidity conditions by boiling.

F2 PRINCIPLE Specimens are immersed in hot water and then boiling water for a specified period of time and inspected for bubbles or other defects.

F3 APPARATUS The apparatus shall be two water baths each of sufficient size to hold the test specimen fully immersed vertically on edge, for the duration of test.

F4 SAMPLES Three specimens of size 300 mm × 300 mm manufactured in a manner identical with the impact test specimens (see Appendix B) and of like thickness shall be tested. These specimens may be cut from production samples of the size and thickness submitted for impact testing. For heat strengthened or toughened laminated glass, test specimens may be cut from a similar original sheet of annealed laminated glass.

F5 PROCEDURE The procedure shall be as follows:

- (a) Immerse the specimens vertically on edge in a bath of water maintained at a temperature of $66 \pm 3^{\circ}\text{C}$ for 3 min.
- (b) Quickly transfer the specimens to a bath of water maintained at boiling point. Immerse the specimens vertically on edge in the bath for 2 h.
- (c) Remove the specimens and examine for bubbles or other defects.

F6 TEST REPORT The following information shall be reported:

- (a) Identification of the test specimen.
- (b) Position of cracks.
- (c) Number, size and location of bubbles in relation to the outer edge of the test specimen and to any cracks.
- (d) Temperature of water in baths.
- (e) Location of testing facility.
- (f) Date and time of the test.
- (g) Names, positions and relevant qualifications of personnel carrying out or supervising the test.
- (h) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

APPENDIX G
WEATHERING TEST
(Normative)

G1 SCOPE This Appendix sets out the method for determining the effect of radiant exposure on safety glazing materials.

G2 PRINCIPLE Specimens are exposed, under specified conditions, to light from an artificial light source. After exposure, safety plastics are then subject to the Charpy impact test. Organic-coated glass is subjected to a tensile test and an adhesion test. The effect of radiant exposure is assessed by comparing the test results of exposed specimens with those of unexposed specimens.

G3 APPARATUS The following apparatus is required:

- (a) Apparatus specified in ASTM G26.
- (b) Apparatus specified in ASTM D756.
- (c) A constant-rate-of-extension tensile testing machine complying with the requirements for a Grade B machine in accordance with AS 2193 (or NZS 6507 in New Zealand). The moving crosshead shall be able to be set to move at 50 mm/min and 300 mm/min.
- (d) Razor cutter.

G4 SAMPLE AND SAMPLE PREPARATION

G4.1 Sampling A minimum of 20 test specimens shall be sampled.

G4.2 Size of specimen The size of specimens shall be 150 mm long by 50 mm wide.

G4.3 Conditioning The organic-coated glass specimens shall be conditioned for 24 h in darkness at a temperature of $23 \pm 2^\circ\text{C}$ and a relative humidity of 55 ± 5 percent.

G5 PROCEDURE

G5.1 General Ten specimens shall be the controls (unexposed specimens). For organic-coated glass they shall be subjected to adhesion and tensile tests. For safety plastics they shall be subjected to a Charpy impact test.

The other 10 specimens (exposed specimens) shall be subject to the weathering test and then subject to the adhesion and tensile test for organic-coated glass and to the Charpy impact test for safety plates.

G5.2 Unexposed specimens

G5.2.1 Adhesion test The procedure shall be as follows:

- (a) Take the specimens.
- (b) Set up the tensile testing machine with the crosshead rate at 300 mm/min and the force range of the machine so that peel occurs between 10 percent and 90 percent of full-scale force.
- (c) Using a razor cutter, cut a 25 mm wide strip of the organic coating in the lengthwise direction of the glazing material sample. Peel back about 50 mm of the 25 mm wide strip.
- (d) Attach a strip of pressure-sensitive tape to the side of the organic strip opposite the adhesive to extend this free end to about 200 mm in length.

- (e) Place the end of the glazing material panel from which the organic strip was removed in the lower clamp of the tensile tester and the free end of the tape in the upper clamp. Peel the remainder of the organic strip from the glazing material mechanically and obtain a record of the peel value.

G5.2.2 Tensile test The procedure shall be as follows:

- (a) Take the specimens used in the adhesion test (see Paragraph G5.2.1).
- (b) Set up the tensile testing machine with the crosshead rate at 50 mm/min, the gauge length at 50 ± 2 mm and the load range so that the specimens will break at approximately midscale deflection.
- (c) Using a razor cutter, cut a 12 mm straight strip of the organic coating in the lengthwise direction of the glazing material sample for the full 150 mm length.
- (d) Carefully peel this strip from the glazing material panel and break it in the testing machine and record the pull-at-breakage for each specimen.

G5.2.3 Impact Subject the specimens to the Charpy unnotched impact test in accordance with ASTM D756.

G5.3 Exposed specimens The procedures shall be as follows:

- (a) Subject six specimens to radiant exposure of 500 MW.s in accordance with ASTM D1499.
- (b) For organic-coated glass determine the peel value and pull-at-breakage in accordance with Paragraphs G5.2.1 and G5.2.2 respectively.
- (c) For safety plastic, subject the specimens to the Charpy unnotched impact test in accordance with ASTM D756, with the exposed surface subject to tension. For thin materials, the span of the specimen shall be reduced to 50 mm to avoid having the specimen bend enough to slip between the supports without breaking.

G6 TEST REPORT The following information shall be reported:

- (a) Identification of the test specimens.
- (b) Test report requirements of ASTM D756 and ASTM D1499.
- (c) For organic-coated glass, the peel value determined from the adhesion test and the pull at breakage determined from the tensile test for both unexposed and exposed specimens.
- (d) Location of testing facility.
- (e) Date and time of the test.
- (f) Names, positions and relevant qualifications of personnel carrying out or supervising the test.
- (g) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

APPENDIX H
AGEING TEST
(Normative)

H1 SCOPE This Appendix sets out the method for determining the effect of accelerated ageing on safety glazing materials.

H2 PRINCIPLE Specimens are exposed under specified conditions to warm, humid and dry cycles and then subjected to an impact test (see Appendix D). The effect of accelerated ageing is assessed by comparing the impact test results of exposed specimens with those of unexposed specimens.

H3 APPARATUS The following apparatus is required:

- (a) Apparatus specified in DIN 50 017.
- (b) Apparatus specified in Appendix D.

H4 SAMPLE AND SAMPLE PREPARATION

H4.1 Sampling A minimum of eight test specimens shall be sampled.

H4.2 Size of specimen The size of specimens shall be in accordance with Appendix D.

H5 PROCEDURE

H5.1 Unexposed specimens The procedure shall be as follows:

- (a) Take four specimens.
- (b) Determine the resistance to impact of each specimen in accordance with Appendix D.

H5.2 Exposed specimens The procedure shall be as follows:

- (a) Take four specimens.
- (b) Subject each specimen to 20 complete humid/dry test cycles of 480 h in accordance with DIN 50 017.
- (c) Determine the resistance to impact for each specimen, in accordance with Appendix D.

H6 TEST REPORT The following information shall be reported:

- (a) Identification of the test specimens.
- (b) Drop height at which breakage of the test specimen occurs for both unexposed and exposed specimens.
- (c) Location of testing facility.
- (d) Date and time of the test.
- (e) Names, positions and relevant qualifications of personnel carrying out or supervising the test.
- (f) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

APPENDIX I
UNIFORMITY/SURFACE COMPRESSION
(Informative)

I1 SCOPE This Appendix sets out the method that enables toughened glazing materials from any one batch, or from any one production run, to be grouped together into groups of toughened glass that have been exposed to a similar heat treatment process for the purpose of subsequent testing of samples by the impact test or the fragmentation test.

I2 PRINCIPLE Specimens are illuminated by polarized light and examined from the opposite side through an analysing device for certain features.

I3 APPARATUS The apparatus required is a polariscope. A suitable type of polariscope is shown diagrammatically in Figure I1. The specimen is placed between two sheets of polarizing film with their optical axes crossed. Diffused light from a suitable source passes through the sheets of polarizing film and the specimen, and the strain pattern is viewed from the side remote from the light source. Other equally satisfactory arrangements are permissible.

NOTE: Equipment to measure surface compression is currently available and may be used as an alternative to the requirements of this Appendix, e.g. ASTM C 1279.

I4 PROCEDURE The procedure is as follows:

- (a) Illuminate the test specimen by having polarized light fall approximately normally on one face, and examine from the opposite side through the analysing device.
- (b) Examine the whole area of glazing material and record the following features:
 - (i) Generally when white light is used as the source, the body of the glazing material will be dark with grey or white patches. If there are any coloured areas, the position and colours of these areas should be recorded.

The area around the perimeter of the glazing material close to the edges will have one or more coloured bands; the innermost band will be black and this is called the 'neutral' line. The distance of the neutral line from the edge should be recorded, and also the number of coloured bands visible and their colours should be noted.

- (ii) When two glazing materials have substantial differences in the features mentioned in Item (i), they should be considered to have been exposed to a different heat treatment. An example of the appearance of a small specimen of 12 mm toughened glazing material when viewed in a polariscope is shown in Figure I2. Thinner toughened glazing material will exhibit fewer coloured bands at the edge.

I5 TEST REPORT The following information should be reported:

- (a) Identification of the test specimens.
- (b) Position and colour of any coloured areas.
- (c) Distance of the neutral line from the edge of the test specimen.
- (d) Number of coloured bands visible and their colours.
- (e) Location of testing facility.
- (f) Date and time of the test.

(g) Names, positions and relevant qualifications of personnel carrying out or supervising the test.

(h) Names, positions and relevant qualifications of witnesses, if any, to the test.

Each page of the report shall be signed and dated by the person responsible for the test.

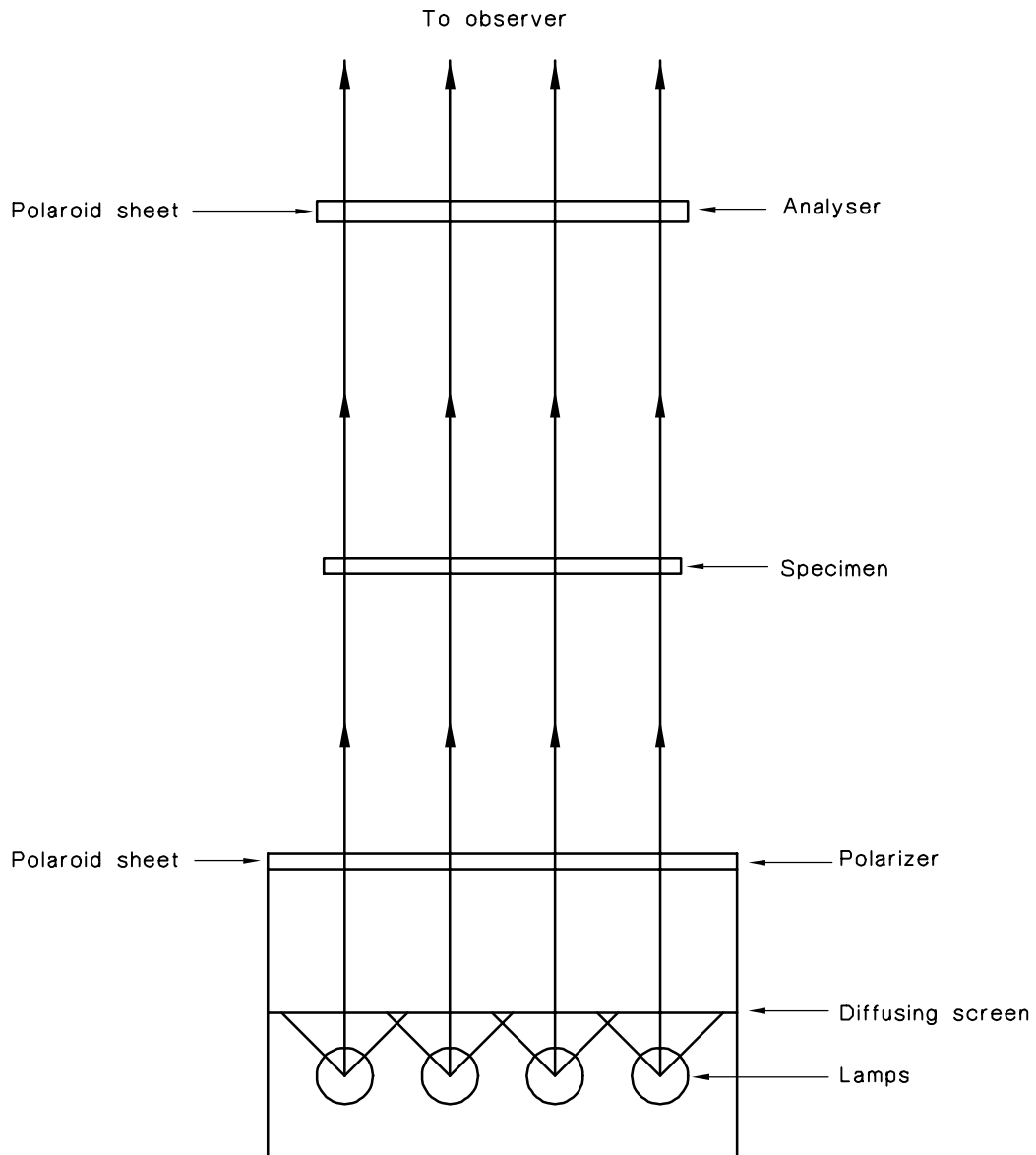


FIGURE 11 DIAGRAM OF A TYPICAL POLARISCOPE

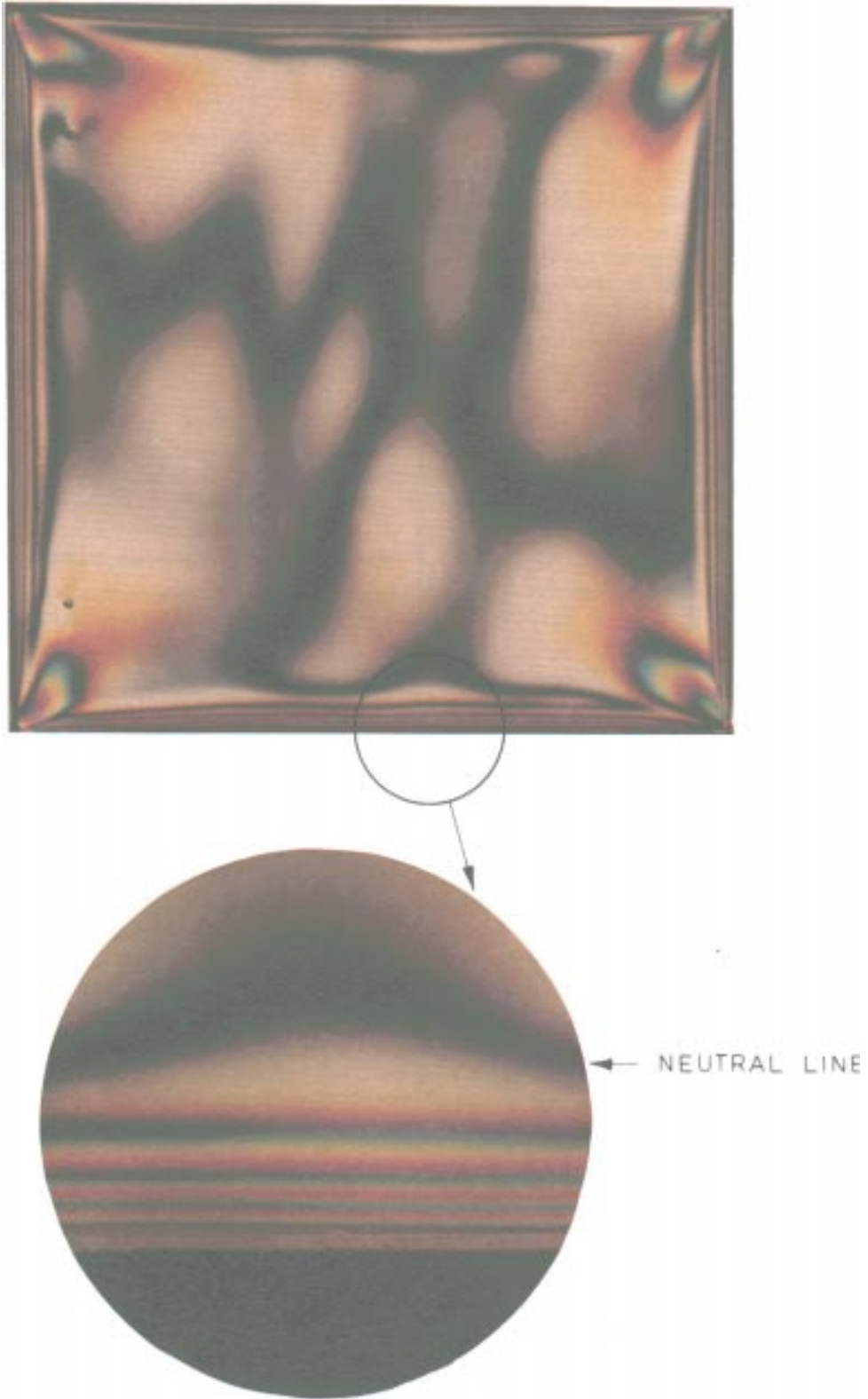


FIGURE I2 APPEARANCE OF 12 mm TOUGHENED GLASS WHEN VIEWED IN A POLARISCOPE