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# INTERNATIONAL STANDARD



# 3650

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## Gauge blocks

*Cales-étalons*

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# Gauge blocks

## 1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the most important dimensional and quality characteristics of gauge blocks with a rectangular cross-section and a length ranging from 0,5 up to and including 1 000 mm.

Deviations and tolerances are specified for four grades of accuracy, i.e. 00, 0, 1 and 2, and information concerning a "calibration" grade is given, thus providing for gauge blocks

used solely for measuring the lengths of other gauge blocks by comparison, as well as for gauge blocks used for a variety of measuring purposes.

## 2 NOMENCLATURE, TERMINOLOGY AND DEFINITIONS

### 2.1 Nomenclature of gauge blocks

See figure 1.

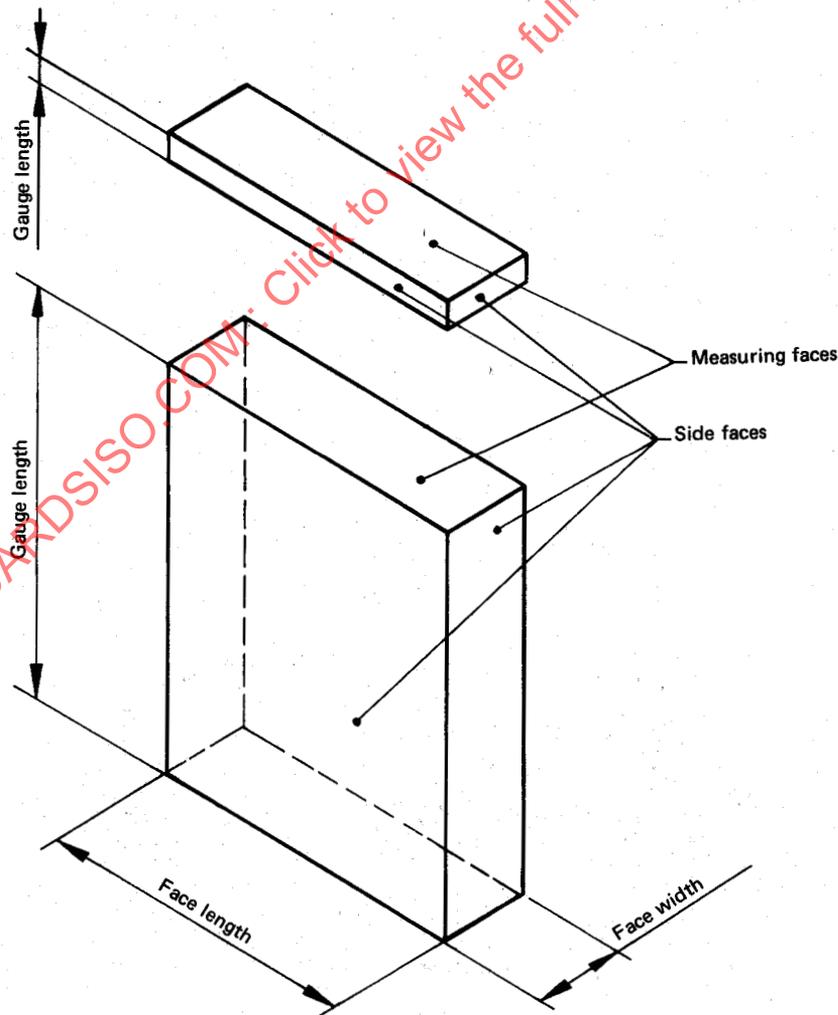


FIGURE 1 – Nomenclature

**2.2 gauge block** : A block of rectangular section, made of durable material, with one pair of plane, mutually parallel measuring surfaces.

NOTE — It is a characteristic of a gauge block that the measuring faces are made with such surface quality that they will adhere to measuring faces of other gauge blocks or to similarly finished plane surfaces. (Adhering is commonly described as "wringing"; see 2.7.)

**2.3 length of a gauge block** : The length of a gauge block at a particular point of the measuring face is the perpendicular distance between this point and a rigid plane surface of the same material and surface texture upon which the other measuring face has been wrung (see figure 2).

NOTES

- 1 The length takes into account one wringing.
- 2 Requirements for the conditions of measurement by interferometry and by comparison are given in annex B.

**2.4 central length** : The length of a gauge block according to 2.3, taken at the centre point of a measuring face.

**2.5 deviation from flatness** : The minimum distance between two parallel planes which just envelop the measuring face (see figure 3).

**2.6 variation in length** : The difference between the maximum and minimum lengths at any points on the measuring faces of a gauge block (see figure 4).

**2.7 wringing** : The property of the measuring faces of a gauge block enabling them to adhere to other similarly flat and well-finished surfaces by molecular forces.

**3 BASIS OF MEASUREMENT**

**3.1** The unit of length, the metre, is defined as equal to 1 650 763,73 wavelengths in vacuum of the unperturbed radiation corresponding to the transition between the levels  $2p_{10}$  and  $5d_5$  of the krypton atom of mass number 86 (11th General Conference of Weights and Measures, 1960). In practice, this wavelength may be produced by means of a  $^{86}\text{Kr}$  gas discharge lamp (Engelhard lamp) under specified conditions of operation.

**3.2** When a gauge block of high grade is to be used as a reference standard of length, i.e. for transference of length to other gauge blocks by use of a comparator, then its lengths, as defined in 2.3, and located at the centre of the block, shall be measured in terms of wavelengths of light using the method known as interferometry (see annex B).

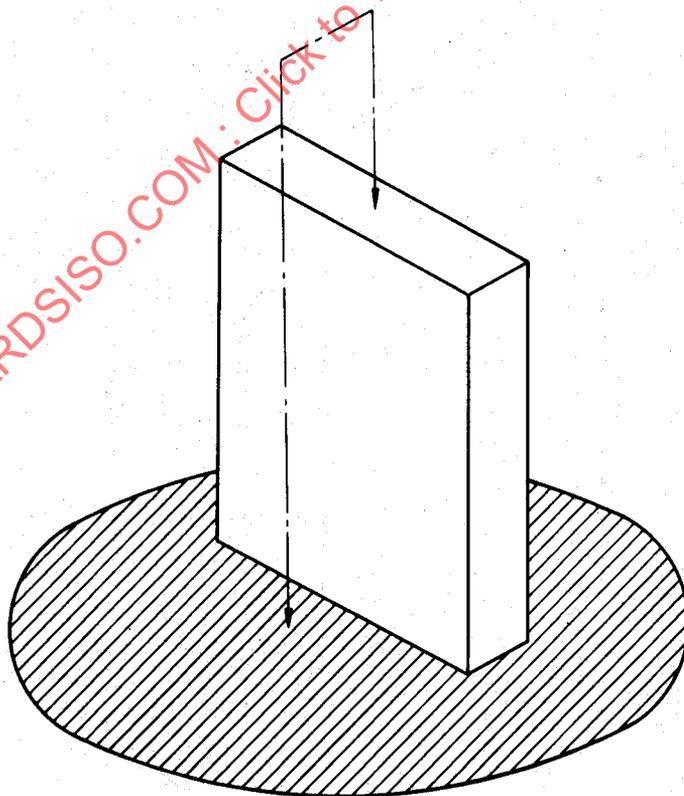


FIGURE 2 — Length of a gauge block

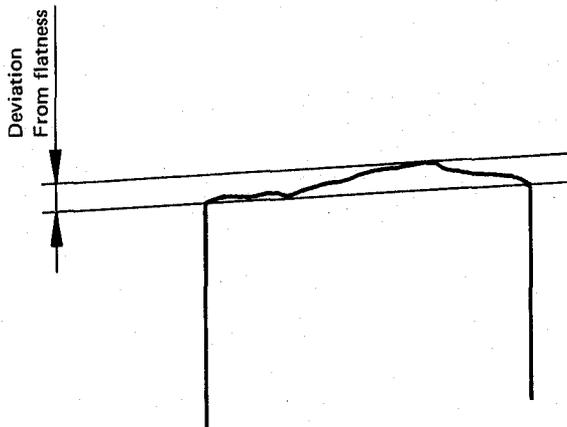


FIGURE 3 – Deviation from flatness (see table 3)

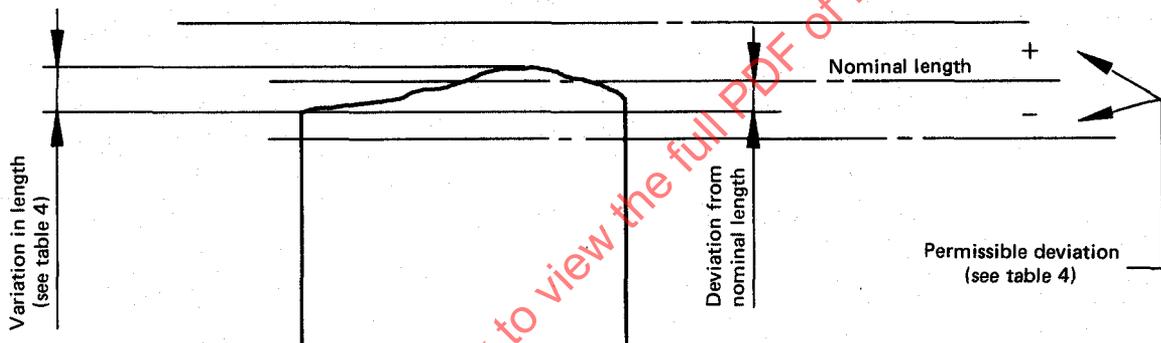


FIGURE 4 – Variations in length (see table 4)

3.3 The nominal length and measured length of a gauge block apply at the reference temperature of 20 °C and standard air pressure of 101,325 kPa (1 013,25 mbar).

NOTE – The effect on the length of a gauge block of variations from the standard air pressure encountered under normal atmospheric conditions may be ignored.

3.4 The lengths of gauge blocks up to and including 100 mm refer to the length of the gauge block in the vertical position, i.e. with the measuring faces horizontal.

The lengths of gauge blocks over 100 mm refer to the length of the gauge block in the horizontal position, the block being supported on one of the smaller side faces without additional stress by two suitable supports, each at a distance of 0,211 times the nominal length from the ends.

4 GENERAL DIMENSIONS, MATERIAL AND MARKING

4.1 General dimensions

The dimensions of the cross-section and their tolerances are given in table 1.

TABLE 1

Values in millimetres

Cross-section	Nominal length, <i>l</i>		Face length	Face width
	over	up to and including		
	–	10,1	30 <sup>0</sup> <sub>–0,3</sub>	9 <sup>–0,05</sup> <sub>–0,2</sub>
	10,1	1 000	35 <sup>0</sup> <sub>–0,3</sub>	

Where longer gauge blocks are provided with holes for coupling blocks together and for supporting the wrung joint, the dimensions and location shall be as shown in figure 5.

NOTE — Gauge blocks of nominal lengths below 1 mm may be made with sections other than 30 mm × 9 mm.

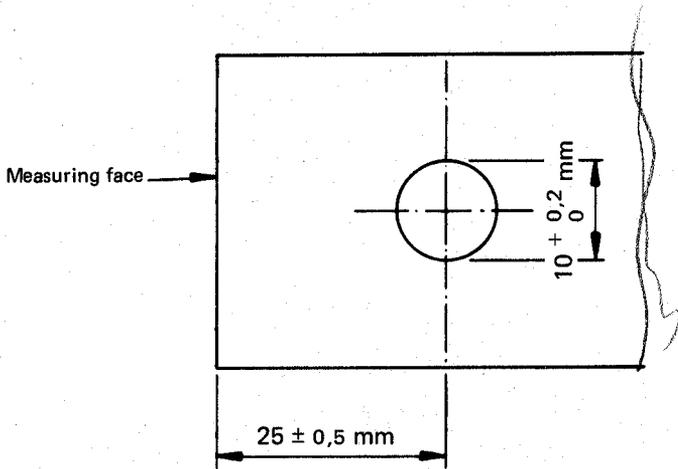


FIGURE 5 — Position of hole for coupling longer gauge blocks

4.2 Material

4.2.1 Gauge blocks shall be made of a wear-resistant material, capable of being worked to give a fine finish that will readily wring and which by nature, or when suitably treated, will be constant in length.

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

If other materials are used, the manufacturer shall state the coefficient of expansion and its limits.

4.2.3 The surface hardness of the measuring faces of steel gauge blocks shall be not less than 800 HV.

4.2.4 When gauge blocks are made of materials other than steel, the physical properties of these materials (coefficient of expansion, modulus of elasticity, etc.) shall be given by the manufacturer and shall be taken into account as appropriate.

4.2.5 Dimensional stability of a material shall be confirmed by tests on samples over a period, during which the temperature of the samples shall be kept within the range 10 to 30 °C, and the influence of other forces such as vibration, shock and magnetic fields shall be avoided.

The maximum permissible changes in length are given in table 2; the period of test shall be sufficiently long for any change in length to be distinguishable from the accuracy of measurement of length.

TABLE 2

Values in micrometres (µm)

Grades	Maximum permissible change in length per year
00 0	$\pm (0,02 + 0,000 5 l)$
1 2	$\pm (0,05 + 0,001 l)$

*l* = nominal length in millimetres

4.3 Marking

Each gauge block shall be legibly and permanently marked with its nominal size, in figures at least 1,5 mm high, and with the name of the manufacturer, or a trademark.

Gauge blocks smaller than 6 mm nominal length may be marked on a measuring face but an area of 9 mm × 12 mm at the centre of the measuring faces shall be left clear of any marking.

Grades 00, 0 and "calibration grade" blocks shall be marked with a serial number.

It is desirable for gauge blocks of other grades also to be identifiable.

Gauge blocks of nominal lengths greater than 100 mm shall bear marks located  $(0,211 \times l)$  mm from the measuring faces, indicating the support positions (see 3.4).

5 ACCURACY

5.1 General

Each gauge block shall conform to the requirements for accuracy appropriate to its grade, as given below.

The requirements for accuracy apply to an area of the measuring face omitting a border zone of 0,8 mm maximum, as measured from the side faces.

In this excluded border zone the surface shall not lie above the plane of the measuring face.

The requirements specified below are related in all cases to the definitions in clause 2, the basis of measurement in clause 3 and the conditions of measurement set out in annex B.

NOTE — In addition to the four grades for which deviations and tolerances are given in tables 3 and 4, a grade known as "calibration grade" is also recognized. Blocks of this grade are intended solely for calibrating other gauge blocks where it is the actual length of the block that is used in computations. For this reason it is therefore less important that it should be very close to nominal than that it should be accurately known. "Calibration grade" blocks are thus required to have a high quality of geometrical form but relatively large deviations from nominal length are permissible and these blocks shall comply with Grade 00 tolerances for flatness and variation in length and Grade 1 deviations from nominal length. Each block of this grade shall be supplied with a calibration certificate stating its measured length.

5.2 Flatness tolerance

5.2.1 Gauge blocks greater in nominal length than 2,5 mm

The deviation from flatness of each measuring face of a gauge block of nominal length greater than 2,5 mm shall not exceed the value given in table 3 for the appropriate grade. This requirement shall apply whether the gauge block is wrung to a rigid plane surface or is in the unwrung state.

5.2.2 Gauge blocks 2,5 mm in length or smaller

Gauge blocks 2,5 mm in nominal length or smaller shall be tested when wrung to the rigid plane surface of an auxiliary body with a thickness of at least 11 mm. With the gauge block in this condition, the deviation from flatness of each measuring face shall not exceed the value given in table 3 for the appropriate grade.

With the gauge block in the unwrung state, each measuring face shall be flat to within 4 µm.

5.3 Variation in length

The variation in length of a gauge block shall not exceed the tolerance given in table 4 for the appropriate grade (see figure 4).

TABLE 3

Nominal length mm		Maximum permitted deviation from flatness µm			
		Grade			
over	up to and including	00	0	1	2
—	150	0,05	0,10	0,15	0,25
150	500	0,10	0,15	0,18	0,25
500	1 000	0,15	0,18	0,20	0,25

5.4 Deviation from nominal length at any point

The deviation from nominal length, at any point, shall not exceed the tolerances for the appropriate grade given in table 4, i.e. any point on the measuring face of the gauge block must lie between two parallel planes whose distance apart does not exceed the tolerances specified in table 4 (see figure 4).

TABLE 4

1	2	3	4	5	6	7	8	9	10
Range of nominal lengths mm		Tolerances and permissible variations, µm							
		Grade 00		Grade 0		Grade 1		Grade 2	
		Tolerances on nominal length at any point	Permissible variation in length						
over	up to and including								
—	10	± 0,06	0,05	± 0,12	0,10	± 0,20	0,16	± 0,45	0,30
10	25	± 0,07	0,05	± 0,14	0,10	± 0,30	0,16	± 0,60	0,30
25	50	± 0,10	0,06	± 0,20	0,10	± 0,40	0,18	± 0,80	0,30
50	75	± 0,12	0,06	± 0,25	0,12	± 0,50	0,18	± 1,00	0,35
75	100	± 0,14	0,07	± 0,30	0,12	± 0,60	0,20	± 1,20	0,35
100	150	± 0,20	0,08	± 0,40	0,14	± 0,80	0,20	± 1,60	0,40
150	200	± 0,25	0,09	± 0,50	0,16	± 1,00	0,25	± 2,00	0,40
200	250	± 0,30	0,10	± 0,60	0,16	± 1,20	0,25	± 2,40	0,45
250	300	± 0,35	0,10	± 0,70	0,18	± 1,40	0,25	± 2,80	0,50
300	400	± 0,45	0,12	± 0,90	0,20	± 1,80	0,30	± 3,60	0,50
400	500	± 0,50	0,14	± 1,10	0,25	± 2,20	0,35	± 4,40	0,60
500	600	± 0,60	0,16	± 1,30	0,25	± 2,60	0,40	± 5,00	0,70
600	700	± 0,70	0,18	± 1,50	0,30	± 3,00	0,45	± 6,00	0,70
700	800	± 0,80	0,20	± 1,70	0,30	± 3,40	0,50	± 6,50	0,80
800	900	± 0,90	0,20	± 1,90	0,35	± 3,80	0,50	± 7,50	0,90
900	1 000	± 1,00	0,25	± 2,00	0,40	± 4,20	0,60	± 8,00	1,00

**5.5 Measuring faces**

The measuring faces shall be free from surface defects likely to have an adverse effect on the use of the gauge block. Fine lapping scratches without burrs may be accepted when they do not affect the wringing quality or accuracy.

The measuring faces of all gauge blocks shall wring readily.

The edges of the measuring faces shall be rounded to a radius not exceeding 0,3 mm or chamfered 0,3 mm and smoothly rounded between the chamfer and the measuring face by a process that does not impair the wringing property of the measuring faces.

**5.6 Side faces**

**5.6.1 Flatness**

The deviation from flatness of the side faces (i.e. the distance between two parallel planes which just envelop the side face) shall not exceed 80 µm for gauge blocks of nominal lengths up to and including 100.

For longer lengths the deviation expressed in micrometres shall be

$$80 + 0,08 l$$

where  $l$  is the nominal length in millimetres.

**5.6.2 Parallelism**

The deviation from parallelism of the side faces (i.e. the difference between the measurements of the distance between the side faces concerned taken at the ends of the gauge block) shall not exceed 40 µm for gauge blocks of

nominal lengths up to and including 100 mm.

For longer lengths the tolerance expressed in micrometres shall be

$$40 + 0,04 l$$

where  $l$  is the nominal length in millimetres.

**5.6.3 Squareness**

The side faces shall be square to the measuring face to within the tolerances stated in table 5 (see also figure 6).

TABLE 5

Nominal length mm		Deviation from squareness
over	up to and including	µm
10	25	50
25	60	70
60	150	100
150	400	140
400	1 000	180

The side faces shall be mutually square to within 10'.

**5.6.4 Edges**

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

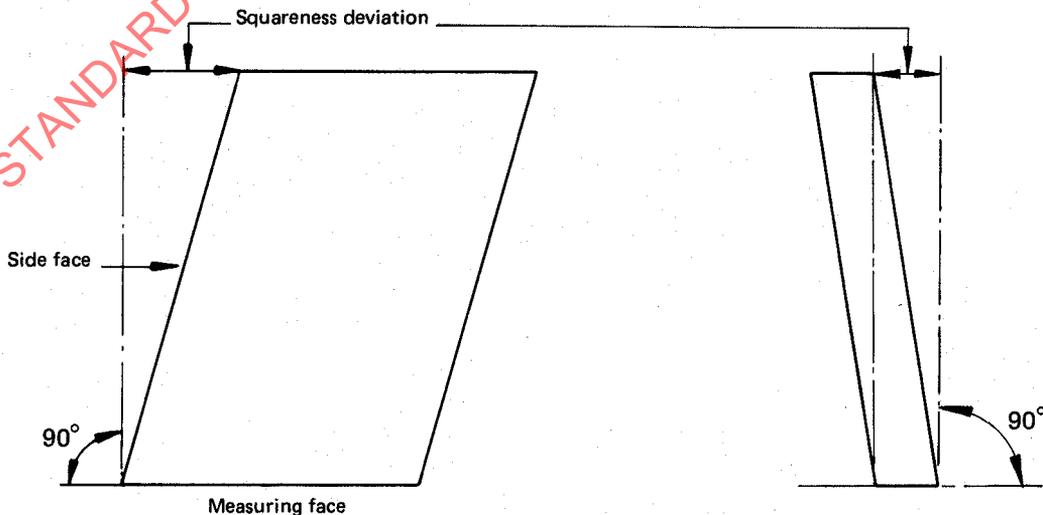


FIGURE 6 – Squareness deviation

## ANNEX A

## DERIVATION OF TOLERANCES – FORMULAE

A.1 The tolerance values specified in table 4 for the permissible deviation of the measured length from the nominal length are calculated from the formulae in table 6.

TABLE 6

Deviations in micrometres ( $\mu\text{m}$ )

Grade	Deviation of measured length from nominal length Formula
00	$\pm (0,05 + 0,001 l)$
0	$\pm (0,10 + 0,002 l)$
1	$\pm (0,20 + 0,004 l)$
2	$\pm (0,40 + 0,008 l)$

$l$  is the maximum nominal length for each range (columns 1 and 2 in table 4) expressed in millimetres.

The calculated values are rounded in accordance with the conventions in clause A.3.

A.2 The values specified in table 4 for permissible variation in length are calculated from the formulae in table 7.

$l$  is the maximum nominal length for each range (columns 1 and 2 in table 4) expressed in millimetres.

The calculated values are rounded in accordance with the conventions in clause A.3.

TABLE 7

Tolerances in micrometres ( $\mu\text{m}$ )

Grade	Variation in length Formula
00	$(0,05 + 0,000 2 l)$
0	$(0,10 + 0,000 3 l)$
1	$(0,16 + 0,000 45 l)$
2	$(0,30 + 0,000 7 l)$

A.3 The conventions for rounding the calculated tolerances given in table 4 are given in table 8.

TABLE 8

Values in micrometres ( $\mu\text{m}$ )

Magnitude of tolerance		Rounded down to
over	up to and including	
—	0,1	0,01
0,1	0,2	0,02
0,2	0,5	0,05
0,5	2	0,10
2	5	0,20
5	10	0,50
10	—	1,00

ANNEX B

**CONDITIONS FOR THE MEASUREMENT OF LENGTH**  
(See clauses 2 and 3)

**B.1 GENERAL**

The length of a gauge block may be measured by interferometry (or a method capable of giving equivalent results) or by comparison with a gauge block used as a reference standard but it will be noted that sub-clause 3.2 requires gauge blocks that are used as reference standards of length to be measured by interferometry. In practice, these are likely to be blocks of Grades 00 and "calibration grade".

Conditions for the measurement of length by both methods are described below.

**B.2 MEASUREMENT BY INTERFEROMETRY**

**B.2.1** To comply with the requirements of 3.2, the length  $L$  is measured at the centre of the block (see figure 7).

**B.2.2** To fulfil the requirements of sub-clause 2.3, the rigid plane surface to which the measuring face is wrung

must be of the same material and surface texture as the measuring face to which the interferometric measurements are being made.

The auxiliary body providing this surface shall have a thickness of at least 11 mm and the surface shall be flat to within 0,025  $\mu\text{m}$  over a diameter of 40 mm and shall not be concave.

When the gauge block is measured in the horizontal position and the auxiliary body is wrung to one measuring face, the mass of the auxiliary body must be compensated for.

**B.2.3** The results of a measurement of length by interferometry should be corrected for possible departures from ideal conditions of measurement, for example :

- effects of temperature, barometric pressure and humidity upon wavelengths in air;
- effects of temperature and barometric pressure or of optical phase shift on the length.

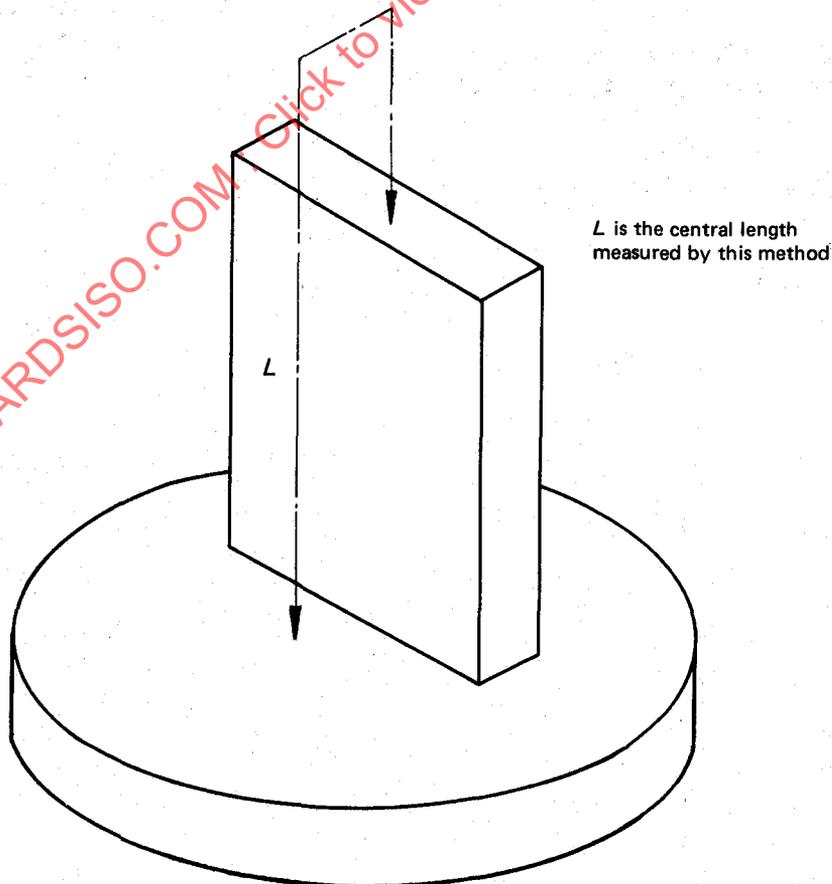


FIGURE 7 – Central length measured by interferometry