British Standard

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1983

Steel, concrete and composite bridges —

Part 9: Bridge bearings —

Section 9.2 Specification for materials, manufacture and installation of bridge bearings

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Cooperating organizations

The Civil Engineering and Building Structures Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

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Brick Development Association
British Constructional Steelwork Association*
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Contents

Foreword

BS 5400 is a document combining codes of practice to cover the design and construction of steel, concrete and composite bridges and specifications for loads, materials, and workmanship. It comprises the following Parts and Sections:

— *Part 1: General statement;*

— *Part 2: Specification for loads;*

— *Part 3: Code of practice for design of steel bridges;*

— *Part 4: Code of practice for design of concrete bridges;*

— *Part 5: Code of practice for design of composite bridges;*

— *Part 6: Specification for materials and workmanship, steel;*

— *Part 7: Specification for materials and workmanship, concrete, reinforcement and prestressing tendons;*

— *Part 8: Recommendations for materials and workmanship, concrete, reinforcement and prestressing tendons;*

— *Part 9: Bridge bearings;*

— *Section 9.1: Code of practice for design of bridge bearings;*

— *Section 9.2: Specification for materials, manufacture and installation of bridge bearings;*

— *Part 10: Code of practice for fatigue.*

This Section of Part 9, together with Section **9.1**, supersede appendix F of BS 5400-2:1978, which is to be withdrawn by an amendment.

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 to iv, pages 1 to 16, 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.

1 Scope

This Section of Part 9 of BS 5400 specifies requirements for the materials and workmanship commonly used in the manufacture and installation of bridge bearings.

NOTE The requirements specified herein are suitable for inclusion in contract documents.

2 References

The titles of the publications referred to in this Section of Part 9 are listed on the page 16.

3 Materials

3.1 ***General.*** Where more than one quality of material is specified in the relevant British Standard or more than one British Standard is referred to herein, the quality required shall be that specified or approved by the Engineer.

3.2 Steel

3.2.1 ***General.*** Steel products shall comply with the appropriate standard given in Table 1.

3.2.2 ***Hardened steel for rollers and rockers.*** Rollers and rockers shall be through hardened and not case hardened.

Table 1 — Steel products

Steel product	Standard
Steel plates and flats	BS 1449, BS 4360
Steel sheet and strip	BS 1449
Steel bars	BS 970, BS 1407, BS 4360
Steel sections	for material: BS 1775, BS 4360 for sizes: BS 4-1, BS 4848
Wrought steel	BS 970
Forged steel	BS 29, BS 970, BS 4670
Cast steel	BS 3100
Stainless steel	BS 970, BS 1449 (the grade of material for sliding surfaces shall be 316S16)
Hot-dip zinc coated and iron-zinc alloy coated steel, plate and strip	BS 2989

3.3 Cast iron. Cast iron shall comply with BS 2789.

3.4 Cast aluminium. Aluminium alloy castings shall comply with BS 1490 and shall be of grade LM5, LM6 or LM25. Aluminium alloy castings shall not be used for roller, rocker, knuckle pin or leaf bearings.

3.5 Copper alloy castings. Copper alloy castings shall comply with BS 1400. For knuckle and leaf bearings, phosphor-bronze inserts shall be of grade PB1, PB2 or PB4 material and leaded-bronze inserts shall be of grade LB4 material.

3.6 Polytetrafluoroethylene (PTFE)

3.6.1 ***General.*** Unfilled PTFE shall be pure virgin PTFE without any addition of regenerated materials or fillers. It shall be free sintered and not pressure cooled. The mechanical properties of unfilled PTFE shall comply with grade A of BS 3784:1973.

The composition of filled PTFE shall be such that its coefficient of friction is not more than twice the coefficient of friction of pure PTFE when measured under the same conditions.

3.6.2 ***Lubrication cavities.*** Lubricant retention cavities in PTFE shall comply with the following requirements.

a) The plan area of the cavities shall be between 10 % and 30 % of the total PTFE bearing surface including the area of the dimples or grooves.

b) The volume of the cavities shall not be less than 3 % nor more than 20 % of the volume of PTFE including the volume of cavities. Only the volume above the top of the recess shall be considered if the PTFE is confined.

c) the depth of the cavities shall not exceed half the thickness of the PTFE sheet, or in the case of confined PTFE, the height of its projection from the top of the recess.

The temperature for hot pressing of cavities shall not exceed 200 °C.

3.6.3 ***Lubricants.*** Lubricants for use with PTFE sliding surfaces shall be compounded for long life and to retain their properties within the temperature range to which the bridge is subject and shall not affect the constituent parts of the bearings.

3.6.4 ***Adhesives.*** Adhesives for bonding PTFE to backing plates shall produce a bond with a minimum peel strength of 4 N/mm width when tested in accordance with BS 5350-C9. They shall be resistant to the action of lubricants, atmospheric and biological agents and temperatures to which the bearing may be subject.

3.7 Elastomer

3.7.1 ***General.*** The elastomer used in the manufacture of bridge bearings shall contain either natural rubber or chloroprene rubber as the raw polymer, and shall have a hardness in the range of 45 IRHD to 75 IRHD (see **3.7.3.1**). No reclaimed or ground vulcanizate rubber shall be used.

The elastomer shall have adequate weathering resistance, as asessed by the test given in **3.7.3.8**, and shall be suitable for use up to 6 weeks at subzero temperatures with occasional periods of up to 3 days below – 25 °C, as assessed by the tests given in **3.7.3.5** to **3.7.3.7**. The shear modulus of the elastomer, measured by the method given in **3.7.3.9**, shall not vary by more than 15 % from the value assumed in the design of the bearing.

3.7.2 ***Mechanical properties.*** The mechanical properties of the elastomer shall comply with the relevant requirements given in Table 2, depending upon the raw polymer used.

Table 2 — Elastomer properties

Property	Rubber	
	Natural	Chloroprene
Tensile strength, minimum (see **3.7.3.2**)	15.5 N/mm^2	15.5 N/mm^2
Elongation at break, minimum (see **3.7.3.2**)		
45 IRHD to 55 IRHD	450 %	400 %
56 IRHD to 65 IRHD	400 %	350 %
66 IRHD to 75 IRHD	300 %	300 %
Ageing resistance (see **3.7.3.3**)		
Maximum change from initial values:		
Hardness	10 IRHD	15 IRHD
Tensile strength	15 %	15 %
Elongation at break	20 %	40 %
Compression set maximum (see **3.7.3.4**)	30 %	35 %

3.7.3 ***Methods of test***

3.7.3.1 *Hardness.* Hardness shall be determined in accordance with method N of BS 903-A26.

3.7.3.2 *Tensile strength and elongation at break.* Tensile strength and elongation at break shall be determined in accordance with BS 903-A2 using dumb-bell test pieces.

3.7.3.3 *Ageing.* Accelerated ageing in air shall be conducted in accordance with either method A or method B of BS 903-A19. Natural rubber shall be aged for 7 days at 70 ± 1 °C and chloroprene rubber for 3 days at 100 ± 1 °C.

3.7.3.4 *Compression set.* Compression set shall be determined in accordance with method A of BS 903-A6. The temperature during the compression period shall be 70 ± 1 °C for natural rubber and 100 ± 1 °C for chloroprene rubber.

3.7.3.5 *Low temperature brittleness.* A low temperature brittleness test shall be carried out in accordance with BS 903-A25 to demonstrate that the impact brittleness temperature lies below – 25 °C.

3.7.3.6 *Low temperature stiffening.* Low temperature stiffening shall be assessed by measuring increases in hardness. Three test pieces shall be initially conditioned for 3 h at 23 ± 2 °C and then their hardness measured. These test pieces shall then be conditioned for 24 h at – 25 ± 2 °C and then their hardness shall be remeasured. For any of the test pieces the difference between the above two measurements shall not exceed 15 IRHD. (See **3.7.3.1**.)

3.7.3.7 *Low temperature crystallization.* The low temperature crystallization resistance of the elastomer shall be assessed from low temperature compression set measurements conducted in accordance with BS 903-A39. Two tests shall be made; one with the test pieces maintained at – 10 ± 2 °C for 10 days, and the other with test pieces held at – 25 ± 2 °C for 3 days. At the end of the chilling period the low temperature compression set shall be measured after a recovery period of 1 800 s. For acceptance, the set in neither test shall exceed 65 %.

3.7.3.8 *Ozone resistance.* Ozone resistance shall be determined in accordance with BS 903-A43, using an ozone concentration of 25 parts per hundred million by volume (p.p.h.m.) unless otherwise specified by the Engineer, a temperature of 30 ± 1 °C, and a duration of 96 h, with the test piece at an elongation of 20 %. At the end of the test there shall be no visible cracks.

3.7.3.9 *Shear modulus.* The shear modulus shall be determined in accordance with BS 903-A14 at a shear strain of 0.25.

3.7.4 ***Test pieces***

3.7.4.1 *General.* The tests required by **3.7.1** and **3.7.2** shall be performed on specially moulded test pieces. When, additionally, the Engineer directs tests to be made on samples cut from a finished bearing, these samples shall be obtained as specified in **3.7.4.2** and **3.7.4.3** and prepared in accordance with BS 903-A36.

NOTE 1 Test pieces taken from finished bearings will exhibit mechanical properties different from those of specially moulded pieces. Nevertheless, they have to satisfy fully the requirements of **3.7**.

NOTE 2 Samples for shear tests conducted in accordance with BS 903-A14 cannot be obtained from a bearing. Appendix A gives a method for determining the shear stiffness of a completed bearing, from which the shear modulus can be inferred.

3.7.4.2 *Test samples from surface of bearing.* Test pieces for the determination of hardness, tensile strength and elongation at break, ageing resistance, ozone resistance and low temperature brittleness shall be such that one of the two larger surfaces is part of the outer surface of the bearing.

3.7.4.3 *Test samples from body of bearing.* Test pieces for the determination of compression set, low temperature stiffness and low temperature crystallization shall be taken from as near the middle of the bearing as possible.

3.7.5 ***Frequency of tests.*** The tests for low temperature brittleness, stiffening and crystallization and for ozone resistance need only be made at the time of development of the elastomer compound. The results of these tests shall be made available to the Engineer on request. All other tests in **3.7.3** shall be made both at the time of development of the compound and for each batch of bearings.

3.8 Fastenings. Fastenings shall comply with the appropriate British Standard.

3.9 Locating keys and keyways. Machined keys and keyways locating parts of bearings in relation to each other shall comply with BS 46-1.

3.10 Other materials. Where materials complying with specifications other than those referred to in this Section of Part 9 are proposed, the performance requirements for such materials, which shall be demonstrated by testing, shall be as given in the relevant specifications quoted in this Section of Part 9. If materials not specified in this Section of Part 9 are proposed for use in a bearing, full details of the bearing including specification and drawings together with relevant test reports shall be submitted to the Engineer for approval.

4 Workmanship

4.1 Interchangeability of parts. Unless specified by the Engineer corresponding parts need not be interchangeable.

4.2 Steel parts. Workmanship in connection with parts made of steel shall comply with Part 6 and as specified in this Section of Part 9.

4.3 Metal elements

4.3.1 ***Finished surfaces.*** Metal-to-metal contact surfaces within bearings shall be prepared either by machining or fine grinding. As far as practicable, machining shall be carried out after welding has been finished. Machining of rolling contact surfaces of roller bearings or sliding contact surfaces shall be carried out only in the principal direction of movement. Care shall be taken to remove abrasive materials from finished surfaces, which shall also be cleaned with a degreasing agent. Finished surfaces shall be protected from contamination and/or mechanical damage.

NOTE Surfaces that are to be in contact with grout or bedded on a suitable material may be left unmachined.

4.3.2 ***Bolts and bolt holes.*** Bolt holes shall be drilled or reamed. Where specified by the Engineer, bolts or screws shall be of a vibration resistant type. Taper washers of the correct angle of taper shall be provided under all heads and nuts bearing on bevelled surfaces.

4.3.3 ***Welding***

4.3.3.1 *General.* Welding procedures shall be such as to minimize distortion of the bearing components and to avoid damage to finished work or bonded materials.

4.3.3.2 *Aluminium.* Metal-arc welding of aluminium shall be in accordance with the recommendations of BS 3571-1.

Tungsten-arc welding of aluminium shall be in accordance with the recommendations of BS 3019-1.

4.3.3.3 *Stainless steel.* Welding of stainless steel sheet to a mild steel backing plate shall be by an inert gas-shielded metal-arc or tungsten inert gas metal-arc process. Electrodes used with the former method shall be austenitic steel electrodes complying with BS 2926.

4.3.4 ***Fixing of stainless steel sheet***

4.3.4.1 *Welding.* The weld attaching the stainless steel to its backing plate shall be continuous so as to prevent ingress of moisture and shall be clean, sound, smooth, uniform, without overlaps and properly fused.

4.3.4.2 *Mechanical fixing with peripheral seal.* Where mechanical fixing is augmented by peripheral sealing, the backing plate shall be completely protected against corrosion by painting prior to the fixing of the stainless steel sheet. A continuous flexible seal shall be provided around the periphery of the stainless steel.

4.3.4.3 *Bonding.* The stainless steel sheet to be bonded shall be prepared for bonding in accordance with BS 5350-A1. It shall be bonded over its entire area.

4.3.5 ***Steel reinforcing plates for elastomeric bearings.*** Internal steel laminates shall be free from sharp edges. Methods used for forming holes or cutting plates shall be such as to leave the material free from flaws, tears and rough edges.

4.4 Bonding of PTFE. The surface of PTFE to be bonded shall be prepared for bonding in accordance with BS 5350-A1. The minimum bond strength between the PTFE and its backing plate, when tested in accordance with BS 5350-C9, shall be 4 N/mm width.

4.5 Bonding of elastomer. Prior to the bonding process the steel plates shall be freed from all contamination by a mechanical or chemical method. Bonding shall be carried out during vulcanization such that the bond peel strength is at least 7 N/mm width when tested in accordance with method B of BS 903-A21.

4.6 Forming of elastomeric bearings

4.6.1 ***Plain pad bearings and strip bearings.*** Plain pad bearings shall be moulded in one piece, or comprise single pieces cut from previously moulded strips or slabs. Cutting shall produce a smooth surface without injurious heating of the elastomer.

4.6.2 ***Laminated bearings.*** A laminated bearing shall be moulded as a single unit under pressure and heat.

4.6.3 ***Spacers in moulds.*** When spacers are used in moulds to ensure correct cover to outer plates, they shall comply with the following requirements:

a) The resulting exposed steel surfaces shall eventually be covered when the bearings are installed in the bridge structure.

b) The spacers shall be located with a minimum distance of 10 mm from the reinforcing plate edge to the edge of the spacer.

c) The size of the hole left at the surface of the bearing shall not exceed 10 mm diameter.

d) The minimum practical number of spacers shall be used to ensure correct location of plates but in no case shall the total area of spacers exceed 3 % of the bearing compression area.

4.7 Final assembly and clamping. After final inspection and acceptance of the various parts of the finished bearing, they shall be assembled and clamped together. If specified by the Engineer, sliding and roller bearings shall be preset at the time of fixing the clamping devices. All deleterious materials shall be excluded from sliding and other contact surfaces.

4.8 Marking. Completed bearings shall have the supplier's name (or trade mark) and a serial number indelibly marked thereon. The serial number shall be unique and such as to enable other bearings manufactured at the same time to be traced through the production control records should the need arise. Where practicable the serial number shall also be visible after installation of the bearing in the structure. The top of each bearing shall be clearly marked and the size and direction of preset, if any, and the direction of installation shall be indicated.

5 Manufacturing tolerances

5.1 General. The tolerances given in this clause shall be observed unless otherwise specified or approved by the Engineer.

5.2 Types of tolerance

5.2.1 ***Standard tolerances.*** Tolerances for flatness, roundness, cylindricity, profile of a surface, parallelism, squareness and position referred to in this Section of Part 9 shall be in accordance with the descriptions and illustrations given in BS 308-3. All other tolerances are defined in **5.2.2** to **5.2.4**.

5.2.2 ***Size.*** Tolerances for size referred to in this Section of Part 9 shall be taken to be variations from the nominal dimensions. They shall be used to control the overall dimensions of components with respect to length, thickness, height and diameter.

5.2.3 ***Fit.*** Tolerances for fit referred to in this Section of Part 9 relate to clearance and shall be taken as the difference between the sizes of an element and the hole in which it fits, where this difference is positive.

5.2.4 ***Surface roughness.*** Surface roughness referred to in this Section of Part 9 shall be taken as the arithmetical mean deviation R_a defined in and measured in accordance with BS 1134-1.

5.3 Overall dimensions of assembled bearings

5.3.1 ***General.*** Overall dimensions of assembled bearings shall be within the tolerances given in Table 3.

Table 3 — Tolerances on overall size

Type of bearing	Tolerance on size	
	Overall plan dimensions	Overall thickness or height
Elastomeric		
up to and including 20 mm thickness or height	$^{+6}_{-3}$ mm	± 1 mm
above 20 mm thickness or height	$^{+6}_{-3}$ mm	± 5 %
Other than elastomeric	± 3 mm	± 3 mm

5.3.2 ***Parallelism of outer surfaces.*** When designed to be parallel, the tolerance on parallelism of the upper surface of a bearing with respect to the lower surface of the bearing, as datum, shall be 0.2 % of the diameter for surfaces circular in plan and 0.2 % of the longer side for surfaces rectangular in plan.

5.4 Dimensions of bearing parts

5.4.1 ***Roller bearings***

5.4.1.1 *General.* The tolerance on flatness for roller plates measured in any direction shall be 0.025 mm for lengths up to and including 250 mm and 0.01 % of the length, in the direction of measurement, for lengths above 250 mm.

The surface roughness R_a of rolling surfaces shall not exceed 0.8 µm.

5.4.1.2 *Cylindrical rollers.* The tolerance on cylindricity shall be 0.025 mm.

The tolerance on size of single rollers with respect to their nominal diameter shall be + 0.5 mm and – 0.0 mm.

The tolerance on size of multiple rollers with respect to their nominal diameter shall be + 0.08 mm and – 0.0 mm.

5.4.1.3 *Non-cylindrical rollers.* Curved surfaces shall have a profile of surface tolerance of 0.3 % of the intended radius.

The tolerance on size with respect to the height at the centreline of the bearing shall be + 0.5 mm and – 0.0 mm.

The tolerance on parallelism between the chord line joining the ends of the top rolling surface with respect to the chord line joining the ends of the bottom rolling surface as datum shall be 1 mm.

The tolerance on squareness between the plane passing through the centres of the rolling surfaces as datum and the top and bottom chord lines joining the ends of the rolling surfaces shall be 1 mm.

5.4.2 ***Rocker bearings***

5.4.2.1 *Steels with hardness of 300 HB and over.* For steels with a hardness not less than 300 HB, determined in accordance with BS 240-1, the tolerance on flatness, along the line of contact, for plates mating with rockers shall be 0.075 mm for lengths up to and including 250 mm, and 0.03 % of the length for lengths above 250 mm.

For rockers, the profile of surface tolerance for the length of the surface over which contact can occur shall be 0.025 mm.

The surface roughness R_a of rocking surfaces shall not exceed 0.8 µm.

5.4.2.2 *Steels with hardness under 300 HB.* For steels with a hardness less than 300 HB, determined in accordance with BS 240-1, the tolerance on flatness, along the line of contact, for plates mating with rockers shall be 0.1 mm for lengths up to and including 250 mm, and 0.04 % of the length for lengths above 250 mm.

For rockers, the profile of surface tolerance for the length of the surface over which contact can occur shall be 0.05 mm.

The surface roughness R_a of both rocking surfaces shall not exceed 0.5 µm.

5.4.3 ***Knuckle bearings***

5.4.3.1 *Pin and leaf knuckle bearings.* For pins and seatings, the tolerance on cylindricity shall be 0.025 mm.

For pins up to and including 250 mm diameter, the diameter of the pins shall be within a size tolerance of – 0.25 mm to – 0.40 mm and the diameter of the seating shall be within a size tolerance of 0.0 mm to + 0.15 mm. For pins exceeding 250 mm diameter, the clearance between the pin and the seating shall be not less than 0.4 mm and not more than 0.75 mm.

5.4.3.2 *Cylindrical and spherical knuckle bearings.* The tolerances on flatness and profile of surface for cylindrical knuckle bearings and tolerance on profile of surface for spherical knuckle bearings shall be $0.0002Xh$ mm or 0.24 mm, whichever is the greater, where X is the length of the chord (in mm) between the ends of the PTFE surface in the direction of rotation, and h is the projection of the PTFE (in mm) above the top of the confining recess, for confined PTFE, or the thickness (in mm) for bonded PTFE. The tolerance on size with respect to the radius of the curved surface on the finished bearing shall be 3 % of the intended radius.

The surface roughness R_a of metal curved sliding surfaces shall not exceed 0.5 µm.

Where PTFE forms one of the contact surfaces it shall comply with the appropriate requirements given in **5.4.4**.

5.4.4 ***Plane sliding bearings***

5.4.4.1 *PTFE sheet.* The tolerance on flatness of PTFE sheet shall be 0.2 mm where the diameter or diagonal is less than 800 mm and 0.025 % of the diameter or diagonal where this dimension is greater than or equal to 800 mm.

On PTFE surfaces made up of more than one piece of PTFE the above conditions shall apply to the diameter or diagonal dimension of the inscribing circle or rectangle around the PTFE.

The dimensional tolerances on PTFE sheet shall be as given in Table 4.

Table 4 — Dimensional tolerances on PTFE sheet

Diameter or diagonal	Tolerance on plan dimension	Tolerance on thickness	
		Recessed PTFE	Bonded PTFE
mm	mm	mm	mm
≤ 600	± 1.0	+0.5 –0	+0.1 –0
> 600, ≤ 1 200	± 1.5	+0.6 –0	+0.2 –0
> 1 200	± 2.0	+0.7 –0	Not applicable

The gap between the edge of the PTFE sheet and the edge of the recess in which it is confined shall not anywhere exceed 0.5 mm or 0.1 % of the corresponding plan dimensions of the PTFE sheet, in the direction measured, whichever is the greater.

The profile tolerance on the specified projection of PTFE above its confining recess shall be as given in Table 5.

Table 5 — Profile tolerance on PTFE projection

Maximum dimension of PTFE (diameter or diagonal)	Tolerance on specified projection above recess
mm	mm
≤ 600	+0.5 –0
> 600, ≤ 1 200	+0.6 –0
> 1 200, ≤ 1 500	+0.8 –0

All measurements on PTFE sheet shall be made at a temperature of 20 °C to 25 °C.

5.4.4.2 *Mating surfaces.* For planar surfaces mating with PTFE, the flatness tolerance in all directions shall be $0.0002Lh$ mm, where L is the length (in mm) of the PTFE surface in the direction measured and h is the projection of the PTFE (in mm) above the top of the confining recess, for confined PTFE, or the thickness (in mm) for bonded PTFE.

The surface roughness R_a of metal planar sliding surfaces shall not exceed 0.15 µm.

5.4.5 ***Elastomeric bearings***

5.4.5.1 *Parallelism.* The tolerance on parallelism for the axes of reinforcing plates with respect to the base of the bearing as datum shall be 1 % of the diameter, for plates circular in plan, or 1 % of the shorter side, for plates rectangular in plan.

5.4.5.2 *Size.* The tolerance on size with respect to the plan dimensions of plates for reinforcing elastomeric bearings shall be + 0 mm and – 3 mm. The tolerance on size with respect to the thickness of the top and bottom covers for laminated elastomeric bearings shall be between + 20 % and 0 % of the nominal thickness, or 1 mm, whichever is the lesser.

The tolerance on size with respect to the thickness of an individual inner layer of elastomer in a laminated elastomeric bearing shall be ± 20 % of its nominal thickness value, or 3 mm, whichever is the lesser.

The tolerance on size with respect to the thickness of the side cover for a laminated elastomeric bearing shall be + 3 mm and – 0 mm.

5.4.6 ***Pot bearings.*** The tolerance of fit between the piston and the pot shall be + 0.75 mm to + 1.25 mm.

5.4.7 ***Guides.*** The surface roughness R_a of metal sliding surfaces shall not exceed 0.5 µm.

5.4.8 ***Fixing holes in bearing plates.*** Where required, tolerances on the position for centres of fixing holes shall be as specified or approved by the Engineer.

6 Protective measures

6.1 Aluminium alloy components. Permanently exposed surfaces of aluminium alloy components shall be degreased and painted as specified or approved by the Engineer. Where aluminium would otherwise be in contact with Portland cement concrete, the former shall be suitably protected.

6.2 Ferrous components. Exposed parts of iron and steel shall be protected against corrosion as specified or approved by the Engineer.

6.3 Dissimilar materials. Care shall be taken to prevent electrolytic action between dissimilar metals in contact by the use of suitable insulation and prevention of moisture penetration.

6.4 Damaged areas. Any damaged areas of protective treatment shall be made good to the satisfaction of the Engineer or the damaged parts replaced.

7 Inspection and testing

7.1 Materials and workmanship. The testing and inspection of materials and workmanship used in the manufacture of bearings shall be carried out to ensure compliance with the appropriate requirements of clauses **3**, **4** and **5** of this Section of Part 9 to the approval of the Engineer. Test certificates shall be made available for inspection by the Engineer.

7.2 Testing of complete bearings. Testing of complete bearings, when specified or required by the Engineer, shall be carried out in accordance with his instructions. The bearings shall be considered satisfactory when the results of the tests comply with this Section of Part 9 and any other special requirement specified by the Engineer.

8 Handling, transport, storage and installation

8.1 Care and protection. During handling, transport, storage and installation, bearings shall be kept clean and protected from mechanical damage, heat, contaminants and other deleterious effects.

8.2 Handling devices. Suitable handling devices shall be provided as required. Temporary clamping devices shall be used to maintain the correct orientation of the parts but shall not be used for slinging or suspending bearings unless specifically designed for this purpose.

8.3 Installation

8.3.1 ***General.*** Bearings shall be installed in the structure as specified or approved by the Engineer. Bearings that have been pre-assembled shall not be dismantled except with the prior approval of the Engineer. The position of any temporary packing between the outer bearing plates and the structure shall be agreed with the Engineer.

After installation, bearings and their surrounding areas shall be left clean. Temporary transit clamps shall be removed at a time to be agreed by the Engineer.

8.3.2 ***Tolerances***

8.3.2.1 *General.* The tolerances given in **8.3.2.2** and **8.3.2.3** shall be observed unless otherwise specified or approved by the Engineer.

8.3.2.2 *Setting of bearings.* Bearings shall be located so that their centrelines are within ± 3 mm of their correct position. The level of a single bearing or the mean levels of more than one bearing at any support shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding ± 5 mm.

Bearings shall be set to their correct inclination within a tolerance of 1 in 200 in any direction unless otherwise specified by the Engineer. Departures from common planarity of twin or multiple bearings shall be within such tolerances as may be specified by the Engineer.

8.3.2.3 *Concrete surfaces.* Concrete surfaces for the direct setting of elastomeric bearings shall not vary from a flat plane by more than 1 in 200 within the plan area of the bearing, and local irregularities shall not exceed 1 mm in height.

8.3.3 ***Threaded fixings.*** Threaded fixings shall be tightened uniformly to avoid overstressing any part of the bearing. Where significant vibration may occur, fasteners shall be of a vibration resistant type.

8.3.4 ***Bedding.*** Bearings shall be bedded over their whole area. After installation there shall be no voids or hard spots. The bedding material shall be capable of transmitting the applied load to the structure without damage.

Surfaces to receive bedding mortar shall be adequately prepared to a state compatible with the mortar chosen.

The top surface of any extension of the bedding beyond the bearing shall have a slope away from the bearing.

Appendix A
A method for determination of shear stiffness of elastomeric bridge bearings

A.1 Apparatus. The testing apparatus should be capable of applying concurrent horizontal and vertical loads. Mechanical, optical or electrical means capable of measuring horizontal deflection in units of 0.01 mm should be provided and used in conjunction with the testing apparatus.

A.2 Test piece. The shear stiffness should be determined using bearings of the same design, material and geometry and with compression deflection characteristics within 5 % of one another.

A.3 Test procedure

A.3.1 ***Assembly for test.*** Locate bearings in pairs opposite each other on both sides of a suitable robust plate; test a sufficient number of pairs of bearings simultaneously to prevent instability of the assembly during testing. Place the assembly horizontally in a compression testing machine such that a horizontal load can be applied to the intermediate steel plate while a vertical load is applied simultaneously to the assembly. All surfaces in contact with the bearings should be plane and prepared so as to prevent slippage between the contact surfaces without causing any damage to the bearing.

A.3.2 ***Compression load.*** Apply and hold constant throughout the test a compression load, normal to the horizontal load plate and equal to the nominal dead load plus superimposed dead load for each bearing multiplied by the number of pairs of bearings in the assembly.

A.3.3 ***Conditioning load.*** Condition the bearings first by applying a horizontal load to the intermediate plate until a horizontal deflection equal to the total height of elastomer in one bearing has been reached. Release the load.

A.3.4 ***Test loading and recording.*** Reapply the horizontal load in five approximately equal increments until a horizontal deflection equal to the total thickness of elastomer in the bearing is obtained. For each increment of load, measure and record the horizontal deflection. Measurements should not be taken until all short-term creep has ceased. From the recordings, plot the horizontal load/deflection graph for one bearing.

A.4 Assessment of shear modulus. Provided that there was no evidence of instability during the test, the shear stiffness can be obtained from the load/deflection graph as the slope K_s of the chord between the points $u = 0.05t_q$ and $u = 0.25t_q$.

The shear modulus G for the elastomer may then be estimated from the expression

$$G = K_s t_q / A$$

where

- u is the horizontal deflection;
- t_q is the total thickness of elastomer in the bearing in shear measured in the unloaded state;
- A is the area of the bearing.

Guidance clauses

These clauses represent a standard of good practice and give guidance on the requirements of this Section of Part 9. The clause numbers and titles correspond to those given in the text.

3 Materials

3.2 Steel. Precautions should be taken to prevent staining of the supporting structure.

For high resistance to corrosion, stainless steel alloy 316S16 or 320S17 complying with BS 970-4 or BS 1449-2 are recommended.
Alloys 321S12, 321S20 and 347S17 provide good weldability. Alloy 431S29 gives high strength and machineability, but lower corrosion resistance, and is unsuitable for welding.

3.3 Cast iron. Where cast iron is subject to significant tensile stresses, it should have an elongation of not less than 7 %.

3.6.3 *Lubricants.* Certain silicone greases to which metallic soaps have been added as thickeners are normally used for lubricating PTFE sliding surfaces.

3.7 Elastomer. The ozone resistance test referred to in **3.7.3.8** is an accelerated test. In order to obtain a meaningful result a high ozone concentration of 2.5 p.p.h.m. is used.

In the test to determine the shear stiffness in accordance with appendix A, instability becomes apparent from the load/deflection graph. Slip or bond failure may show as excessive set or a marked reduction in the slope of the load/deflection curve.

Where the shear modulus inferred from the results of tests carried out in accordance with appendix A varies considerably from that assumed in the design of the bearing, further testing should be considered; for example, tests to determine the tensile strength and elongation at break and high temperature compression set of the elastomer from samples cut from the bearing in accordance with **3.7.4.2** and **3.7.4.3**.

Test samples required to be taken from near the centre of a laminated bearing may be taken from a finished bearing when it has been manufactured with steel reinforcing plates having holes of suitable size and location to allow cored samples to be taken. Finished bearings having test samples removed may be used provided that, after repair, they pass the compression test outlined in guidance clause **7.2** b) 2) i).

3.10 Other materials. When assessing the suitability of materials other than those specified in this Section of Part 9 for use in bridge bearings, the following factors should be taken into consideration.

a) *Physical and mechanical properties*

ultimate compressive strength;

uiltimate tensile strength;

ultimate shear strength;

proof strength;

impact strength;

resistance to sustained and repeated loading;

permissible bearing stress;

permissible tensile stress;

permissible shear stress;

stress/strain curves;

elastic modulus;

bulk modulus;

creep, ductility, pliability;

coefficient of friction (static and dynamic);

effect of high and low temperatures on these properties.

b) *Durability*

attack by water, alkalis, acids, bacteria, oxygen, ozone, chlorides, sulphates, hydrocarbons, and other chemicals commonly transported by road;

effect of ultraviolet and infra-red rays, fire, heat and cold;

electrolytic action between materials likely to be in contact with each other.

4 Workmanship

4.7 Final assembly and clamping. If bearings are preset at the manufacturer's works, the amount of preset is very difficult to determine owing to the uncertainty of the amount of creep and shrinkage that will have taken place and the temperature at the time of installing the bearing. If bearings are to be preset on site, the manufacturer should be so notified at the time of ordering so that due provision can be made for the movement of the relevant parts. Wherever possible, presetting of bearings should be avoided.

5 Manufacturing tolerances

The diagrams and the section on terminology and definitions in BS 4500-1 usefully supplement the information given in this Section of Part 9. The term "clearance" is used in the same context as in BS 4500-1.

Tolerances given in this Section of Part 9 are suitable for bearings in normal use. In special circumstances of unusual loading or movement, it may be necessary to specify different tolerances.

For flat-sided rollers, the tolerances for roundness, cylindricity and size apply to the remaining parts of the rollers as though they were part of a whole cylinder.

Tolerances for holes for fixing bolts should be related to the function of the bolts and the likely conditions prevailing at the time of installation of the bearings. As a guide, holes for fixing bolts or locating devices should be drilled within 1 mm of the positions shown on the drawings. Their diameter should be 2 mm larger than the nominal diameter of the bolt or locating key for fixing bearings to steel or precast concrete members, and 3 mm larger than the nominal diameter of bolt or shear key for fixing bearings to cast-in-place concrete. For bolts or locating devices required to resist horizontal forces in shear, a close tolerance fit may need to be provided.

6 Protective measures

Guidance on protective measures that can be adopted to prevent the corrosion of iron and steel under various atmospheric conditions is given in BS 5493. Shop-applied treatment should be returned on to faces not permanently exposed, other than sliding, mating and interleaved surfaces, for a distance of at least 20 mm.

Because of the risk of electrolytic action, it is important to prevent the contact of dissimilar materials. In this context, mild steel and stainless steel are dissimilar. In particular, direct contact between copper, nickel and their alloys (e.g. brass and bronzes) with aluminium, and aluminium with steel should be avoided. Copper may be affected by direct contact with concrete. (For further information refer to PD 6484 and BRS Digest 71 second series.)

7 Inspection and testing

7.2 Testing of complete bearings

a) *Selection of tests.* The requirement for and the extent of testing of completed bearings depend upon the evidence of previous tests and the level of quality control on the bearings and their parts (materials and workmanship). The properties and performance of proprietary and special types of bearings should be confirmed to the satisfaction of the Engineer by tests or by properly documented evidence.

The usual tests are:

1) *Prototype tests,* to verify the adequacy of design. These tests are generally carried out by the manufacturer during the development of the bearing.

2) *Production tests,* to ensure the use of correct materials and procedures in manufacture. These tests are carried out by the manufacturer for his own guidance and control.

3) *Acceptance tests,* to confirm that the complete bearing complies with the specified requirements. These tests should be carried out as specified or when required by the Engineer. When available, the results of prototype and production tests should be taken into account in specifying the acceptance tests.

In deciding on the need for and the type and scope of the acceptance tests, the following factors are relevant.

i) The existence of previous well attested and documented information.

Well attested data should give a full description of the bearings tested, their material properties, and all other data that could affect the performance of the bearing.

ii) Service conditions of the bearings.

Careful consideration should be given to conditions likely to affect the bearing in service and reduce its efficiency. These should, where practicable, be simulated in the tests. Examples of possible causes of adverse effects are: extremes of temperature, variations in rate of loading compared to that used in the tests, exposure of rubber to sunlight, deterioration of lubricants used to reduce the coefficient of friction in sliding bearings.

iii) The importance of the bearing in relation to the structure.

iv) The complexity of the bearing design.

v) The extent of testing and inspection of materials and workmanship during fabrication.

vi) The extent to which previous tests are representative of the routine fabrication procedure.

vii) The access for inspection and ease of replacement of the bearing after installation.

viii) The type of testing required.

The choice of the type of test or combination of tests will be determined by the objectives, since each of the tests has a different purpose.

In the case of bearings whose performance cannot be fully evaluated prior to manufacture, the need for well attested data and testing to validate their design is usually essential.

ix) The number of bearings of any one type to be tested. Additional bearings should be allowed for where any testing under ultimate limit state loads is called for. Sampling of bearings for the test should be as representative as possible.

x) The availability of facilities for testing.

In deciding on the nature and extent of testing, due regard should be paid to the availability of equipment of adequate capacity. Where such equipment is not readily available, proof loading may be impracticable and tests on reduced-size bearings may have to be adopted to provide evidence of the performance of full-size bearings.

b) *Load testing*

1) *Bearings, other than elastomeric bearings.* For bearings other than elastomeric bearings, load tests are made to check the performance of the bearing at both serviceability and ultimate limit states.

Both vertical and horizontal loads, where applicable, should be applied to the bearing in the most adverse combinations as specified in Part 2.

Where load transfer due to tilting of the bearing can occur it should be taken into account.

Before recording measurements, the bearing should be bedded in by applying a load equal to the serviceability limit state load and then releasing it. The test loads should then be applied in increments and load deflection measurements made at each increment. The rate of loading should be slow enough to avoid any adverse shock effects and the maximum load should be maintained until any obvious short-term creep has ceased.

The load should then be removed in decrements and load deflection measurements made at each decrement. For serviceability limit state load tests, after complete unloading, the amount of set should be checked and, if significant, the loading and unloading cycle repeated. If the set is shown to be progressive, the bearing should be deemed not to comply with this Section of Part 9.

After being tested, a bearing should be dismantled as necessary for inspection. Where a bearing is to be test loaded to both limit states, it should be tested for serviceability first and be dismantled as necessary and inspected before being tested for the ultimate limit state. In such cases it should have a second bedding-in cycle before the second load test.

Load tests to check the performance of a bearing at the serviceability limit state should be carried out using the serviceability design load effects on the bearing multiplied by the partial material factor, γm. A bearing should be considered to have passed a serviceability limit state test provided that there is no visible damage or permanent deformation of any part due to loading cycles subsequent to the initial bedding-in cycle.

Load tests to check the performance of a bearing at the ultimate limit state should be carried out using the ultimate design load effects on the bearing multiplied by γm. A bearing may be considered to have passed this test if it supports the test load. However, due regard should be paid to the results of the tests to establish the strength of materials used in the fabrication of the bearing. Where the material strength is significantly above the minimum specified, the possibility of weaker materials being used in other bearings should be taken into account when assessing the strength of such bearings.

Bearings tested for the serviceability limit state should be suitable for subsequent incorporation in the structure, but bearings tested for the ultimate limit state should not be expected to be suitable for further use.

2) *Elastomeric bearings.* As the loads on elastomeric bearings are limited by long service considerations, the single application of either the serviceability or ultimate limit state design load to a bearing cannot be expected to produce any visible permanent damage. However, load tests should be made on laminated bearings to check other properties of the bearing. The following tests are commonly employed.

i) *Quick production test.* This test is normally made on all bearings by the manufacturer to check for misplaced reinforcing plates, bond failures at the steel/elastomer interface, surface defects and stiffness.

A compressive test load, normally the serviceability limit state load, should be applied to the bearing and held constant while a visual examination for the above defects is made. Where defects are suspected they should be proved by other appropriate tests.

During this test the deflection between one-third and full test load should be recorded and used to check the consistency of the stiffness values. The details of this method used to obtain the deflection measurement should be such that the result for stiffness obtained for any particular bearing is repeatable to within 5 %. Where test results on a series of bearings are being compared, the same method should be used throughout. Where, on a batch of the same bearings, the vertical stiffness value of an individual bearing varies by more than 20 % from the average value from the batch, the bearing should be deemed not to comply with this Section of Part 9.

If the manufacturer performs this test as part of his own quality control procedures, and makes the results available to the Engineer, further tests for acceptance of bearings should not be necessary.

ii) *Stiffness test.* This test should be made where the compressive stiffness of the bearing is critical to the design of the structure. The quick production test is likely to overestimate the bearing stiffness.

Prior to any measurement being recorded, a vertical conditioning load, equal to the serviceability limit state load, should be applied to the bearing and then released. The vertical test load, equal to the serviceability limit state load, should then be applied in increments to the bearing. The load should then be released in decrements.

Load/deflection measurements should be taken at each increment and decrement after any obvious short-term creep has ceased. The vertical deflection of the bearing, between one-third and full test load, for the last loading cycle, should be used to calculate the vertical stiffness of the bearing, which should lie within the range allowed in the design of the structure.

The range of compressive stiffness used in the design of the structure should be as large as possible to give the bearing designer maximum flexibility.

c) *Testing resistance to movement*

1) *Frictional.* Bearings designed and fabricated in accordance with this Section of Part 9 need not be tested for resistance to movement, unless the supplier claims a substantial improvement in this respect. The design coefficients of frictional resistance given in Section 9.1 are intended to represent the worst coefficients likely to develop during the life of the bearing and can only be verified by tests simulating the conditions that may be expected to arise during the design life of the bearing.

Short-term tests are not suitable for determining coefficients of friction for design purposes, as such tests will give much lower coefficients than recommended in Section 9.1, the reduction depending on the type of bearing and the nature of the contact surfaces, especially if lubricants are used.

2) *Elastomeric.* Where well attested test results are available for both compression and shear stiffness tests and where the compression stiffness test result for a bearing is within 20 % of the average of the previous results, the shear stiffness of such a bearing may be assumed to be within 20 % of the average of the corresponding shear stiffness results.

Where such results are not available, or where the Engineer requires additional confirmation, a shear stiffness test may be performed as described in appendix A.

Should the method described in appendix A prove unsatisfactory owing to instability, the shear stiffness can be calculated from the shear modulus of the elastomer obtained as described in **3.7.3.9**. It should be noted that, in these circumstances, the calculated value of shear stiffness for a single bearing may give an overestimate of the actual value and should only be used as an upper bound value.

8 Handling, transport, storage and installation

8.3 Installation

a) *General.* Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure. In order that moving surfaces are not contaminated, bearings should not normally be dismantled after leaving the manufacturer's works but, if for any reason they are, then this should only be done under expert supervision and the manufacturer's assistance should be sought.

Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding to resist the applied load. Temporary clamping devices should be removed at the appropriate time before the bearings are required to accommodate movement. Consideration should be given to any treatment required to holes exposed on the removal of temporary transit clamps. Where reuse of these fixing holes may be required, the material selected to fill them should not only give protection against deterioration but also should be easily removable without damaging any threads.

Where necessary, suitable arrangements should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure. When provided, temporary supports under bearing baseplates should be compressible under design loading or removed once the bedding material has reached the required strength. Any voids left as a consequence of their removal should be made good using the same type of bedding material. Steel folding wedges and rubber pads are suitable for temporary supports under bearing baseplates.

The installation tolerances given in **8.3.2** may be relaxed by the Engineer provided he allows for the relaxed tolerances in his design. Twin and multiple bearings are normally used on box girders; the tolerances for departures from common planarity should be determined by the Engineer from the capacity of the box girders to resist torsion caused by this imperfection.

b) *Bedding.* The choice of bedding material is influenced by the method of installing the bearings, the size of the gap to be filled, the strength required and the required setting time. When selecting the bedding material, consideration should therefore be given to the following factors: type of bearing; size of bearing; loading on bearing; construction sequence and timing; early loading; friction requirements; dowelling arrangements; access around the bearing; thickness of material required; design and condition of surfaces in the bearing area; shrinkage of the bedding material.

It is essential that the composition and workability of the bedding material is specified with the above factors in mind. In some cases it may be necessary to carry out trials to ascertain the most suitable material. Commonly used materials are cementitious or chemical resin mortar, grout and dry packing. The use of materials such as lead, which tend to flow under load, leaving hard spots, should be avoided.

To ensure even loading of bearings and their supporting structures, it is essential that any bedding material, whether above or below the bearing, extends over the whole area of the bearing.

c) *Fixing of bearings other than elastomeric.* To cater for vibration and accidental impact, some fixing should be provided. Shear keys or holding-down bolts should be accurately set into recesses cast into the structure using templates, and the remaining voids in the recesses should be filled with a material capable of withstanding the loads involved. Close tolerance bolts should be set using the bearings as templates. In this case special precautions should be taken to prevent contamination of the bearings during bolt installation.

Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by the holding-down bolts or other means to prevent disturbance during subsequent operations. The method of bolt tightening should be such as not to deform the bearings. Finally, voids beneath the bearings should be completely filled with bedding material using the appropriate method.

Hardspots should be avoided, e.g. by removal of temporary packing shims and the use of sufficiently resilient washers under backnuts. Alternatively, bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure to the correct level and location. Only a thin layer of bedding mortar should be used and when other than synthetic resin mortar is used for this purpose it should be housed in a recess suitably reinforced on all sides.

If the substructure is of steel, the bearings may be bolted directly to it. In such cases there may be difficulties in achieving location to line and level within the tolerances unless other provision is made. Before providing for adjustment, the need for such accurate location should be assessed.

d) *Fixing of elastomeric bearings.* Elastomeric bearings may be laid directly on concrete, provided it is within the specified tolerance for flatness and smoothness. Alternatively, they may be laid on a layer of bedding material.

e) *Bearings supporting in situ concrete deck.* Where bearings are installed prior to forming an in situ concrete deck, formwork around bearings should be carefully sealed to prevent grout leakage. However, it is essential that the bearings and particularly the working surfaces are protected during concreting operations. Sliding plates should be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of wet concrete. Any mortar contaminating the bearings should be completely removed before it sets.

f) *Bearings supporting precast concrete or steel elements.* A thin layer of synthetic resin mortar should be used between bearings and precast concrete beams. Alternatively, bearings with outer bearing plates may be bolted to anchor plates or sockets embedded in precast elements, or to machined sole plates on steel elements.

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Publications referred to

Standards publications

BS 4, *Structural steel sections.*
BS 4-1, *Specification for hot rolled sections.*
BS 290, *Specification for carbon steel forgings above 150 mm ruling section.*
BS 46, *Keys and keyways and taper pins.*
BS 46-1, *Keys and keyways.*
BS 240, *Method for Brinnell hardness test.*
BS 240-1, *Testing of metals.*
BS 308, *Engineering drawing practice.*
BS 308-3, *Geometrical tolerancing.*
BS 903, *Methods of testing vulcanized rubber.*
BS 903-A2, *Determination of tensile stress-strain properties.*
BS 903-A6, *Determination of compression set after constant strain.*
BS 903-A14, *Determination of modulus in shear of rubber (bonded quadruple shear test piece).*
BS 903-A19, *Heat resistance and accelerated air ageing tests.*
BS 903-A21, *Determination of rubber-to-metal bond strength.*
BS 903-A25, *Determination of impact brittleness temperature.*
BS 903-A26, *Determination of hardness.*
BS 903-A36, *Preparation of test pieces.*
BS 903-A39, *Determination of compression set under constant deflection at low temperatures.*
BS 903-A43, *Determination of resistance to ozone cracking (static strain test).*
BS 970, *Wrought steels in the form of blooms, billets, bars and forgings.*
BS 1134, *Method for the assessment of surface texture.*
BS 1134-1, *Method and instrumentation.*
BS 1400, *Copper alloy ingots and copper and copper alloy castings.*
BS 1407, *High carbon bright steel (silver steel).*
BS 1449, *Steel plate, sheet and strip.*
BS 1490, *Aluminium and aluminium alloy ingots and castings.*
BS 1775, *Steel tubes for mechanical, structural and general engineering purposes.*
BS 2789, *Iron castings with spheroidal or nodular graphite.*
BS 2926, *Chromium-nickel austenitic and chromium steel electrodes for manual metal-arc welding.*
BS 2989, *Specification for continuously hot-dip zinc coated and iron-zinc alloy coated steel: wide strip, sheet/plate and slit wide strip.*
BS 3019, *General recommendations for manual inert-gas tungsten-arc welding.*
BS 3019-1, *Wrought aluminium, aluminium alloys and magnesium alloys.*
BS 3100, *Specification for steel castings for general engineering purposes.*
BS 3571, *General recommendations for manual inert-gas metal-arc welding.*
BS 3571-1, *Aluminium and aluminium alloys.*
BS 3784, *Polytetrafluoroethylene (PTFE) sheet.*
BS 4360, *Specification for weldable structural steels.*
BS 4500, *ISO limits and fits.*
BS 4500-1, *General, tolerances and deviations.*
BS 4670, *Alloy steel forgings.*
BS 4848, *Hot-rolled structural steel sections.*
BS 5350, *Methods of test for adhesives.*
BS 5350-A1, *Adherend preparation.*

BS 5350-C9, *Floating roller peel test.*
BS 5400, *Steel, concrete and composite bridges.*
BS 5400-2, *Specification for loads.*
BS 5400-6, *Specification for materials and workmanship, steel.*
BS 5493, *Code of practice for protective coating of iron and steel structures against corrosion.*
PD 6484, *Commentary on corrosion at bimetallic contacts and its alleviation.*

Other publications

BRS Digest 71 Second series.

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