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Incorporating corrigendum No. 1

BRITISH STANDARD

Gauge blocks manufactured to imperial specification – Part 1: Specification and validation

ICS 17.040.30

British Standards

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iii, a blank page, pages 1 to 11 and a back cover.

Foreword

Publishing information

This part of BS 4311 is published by BSI and came into effect on 31 August 2007. It was prepared by Technical Committee TDW/4, *Technical product specification – Methodology, presentation and verification* under the direction of the Consumer products and services business sector. TDW/4 has, within its scope, responsibility for "metrology and precision measurement" with resulting access to appropriate technical expertise. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 14311 supersedes BS 4311-1:1993 and BS 4311-3:1993, which are withdrawn.

Information about this document

This new version of BS 4311-1 has been prepared in response to a requirement for the ongoing support for gauge blocks manufactured to the imperial system, following the publication of BS EN ISO 3650:1999, which provides for gauge blocks manufactured to the metric system, and the consequent withdrawal of BS 4311-3:1993.

Throughout this revision, the principles and practices specified in BS EN ISO 3650:1999 have been given precedence and have been cross-referenced wherever appropriate. The main function of this new version of BS 4311-1 is to provide for the application of the requirements of BS EN ISO 3650:1999 to the many gauge blocks manufactured to the imperial system, which remain in use and which will continue to be in use for the foreseeable future.

The effects of uncertainty of measurement continue to be taken into account in that the method of measurement is clearly stated for each grade and the line of traceability to internationally recognized, universal standards of length is established.

[C1] Additionally, BS 4311-2 is being reissued in order to specify requirements for accessories for use with gauge blocks in both metric and inch units. [C1]

As with BS EN ISO 3650:1999, and unlike the former BS 4311-1:1993 and BS 4311-3:1993, this standard does not make any distinction between new and used gauge blocks. However, the fact that during use gauge blocks wear and consequently fall outside their original specification is still recognized. To preserve the required standards of accuracy during use, gauge blocks should be carefully maintained and regularly calibrated. Guidance on these aspects is provided in Annex A, Annex B, Annex C and Annex D. Because of their inclusion in this standard, the contents of these annexes relate specifically to gauge blocks manufactured to the imperial system, but it should be recognized that the principles and recommendations presented here, apply equally to gauge blocks manufactured to the metric system.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

A comma, rather than a full point, has been used as the decimal indicator throughout this British Standard in order to align it with the Geometrical Product Specifications listed in Clause **2**. Care should be taken when using this publication in conjunction with other British Standards.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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1 Scope

This part of BS 4311 specifies the most important design and metrological characteristics of gauge blocks with a rectangular cross-section and a nominal length l_n of not more than 4 in.

Limit deviations and tolerances are stated for the calibration grade K and for the grades 0, 1 and 2 for various measuring purposes.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN ISO 1, *Geometrical Product Specifications (GPS) – Standard reference temperature for geometrical product specification and verification*

BS EN ISO 3650:1999, *Geometrical Product Specifications (GPS) – Length standards – Gauge blocks*

BS EN ISO 6507-1, *Metallic materials – Vickers hardness test – Part 1: Test method*

BS EN ISO 14253-1, *Geometrical Product Specifications (GPS) – Inspection by measurement of workpieces and measuring equipment – Part 1: Decision rules for proving conformance or non-conformance with specifications*

BS ISO 1101, *Geometrical Product Specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out*

3 Definitions

For the purposes of this British Standard, the definitions given in BS EN ISO 3650 apply.

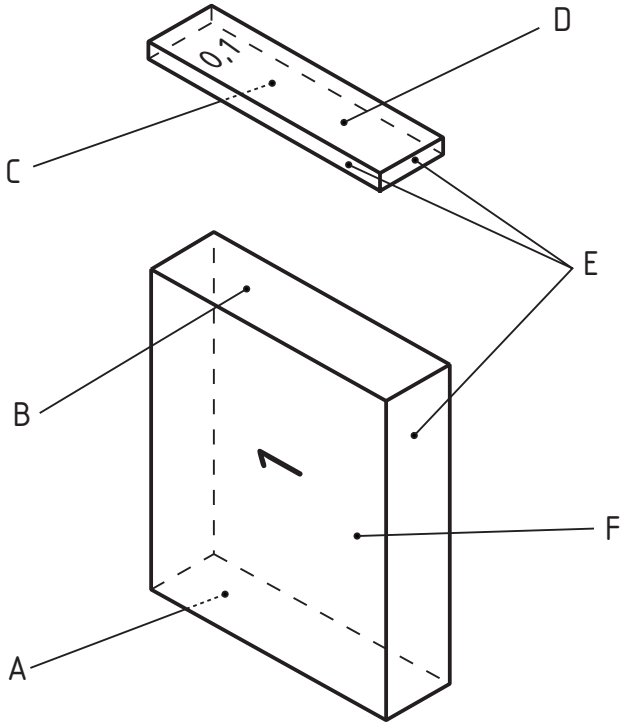
4 Nomenclature of faces

The nomenclature used to describe the faces of a gauge block shall be as identified in Figure 1.

Figure 1 **Nomenclature of faces**

a) for nominal lengths l_n = < 0,19 in

b) for nominal lengths l_n > 0,19 in



Key

A	Left hand measuring face
B	Right hand measuring face
C	Unmarked measuring face
D	Marked measuring face
E	Side faces
F	Marked side face

*NOTE For the complete marking, see **6.3**.*

5 Basis of measurement, traceability, reference condition

NOTE For the purposes of relating measurements made on gauge blocks manufactured to imperial specifications to the SI unit of length, the metre, the following conversion may be used: 1 in = 25,4 mm exactly. The abbreviated form of inch, as used in this document is "in".

5.1 Traceability of the length of a gauge block

The measured length of a gauge block shall be traceable to national or international length standards if the measurement result can be related by an unbroken chain of comparison measurements, each with stated uncertainties, to a gauge block which has been calibrated by interferometry using appropriate wavelength standards.

5.2 Reference temperature and standard pressure

The nominal length and the measured lengths of a gauge block shall apply at the reference temperature of 20 °C (see BS EN ISO 1) and the standard pressure 101 325 Pa = 1,013 25 bar.

NOTE The effect on the length of a gauge block caused by deviations from the standard pressure can be ignored under normal atmospheric conditions.

5.3 Reference orientation of gauge blocks

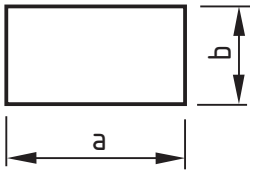
The length of a gauge block up to and including 4 in nominal length refers to the vertical orientation with the measuring faces horizontal.

6 General dimensions, material properties, marking

6.1 General dimensions

The nominal dimensions of the cross-section and their limit deviations shall be as given in Table 1.

Table 1 **Cross-section**

Cross-section	**Nominal length** in	**Length a** mm		**Length b** mm	
		nominal	**limit deviation**	**nominal**	**limit deviation**
	$0 \leqslant l_n \leqslant 0{,}19$	30	0 –0,30	9	–0,05 –0,20
	$0{,}19 < l_n \leqslant 4{,}0$	35			

6.2 Material properties

6.2.1 Material

Gauge blocks shall be made of high grade steel or of other similarly wear-resistant material capable of being finished with surfaces that will wring readily, and which will be stable for length within the tolerances in Table 2.

6.2.2 Coefficient of thermal expansion

The coefficient of thermal expansion of steel gauge blocks in the temperature range 10 °C to 30 °C shall be $(11{,}5 \pm 1{,}0) \times 10^{-6}\ K^{-1}$.

The coefficient of expansion with its estimated uncertainty of determination shall be supplied with steel grade K gauge blocks, and also for all gauge blocks of all grades made of materials other than hardened steel.

6.2.3 Hardness

The measuring faces of steel gauge blocks shall have a Vickers hardness of not less than 800 HV 0,5 (see BS EN ISO 6507-1).

6.2.4 Dimensional stability

The maximum permissible changes in length per year of gauge blocks shall be as stated in Table 2. They apply when the gauge blocks are not exposed to exceptional temperature, vibrations, shocks, magnetic fields or mechanical forces

Table 2 **Dimensional stability**

Grade	Maximum permissible change in length per year
K 0	$\pm$ (0,8 µin + 0,25 × 10^{-6} × l_n)
1 2	$\pm$ (2 µin + 0,5 × 10^{-6} × l_n)

NOTE l_n *is expressed in inches.*

6.3 Marking

Each gauge block shall be permanently marked with its nominal length in inches and shall be permanently and individually identifiable in characters not less than 1,5 mm high. Gauge blocks smaller than 0,19 in nominal length can be marked on a measuring face, but an area of 9 mm × 12 mm at the centre of the measuring face and an area of 2,5 mm × 2,5 mm in each of the four corners shall be left clear of any marking.

If the grade is indicated on the gauge block, the following markings shall be used:

a) calibration grade K: K

b) grade 0: 0

c) grade 1: –

d) grade 2: =

7 Metrological requirements

7.1 General

Each gauge block shall conform to the requirements of its grade, as indicated below.

Conformance to specifications shall be proved:

a) in accordance with BS EN ISO 14253-1; or

b) in accordance with a prior agreement with the customer.

The requirements of Table 3 and Table 4 shall apply to the measuring faces of the gauge block omitting a border zone with a maximum width of 0,8 mm as measured from the plane of the side faces. In this border zone the surface shall not lie above the plane of the measuring face.

Grade K blocks shall comply with the tolerance t_e for limit deviations from nominal length as grade 1. Very close tolerances for flatness and variation in length for grade K blocks shall be as given in Table 3 and Table 4. These gauge blocks are intended for calibrating other gauge blocks and shall always be used in connection with a calibration certificate.

Limit deviations for length and for variation in length applicable to all grades of gauges shall be as given in Table 5.

7.2 Flatness tolerance, t_f

7.2.1 Gauge blocks with nominal lengths exceeding 0,1 in

The deviation f_d from flatness of each measuring face of a gauge block of nominal length greater than 0,1 in shall not exceed the appropriate tolerance in Table 3, whether the gauge block is wrung to an auxiliary plate or is in the unwrung state.

7.2.2 Gauge blocks with nominal lengths up to 0,1 in

The deviation f_d from flatness of each measuring face of a gauge block of nominal length up to 0,1 in shall not exceed the appropriate tolerance in Table 3 when the gauge block is wrung to an auxiliary plate with a thickness of not less than 11 mm.

With the gauge block in the unwrung state, each measuring face shall be flat to within 150 µin.

Table 3 **Flatness tolerances for new inch gauge blocks**

Grade	Tolerance
K	2
0	4
1	6
2	10

7.3 Measuring faces

The measuring faces of all gauge blocks shall wring readily.

NOTE Fine scratches without burrs can be accepted when they do not impair the wringing property.

The edges of the measuring faces shall be rounded to a radius not exceeding 0,3 mm or provided with a chamfer not exceeding 0,3 mm. The transition between the chamfer and the measuring face shall be such that the wringing property of the measuring faces is not impaired.

7.4 Side faces

7.4.1 Flatness

The side face shall have a flatness tolerance (see BS ISO 1101) of 0,001 5 in for nominal lengths up to 4 in.

7.4.2 Parallelism

The deviation from parallelism (see BS ISO 1101) of a side face with the opposing side face as a datum shall not exceed 0,003 in for nominal lengths up to 4 in.

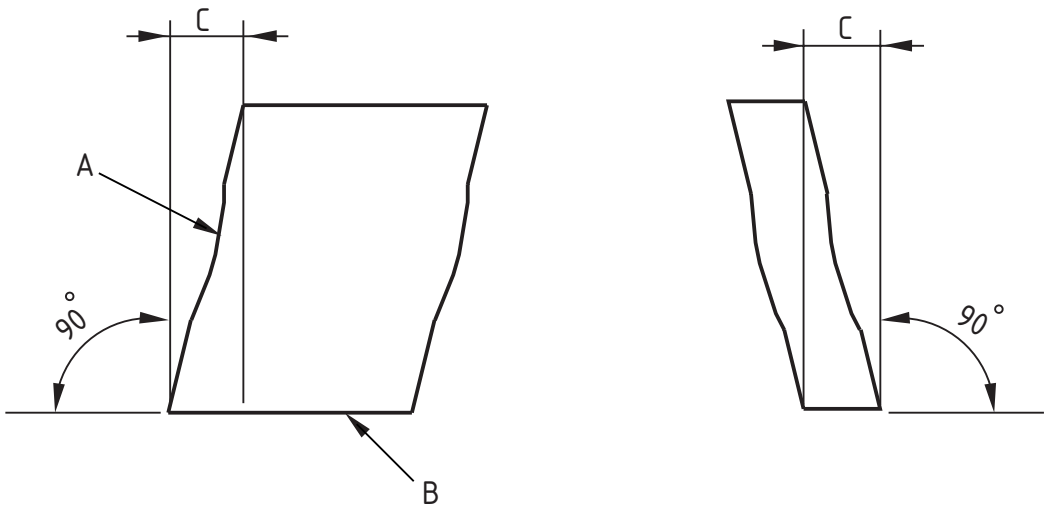
7.4.3 Perpendicularity

7.4.3.1 The perpendicularity tolerance (see BS ISO 1101) of a side face with a measuring face as a datum shall be as given in Table 4 (see Figure 2).

Table 4 **Perpendicularity tolerance**

Nominal length, l_n in	**Perpendicularity tolerance** µm
$0 \leqslant l_n \leqslant 1$	50
$1 < l_n \leqslant 2$	70
$2 < l_n \leqslant 4$	100

Figure 2 **Perpendicularity deviation of side faces with a measuring face as a datum**



Key

A Side face
B Measuring face
C Deviation from perpendicularity

7.4.3.2 The angle between adjacent side faces shall be 90° ± 0° 10′.

Table 5 **Limit deviation, l_e of the length at any point of the measuring face from nominal length and tolerance, for the variation in length**

Nominal length	Calibration grade K		Grade 0		Grade 1		Grade 2	
	limit deviation of length at any point from nominal length	tolerance for the variation in length	limit deviation of length at any point from nominal length	tolerance for the variation in length	limit deviation of length at any point from nominal length	tolerance for the variation in length	limit deviation of length at any point from nominal length	tolerance for the variation in length
l_n in	$\pm t_e$ µin	t_v µin	$\pm t_e$ µin	t_v µin	$\pm t_e$ µin	t_v µin	$\pm t_e$ µin	t_v µin
$0 \leqslant l_n \leqslant 0{,}4$	8	2	5	4	8	6	18	12
$0{,}4 \leqslant l_n \leqslant 1$	12	2	6	4	12	6	24	12
$1 < l_n \leqslant 2$	16	3	8	4	16	7	32	12
$2 < l_n \leqslant 3$	20	3	10	5	20	7	40	14
$3 < l_n \leqslant 4$	24	3	12	5	24	8	48	14

7.4.4 Edges

The edges between the side faces shall have a radius or chamfer of not greater than 0,3 mm.

8 Calibration of gauge blocks

Calibration shall be in accordance with BS EN ISO 3650 for nominal lengths up to and including 4 in.

Annex A (informative) Frequency of calibration

A.1 General

Although this Annex relates specifically to gauge blocks manufactured to the imperial system, the principles and recommendations apply equally to those manufactured to the metric system.

A.2 Frequency of calibration

Where the use of a particular set does not change, it should be recalibrated at intervals appropriate to the rate of wear as determined initially by the results of two calibrations separated by a time interval not greater than one year.

Where there is a change of use, frequency of use or application of a gauge block, the recalibration interval should be reviewed.

Annex B (informative) Care of gauge blocks

B.1 General

Although this Annex relates specifically to gauge blocks manufactured to the imperial system, the principles and recommendations apply equally to those manufactured to the metric system.

B.2 General care

The greatest care should be exercised in protecting gauge blocks and their cases from dust, dirt and moisture.

When not in use, gauge blocks should always be kept in their case, which should be kept closed.

Gauge blocks should be used, as far as possible, in an atmosphere free from dust. Care should be taken to ensure that the gauge blocks do not become magnetized as this can cause them to attract ferrous dust.

B.3 Preparation before use

If gauge blocks are new or have been covered with a protective coating (see **B.7**) after being used, most of this coating should be removed with an appropriate solvent. Gauge blocks should finally be wiped with a clean chamois leather, soft linen cloth or similar, before use.

B.4 Care in use

Fingering of the lapped faces should be avoided to preclude the risk of tarnishing. Unnecessary handling of gauge blocks in use should also be avoided in order to prevent transfer of heat from the hand.

When a high degree of accuracy is required, a test room thermostatically controlled at the reference temperature of 20 °C should be used. For a sufficient degree of accuracy to be attained for ordinary purposes, the workpiece to be tested and the gauge blocks to be used should be allowed to assume the prevailing temperature of the test area. A workpiece should not be tested directly after cutting, grinding or other temperature disturbing operations have been completed, nor should large combinations of gauge blocks be used immediately after they have been wrung together.

B.5 Wringing

Gauge blocks should not be held above the open case when being wrung together. The gauge blocks required should be selected and the case should then be closed.

Before wringing gauge blocks together, their faces should be wiped free from dust and examined for burrs. When attempting wringing, if the slightest obstruction or grittiness is detected, the attempt should be stopped, the faces wiped clean, and the wringing re-attempted. If the reluctance to wring persists, the cause should be traced and removed.

B.6 Damaged gauge blocks

Damage to gauge blocks is likely to occur on the edges, resulting from the gauge blocks being knocked or dropped. Such slight burrs should be removed with care by drawing an Arkansas type stone lightly across the damaged edge in a direction away from the measuring face of the gauge block. Any gauge block so treated should be thoroughly cleaned before wringing.

A gauge block with a damaged measuring face should preferably be returned to the manufacturer for the surface to be restored.

B.7 Care after use

Gauge blocks should not be left wrung together for any length of time after use or overnight. Immediately after use, each gauge block should be wiped clean and replaced in its designated compartment in the case. Particular care should be taken to remove any finger marks from the measuring faces.

If gauge blocks are used infrequently, they should be coated with a suitable corrosion preventative before being put away.

Annex C (informative) Wear in use and maintenance of gauge blocks

C.1 General

Although this Annex relates specifically to gauge blocks manufactured to the imperial system, the principles and recommendations apply equally to those manufactured to the metric system.

C.2 Wear in use

Despite the adoption of the recommendations for care of gauge blocks in Annex B, over time burrs might be raised at the edges and on the measuring faces and also many fine scratches in the surface can gradually impair the wringing properties. In addition, deeper scratches might throw up proud metal. These defects will impair the accuracy and performance of the gauge blocks.

To keep a gauge block in use in its grade as long as possible, i.e. while it complies with the tolerances for the grade, regular inspection, servicing and calibration is essential.

C.3 Restoration of wringing property

Gauge blocks should be returned regularly to specialized organizations for removal of burrs, for minimal lapping to restore wringing property, and for measurement.

One essential property of a gauge block is that it should be able to be combined or wrung to other gauge blocks, the length of the combinations being equal to the sum of the individual lengths. Another essential property is that it should be able to be wrung to a similarly finished plane surface, with the result repeatable to within 1 μin.

During use, accidental damage and gradual deterioration of surface texture cause a reduction or complete loss of wringing power, which prevents accurate combination. The gauge block then ceases to fulfil its intended function.

To restore the wringing ability of the gauge block, minimal lapping or surface conditioning should be employed to remove all the surface and edge burrs which project above the level of the gauging plane, and to improve surface texture.

It is not necessary to return the surfaces to their original unblemished condition. Normally, minimal lapping should reduce the length of the gauge block by not more than 0,03 μm and this will not significantly reduce service life. When gauge blocks are heavily used, it might be necessary to reduce the length by more than this amount. However, the length reduction due to this minimal lapping will still be small compared to the reduction due to wear.

Minimal lapping, properly implemented, will not normally alter the flatness or variation in length of the gauge block. The particular technique used should be appropriate for the type of material from which the gauge block is made, with strict control of the process.

Annex D (informative) Selecting grade of gauge blocks

D.1 General

Although this Annex relates specifically to gauge blocks manufactured to the imperial system, the principles and recommendations apply equally to those manufactured to the metric system.

D.2 Selecting grade of gauge blocks

Gauge blocks are required for a variety of measuring purposes, such as inspection of workpieces, setting of comparators, verification of measuring tools and precise complements to other measuring equipment, e.g. sine bars and test indicators. The four grades specified in this standard provide a range of accuracies, with different permitted deviations from nominal length, and queries often arise as to which grade of set should be used for a particular application.

Gauge blocks of the higher grades, i.e. with close to nominal measured length are attractive since their deviations encroach minimally on the workpiece tolerance. However, higher grades should not be used on workpieces that have coarse surface finish and large tolerances, so when several grades are available it can be economical to use the lowest grade suitable to avoid using more refined grades unnecessarily.

Some users prefer to include a protector gauge block at each end of a combination to concentrate contact wear on a supplementary pair of blocks.

Gauge blocks are often used on the assumption that they are acceptably close to their nominal length. Whilst this might be correct under certain circumstances, to achieve greater accuracy reference should be made to the most recent calibration chart, taking into account the known deviation from nominal length of each gauge block used.

The grade of gauge blocks should be matched to their measuring purpose and should be selected following responsible assessment, according to the conditions of each application. Workpieces that are not accepted by inspection, when neglecting the deviations from nominal length of the gauge blocks used, should be re-checked more precisely by applying measured lengths of the gauge blocks. In all cases of dispute, reference measurement and border line cases, it is essential that the precise measured lengths of gauge blocks be taken into account.

For further guidance on the selection of grade of gauge blocks for a specific measuring application, the manufacturer of the gauge blocks should be consulted.

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