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Specification for precision vernier height gauges

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C1	August 2009	Correction to equation in Clause **4**

Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 12, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 20 November 2008. It was prepared by Technical Committee TDW/4, *Technical product realization*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 1643:1983, which is withdrawn.

Relationship with other documents

prEN ISO 13225-1 is in preparation and covers design and metrological characteristics of simple vertical length measuring instruments for linear-dimensional measurements perpendicular to a surface plate with either analogue or digital indication.

Information about this document

This new edition has been fully revised to bring it up to date.

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.

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.

Introduction

The principal features of a vernier height gauge are shown in Figure 1 but details of design may vary between manufacturers. The accuracy of performance of a vernier height gauge is based upon the quality and precision of the various features, e.g. the accuracy of the dividing of the scales, the quality of the graduation marks, the straightness of the guiding edge, the flatness of the base datum and the measuring faces. These are all features which the manufacturer controls in order that measurements made with the instrument are reliable within the tolerances given in Clause **6**.

1 Scope

This British Standard specifies requirements for the construction, accuracy at the reference temperature of 20 °C and the protection of metric and imperial precision vernier height gauges which include a scriber for marking heights. The metric height gauges measure height up to a maximum of 1 000 mm using a main scale and vernier scale graduated to read to 0.02 mm. The imperial height gauges measure height up to a maximum of 48 in using a main scale and vernier scale graduated to read to 0.001 in.

NOTE 1 Attention is drawn to the fact that the metric dimensions are not necessarily direct conversions of the imperial dimensions. For instance, the vernier division of 0.02 mm marked on the metric height gauge corresponds to a 0.001 in vernier division on the imperial height gauge, whereas the actual conversion is 0.001 in = 0.0254 mm.

Requirements for setting blocks which might be supplied are also specified.

Methods of testing height gauges are specified in Annex A.

2 Normative references

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

BS 817, *Specification for surface plates*

3 Terms and definitions

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

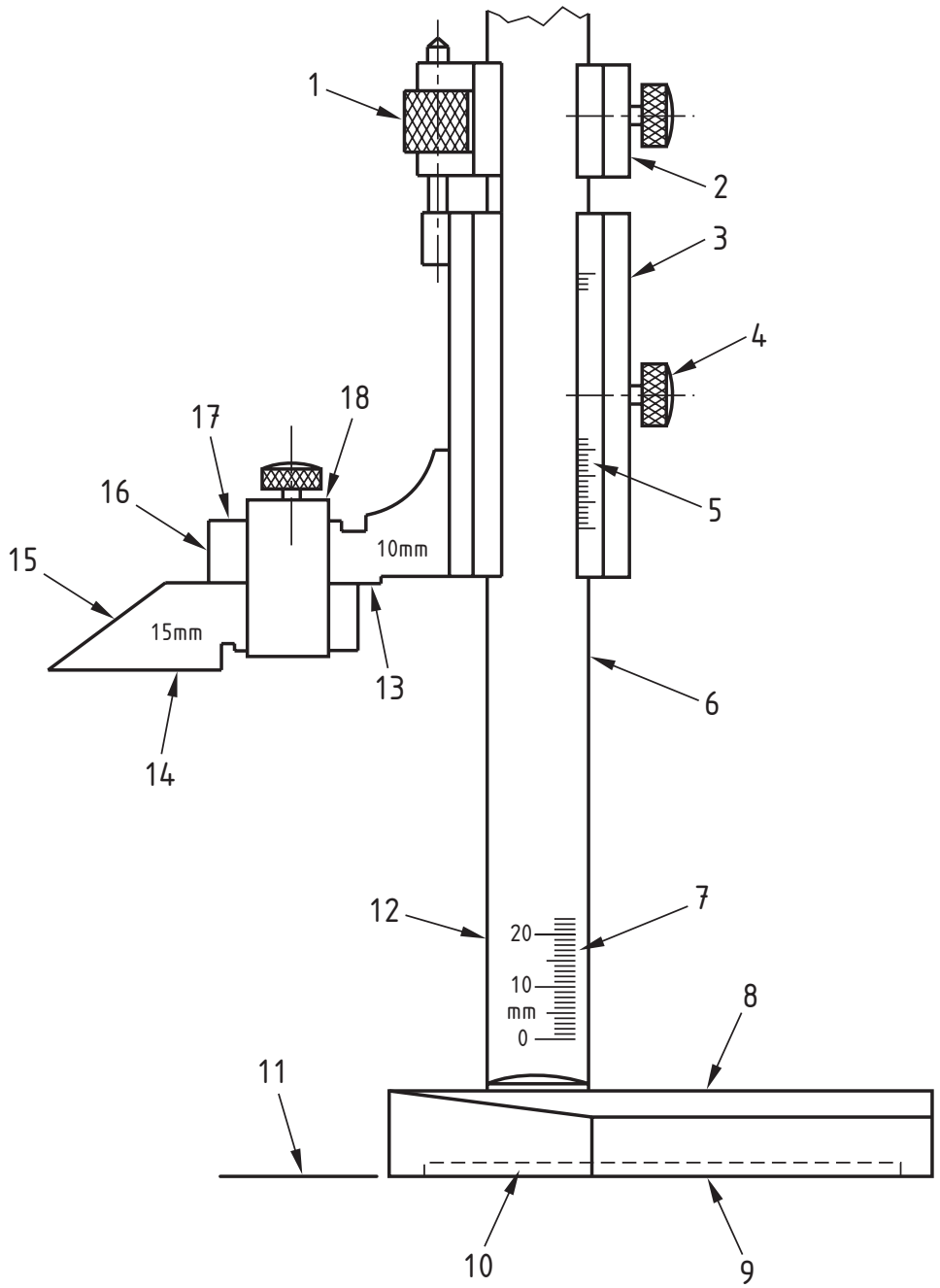
NOTE The components of a precision vernier height gauge are illustrated in Figure 1, which also gives the nomenclature.

3.1 measuring range
range of heights that the gauge can be used to measure without the vernier scale extending beyond the main scale

3.2 zero datum surface
plane that supports both height gauge and the object to be assessed for height

3.3 deviation of reading
difference between the actual height of a designated measuring face above the zero datum surface and the vernier reading

Figure 1 **Example and nomenclature of a precision vernier height gauge**



Key

1	Fine adjustment	7	Main scale	13	Measuring face [see **4.8** b)]
2	Fine adjustment clamp	8	Base	14	Measuring face [see **4.8** c)]
3	Slider	9	Base datum	15	Scriber
4	Locking mechanism (e.g. locking screw)	10	Relief	16	Measuring jaw
5	Vernier scale	11	Zero datum plane	17	Measuring face [see **4.8** a)]
6	Beam	12	Guiding edge	18	Scriber clamp

NOTE The illustrations are not intended to specify details of design.

4 Construction

4.1 Material

The principal components shall be of carbon steel or stainless steel. The coefficient of thermal expansion within the temperature range of 10 °C to 30 °C shall be within $(11.5 \pm 1.0) \times 10^{-6}$/°C. The measuring faces of the sliding jaw and the underside of the base shall be hardened to not less than 700 HV for carbon steel and not less than 500 HV for stainless steel. The scriber shall be hardened throughout to not less than 700 HV. Finished height gauges shall be free from internal stresses.

4.2 Measuring ranges

The measuring ranges shall be as shown in Table 1.

Table 1 **Measuring ranges**

Metric	**Imperial**
mm	in
0 to 300	0 to 12
0 to 450	0 to 18
0 to 600	0 to 26
0 to 1 000	0 to 36
	0 to 48

4.3 Beam

When tested in accordance with **A.5**, any recorded deflection shall be not greater than 0.05 mm, and the cross section of the beam shall be such as to ensure rigidity during measurement and marking out. The beam shall be long enough to prevent overhang of the slide assembly at the nominal measuring range.

4.4 Base

The base shall be of sufficient size to ensure the stability of the gauge. It shall be relieved on the underside, leaving a surface around the outside edge at least 5 mm or 0.25 in wide and shall have an air groove machined across this surface. The base datum shall have a surface texture less than 0.1 µm *Ra* or 4 µin *Ra* at a sampling length of 0.8 mm. When tested in accordance with **A.4**, any departure from flatness shall be of a concave nature and shall not exceed 0.005 mm or 0.000 2 in as measured over the length or width of the base. Sharp edges shall be removed.

4.5 Slider

The slider shall be a good sliding fit over the full working height of the gauge and shall not move under its own weight. A fitting shall be incorporated to give fine adjustment of the slider. A locking mechanism shall be provided on the slider so that it can be effectively locked after fine adjustment has been made and in such a manner

that the setting of the vernier scale relative to the main scale is not altered. Parallelism of the measuring faces with a zero datum surface shall remain within its tolerance upon clamping or locking the slider.

4.6 Measuring jaw

The projection of the measuring jaw from the guiding edge of the beam shall be not less than the projection of the base from the guiding edge of the beam. For all positions of the slider on the beam, the gauging surfaces of the measuring jaw shall be flat and parallel to a zero datum surface within 0.008 mm or 0.000 3 in when tested in accordance with **A.3** and **A.6** and shall have a surface texture less than 0.1 µm *Ra* or 4 µin *Ra* at a sampling length of 0.8 mm. When the design of the instrument requires the depth of the measuring jaw to be taken into account when setting or reading, the measuring jaw shall be marked clearly with its depth, and its measured depth shall be within 0.01 mm or 0.000 4 in of the marked size.

4.7 Scriber

The measuring faces of the scriber shall be flat and parallel to within 0.005 mm or 0.000 2 in when tested in accordance with **A.3** and **A.6** and shall have a surface texture less than 0.1 µm *Ra* or 4 µin *Ra* at a sampling length of 0.8 mm.

The projection of the scriber beyond the end of the measuring jaw shall be at least 25 mm or 1 in.

When the design of the instrument requires the depth of the scriber to be taken into account when setting or reading, the scriber shall be marked clearly with its depth, and its measured depth shall be within 0.01 mm or 0.000 4 in of the marked size.

A clamping device shall be provided to locate and retain the scriber in position on the measuring jaw.

4.8 Measuring face

A height gauge shall have one or more of the following designated as measuring faces (see Figure 1).

a) The top face of the measuring jaw.

b) The lower face of the measuring jaw.

c) The underside of a scriber allowing the instrument to read zero when the underside of the scriber is coplanar with the base datum.

4.9 Setting block

If the height gauge will not permit direct reading from zero with the manufacturer's scriber clamped to the measuring jaw, a setting block shall be provided for checking the scale and vernier reading at one position. It shall have hardened faces, flat and parallel to within 0.005 mm or 0.000 2 in, and its mean measured length shall agree with its marked size to within 0.005 mm or 0.000 2 in.

5 Scales

5.1 General

The layout of the main scale and vernier scale shall be as shown in Table 2 or Table 3. The minimum length of the main scale shall be the nominal measuring range of the instrument plus the length of the vernier scale.

Provision shall be made for re-setting the zero position.

NOTE It is recommended that for ease of reading, the surface of the beam and vernier should have a dull finish, and the graduated lines should be black.

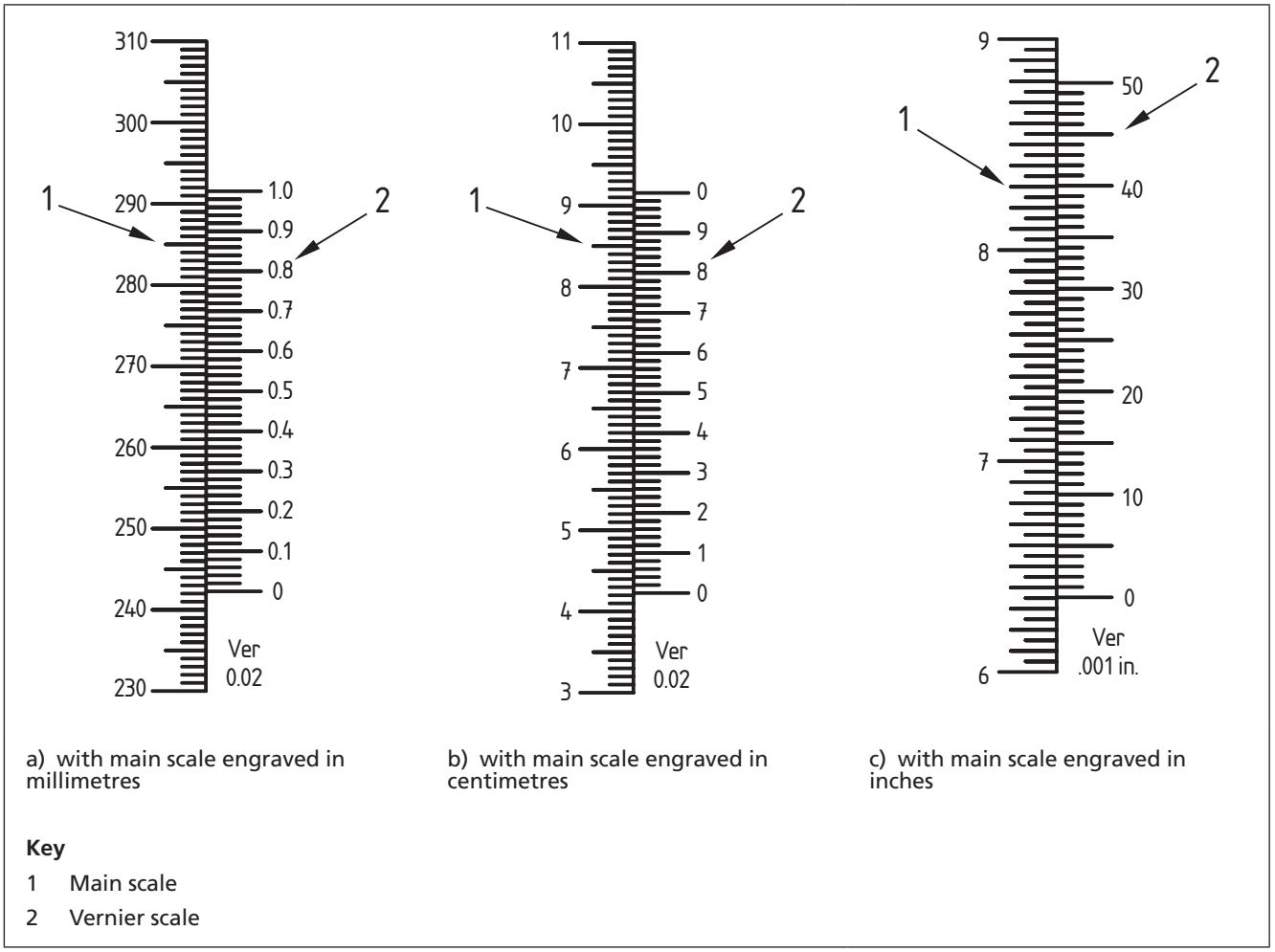
Table 2 **Layout of scales – Metric scales**

Main scale		Vernier scale			
Graduations	**Graduations and numbering**	**Number of divisions**	**Length**	**Graduations and numbering**	**Other marking**
1 mm intervals [see Figure 2 a)]	Each 5 mm line extended. Zero and each 10 mm line extended and numbered: 0 10 mm 20 30 40 50 etc.	50	49 mm	Zero and each 5th line extended and numbered: 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0	VER 0.02 mm
1 mm intervals [see Figure 2 b)]	Each 5 mm line extended. Zero and each 1 cm line extended and numbered: 0 1 cm 2 3 4 5 6 etc.	50	49 mm	Zero and each 5th line extended and numbered: 0 1 2 3 4 5 6 7 8 9 0	VER 0.02 mm

Table 3 **Layout of scales – Imperial scales**

Main scale		Vernier scale			
Graduations	**Graduations and numbering**	**Number of divisions**	**Length**	**Graduations and numbering**	**Other marking**
0.050 in intervals [see Figure 2 c)]	Zero and each inch line extended and numbered: 0 1 in 2 3 4 5 6 etc. Each 0.1 in line extended	50	2.450 in	Each 5th line extended. Zero and each 10th line extended and numbered: 0 10 20 30 40 50	VER 0.001 in

Figure 2 **Enlarged view of vernier scales**



a) with main scale engraved in millimetres

b) with main scale engraved in centimetres

c) with main scale engraved in inches

Key

1 Main scale

2 Vernier scale

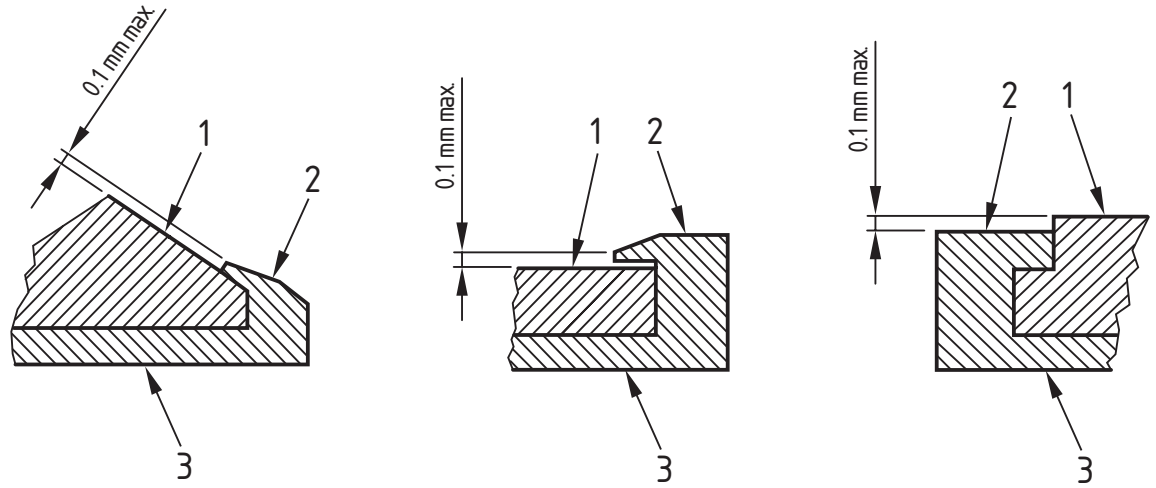
5.2 Graduation marks

The main scale and vernier scale graduation marks shall be clear and square to the edge of the beam and the width of the marks shall be not less than 0.08 mm or 0.003 in and not more than 0.18 mm or 0.007 in. The variation of line thickness shall not exceed 0.05 mm or 0.002 in throughout an instrument when checked in accordance with **A.7**.

5.3 Fitting of vernier scale with main scale

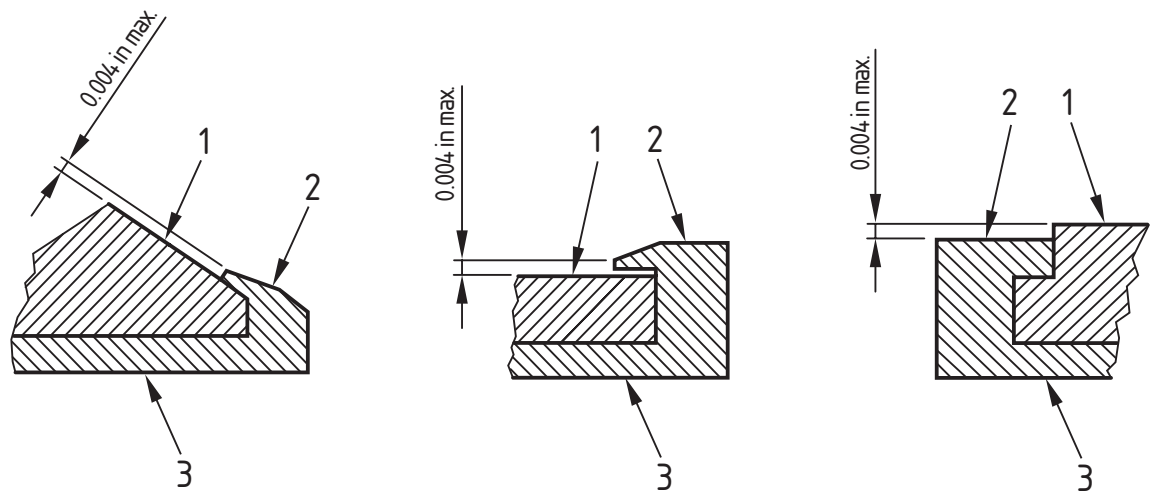
The distance from the graduated face of the beam to the edge of the graduated face of the vernier shall not exceed 0.1 mm or 0.004 in (see Figure 3).

Figure 3 **Distance of vernier from main scale**



Overlaid vernier — Overlaid vernier — Edge to edge vernier

a) Metric



Overlaid vernier — Overlaid vernier — Edge to edge vernier

b) Imperial

Key

1 Beam
2 Vernier
3 Slider

5.4 Marking (other than graduation marks)

The beam shall be marked with the unit symbol of the scale figures, i.e. either a) mm or cm, or b) in.

The vernier scale shall be marked with the value of a vernier division, i.e. VER 0.02 mm or VER 0.001 in.

Each height gauge shall have clearly and permanently marked upon it, in characters not less than 1 mm high, the manufacturer's name or trade mark.

6 Accuracy of reading

The deviation of reading at any position within the measuring range of the height gauge shall be not greater than that specified in Table 4 or Table 5 when tested in accordance with the method given in **A.2**.

Table 4 **Deviation of reading – Metric**

Measured height	**Maximum deviation of reading**
mm	mm
> 0 ⩽ 300	± 0.02
> 300 ⩽ 600	± 0.04
> 600	± 0.06

Table 5 **Deviation of reading – Imperial**

Measured height	**Maximum deviation of reading**
in	in
> 0 ⩽ 12	± 0.001
> 12 ⩽ 24	± 0.001 5
> 24	± 0.002

7 Protection

Each height gauge shall be supplied in a suitable protective case and, as a protection against climatic conditions, shall be coated with a thin non-corrosive oil and securely wrapped.

Annex A (normative) Methods of test

A.1 Zero datum

Throughout the tests the zero datum surface shall be a Grade 0 surface plate conforming to BS 817.

A.2 Deviation of reading

Check the deviation of reading of the height gauge by comparison with a known standard at a minimum of five approximately equally spaced positions which cover the measuring range of the instrument and the vernier scale.

A.3 Parallelism

Carry out the test for parallelism of the measuring faces to the datum plane by sliding the height gauge on a Grade 0 surface plate and presenting the measuring faces to a dial test indicator (see BS 2795) fixed in relation to the surface plate. The magnification of the indicator is to be at least ×350.

A.4 Flatness of the base

A.4.1 General

Examine the flatness of the base datum by means of an optical flat and, if necessary, confirm by the tests given in **A.4.2** and **A.4.3**.

A.4.2 Convexity

Place the height gauge on a Grade 0 surface plate and position a dial test indicator on the designated measuring face. Apply a hard downward pressure on the back of the base and then on the front of the base. Any movement of the dial test indicator reading will then show if the base is convex.

A.4.3 Concavity

Support the base at triangular extremities of the base on three 10.0 mm gauge blocks (see BS EN ISO 3650) situated on a Grade 0 surface plate. Observe whether a 10.005 mm gauge block combination enters freely at any point of the periphery of the base.

A.5 Check for rigidity

With the base held firmly in contact with a Grade 0 surface plate and the slider set at the nominal maximum range of the instrument and locked in position, apply a downward force of 10 N to the scriber at a point approximately 70 mm from the nearer beam edge. Measure the deflection at a point on the underside of the scriber 75 mm from the nearer beam edge.

A.6 Flatness of the working surfaces of the measuring jaw and scriber

Check the flatness of the working surface of the measuring jaw and scriber by applying a dial test indicator or an optical flat.

A.7 Scale lines

Check the thickness of main scale lines and vernier scale lines either by using a measuring machine or with a microscope fitted with a micrometric device.

Bibliography

BS 2795, *Specification for dial test indicators (lever type) for linear measurement*

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

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