BRITISH STANDARD

BS 6206:1981

(Reprinted, incorporating Amendments Nos. 1, 2, 3, 4 and 5)

Specification for

Impact performance requirements for flat safety glass and safety plastics for use in buildings

UDC 698.3:[666.155 + 666.181 + 678 – 419]:620.178.7

Cooperating organizations

The Elements and Components (of Diverse Materials) for Buildings Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

Agrement Board
Aluminium Federation
Asbestos Cement Manufacturers' Association Limited
Association of British Roofing Felt Manufacturers
Brick Development Association
British Ceramic Research Association
British Hardware Federation
British Plastics Federation*
British Precast Concrete Federation Ltd.
British Steel Industry
British Woodworking Federation*
Consumer Standards Advisory Committee of BSI*
Convention of Scottish Local Authorities
Department of the Environment (PSA)*
Department of the Environment (Building Research Establishment, Princes Risborough Laboratory)
Department of the Environment (Housing and Construction)*
Flat Glass Manufacturers' Association*
Glass and Glazing Federation*
Health and Safety Executive*
Incorporated Association of Architects and Surveyors*
Institute of Building Control
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Scottish Development Department
Society of Chemical Industry
Timber Research and Development Association
Trades Union Congress

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

Aluminium Window Association
Architectural Aluminium Association
Chief and Assistant Chief Fire Officers' Association
Child Accident Prevention Committee
Department of the Environment (Building Research Establishment)
Department of Trade (Metrology, Quality Assurance, Safety and Standards Division)
Greater London Council
Metal Window Federation of Great Britain
National Association of Shopfitters
National House-building Council
Patent Glazing Conference
Sealant Manufacturers' Conference
Union of Construction, Allied Trades and Technicians

This British Standard, having been prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Committee, was published under the authority of the Board of BSI and comes into effect on
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The following BSI references relate to the work on this standard:
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Contents

Foreword

This British Standard has been prepared under the direction of the Glass Standards Committee[1)] at the request of the Glass and Glazing Federation, in order to provide specified and verifiable safety performance criteria for the types of flat safety glass and safety plastics used in buildings so as to reduce cutting and piercing injuries to persons who impact them.

In the preparation of this standard, full consideration has been given to the United States standard ANSI Z 97.1-1975 "Safety performance specifications and methods of test for safety glazing material used in buildings", which appears to have been successful in reducing injury due to accidents involving glass and plastics since its initial publication in 1972.

Work is currently being carried out by CEN Technical Committee 129, Glass in building, with the objective of producing a European Standard on the impact performance of flat glass for use in buildings. The United Kingdom is actively participating in the preparation of this new European Standard, which will be adopted as a British Standard when it is published. It is anticipated that the new standard will be available in approximately 3 years time and will supersede the impact performance requirements for flat glass given in BS 6206.

The Technical Committee responsible for BS 6206 decided that changes were required to improve and clarify the test procedure to overcome the deficiencies identified in the existing procedure and thereby extend the validity of the standard.

ANSI Z 97.1-1975 "Safety performance specifications and methods of test for safety glazing material used in buildings", which appears to have been successful in reducing injury due to accidents involving glass and plastics since its initial publication in 1972.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

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[1)] After the main drafting work on this British Standard had been completed, the Technical Committee responsible for it was transferred from the Glass Standards Committee (which was subsequently disbanded) to the Elements and Components (of Diverse Materials) for Buildings Standards Committee (ECB/-). In consequence the committee reference for the work was changed from GLC/1 to ECB/4.

0 Introduction

0.1 Safety performance levels

Experts working on the use of safety glass and safety plastics in buildings in the United States concluded that a child weighing 100 lb (45.36 kg) could reasonably be regarded as representative of persons involved in accidents where glass or plastics are impacted. Such a child, if running at full speed, theoretically develops about 1 000 J of kinetic energy but, because of dispersion of energy at the time of impact, the actual impact energy is considerably less. The proportion of the kinetic energy delivered as impact energy to a glazed opening depends upon the angle and manner of impact; for example, a "straight arm" impact transmits more energy to the glass or plastics than if the arm is flexed on impact.

In seeking to establish appropriate safety performance levels for glass and plastics, it was therefore accepted that test energies considerably below 1 000 J would be adequate, because the energies actually transmitted on impact, e.g. first by the hands, then by the head, then by the knees, would in total be much less than the kinetic energy of the running child. In addition, the incident angle of impact would seldom be at right angles to the glazed surface.

After extensive evaluation of experimental data, the American National Standards Institute Inc. decided (Z 97.1-1975) to use for test purposes:

a) a carefully specified impactor of 100 lb (45.36 kg) overall mass to simulate the running child;

b) selected "drop heights" of 12 in (305 mm), 18 in (457 mm) and 48 in (1 219 mm), equivalent to impact energies representative of those likely to be delivered accidentally by persons in glazed areas.

With an impactor of 45 kg overall mass (see Appendix A), the three specified drop heights correspond to impact energies of 135 J, 202 J and 538 J.

0.2 Safety breakage criteria

The concept of "safety" in this standard relates to a given level of impact energy and to a requirement for the glass and plastics: "break safe" or "no break". The break safe criteria adopted (see **5.3**) are those specified in ANSI Z 97.1-1975. They were developed following very extensive observation of available materials breaking under the test conditions and following the use of different impact energies to test materials having different levels of mechanical strength.

A material that is tested at one or more of the specified drop heights and that either does not break or breaks safely (see **5.3**), and that complies with all relevant requirements of this standard, may be described as a "safety glass" or "safety plastics" in accordance with BS 6206 Class A, B or C as appropriate (see clause **4**). A material that does not break, or breaks safely, at a given drop height will not necessarily break safely at the next higher drop height.

0.3 Applicability of safety glass and safety plastics

Safety glass and safety plastics are intended for use in potentially hazardous situations in buildings. Detailed recommendations for their application will be given in the forthcoming revision of CP 152.

0.4 Durability

It is most important that safety glass and safety plastics have the durability to continue to perform satisfactorily for their expected life, taking into account the external and internal environments to which they will be exposed and the method of glazing.

This standard assesses only the ability of glass and plastics to withstand specific impacts in order to qualify as a safety glass or safety plastics. It does not specify any requirements for durability. Several homogenous and composite materials have been proven to perform satisfactorily, but it has not been possible to devise a test or tests that can accurately validate their durability.

Users should therefore satisfy themselves that any safety glass or safety plastics specified will meet the service requirements of the installation. Information on the durability of the material under the proposed environmental conditions should be obtained from the manufacturer or supplier in written or published form.

If safety glass and safety plastics are subjected to exceptional or unusual circumstances such as undue abrasion, unsatisfactory methods of cleaning, chemical attack or excessive ultra-violet light from an artificial source, their durability may be affected. If it is desired to make provision for such circumstances it may be necessary for additional requirements to be agreed on a contractual basis.

1 Scope

This British Standard specifies performance requirements and a test method in respect of energy absorption (impact) for flat safety glass and safety plastics for use in buildings. These requirements are intended to reduce the risk of injuries caused by cutting and piercing in accidents where these materials are involved. Three classes of safety glass and safety plastics are defined.

This standard does not specify situations where safety glass and safety plastics should be used, nor does it specify requirements for their durability (see **0.4**).

2 References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this British Standard the following definitions apply.

3.1
glazing

the securing of glass or plastics glazing sheet materials in prepared openings as in windows, door panels, screens and partitions

3.2
safety glass and safety plastics

material that, when tested by the method given in Appendix A at one of the drop heights specified in clause **4**, either does not break or else breaks safely according to the criteria given in **5.3**

3.3
asymmetric safety glass and safety plastics

material made in such a way that its two surfaces give significantly different results under the specified impact test, e.g. laminated glass with different laminates, patterned glass and plastics and plastics-coated sheets

3.4
drop height

the vertical height from the horizontal centreline of the maximum diameter of the impacting object when it is released to a similar horizontal centreline when it is at rest vertically (see Figure 2)

4 Classification

Safety glass and safety plastics shall be classified as follows (see also Table 1).

Class A: material that complies with the requirements of **5.3** when tested by the method given in Appendix A at drop heights of 305 mm, 457 mm and 1 219 mm.

Class B: material that complies with the requirements of **5.3** when tested by the method given in Appendix A at drop heights of 305 mm and 457 mm.

Class C: material that complies with the requirements of **5.3** when tested by the method given in Appendix A at a drop height of 305 mm.

Table 1 — Classification of safety glass and safety plastics according to behaviour on impact

Class	Behaviour on impact		
	Drop height 305 mm	Drop height 457 mm	Drop height 1 219 mm
A	No breakage, or breaks safely	No breakage, or breaks safely	No breakage, or breaks safely
B	No breakage, or breaks safely	No breakage, or breaks safely	No requirement
C	No breakage, or breaks safely	No requirement	No requirement

Asymmetric safety glasses and safety plastics impact tested on one side only (see **5.4**), i.e. intended for use in situations where the risk of impact is from one side only, shall be classified Ao, Bo or Co respectively against the above requirements.

5 Impact test

5.1 Test pieces

5.1.1 For any given material, the test piece shall be identical in type, construction, composition, nominal thickness and manufacture to the material to be assessed.

5.1.2 Each test piece shall be rectangular, 865 ± 3 mm wide by 1 930 ± 3 mm high, or the maximum size available if that is smaller.

5.1.3 In the case of a plastics film bonded to a glass sheet, the material shall be tested as submitted by the manufacturer, either

a) with the film continued to the edge of the test piece, or

b) with a margin of uncoated glass round the test piece which may be covered during the test by the chloroprene strips of the sub-frame assembly.

5.1.4 In the case of a toughened glass, at least one extra test piece shall be supplied over and above the minimum number required for the impact tests, as follows.

a) One test piece, selected at random from the test pieces, shall be tested by the method given in Appendix B before any other test is carried out.

b) The test piece, when tested by the method given in Appendix B, shall have a minimum particle count of 40 particles in any 50 mm × 50 mm square. Should the particle count be less than this value, the impact test procedure shall not be carried out. The material shall not be classified.

c) The results of the particle count shall be reported.

5.2 Procedure

Test each test piece by the method given in Appendix A. Test four test pieces at each drop height appropriate to the class for which the material is intended.

5.3 Test requirements

All four test pieces shall not break (see note 1), or shall break safely as defined for the specified material when tested by the method given in Appendix A, at any drop height appropriate to the class for which the material is intended.

NOTE 1 In the event of a safety plastics test piece remaining unbroken, it is not required that it should necessarily remain within the subframe.

a) *Toughened glass* shall be deemed to break safely if the following applies.

1) If the test piece breaks, the 10 largest crack-free particles remaining 3 min after impact shall together weigh no more than the mass equivalent to 6 500 mm^2 of the original test piece. The particles shall be selected only from the portion of the original test piece exposed in the test frame. Only the exposed area of any particle retained in the test frame shall be taken into account in determining the mass equivalent.

2) If the test piece does not break at the selected maximum drop height, it shall be removed and shall conform to **5.1.4** b). The results of the particle count shall be reported.

b) *Laminated glass, wired glass, plastics film bonded to glass* shall be deemed to break safely if numerous cracks or fissures appear in the test piece, but no shear, or opening, develops within the body of the test piece through which a 76 mm diameter sphere can be passed freely. Additionally, if particles 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 mm^2 of the original test piece. The largest single particle shall weigh less than the mass equivalent to 4 400 mm^2 of the original test piece.

NOTE 2 The test piece may, or may not, be retained within the subframe.

c) *Safety plastics* shall be deemed to break safely if the following applies.

1) Numerous cracks or fissures appear in the test piece, but no shear, or opening, develops through which a 76 mm diameter sphere can be passed freely.

2) When breakage occurs which results in the production of separate fragments containing pointed protrusions, then such fragments shall be permitted provided that any pointed protrusion satisfies the following.

The length of the chord between the two points which are established when an arc of radius 25 mm, whose centre is the apex of the protrusion, crosses the perimeter on each side of the apex shall be not less than 25 mm (see Figure 7).

d) *Other materials.* Materials other than those identified in a), b) or c) above do not have recognized break-safe criteria and hence can only meet these requirements if they do not break when tested.

5.4 Asymmetric materials

In the case of asymmetric materials, the complete test shall be carried out on both sides, using separate sets of test pieces, and the classification shall be based on the worst performance.

In the case of asymmetric materials intended solely for installation in situations where the risk of impact is from one side only, the complete test shall be carried out on the risk side only.

NOTE For materials so tested there are specific classification and marking requirements (see clauses **4** and **6**).

6 Marking

All installed panels shall be marked as follows. These marks shall be permanent and applied before installation in a position to remain visible after installation.

a) an identifiable name or trademark or other mark capable of identification through a suitable source[2)];

b) the type of the material;

c) the number of this British Standard, i.e. BS 6206[3)];

d) the classification relating to impact test behaviour (see clause **4**).

Asymmetric materials claiming an Ao, Bo or Co classification shall have the above marking readable from the side which, when impacted, resulted in the classification.

In the case of multiple glazing units, each pane which complies with BS 6206 shall be marked accordingly. Alternatively, units in which all panes are classified safety glazing material may be marked on one pane only provided this mark clearly indicates that it applies

1) to all panes, and

2) to the lowest performance, if different performances apply to the individual panes.

Where sheets for further processing are supplied, if required they may be pre-marked as a) to d) above until final marking. This pre-marking may be by means of permanent labelling.

NOTE Permanent labelling is considered to be that which cannot be removed intact and re-used.

[2)] One such source is the Register of Safety Glazing Marks, 44-48 Borough High Street, London SE1 1XP (Telephone: 071-403 7177).

[3)] Marking BS 6206 on or in relation to a product is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification to support such claims should be addressed to the Director, British Standards Institution, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ in the case of certification marks administered by BSI or to the appropriate authority for other certification marks.

Appendix A
Test for behaviour on impact

A.1 Conditioning of test pieces. Remove all masking and protective material from the test pieces and store them for a minimum of 4 h at a temperature of 20 ± 5 °C with the test surfaces exposed to free air at that temperature.

A.2 Test temperature. Carry out the test at a temperature of 20 ± 5 °C.

A.3 Apparatus. The following apparatus is required.

A.3.1 *Test frame,* constructed of securely welded or bolted sections, designed to present a flat face to the sub-frame. The test frame sections and bracing members shall be steel channel 102 mm × 51 mm complying with the requirements of BS 4-1, or equivalent material of equal or greater strength and rigidity. This frame shall be securely bolted to the floor and securely braced as shown in Figure 1, Figure 2 and Figure 3.

A.3.2 *Sub-frame,* constructed of wood or other suitable material designed to hold the test piece as shown in Figure 4 so that the test piece can make contact only with the strips of chloroprene[4)] or similar material. These strips shall be capable of being compressed by 10 % to 15 % of their original depth without a permanent set being introduced. The edge cover of the chloroprene on the test pieces shall be such that for the nominal 865 mm × 1 930 mm specimens the central area of 845 ± 3 mm × 1 910 ± 3 mm is unsupported. A similar edge cover shall be provided in other subframes used for smaller test pieces.

NOTE In order to limit the compression of the chloroprene strips to within approximately 15 %, spacers of appropriate thickness and material are recommended (see Figure 4).

The components of the sub-frame shall be held together, and the sub-frame shall be held to the test frame, by bolts, toggle clamps or similar fixing devices as convenient, these being uniformly spaced no more than 450 mm apart and no fewer than two per side.

A.3.3 *Impactor,* consisting of a leather case of a punch bag type[5)], modified with a central support rod and fitting system as shown in Figure 5, and filled with chilled lead shot no. 7.

The leather case shall be made from six panels, as shown in Figure 6, which shall be securely stitched together leaving a slit approximately 175 mm long to allow for filling with the lead shot. Lace holes shall be inserted on each side of the slit which is closed by a leather thong. The exterior of the leather case shall be completely covered with three rolls of 12 mm wide polyester filament tape[6)], each 55 m in length, wound in a diagonal and overlapping manner. The neck shall be taped separately to cover the worm-drive hose clamp.

The complete impactor shall weigh 45 ± 0.1 kg.

The impactor shall be supported as shown in Figure 1 and Figure 2, and provision shall be made for raising the impactor to drop heights (see **A.4** and Figure 2) of up to 1 219 mm. Prior to release it shall be supported so that the central support rod is in line with the steel cable.

The impactor shall not wobble or oscillate after its release.

A.4 Procedure

A.4.1 Immediately preceding the test, condition the test piece as described in **A.1**. Place the test piece in the frame and clamp it so that the chloroprene strips are compressed by no more than 10 % to 15 % of their original thickness. When the impactor is hanging at rest, suspended from the overhead support, check that it is, at its greatest diameter, not more than 13 mm (see Figure 2) from the surface of the test piece and within 51 mm radially from the centre of the test piece (see Figure 2)

Raise the impactor to a drop height of 305 mm (see **3.4** and Figure 2) and steady it.

A.4.2 Release the impactor so that it swings in a pendulum arc and strikes the test piece.

A.4.3 Inspect the test piece after impact and report whether:

a) it has remained unbroken;

b) it has broken safely in accordance with the requirements of **5.3**;

c) it has broken and failed to comply with the requirements of **5.3**.

[4)] Commonly referred to by the trade name of "Neoprene".

[5)] A suitable impactor bag can be obtained from the Director, BSI Hemel Hempstead Centre, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ.

[6)] 3M 898 has been found to be satisfactory.

A.4.4 If any one test piece fails to comply with the requirements of **5.3**, terminate the procedure. If all four test pieces either do not break or else break safely, and if it is required to test the material to a higher impact level, increase the drop height to 457 mm and repeat the test on four more test pieces of the same material. At the manufacturer's discretion, these test pieces may either be new ones or the four which have undergone the previous test and remained unbroken.

A.4.5 Inspect and report as described in **A.4.3**.

A.4.6 If any one test piece fails to comply with the requirements of **5.3**, terminate the procedure. If all four test pieces either do not break or else break safely, and if it is required to test the material to a higher impact level, increase the drop height to 1 219 mm and repeat the test on four more test pieces of the same material. At the manufacturer's discretion, these test pieces may either be new ones or the four which have undergone the previous tests and remained unbroken.

A.4.7 Inspect and report as described in **A.4.3**.

Appendix B
Test for toughening quality

NOTE This appendix provides a test which will determine whether toughened safety glass possess the breakage characteristics that result in minimum risk of cutting and piercing injuries in the event of glass breakage.

B.1 Conditioning of test pieces. Remove all masking and protective material from the test piece and store it for a minimum of 4 h at a temperature of 20 °C ± 5 °C with the test surfaces exposed to free air at that temperature.

B.2 Test temperature. Carry out the test at a temperature of 20 °C ± 5 °C.

B.3 Apparatus. The following apparatus is required.

B.3.1 *Impactor,* with a radius of curvature of the point of 0.20 mm ± 0.05 mm.

NOTE A pointed hammer of about 75 g mass, a spring loaded centre punch or similar appliance can be used.

B.3.2 *Means of support,* comprising a flat base on which the test piece is laid without any mechanical constraint. In order to prevent scattering of fragments, the test piece shall be simply held at the edges so that the fragments remain interlocked after breakage, without hindering extension of the test piece.

B.4 Procedure. Strike the test piece 13 mm from its longest edge at the midpoint of that edge until breakage occurs [see Figure 8 a)].

B.5 Particle count determination

B.5.1 All particle count determinations on any one test piece shall be conducted as follows:

a) within 4 min of the fracture, identify the region for the particle count;

b) after 4 min, but within 5 min, of the fracture, complete the fragmentation assessment.

B.5.2 Make the particle count in the region of the coarsest fracture, excluding a segment of radius 75 mm centred on the point of impact and a border of 25 mm round the edge of the test piece [see Figure 8a), Figure 8b) and Figure 8c)].

B.5.3 Place a mask of 50 mm × 50 mm on the test piece and count the number of crack-free particles within the mask [see Figure 8c)].

B.5.4 In the particle count, all particles wholly contained within the mask shall be counted as one particle and all particles which are partially within the mask and partially outside the mask shall be counted as half a particle [see Figure 8d) and Figure 8e)].

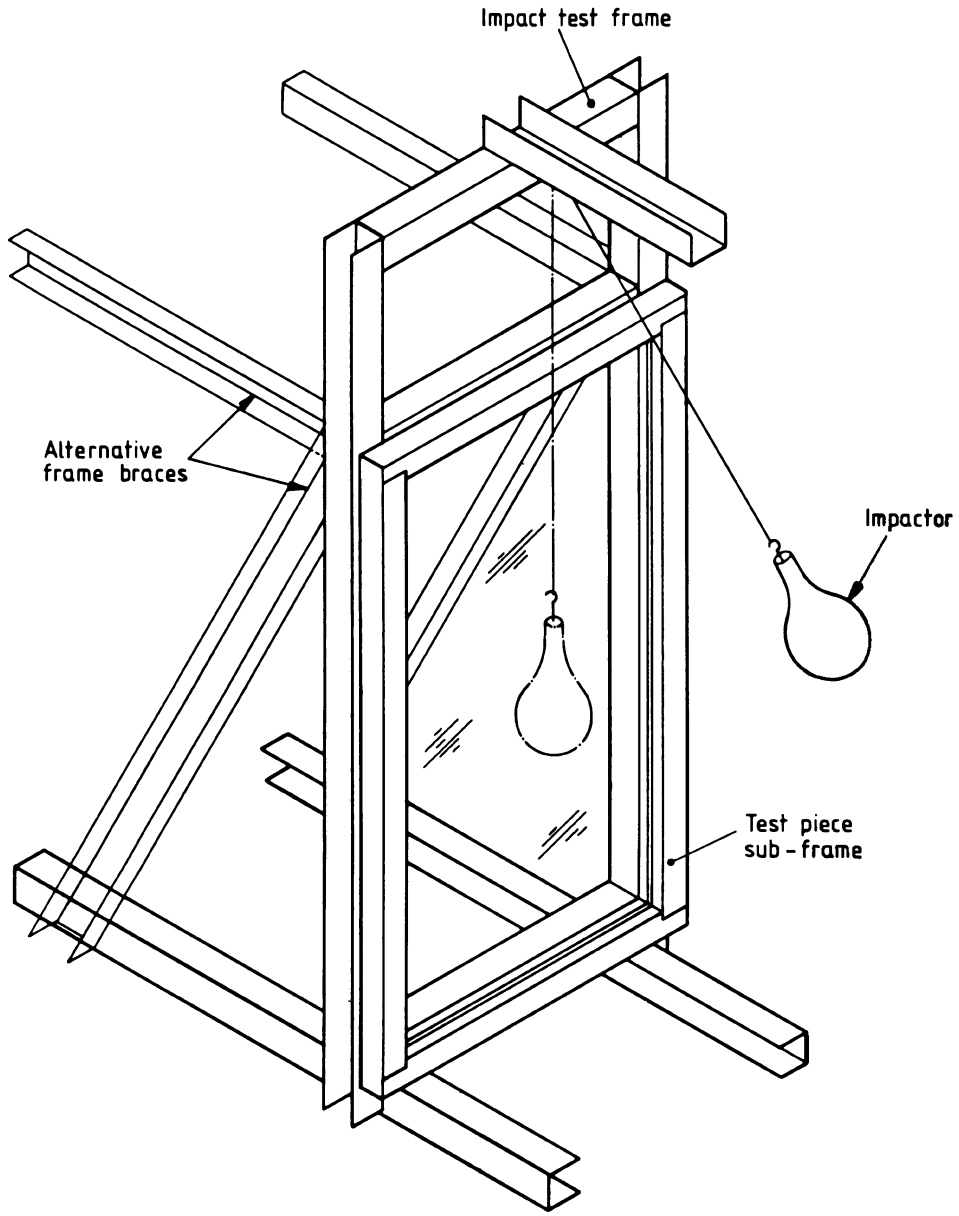
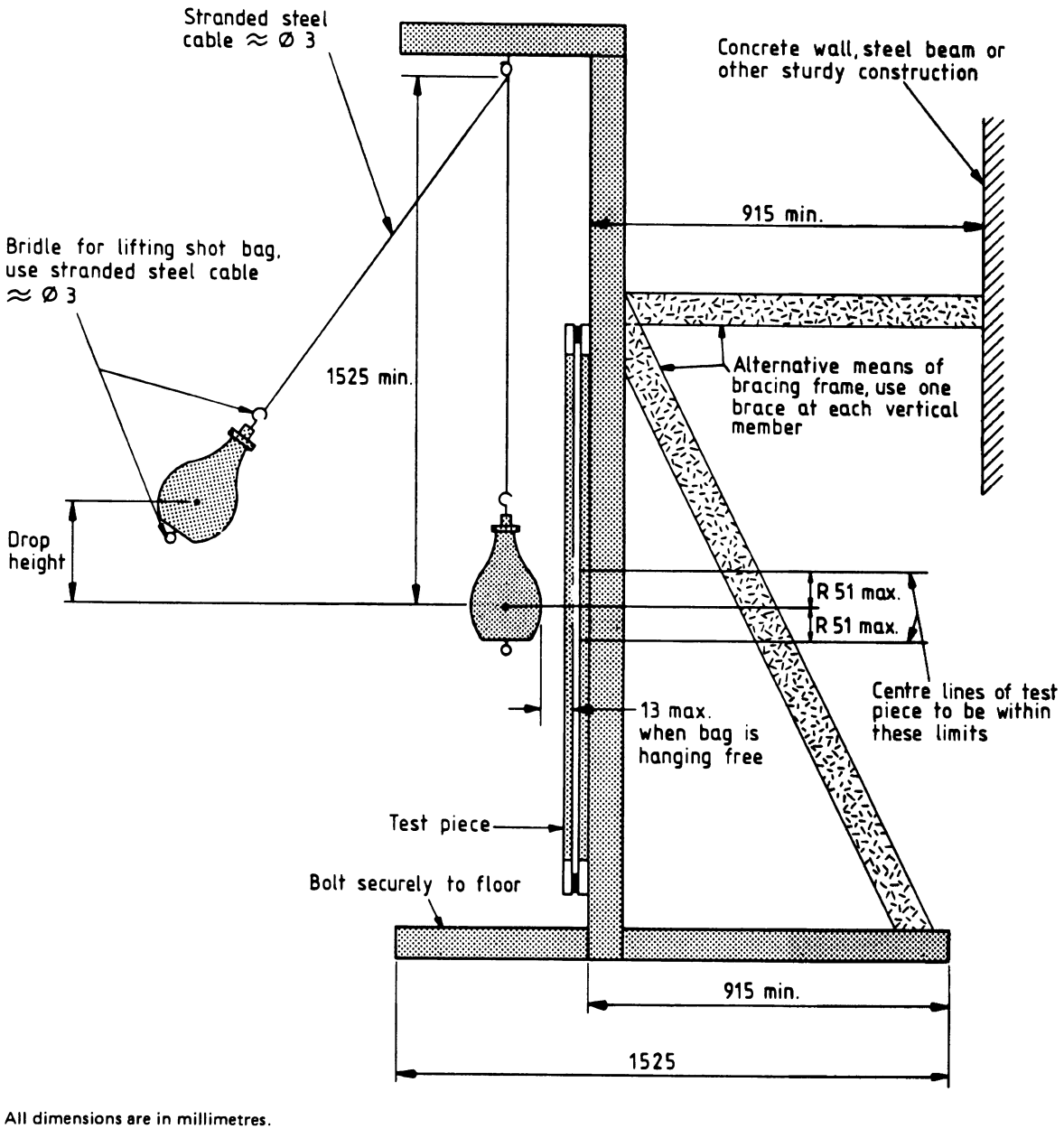
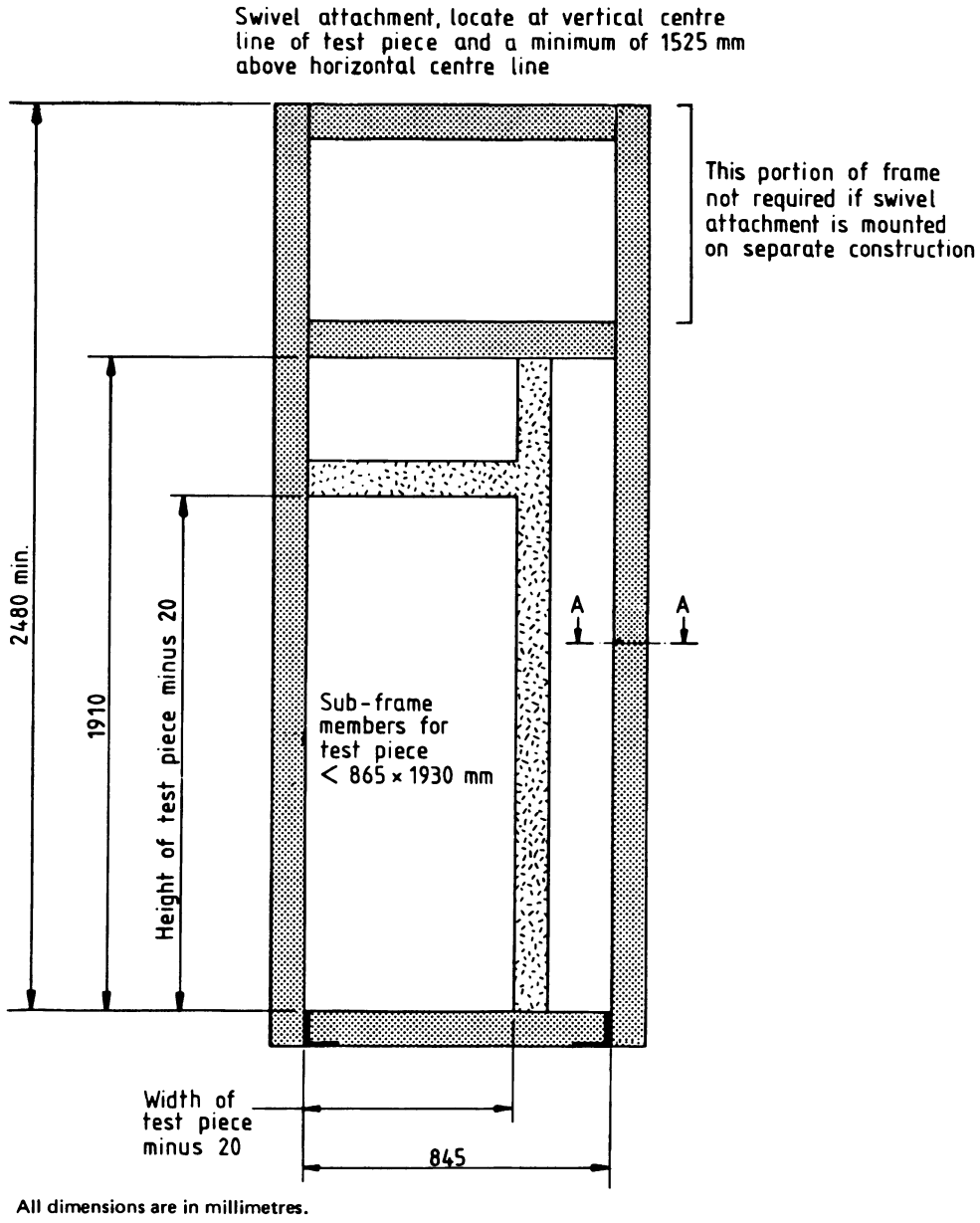


Figure 1 — Impact test structure: general arrangement



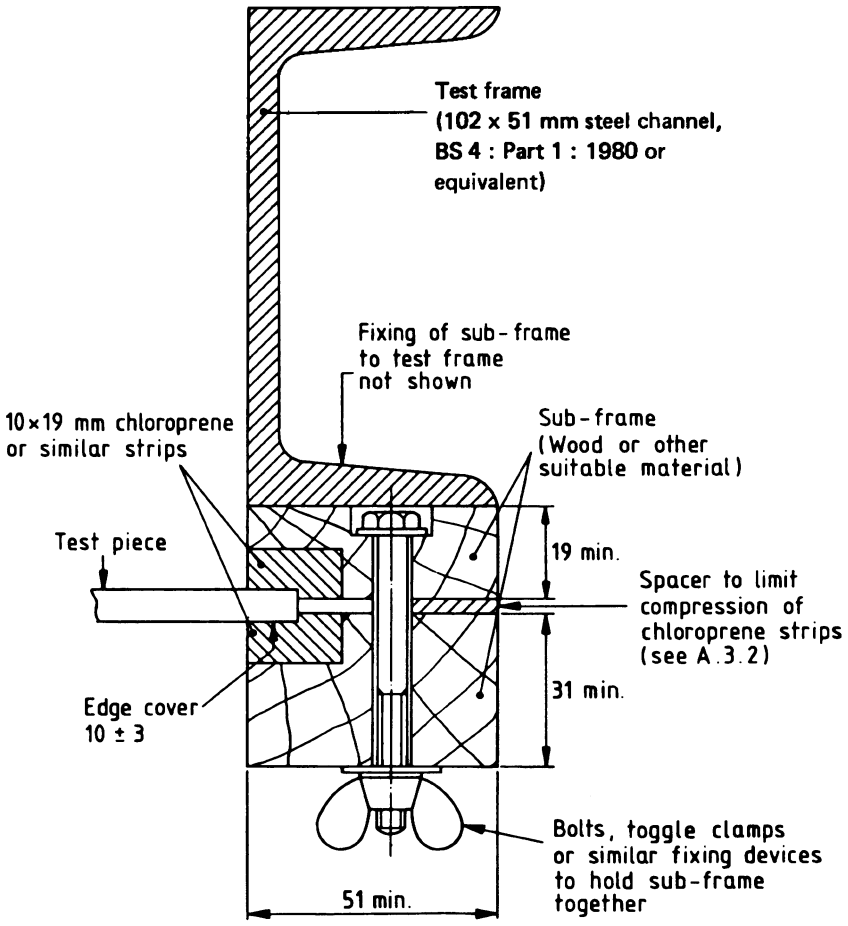
All dimensions are in millimetres.

Figure 2 — Impact test structure: side elevation



NOTE Sub-frame for holding test piece not shown.

Figure 3 — Impact test structure: front elevation



All dimensions are in millimetres.

Figure 4 — Clamping of test piece (section A-A of Figure 3)

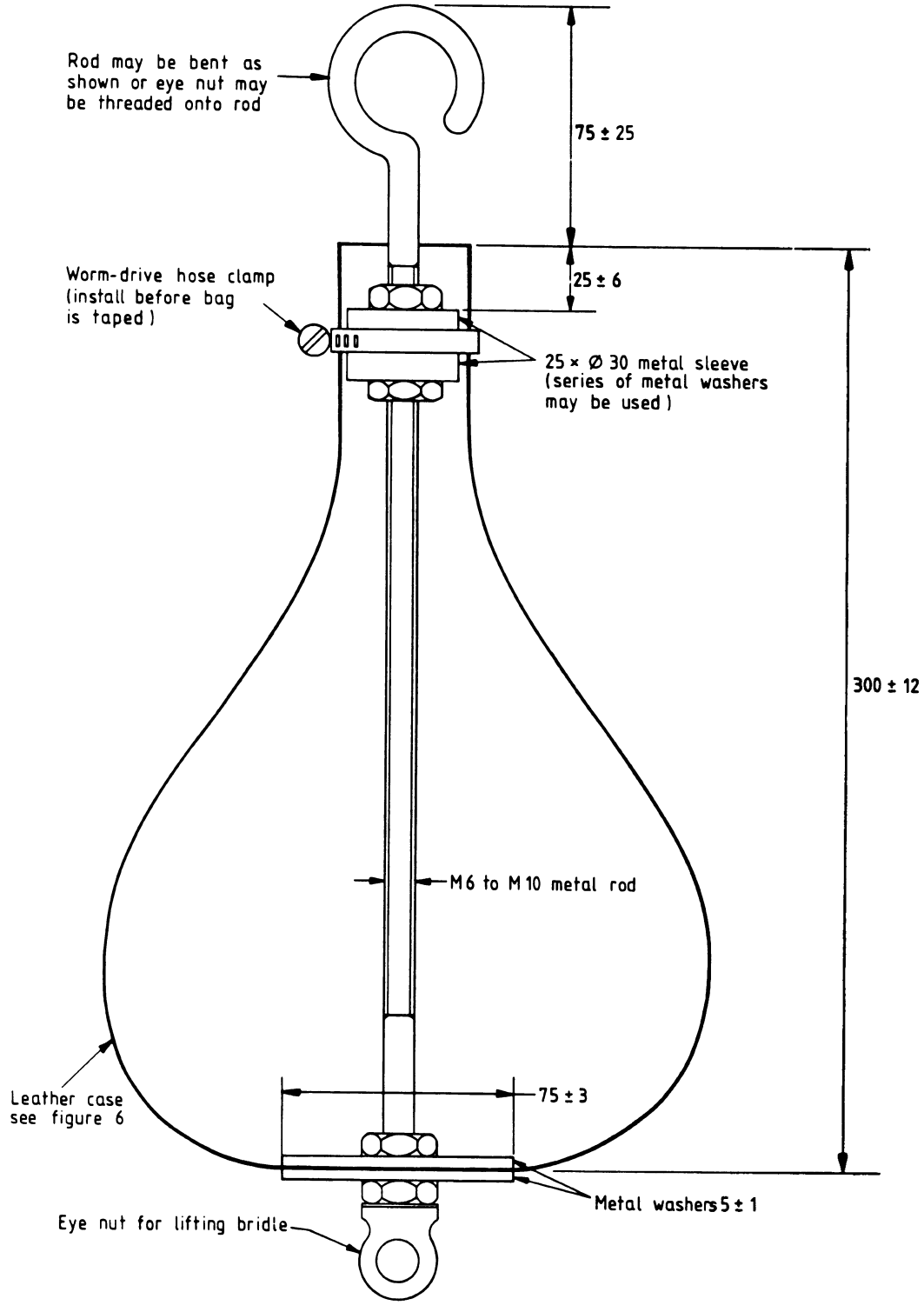


Figure 5 — Impactor

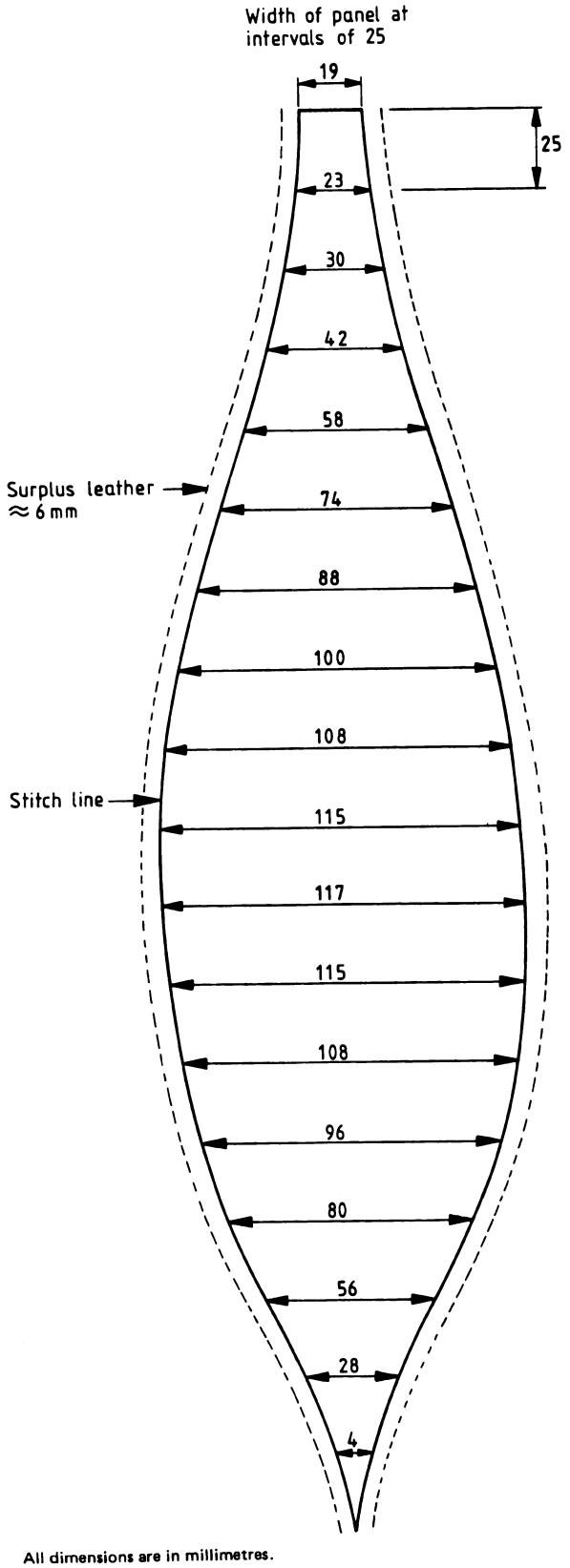
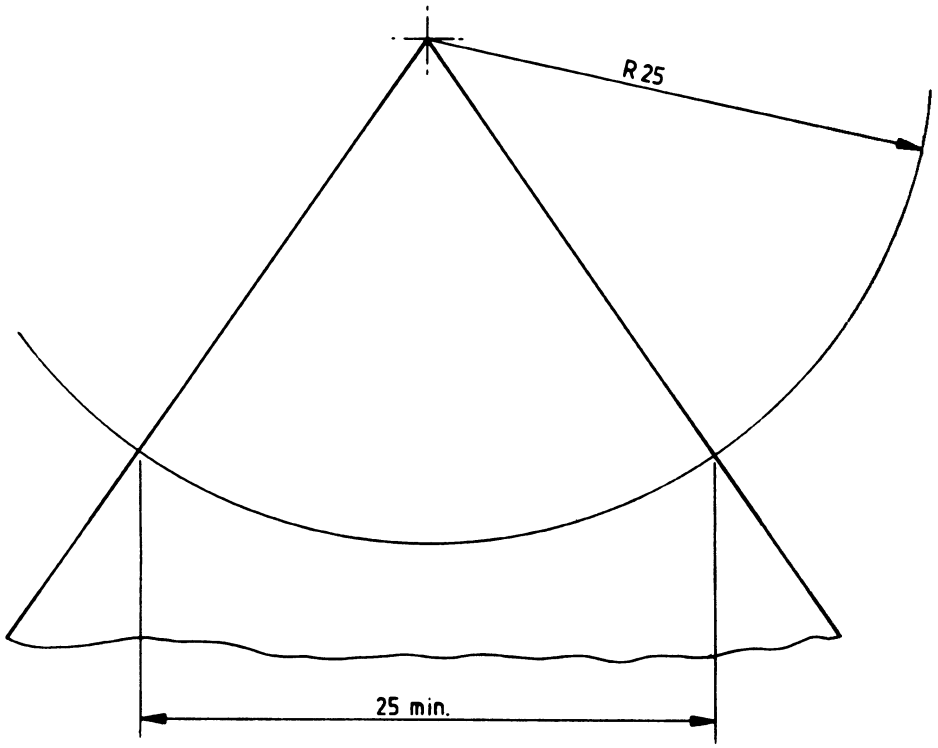
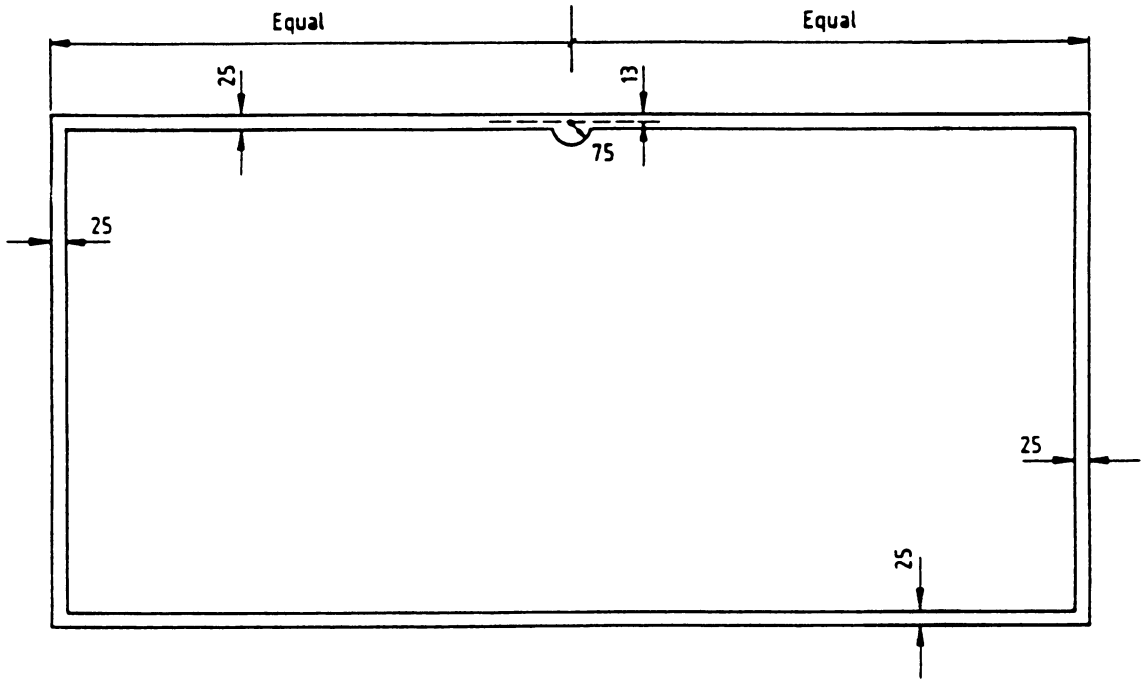


Figure 6 — One panel of six panelled impactor case



All dimensions are in millimetres.

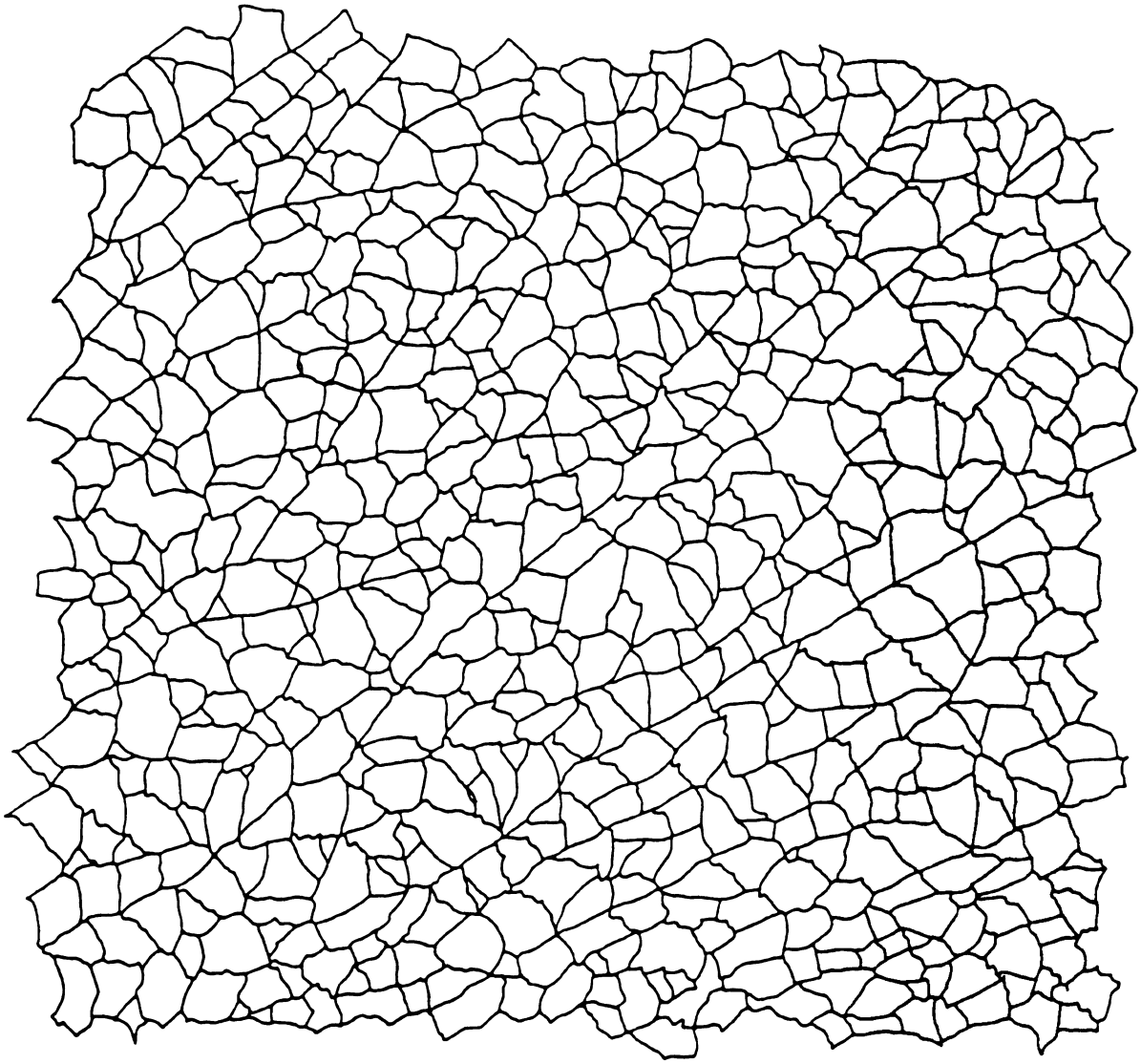
Figure 7 — Diagrammatic representation of the requirement given in item 2) of 5.3 c)



All dimensions are in millimetres.

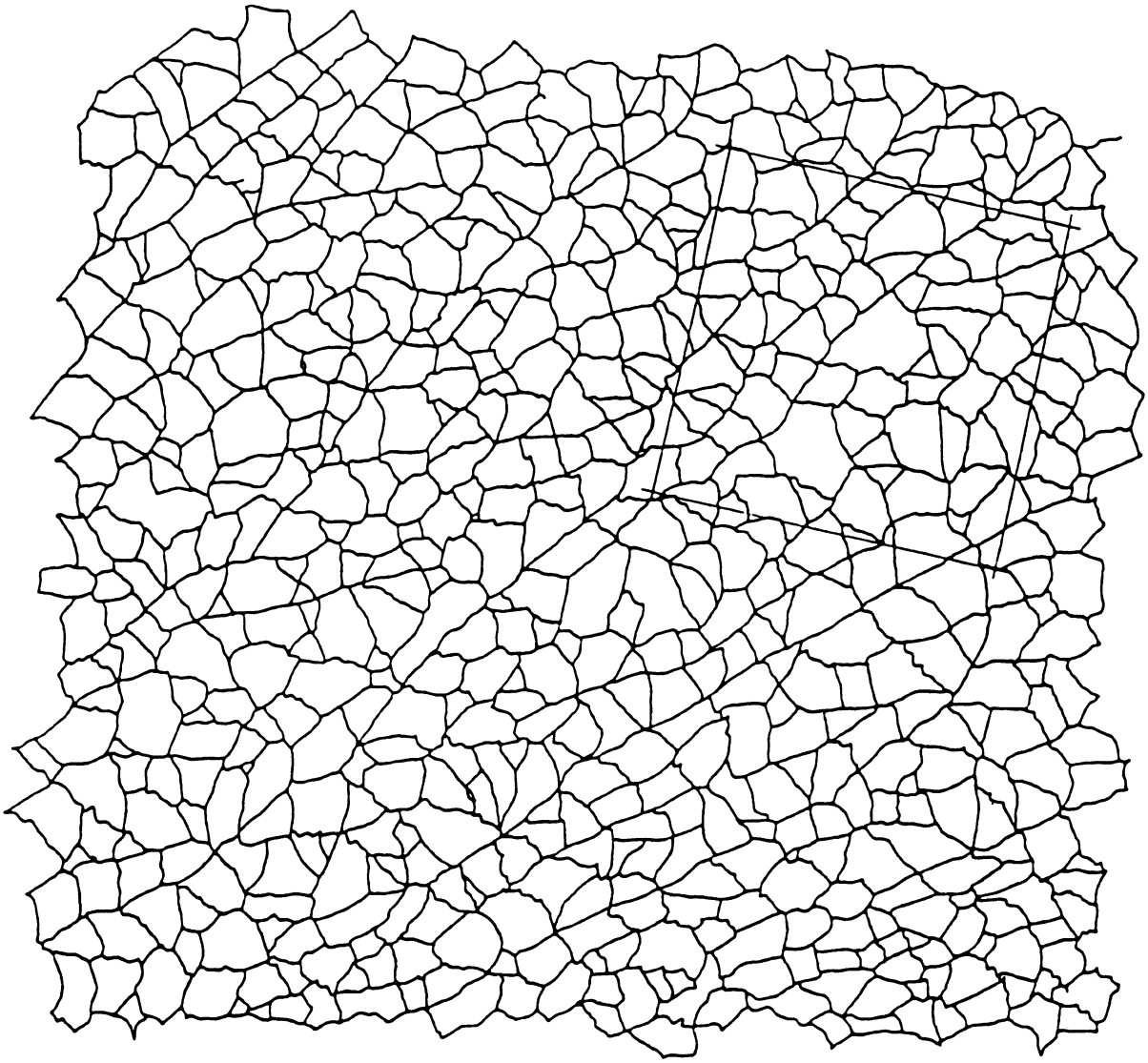
(a) Point of impact and areas to be excluded in particle count determination

Figure 8 — Particle count determination



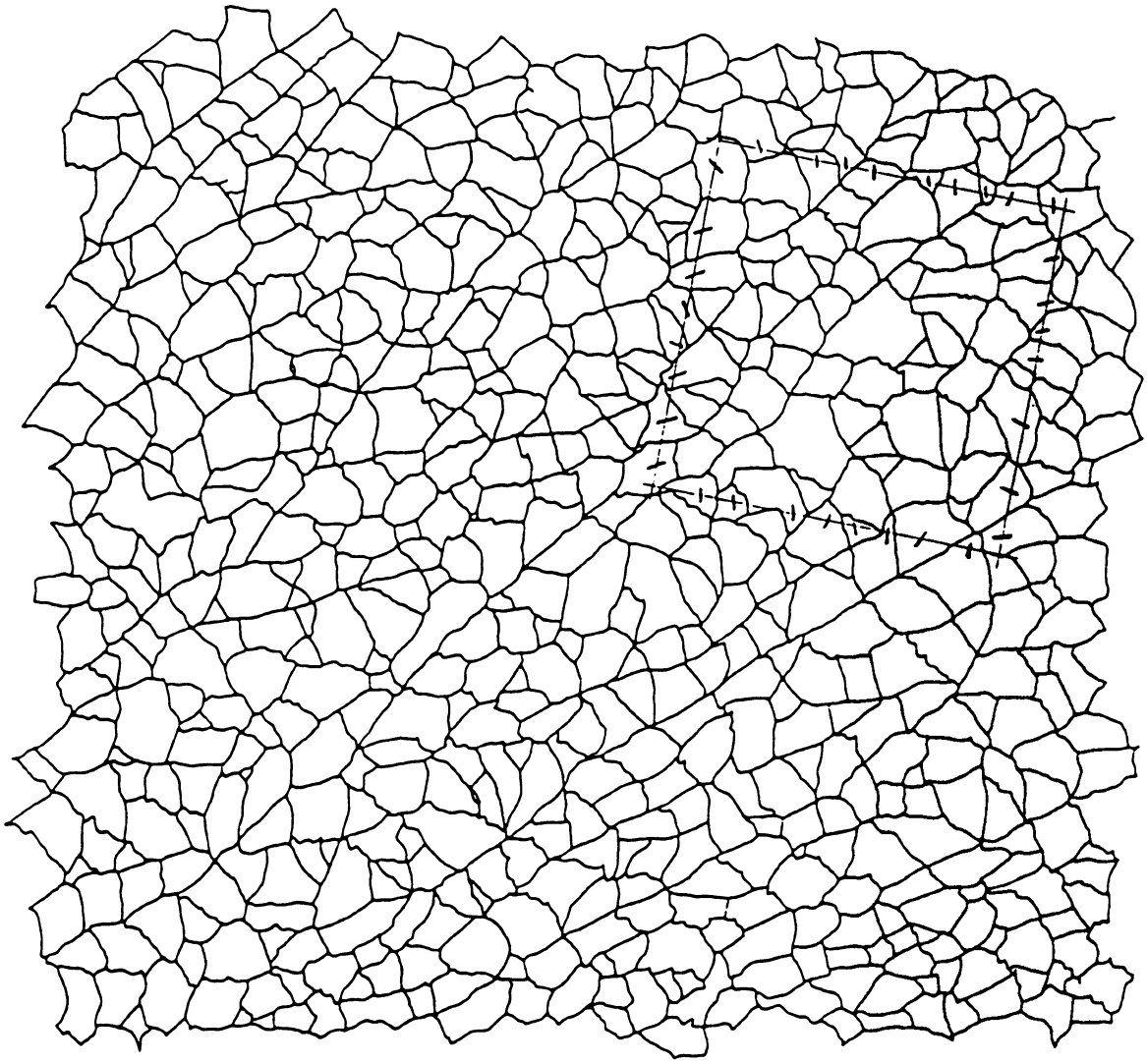
(b) Typical area of toughened glass after punch test

Figure 8 — Particle count determination *(continued)*



(c) Select area of coarsest fracture and draw a 50 mm square. This is normally done using a template with an opening 50 mm square in the middle.

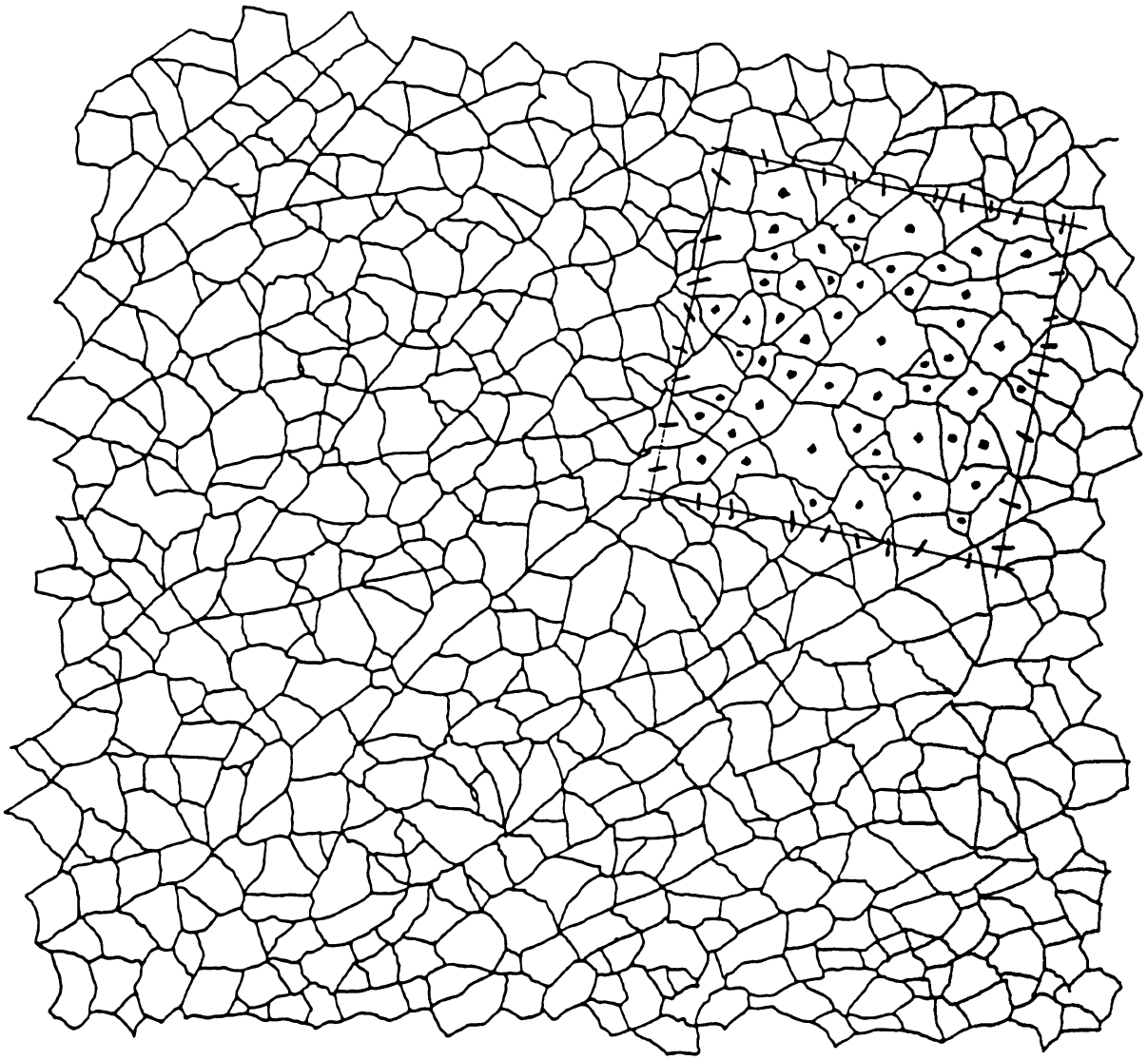
Figure 8 — Particle count determination *(continued)*



Number of half particles = 32
Particle count = 16

(d) Mark and count all those particles which cross the drawn boundary. Count these each as half a particle.

Figure 8 — Particle count determination *(continued)*



Number of particles = 53
Number of half particles = 16 ($32 \times {}^{1}/_{2}$)
Total particle count = 69

(e) Mark and count all those particles totally enclosed within the boundary. Add this number to the edge particle count. This gives the total particle count.

Figure 8 — Particle count determination *(concluded)*

Publications referred to

BS 4, *Structural steel sections.*
BS 4-1, *Hot-rolled sections.*
CP 152, *Glazing and fixing of glass for buildings.*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

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