BRITISH STANDARD

BS 5051-1: 1988

Bullet-resistant glazing —

Part 1: Specification for glazing for interior use

UDC 691.6:666.155:[.004.15 + .001.4]

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Elements and Components (of Diverse Materials) for Buildings Standards Committee (ECB/-) to Technical Committee ECB/4, upon which the following bodies were represented:

Aluminium Window Association
Architectural Aluminium Association
British Adhesives and Sealants Association
British Plastics Federation
British Woodworking Federation
Chief and Assistant Chief Fire Officers' Association
Child Accident Prevention Trust
Consumer Policy Committee of BSI
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Department of the Environment (Building Research Establishment)
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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

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Business Equipment and Information Technology Association
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Post Office
Society of Glass Technology
Society of Motor Manufacturers and Traders Limited

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Contents

Foreword

This revision of BS 5051-1 was prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Committee. It supersedes BS 5051-1:1973 which is withdrawn.

The title has been changed to distinguish bullet-resistant glazing from other kinds of security glazing, such as anti-bandit glazing resistant to manual attack (covered by BS 5544:1978).

Major changes include the introduction of a new category of glazing designed to protect against attack by a 5.56 mm calibre rifle, reclassification of the old G3 grade as R2 (designed to protect against attack by a 7.62 mm calibre rifle), and the introduction of a revised test for glazing resistant to shotgun attack.

Other changes include the deletion of imperial equivalent dimensions, the omission of barrel length requirements for test weapons, and the deletion of the old Appendix C (which gave details of specific systems of bullet velocity measurement). General information on velocity detection methods now appears in the notes to Table 1, and adjustments have been made to the tolerances on striking velocities.

Background information in the foreword of the last edition has been transferred to an introduction (see clause **0**).

Requirements for through-vision and light transmission have been removed from the specification.

The committee considered it inadvisable to draw up detailed specifications for each type of bullet-resistant glazing known to be satisfactory because:

a) these could not replace performance tests, and

b) the subject continues to be in an active stage of development and it would be extremely difficult to keep such specifications comprehensive and up-to-date by including the new or improved materials that are becoming available or will do so in future.

Correct installation of bullet-resistant glazing is considered to be vital to its effectiveness. Attention is therefore drawn to BS 5357 which covers installation of security glazing, and to Appendix C of this standard, which details some essential installation requirements.

This British Standard calls for the use of procedures that may cause injury if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

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 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

0.1 Designation system

In considering the various types of potential attack against which bullet-resistant glazing may be required to provide protection, it has been found convenient to define six categories of glazing, to be designated by code letters and numbers (see clause **3**).

0.2 General requirements

The first requirement for bullet-resistant glazing is that it will provide protection by preventing the passage of projectiles from various types of weapon. The second requirement is that it will protect personnel against injury from splinters of glass which may be ejected from the rear surface when the glazing is attacked. Because of the need to comply with this second requirement, the glazing may be either a unitary type or a duplex type in which a primary screen stops the bullet and a thin, secondary screen stops flying splinters. In a duplex installation the secondary screen is permanently fixed, for example, by hanging on chains from the ceiling, and is not necessarily attached directly to the main screen.

0.3 Service life

Some types of bullet-resistant laminated glass have been in use for many years and are known to maintain their resistance to attack over this period of time. However, new types of assembly are being developed and a safeguard against possibly inadequate service life has therefore been included. The lack of an agreed accelerated exposure test for plastics materials and their adhesion to glass was one of the most difficult problems. A period of exposure to external weathering prior to the type tests has therefore been specified (six months) in the belief that this will exclude any assemblies which would have inadequate service life.

NOTE Scratches on any bullet-resistant glazing may lessen its resistance to attack. So may undue abrasion, unsatisfactory methods of cleaning or excessive exposure to ultraviolet light.

0.4 Fixing

Bullet-resistant glazing may be fitted in a wide variety of internal windows, counter screens, partitions, etc., and it has not been considered possible to include a detailed specification for the fixing of the glass. Nevertheless, it should be recognized that the protection provided by bullet-resistant glazing depends just as much upon the design, fixing and maintenance of the window, counter screen or partition as it does upon the glazing itself. BS 5357 makes detailed recommendations for the installation of security glazing, and some of the essential points are given in Appendix C.

1 Scope

1.1 This Part of BS 5051 specifies performance requirements and type test methods for six classes of bullet-resistant glazing for interior use, designed to resist attack by handguns, rifles and shotguns. It covers glazing for use at temperatures between 10 °C and 30 °C.

NOTE Glazing resistant to manual attack (anti-bandit glazing) is covered in BS 5544. However, glazing complying with this Part of BS 5051 may also be highly resistant to many forms of manual attack.

1.2 This Part of BS 5051 does not include requirements for freedom from visible defects or for light transmission. It does not specify requirements for the retention of bullet-resistant qualities over a stated period (but see **0.3**).

NOTE 1 Under conditions where bullet-resistant glass may be subjected to abrasion, unsatisfactory methods of cleaning or excessive ultraviolet light, bullet resistant qualities may be impaired. Additional requirements should therefore be agreed between the purchaser and the vendor.

NOTE 2 Panels of bullet-resistant glass much smaller than the test piece specified (see **4.1**) may provide less protection in service than would be indicated by the performance of the test piece. Additional requirements should therefore be agreed between the purchaser and the vendor.

NOTE 3 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5051 the following definitions apply.

2.1
bullet-resistant glazing

a glazing material that affords protection to personnel and property by preventing the passage of projectiles from the range of weapons described in Table 1

NOTE The term "bullet-resistant glazing" as used in this Part of BS 5051 applies to products that have the obvious characteristics of a conventional glass, but it is understood to include also such products as:

a) rigid plastics;
b) laminates of glass with one or more plastics interlayers;
c) laminates of glass incorporating high tensile steel wire mesh in a plastics interlayer;
d) glass and/or plastics bonded with one or more plastics interlayers;
e) any combinations of the above.

2.2
panel

a complete bullet-resistant glazing unit, e.g. in the case of a duplex unit the panel comprises both the primary and the secondary screens

2.3
unitary bullet-resistant panel

a panel consisting of a single screen of bullet-resistant glazing as defined in **2.1** which is capable of resisting the specified level of attack in accordance with **5.2**

NOTE The glass or plastics components of a unitary bullet-resistant panel may be separated by air spaces.

2.4
duplex bullet-resistant panel

a unit formed by a primary screen in permanent association with a supplementary anti-splinter screen (the secondary screen) on the side remote from the direction of attack, the unit being capable of resisting the specified level of attack in accordance with **5.2**

2.5
primary screen

a component of a duplex bullet-resistant panel consisting of a single screen of security glazing on the side nearest to the direction of attack and of such properties that it will not allow the passage of the projectile or projectiles used in the specified level of attack but may during attack suffer ejection of splinters of glass from the side remote from the attack

NOTE The glass or plastics components of a primary screen may be separated by air spaces.

2.6
secondary screen

an installed supplementary screen of a duplex bullet-resistant panel used with the primary screen and on the side remote from the direction of attack. Its function is to withstand the impact of any splinters detached from the primary screen by the attack without itself suffering the detachment of splinters from the face remote from the primary screen

2.7
public side

the side of a bullet-resistant glazing that is designed to face the attack

2.8
level of attack

the designated ballistic impact directed against bullet-resistant glazing

2.9
traceability number

a coded number, assigned by the manufacturer, that identifies the class, batch and date of manufacture of the bullet-resistant glazing

3 Classification of panels

3.1 Bullet-resistant glass shall be classified as follows.

Class G0	resistant to attack by a 9 mm parabellum hand gun.
Class G1	resistant to attack by a 357 magnum hand gun.
Class G2	resistant to attack by a 44 magnum hand gun.
Class R1	resistant to attack by a 5.56 mm rifle.
Class R2	resistant to attack by a 7.62 mm rifle.
Class S86	resistant to attack by a 12 bore shot gun.

NOTE 1 Table 1 gives details of the weapons, ammunition and conditions that produce these levels of attack.
NOTE 2 The classes of glazing resistant to hand gun and rifle attack (G and R) are here classified in order of the level of protection offered, e.g. a panel complying with the requirements specified for class R1 will also comply with those specified for the preceding classes G2, G1 and G0.
However, a panel of class S86 may or may not comply with the requirements of one or more of the G and R classes, and compliance should be separately verified.

3.2 A panel that complies with the requirements of class S86 and one or more of the G and R classes shall be classified with a dual classification, e.g. S86/G2.

4 Panel test pieces for type testing

4.1 Test pieces from unitary and duplex panels submitted for type testing shall be 420 ± 5 mm square. They shall be prepared from the same materials as, and processed under identical conditions to, the product which they represent.

4.2 Test pieces from the primary and secondary screens of a duplex panel shall be submitted for type testing at the same time, together with a means of locating the secondary screen test pieces in correct relation to the primary screen test pieces.

4.3 Three panel test pieces shall be submitted for the type tests.

NOTE 1 In view of the six month weathering period, and the possibility of accidental damage or "no-test" situations, it is advisable for the manufacturer to provide additional test pieces.
NOTE 2 If glazing is to be tested for verification of compliance with more than one class, an additional set of three panel test pieces will be required for each classification.

5 Performance

5.1 The three panel test pieces shall comply with **5.2** after external weathering in accordance with Appendix A.

5.2 When tested in accordance with Appendix B, under the conditions specified for their class in Table 1, the three panel test pieces shall comply with the following.

a) Projectiles shall not pass through the test pieces.

b) No fragments from projectiles shall perforate the witness cards.

c) No fragments ejected from the glazing shall perforate the witness cards.

6 Marking

6.1 The following particulars shall be indelibly and distinctly marked on every panel:

a) a name or trade mark, enabling the manufacturer to be identified;

b) a traceability number (see **2.9**).

6.2 Where applicable, the following additional particulars shall be indelibly and distinctly marked on the panels:

a) the word "primary" on the primary screen of a duplex panel;

b) the words "public side" on the surface of a panel intended to face the direction of expected attack.

6.3 The following particulars shall be marked on every panel by means of a label which cannot be removed intact and re-used:

a) the number and date of this British Standard, i.e. BS 5051-1:1988[1)];

b) the class designation, e.g. R2.

NOTE 1 This label is intended to be removed after installation of the panel.

NOTE 2 It is important to ensure that the adhesive used to secure the label is compatible with the material to whose surface it is to be affixed.

[1)] Marking BS 5051-1:1988 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Appendix A External weathering procedure for panel test pieces

A.1 Preparation of test pieces

Test pieces may have the edges protected to prevent entry of moisture into any laminates or air spaces, but this protection shall not cover the surfaces of the test piece at any point to a depth greater than 10 mm nor shall the surround be thicker than 3 mm.

A.2 Test racks and fittings

Test racks and fittings shall be constructed of materials that will not affect the materials under test.

The racks may be placed either on open ground (preferably on concrete rafts), or on the roofs of buildings; in either case, care shall be taken to ensure that environmental conditions (heat reflection from buildings, smoke discharges, etc.) are not such as may distort the results of exposure.

Racks shall be so designed that the exposed surfaces of the test pieces are at an angle of 45° to the horizontal, facing due south (see note), and so placed that any obstructions in an easterly, southerly or westerly direction do not cause a greater degree of shelter to the test pieces than the limit shown in Figure 1. The racks shall be so constructed that there is no background for a distance of at least 0.3 m in any direction from the back of the test pieces mounted on them. If the rack is positioned on soil, the vegetation shall be kept cleared as completely as possible; the bottom edge of any test piece shall be not less than 0.5 m above the plane of the cleared area to avoid any undesirable effects from grass or plant growth, or from rain splashes from the ground.

Racks shall be so designed that test pieces can be fixed directly to the rack by means of clamps of an inert material. Where metal fixings are used, aluminium is usually more suitable than brass because of the possible adverse catalytic effect of copper ions; alternatively, a suitable inert plastics material or a ceramic may be used. The method of fixing shall minimize any stresses applied to the test pieces and shall not cause rainwater to collect in contact with the test pieces.

NOTE For tests carried out in the southern hemisphere read "north" and "northerly" in place of "south" and "southerly".

A.3 Procedure

Fix the test pieces to the exposure racks and record the date of the original exposure. Inspect the exposed test pieces periodically to ensure that they have not been loosened or removed from the racks by wind effects, etc. Also inspect for incidental damage caused by factors other than weathering agencies (solar radiation, warmth or cold and moisture). Record any such damage and notify the manufacturer immediately so that, where necessary, further test pieces can be supplied.

After exposure for six months wash the test pieces free of surface dirt, using the minimum of abrasion, allow to drain, condition the test pieces and test for bullet resistance as soon as possible. Avoid conditions of storage and transit that may introduce changes in the material of test pieces which it is not intended to test immediately.

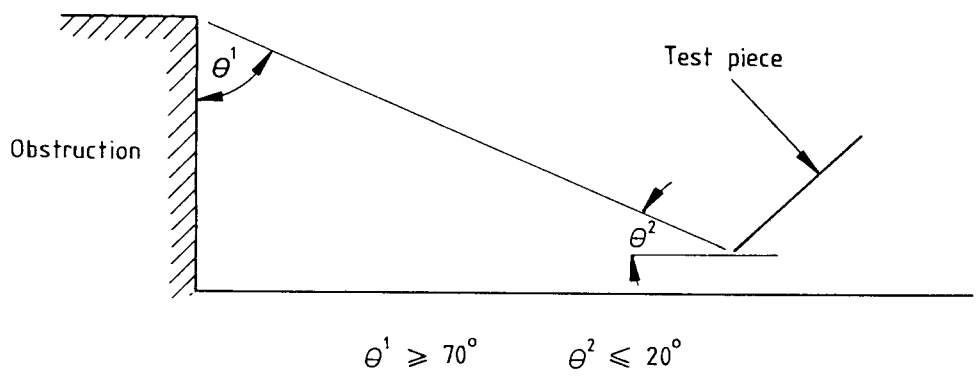

Figure 1 — Limit of shelter from obstructions in an easterly, southerly or westerly direction

Appendix B Procedure for type testing for performance requirements

WARNING NOTE. Any range used for testing will require to be approved by a competent authority with regard to design and construction, as well as with regard to equipment and use.

CAUTION. Particular attention should be paid to the risk of injury from flying particles.

B.1 Conditioning of test pieces

Protect the perimeter of each test piece with self-adhesive tape. Store the test pieces for a minimum of 12 h at a temperature of 20 ± 5 °C.

NOTE It is important to ensure that the adhesive used on the tape is compatible with the material of the test piece.

B.2 Apparatus

B.2.1 *Rigid test frame.* A frame to mount the conditioned test piece in a vertical position, with all four edges clamped, so that there is a clear fire space (test area) of 350 mm × 350 mm.

NOTE It is essential to ensure that the frame is sufficiently rigid to retain the test piece in position during test firing.

B.2.2 *Witness card.* An unbacked witness card, 600 mm × 600 mm of cartridge paper of grammage 115 g/m^2, mounted rigidly by its edges at a distance of 450 mm from the rear of the test piece. It shall be sufficiently rigidly mounted to ensure that it remains in position during the test: there shall be no tendency for the card to tear at the edges.

B.2.3 *Velocity measurement system.* A suitable calibrated system of velocity measurement between the gun and the test piece in order to measure the velocity of the slug or bullet. The accuracy of measurement should be of the order of ± 3 m/s, and measurements should be made sufficiently close to the target to ensure that there is no significant loss of velocity of the projectile(s), between the point of measurement and the target. See also notes 2 and 4 to Table 1.

B.2.4 *Ballistic testing equipment.* Ballistic equipment to produce the testing conditions described in Table 1.

B.3 Procedure

Subject the test piece to a firing test at normal incidence in accordance with the details given in Table 1 corresponding to the classification of the panel test piece. Note whether the projectile passes through the test piece, and whether fragments from the projectile or test piece perforate the witness card. To detect such perforation, lightly brush the witness card with a camel hair brush to detach any adherent particles, and examine it against a strong light; any penetration of light through the card indicates that it has been perforated.

Repeat the test with the two other panel test pieces.

Appendix C Installation of bullet-resistant glazing

In the installation of bullet-resistant glazing it is essential to ensure that the following recommendations are met.

a) The frames and the area surrounding a unitary bullet-resistant screen, or the primary screen of a duplex installation, provide at least as high a level of protection as the glazing itself.

b) The bullet-resistant glazing is correctly orientated in relation to the expected direction of attack.

c) The secondary screen of a duplex panel is mounted at the correct distance from the primary screen as recommended by the manufacturer.

d) Any frame holding the glazing in position provides sufficient overlap to prevent dislodgement.

e) A glazing compound appropriate to the bullet-resistant glazing is used. Adverse effects have been caused by the use of linseed oil putty.

If installation is not carried out by the manufacturer he should provide all necessary information on the above matters to the person responsible for installation.

Table 1 — Conditions of test for panels

Class	Type of weapon and calibre (see note 1)	Striking velocity (see notes 2 and 4)	Ammunition (see note 3)	Test range (minimum)	Number of strikes	Pattern of strikes
G0	Hand gun 9 mm parabellum	m/s 390^{+30}_{-0}	9 mm Mk 2Z standard	m 3	3	Centres 100^{+10}_{-0} mm apart, forming an equilateral triangle within a square of 200 mm side located centrally on the test piece
G1	Hand gun 357 magnum	435^{+30}_{-0}	Soft point, semi jacketed, flat nose, 10.2 g (158 grain) bullet	3	3	
G2	Hand gun 44 magnum	456^{+30}_{-0}	Soft point, semi jacketed, flat nose, 15.2 g (240 grain) bullet	3	3	
R1	Rifle (1-7 twist) 5.56 mm	919^{+30}_{-0}	NATO standard 5.56 mm ball (SS 109)	10 (see note 5)	3	Centres 100^{+20}_{-0} mm apart, forming an equilateral triangle within a square of 200 mm side located centrally on the test piece
R2	Rifle 7.62 mm	815^{+30}_{-0}	NATO standard 7.62 mm ball	10 (see note 5)	3	
S86	12 bore shotgun	40^{+40}_{-0}	12 bore solid lead slug Mass 28.35 g (1 oz)	10	1	Centre of point of impact as near centre of test piece as possible and within a circle of radius 100 mm located centrally on the test piece

NOTE 1 With the exception of class S86, the tests are sometimes conveniently carried out not with the specified weapons, but with ballistic testing equipment that produces the striking velocities given above, which are slightly higher than would result from the use of commercially available weapons. Details of the ballistic testing equipment can be obtained by applying to the Central Enquiries Section, BSI, enclosing a stamped addressed envelope for reply.

NOTE 2 Suitably accurate systems of velocity assessment are now commercially available. In general the equipment does not measure velocity at a point, but rather the average velocity over a reference distance (e.g. 1 m). By various methods the time taken for the bullet to travel through the reference distance is measured electronically, enabling the average velocity over the distance to be obtained directly or by simple evaluation. More detailed information on the systems available can be obtained from the Central Enquiries Section, BSI, enclosing a stamped addressed envelope for reply.

NOTE 3 Attainment of the specified striking velocity requires the use of specially selected ammunition. Further information about ammunition can be obtained from the Central Enquiries Section, BSI, enclosing a stamped addressed envelope for reply.

NOTE 4 If the upper limit for the specified striking velocity is exceeded during test, but the test piece meets the criteria for compliance (see **5.2**) for its class, it is deemed to have withstood the specified level of attack.

NOTE 5 Having regard to the test range, for classes R1 and R2 in particular, for safety reasons it is strongly recommended either to install a system of remote firing of the weapon or provide sufficient protection for the operator.

Publications referred to

BS 5357, *Code of practice for installation of security glazing.*
BS 5544, *Anti-bandit glazing (glazing resistant to manual attack).*

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