BS 5204-1:
1975

Incorporating Amendment No. 1

Specification for

Straightedges —

Part 1: Cast iron straightedges (bow shaped and I-section)

Confirmed
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Co-operating organizations

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and professional and industrial organizations:

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Association of Hydraulic Equipment Manufacturers Ltd.
Association of Mining Electrical and Mechanical Engineers
British Compressed Air Society
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The Government department and the organization marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard.

British Calibration Service
Department of Prices and Consumer Protection
Gauge and Toolmakers' Association
Joint Equipment Standardization Committee

This British Standard, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the Executive Board on 30 April 1975

The following BSI references relate to the work on this standard:
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Amendments issued since publication

Amd. No.	Date of issue	Comments
4129	November 1982	Indicated by a sideline in the margin

Contents

Foreword

This Part of this British Standard is one of a series for engineers' precision measuring equipment that is now being revised and metricated to replace those in imperial units.

This standard replaces BS 818 "*Cast iron straightedges (bow shaped and I-section)*" which was first published in 1938 to cover the bow shaped type and revised in 1963 to include straightedges of I-section. BS 818 is now withdrawn.

Part 2[1)] of this standard will replace BS 863 "*Steel straightedges of rectangular section*" and will be in metric units.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

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 12, 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)] In course of preparation.

1 Scope

This Part of this British Standard specifies requirements for cast iron straightedges of bow shaped design and of I-section in metric sizes. Two grades of accuracy are provided for each type, namely grade A and grade B.

Requirements applicable to both types are given in clauses **3** and **4** and **7** to **14** inclusive while clauses **5** and **6** specify particular requirements relating to bow shaped straightedges in lengths up to and including 8 000 mm and I-section straightedges in lengths up to and including 5 000 mm.

Recommended general dimensions, methods of testing and heat treatments are given in appendices.

NOTE A straightedge complying fully with the requirements of a superseded standard continues to be operational but it should be brought into full association with this standard when convenient, i.e. when the surfaces are reconditioned and/or retested.

2 References

The titles of the British Standards referred to in this standard are listed on page 12.

3 Nomenclature and definitions

For the purposes of this Part of this British Standard the nomenclature indicated in Figure 1 and Figure 2 has been adopted and the following definitions apply.

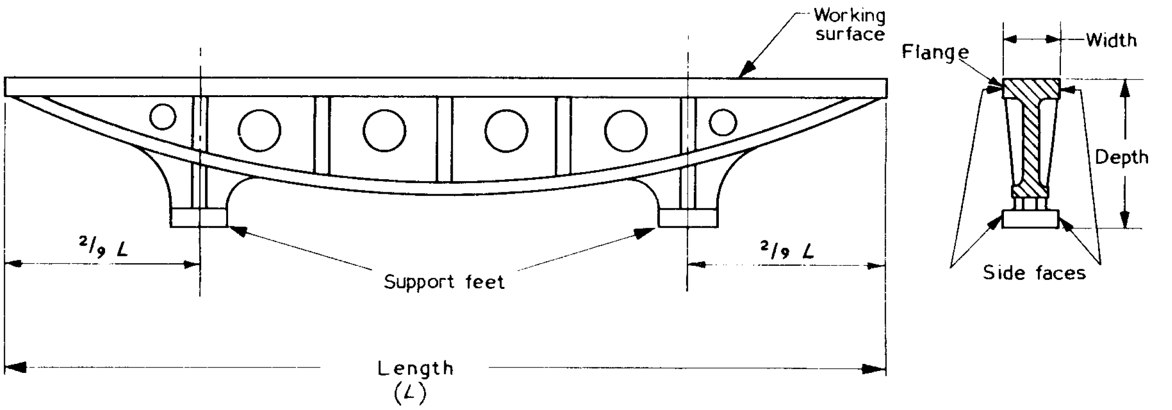

Figure 1 — Bow shaped straightedge

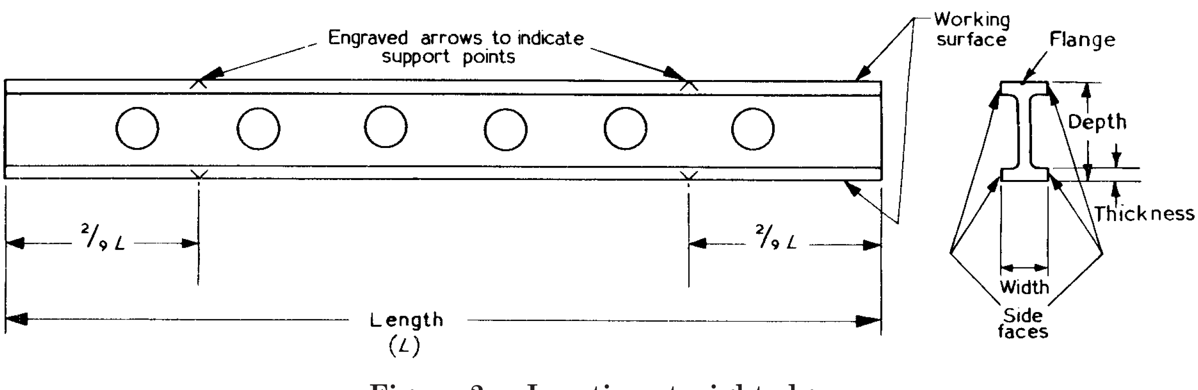

Figure 2 — I-section straightedge

3.1
deviation from flatness of the working surface

the minimum distance between two parallel planes which just envelope the working surface

NOTE It may be necessary to control the maximum slope of the surface deviations with respect to the enclosing planes.

3.2
flatness tolerance

the maximum permissible value of the deviation from flatness

NOTE The working surfaces of straightedges covered by this standard are not strictly speaking straight edges; they are elongated surfaces for which it is appropriate to specify flatness tolerances.

3.3
deviation from squareness of two surfaces

the minimum distance between two parallel planes which just enclose one surface and are perpendicular to a datum plane in contact with the other surface

NOTE See Figure 3.

3.4
squareness tolerance

the maximum permissible value of the deviation from squareness

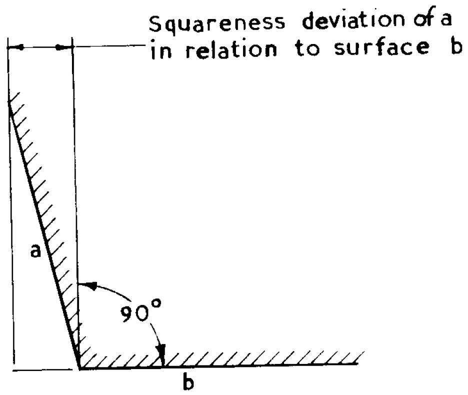

Figure 3 — Exaggerated illustration of squareness deviation

4 Material

The straightedges shall be of close-grained, plain or alloy cast iron in accordance with the minimum requirements for grade 12 as specified in BS 1452:1961.

NOTE Higher grades of cast iron are available which would be more resistant to possible mishandling than grade 12, but grade 12 is specified for this equipment because it offers the best combination of wear resistance and rigidity.

The material shall be sound and free from blowholes and porosity. Minor defects may, however, be repaired by plugging with material of similar composition to that from which the straightedge is made.

A suitable heat treatment to relieve internal stresses is given in Appendix C.

5 Lengths of straightedges

The recommended lengths of straightedges are as follows:

Bow shaped:	300, 500, 1 000, 2 000, 4 000, 6 000 and 8 000 mm,
I-section:	300, 500, 1 000, 2 000, 3 000, 4 000 and 5 000 mm.

Straightedges of intermediate lengths should be ordered only when it is not practicable to adopt one of the recommended lengths. Such straightedges shall conform to the same tolerances as those given for the next shorter recommended length.

6 General features

6.1 Bow shaped. The general design of the straightedge is left to the manufacturer (see Appendix A for recommended dimensions). Provision shall be made for two feet (see Figure 1) of the same width as the working surface and so located as to allow the straightedge to be used in the following positions (shown in Figure 4):

a) resting upon the feet;

b) with the working surface downward;

c) lying on either side.

In any of these positions the accuracy of the straightedge as specified in clauses **8** to **11** inclusive shall be maintained.

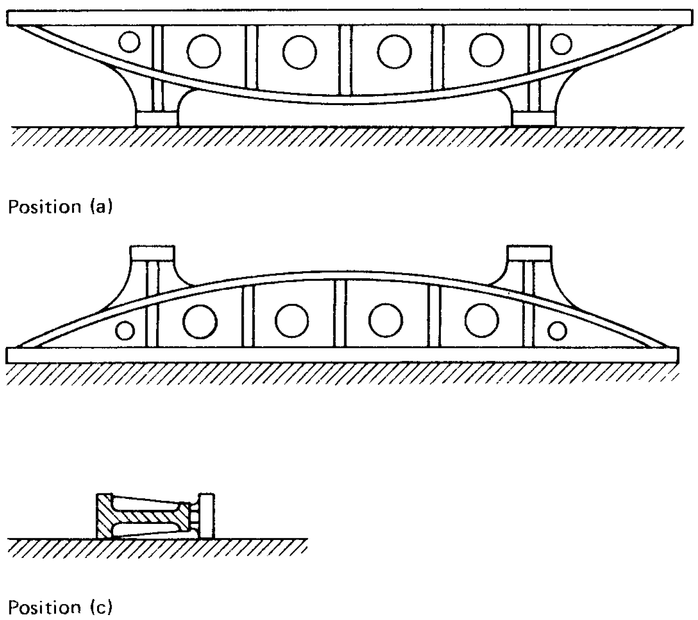

Figure 4 — Alternative positions

The feet shall be designed in the form shown in Figure 5, one foot having two supporting surfaces comprising not more than the two outer thirds of the foot and the other having one supporting surface comprising not more than the middle third of the foot.

For supporting in position (b) of Figure 4, two or three equal and parallel blocks providing localized support may be used, disposed as shown in Figure 6.

NOTE Failure to support the straightedge in the manner shown in Figure 6 may cause it to wind or distort over its width.

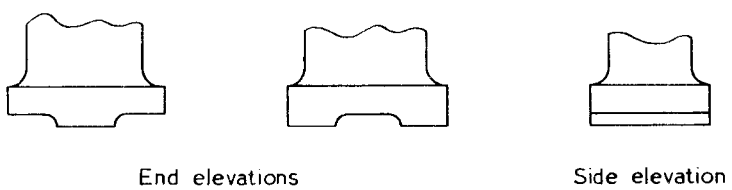

Figure 5 — Design of supporting feet

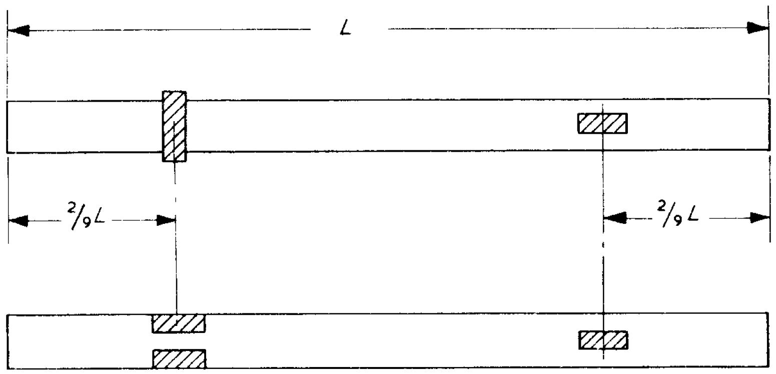

Figure 6 — Alternative methods of using parallel blocks to support the straightedge in position (b) of Figure 4

6.2 I-section. The general design of the straightedge is left to the manufacturer (see Appendix A for recommended dimensions) but the two working surfaces shall have the same width and the rigidity shall be such that when the straightedge is supported on either working surface in the manner shown in Figure 6 at the points indicated by the engraved arrows, or lying on either of its side faces, the working surfaces shall conform to the tolerances given in clauses **8** to **11** inclusive.

NOTE Failure to support the straightedge in the manner shown in Figure 6 may cause it to wind or distort over its width.

Arrows, together with the word SUPPORT, shall be engraved on the side faces to indicate the points at which the straightedge should be supported to ensure minimum deflection under its own weight. These arrows are placed two-ninths of the length of the straightedge from each end (see Figure 2).

7 Finish

The working surfaces and supporting feet of grade A straightedges shall be finished by scraping or any other process which produces a similar type of surface to that obtained by scraping.

The working surfaces of grade B straightedges and the side faces of all straightedges shall be finished by similar processes or by smooth machining.

The proportion of bearing area of the working surface shall be not less than 20 % for grade A straightedges and not less than 10 % for grade B straightedges. High spots shall be uniformly distributed and the percentage of bearing area should not be so high as to cause wringing.

NOTE Recommended methods of testing applicable to straightedges with scraped surfaces are given in Appendix B.

All sharp edges shall be removed.

All unmachined parts shall be painted.

8 Flatness of working surfaces

The bearing area of the working surfaces shall be flat within the tolerances given in Table 1.

Table 1 — Tolerances on flatness of working surfaces

NOTE These tolerances apply to the straightedge supported in any of the three positions as specified in clause **6**.

Length of straightedge	Flatness tolerance	
	Grade A	Grade B
mm	mm	mm
300	0.003	0.006
500	0.005	0.010
1 000	0.010	0.020
2 000	0.020	0.040
3 000	0.030	0.060
4 000	0.040	0.080
5 000	0.050	0.100
6 000	0.060	0.120
8 000	0.080	0.160

NOTE Tolerances on flatness of working surfaces for straightedges with lengths other than those listed in Table 1 can be calculated at the rate of 0.001 mm per 100 mm for grade A and 0.002 mm per 100 mm for grade B, with minimum of 0.003 mm for grade A and 0.006 mm for grade B.
Grade A tolerances are to be rounded up to the nearest 0.001 mm and grade B tolerances expressed to the nearest 0.002 mm.

In addition to conforming to the tolerances given in Table 1, the deviation from flatness over any local length on straightedges 1 000 mm and larger shall not exceed the following amounts:

grade A: 0.003 mm per 300 mm

grade B: 0.006 mm per 300 mm.

9 Equality of depths (working surface to faces of support feet) (see Figure 1)

When a bow shaped straightedge rests on a flat base (see position (a) of Figure 4), the depths from the working surface of the straightedge to this base, measured immediately over each support foot, shall be equal to each other to within the tolerances given in Table 2.

Table 2 — Tolerances on equality of depth between working surface and faces of support feet (bow shaped): tolerances on uniformity of depth between working surfaces (I-section)

NOTE These tolerances apply to the straightedge supported in any of the three positions as specified in clause **6**.

Length of straightedge	Tolerances on equality or uniformity of depth	
	Grade A	Grade B
mm	mm	mm
300	0.003	0.006
500	0.005	0.010
1 000	0.010	0.020
2 000	0.020	0.040
3 000	0.030	0.060
4 000	0.040	0.080
5 000	0.050	0.100
6 000	0.060	0.120
8 000	0.080	0.160

10 Flatness of side faces

Any 300 mm length of each side face of a grade A straightedge shall be flat to within 0.025 mm and any 300 mm length, of each side face of a grade B straightedge shall be flat to within 0.05 mm.

The maximum tolerance on flatness over the whole length of straightedges up to and including 4 000 mm shall be 0.05 mm for grade A and 0.1 mm for grade B; for longer straightedges, these tolerances shall be doubled for both grades.

11 Squareness of working surface and side faces

When a straightedge is laid on its side on a grade A surface plate (as specified in BS 817:1972) the working surface shall be square to the surface plate to within 0.008 mm per 25 mm for grade A straightedges and 0.015 mm per 25 mm for grade B straightedges. (See also Figure 4.)

NOTE If squareness of the individual side faces adjacent to working surfaces is required, the purchaser should specify the accuracy.

12 Marking

Each straightedge shall be legibly and permanently marked with the following particulars.

a) The manufacturer's name or trade mark.

b) The number of this British Standard, i.e. BS 5204-1.

c) An identification number (serial number).

d) Grade A or B, as appropriate.

e) The year of manufacture.

NOTE 1 The mark BS 5204-1 on the product is a claim by the manufacturer that it complies with the requirements of the standard.

NOTE 2 Inspection of straightedges and certification that they comply with the requirements of this standard may be undertaken by laboratories approved by the British Calibration Service; addresses can be obtained on application to the Director, British Calibration Service, National Physical Laboratory, Teddington, Middlesex, TW11 0LW.

13 Protection against climatic conditions

All working surfaces of the straightedges shall be protected against climatic conditions by being covered with a suitable corrosion-preventive preparation[2)].

14 Case

It is recommended that each straightedge shall be provided with a suitable case or protective cover of substantial construction.

[2)] See BS 1133-6 and BS 1133-19.

Appendix A Minimum general dimensions for straightedges

The minimum dimensions given for straightedges in Table 3 and Table 4 are for guidance only.

Table 3 — Minimum general dimensions for bow shaped straightedges

Length of straightedge	Minimum width of working surface and feet	Minimum overall depth	Minimum flange thickness
mm	mm	mm	mm
300	30	80	10
500	35	130	12
1 000	45	180	16
2 000	65	300	24
3 000	90	400	32
4 000	100	500	38
6 000	100	600	50
8 000	100	800	55

Table 4 — Minimum general dimensions for I-section straightedges

Length of straightedge	Minimum width of working surface and feet	Minimum overall depth	Minimum flange thickness
mm	mm	mm	mm
300	25	75	8
500	30	75	10
1 000	35	100	12
2 000	50	150	14
3 000	55	250	16
4 000	60	300	18
5 000	65	350	20

Appendix B Recommended methods of testing cast iron straightedges

B.1 General. The whole surface of a straightedge may be used as a datum flat surface; alternatively, a central longitudinal band or track may be used for establishing a datum straight line. Although tests for straightness may often be made by comparison with a datum straight line it is necessary to use the inclination method to determine the errors in straightness of the datum straight line and in all instances where the highest possible accuracy is required.

B.2 Inclination method. This method of test requires a type of instrument which will measure very small angular variation of a carriage or block as it is moved step by step along the centre line of the working surface of the straightedge. It may be a spirit level, an electronic level, an autocollimator or, in fact, any instrument which will measure small angular variations, but it is important to note that the weight of the equipment should be kept to a minimum in order to avoid distortion of the surface under test. The measurements should also be made in a controlled environment to ensure that rapid temperature variations and temperature gradients are kept to a minimum.

The principle of the inclination method is illustrated in Figure 7 and Figure 8. The carriage may consist of a plate or block to the underside of which may be fitted (by wringing or otherwise) parallel blocks of equal thickness. These blocks are placed at a separation suited to the step chosen for measurement and the carriage is moved along the line in steps of this value (see Figure 7). It is also quite satisfactory to use a carriage with feet at a fixed distance, a block level with fixed feet, for example, provided the pitch covered by the feet is suitable for the measurement in hand. In either case, the span may be marked on the feet of the carriage.

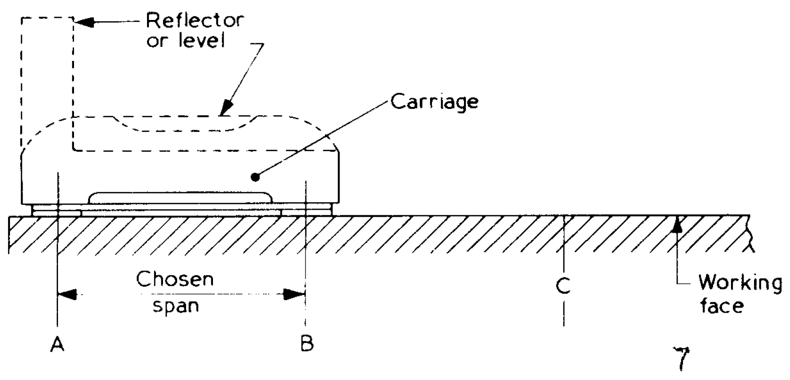

Figure 7 — Test by inclination method

To carry out a test, the straightedge is stood on a firm support and the working surface under consideration is approximately levelled in both longitudinal and transverse directions. The carriage to be used for making the flatness test is placed at one end of the straightedge with its length in the same direction as the latter. After making the first reading, the carriage is advanced along the straightedge through a distance equal to the span of its feet and the second reading is made. In this way, the carriage is advanced step by step along the straightedge until the other end of the working surface is reached, when it is usual to move the carriage backwards over the same path and to obtain a check series of readings terminating at the starting position. The inclination of each span relative to the first setting can therefore be found and the continuous angular contour recorded. No absolute datum, such as true level, is necessary. The datum is the first angular reading, all other inclinations being initially related to this.

Assume, for example, positions A, B, C, D, etc. in Figure 8 are laid out, 250 mm apart, along the centre line of the carriage. A 250 mm span will also be marked out on the feet or base of the carriage. The first span will be from A to B and this will be taken as the initial datum from which the other inclinations will be measured. Assume also that the span B – C shows an upward tilt of 5 seconds and C – D a downward tilt of 2 seconds when the carriage is moved to these positions. On a 250 mm base 1 second of arc represents a vertical displacement of 0.001 21 mm; C will therefore be 0.0060 mm above the datum line through A – B, and D will be 0.0024 mm below C or 0.0036 mm above the datum, and so on. The end point of the line will generally not be zero although it is usually convenient to take as a datum line the one between the extreme points. The final graphs must therefore be tilted about the origin, either arithmetically or graphically, to bring the end point to zero (see Figure 8).

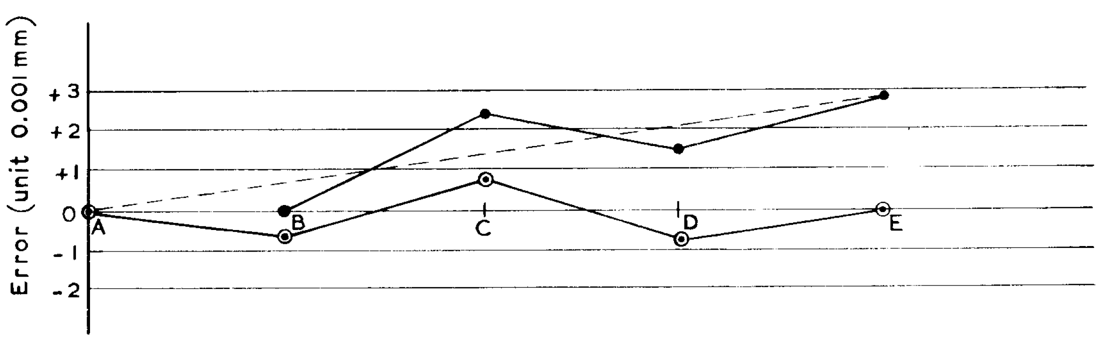

Figure 8 — Plotting of readings

The sample table below shows the method of recording observations and working up the results. It will be noted that an additional zero is placed above the first reading in column 5; this is because the first reading, although taken as datum zero, represents the relative levels of two points A and B. In this case the error at B will not therefore be zero in column 7 if the graph has to be swung about the origin.

Example of recording observations

1	2	3	4	5	6	7	8
Position of carriage	**Angular reading**	**Difference from first reading at position A – B**	**Tilt over 250 mm span**	**Cumulative deviations from plane A — B**	**Proportional adjustments to bring E to zero**	**Error (algebraic sum of columns 5 and 6)**	**Position along straightedge**
			Unit 1 × 10^{-3} mm				
	Second	Second					
—	—	—	—	0	0	0	A
AB	15	0	0	0	– 1.8	– 1.8	B
BC	20	+ 5	+ 6.0	+ 6.0	– 3.6	+ 2.4	C
CD	13	– 2	– 2.4	+ 3.6	– 5.4	– 1.8	D
DE	18	+ 3	+ 3.6	+ 7.2	– 7.2	0	E

Although the span used may be any value within reasonable limits, it is convenient to make it about one-tenth of the length of the straightedge, giving ten steps of measurement.

In addition to the above test, which is usually carried out along the centre line of the working surface, it is necessary to test the face for a transverse twist (wind). This is most conveniently done with a level, an autocollimator being unsuitable for this test without certain special equipment. The level is turned so as to lie transversely across the surface of the straightedge and any variations in its readings are noted as it is moved from one end of the surface to the other.

B.3 Comparison methods. These methods of test require a datum reference surface of known accuracy against which a cast iron straightedge can be compared. For this purpose either a rectangular steel straightedge complying with the requirements of BS 863 or a calibrated reference track of a grade AA surface plate (as specified in BS 817:1972) is suitable.

B.3.1 *Comparison with a rectangular steel straightedge.* The steel straightedge is stood on its edge and supported on the working surface of the cast iron straightedge by two equal block gauge combinations placed at the positions of support marked on the steel straightedge. A suggested combination is 2.005 mm + 2.05 mm, i.e. 4.055 mm. A gap is thus formed between the two straightedges. The width of this gap is then measured at any desired number of positions by fitting gauge blocks into it.

To obtain the true errors of the working surface of the cast iron straightedge from the results thus obtained, it is necessary to allow for the errors in the steel straightedge.

If the actual errors of the steel straightedge are not known, this method of test can still be used, but it becomes necessary to repeat the measurements of the gap between the two straightedges after inverting the steel straightedge and to measure the width of the latter at a number of positions so as to determine any errors of parallelism between its two working edges. Details of the way in which the errors in the straightness not only of the cast iron straightedge but also of both edges of the steel straightedge can be obtained from the results of these measurements will be found in Appendix C of BS 863:1939.

B.3.2 *Comparison with a reference track of a grade AA surface plate.* It is necessary first to establish the errors in straightness of a track of the surface of a grade AA surface place using the inclination method as described in **B.2**. Comparison between the reference track and the working surfaces of bow shaped and I-section cast iron straightedges may then be made by means of a test indicator complying with the requirements of BS 2795-1, and mounted on a suitable block. The test indicator block is moved along the reference track and the difference between the known errors of the reference track and the errors of the straightedge are registered on the test indicator. To ensure that the readings obtained relate only to the bearing area of the scraped surface of the straightedge, a block gauge must be interposed between the scraped surface and the stylus of the test indicator. Where it is required to measure a large number of straightedges with their measuring surfaces uppermost, i.e. position (a) of Figure 4, it is advantageous to replace the test indicator block with, a carriage which just straddles the straightedge and bears on two tracks located close to either longitudinal side of the straightedge. In this instance, in addition to measuring the straightness of each track, it would be necessary to verify that the transverse twist (wind) relationship between the two tracks will not significantly influence the test indicator reading.

The method of comparison described in **B.3.1** can also be used for checking straightedges when they are positioned with their surfaces facing downward, i.e. position (b) of Figure 4.

B.4 Local deviations from straightness. Clause **11** states tolerances for local deviations from straightness and the methods described above may be used for checking compliance.

B.5 Flatness. Twist or wind may be checked by observing the variations of reading of a precision level placed transversely on the straightedge at various positions in its length. A small level of sensitivity, 5 seconds or 10 seconds per division and mounted in a light frame, may be used.

B.6 Tests in three positions. Clause **9** requires that the straightedges conform to the tolerances in positions (a), (b) and (c) of Figure 4. The tests for straightness described in **B.2** and **B.3** cater for positions (a) and (b). The straightedge may be tested in position (c) by the inclination method (see **B.2**), using an autocollimator or, by comparison with a reference straightedge, a test indicator or gauge blocks. The indicator must contact on a gauge block bearing on the high spots of the surface being inspected.

B.7 Determination of the proportion of bearing area. In order to determine the proportion of the bearing area of a scraped cast iron straightedge, its surface is first blued and rubbed with a small surface plate so that the small bearing areas are brought up clearly into view. A small glass plate[3)] on which a rectangle 50 mm × 25 mm has been ruled into small rectangles 5 mm × 2.5 mm[4)] is then placed upon the surface. Each small rectangle is then observed in turn and a note made of the estimated fraction of its area (in tenths) which is occupied by a "high spot" on the surface underneath.

The addition of all these fractions gives the percentage of the bearing area of the surface over the region tested. The test can be repeated at other positions on the surface in order to obtain a fair average figure.

It may be mentioned that after testing a few surfaces by this method, the results obtained, coupled with the general appearance of the bearing areas, enable a fairly close estimate to be made of the proportion of bearing area of a surface merely from its general appearance.

Appendix C Recommended chemical compositions of plain and alloy cast irons and method of heat treatment

C.1 Plain cast iron. The recommended chemical composition for plain cast iron is as follows:

	%
total carbon	3.0 to 3.5
combined carbon	0.4 to 0.7
manganese	0.5 to 1.2
silicon	1.0 to 1.6[a]
sulphur	0.15 max.
phosphorus	1.2 max.

[a] The higher silicon limits are intended for the lighter sectional castings.

The appropriate treatment for the dimensional stabilization by stress relieving of straightedges made from plain cast iron of the above composition is as follows.

The straightedges, after being rough machined and fully fettled, should be placed in an annealing furnace and heated slowly to a temperature of 510 °C to 560 °C maximum, and be maintained at this temperature for a long period (25 h for best results). The casting must be protected from the direct heat of the flames by means of suitable baffle plates and the heating should be as uniform as possible throughout. Also the casting should be supported in the furnace on the points on which it will subsequently stand in service.

For small castings, more uniform heating may be achieved by packing the castings in iron filings in boxes. Rigorous control of the cooling rate must be exercised. The furnace should be "fired down"at a rate not exceeding 5 °C/h down to 100 °C before opening the furnace and allowing it to cool naturally.

3) These glass plates can readily be produced like lantern slides by photographing a chart drawn on paper.

4) The exact size of the rectangles is unimportant provided that they are all of the same size.

C.2 Alloy cast iron. The recommended chemical composition for alloy cast iron is as follows:

	%
total carbon	2.8 to 3.2
silicon	0.8 to 1.5[a]
manganese	0.6 to 1.0
sulphur	0.12 max.
phosphorus	0.3 max.
nickel	1.4 to 1.6
chromium	0.4 to 0.6

[a] The higher silicon limits are intended for the lighter sectional castings.

The stress relieving of straightedges made from alloy cast iron of the above composition is similar to that given above for plain cast iron, except that the castings should be slowly heated to a temperature of 560 °C to 590 °C maximum.

The lower ranges of temperature must be used with irons with high carbon equivalents. The higher ranges will be necessary for irons with lower carbon equivalents.

Carbon equivalent = Total carbon $+\frac{1}{3}\%\,\mathrm{Si}+\frac{1}{3}\%\,\mathrm{P}$.

Publications referred to

This standard makes reference to the following British Standards:

BS 817, *Surface plates and tables.*

BS 863, *Steel straightedges of rectangular section.*

BS 1452, *Grey iron castings.*

BS 2795, *Dial test indicators (lever type) for linear measurement.*

BS 2795-1, *Metric units.*

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