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Incorporating Corrigendum No. 1

BSI British Standards

Specification for dial gauges for linear measurement

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COR 1	August 2009	Table 1, Figure A.1

Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 14, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 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This British Standard supersedes BS 907:1965, which is withdrawn.

Relationship with other documents

BS EN ISO 463 specifies the most important design and metrological characteristics of mechanical dial gauges.

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.

1 Scope

This British Standard specifies requirements for dial gauges with the plunger movement parallel to the plane of the dial.

The standard is applicable to gauges having dial diameters from 47.6 mm or 1⅞ in to 63.5 mm or 2½ in, as measured from the outside of the scale marks, and scale divisions of 0.01 mm, 0.001 in (sometimes sub-divided into half divisions of 0.000 5 in, in which case they are commonly designated "0.000 5 in gauges") or 0.000 1 in.

NOTE 1 Attention is drawn to the fact that the metric dimensions are not necessarily direct conversions of the imperial dimensions.

NOTE 2 Recommended dimensions for dial gauges are given in Annex A (Figure A.1) and notes on methods of testing and on the care and use of dial gauges are given in Annex B and Annex C respectively.

2 Terms and definitions

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

NOTE The components of a dial guage are illustrated in Figure 1, which also gives the nomenclature.

2.1 minimum scale value
smallest value of the measured quantity which the scale is graduated to indicate

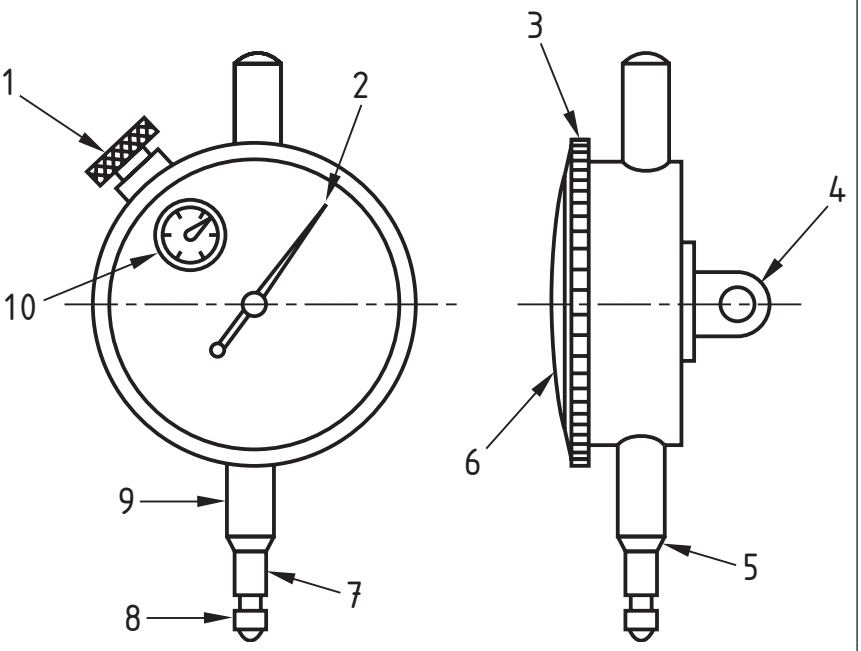
2.2 scale division
part of a scale delimited by two adjacent scale marks

2.3 discrimination
sensitiveness of an instrument, the smallest change in the quantity measured which produces a perceptible movement of the pointer

2.4 repeatability
reproducibility of the readings of an instrument when a series of tests is carried out in a short interval of time under fixed conditions of use

2.5 limit of error
positive and/or negative value of error which is not to be exceeded under test

Figure 1 **Nomenclature of dial gauges**



Key

1	Bezel clamp	6	Transparent dial cover (or crystal)
2	Pointer	7	Plunger
3	Bezel	8	Removable contact point
4	Back lug	9	Stem
5	Stem bush	10	Revolution counter

3 General features of design

The mechanism shall incorporate some means to eliminate backlash.

The design and rigidity of the case shall be such that the freedom of movement of the mechanism is not impaired by the tightening of the screws used for attaching the back or by the clamping of the stem of the instrument, provided that such clamping is carried out in an appropriate manner.

NOTE 1 See Annex C for recommendations on the care and use of dial gauges.

The transparent dial cover (or crystal) shall be of durable material which will retain its transparency without undue discolouration. Both the transparent dial cover and the case shall be dust proof.

The gauge shall be provided with a satisfactory means of setting to zero.

NOTE 2 If this is achieved by rotation of the bezel then a clamping screw may or may not be provided, but care should be taken to ensure that the setting is maintained on those which have no means of locking.

Back lug fixings shall be square or parallel to the measuring axis of the instrument within 0.150 mm per 25 mm or 0.006 in per inch in the design position.

NOTE 3 Back lug fixings may be integral with the gauge or may be removable.

NOTE 4 Gauges should be fitted with stainless steel plungers and hardened or stainless steel pinions.

NOTE 5 The ranges of movement of the plunger vary with the make and type of gauge, and if the purchaser has any particular requirements in respect of this range of movement, it should be stated at the point of enquiry and order.

4 Dial

4.1 The dial shall be marked with the appropriate minimum scale value, as follows:

a) metric dials: 0.01 mm;

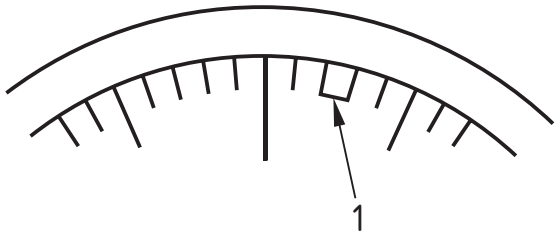
b) inch dials: 0.000 1 in, 0.000 5 in or 0.001 in.

4.2 The scale shall be marked with clear lines on a suitable background so as to be easily read. The thickness of the scale marks shall be uniform and shall be not less than 0.152 mm or 0.006 in or more than 0.254 mm or 0.010 in.

4.3 Every tenth scale mark shall be indicated by a longer line and shall be numbered. Every fifth scale mark (except on a 0.000 5 in dial gauge) shall be indicated by a line slightly less in length. A 0.000 5 in dial gauge shall have alternate scale divisions indicated by a shorter line.

NOTE It is recommended that the length of the visible portion of the scale marks indicating each scale division should be approximately equal to the width of that division as shown in Figure 2 and Figure 3.

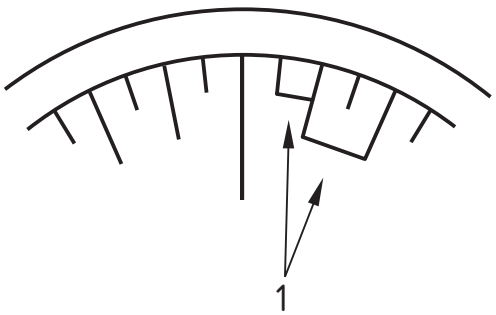
Figure 2 **0.01 mm, 0.000 1 in or 0.001 in dial**



Key

1 Length equals width

Figure 3 **0.000 5 in dial**



Key

1 Length equals width

5 Pointer

5.1 The pointer shall move in a clockwise direction when the plunger is pressed in.

5.2 The pointer shall be attached to its spindle in such a manner as to ensure that there will be no relative movement between them when the spindle is subjected to rapid acceleration or deceleration, as, for example, in the event of the plunger being suddenly released and its motion arrested by a fixed stop.

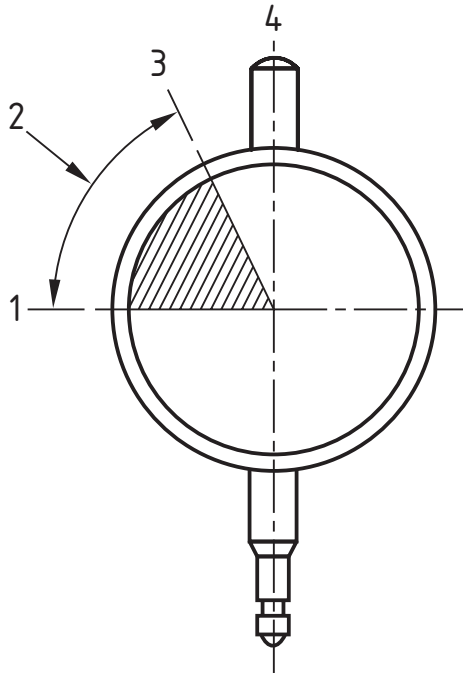
5.3 The length of the pointer shall be such that its tip lies approximately over the centre of the length of the shortest scale marks.

5.4 The thickness of that portion of the pointer immediately over the scale shall not exceed one-fifth of the width of one scale division and should preferably be of approximately the same thickness as the scale mark.

5.5 The pointer tip shall be as close to the scale as practicable in order to minimize parallax errors.

5.6 When the plunger is in the position of rest and the zero mark on the dial is in the 12 o'clock position, the pointer shall lie between the 9 o'clock and 11 o'clock positions (see Figure 4).

Figure 4 **Free position of pointer**



Key

1 9 o' clock
2 Range of the position of pointer when the plunger is in position of rest
3 11 o' clock
4 12 o' clock

6 Revolution counter

When a revolution counter is provided, its pointer shall correctly indicate on its scale the number of revolutions made by the dial guage pointer.

NOTE Preferably the pointer on the revolution counter will move in a clockwise direction.

7 Plunger

7.1 The plunger shall move freely in the stem bush, with any shake, including rotational shake, being insufficient to affect the indication of the instrument by more than the thickness of a scale mark.

7.2 On 0.000 1 in gauges with a travel up to 0.25 in, the working force at any position of the plunger shall not exceed 170 g.

On 0.000 1 in gauges with a travel greater than 0.25 in and up to and including 0.5 in, the working force shall not exceed 227 g.

On 0.000 1 in gauges with a travel greater than 0.5 in, the working force shall be the subject of agreement between manufacturer and purchaser.

NOTE For most purposes the force required to operate a dial gauge should be as light as possible. It should be measured with the gauge in the vertical position and with the plunger going in.

The working force on dial gauges, other than 0.000 1 in gauges, should be of the order of 57 g at the beginning of the movement and any increase in force should not exceed 14 g for each successive 0.1 in or 2.54 mm movement. If lighter or heavier working forces are required on 0.01 mm, 0.001 in and 0.000 5 in gauges they should be as specified by the purchaser.

8 Contact point

The contact point shall have as large a radius as practicable and shall be readily removable from the plunger for the purpose of replacement or the substitution of a contact point of different form.

*NOTE 1 Dial gauges are normally supplied with a hardened spherically formed point. If some other form of point is required, this should be as specified by the purchaser. (See **C.7**.)*

NOTE 2 It is recommended that in all new gauge designs the dimensions of the threads for the attachment of the contact point are in accordance with those given in Figure A.1.

9 Performance

9.1 General

All measurements of the accuracy of performance specified in this Clause shall be referred to the standard reference temperature of 20 °C.

9.2 Repeatability of reading

The gauge shall repeat its readings under all ordinary methods of operation to within 0.002 mm on metric gauges, 0.000 2 in on 0.001 in and 0.000 5 in gauges and 0.000 02 in on 0.000 1 in gauges. (See **C.6**.)

9.3 Discrimination

The gauge shall be capable of indicating small gradual changes as specified in Table 1.

The degree of discrimination specified in Table 1 shall be achieved without resort to tapping the gauge.

Table 1 **Discrimination capability**

Gauge	Discrimination	Tolerance
Metric	0.025 mm	0.003 mm
0.001 in	0.001 in	0.000 3 in
0.000 5 in		
0.000 1 in	0.000 2 in	0.000 04 in

9.4 Limits of error

NOTE 1 Errors permissible in dial gauges differ according to the type of instrument and the magnitude of the difference measured.

Permissable errors for different types of gauges in common use shall be as specified in Table 2, Table 3 and Table 4.

NOTE 2 The performance of the dial gauge, in terms of limt of error, meets specification if the error of indication is not greater than the limits of error specified in Table 2, Table 3 and Table 4, taking into account the uncertainty of measurement according to BS EN ISO 14253-1.

NOTE 3 Since dial gauges are primarily intended for the measuring of small differences in dimensions, the same order of accuracy of the instrument when used for the measuring of small differences in dimensions will not be realized when larger differences are concerned.

The error over an interval of reading may be either plus or minus and the permissible errors shall not be exceeded for either direction of movement of the pointer.

Calibration shall take place from the first 12 o'clock position of the pointer (see Figure 4), unless otherwise specified by the purchaser.

The permissible errors stated in Table 2, Table 3 and Table 4 shall apply to any intervals and are not restricted to those commencing at zero; they shall also embrace any eccentricity of the dial in relation to the axis of rotation of the pointer and shall not be exceeded for any position of the bezel, when this is rotatable.

Table 2 **Limits of error for dials with scale divisions of 0.001 in and 0.000 5 in**

Interval of reading	Error in reading over stated interval
	in
Any 0.01 in	0.000 25
Any half revolution	0.000 5
Any one revolution	0.000 5
Any two revolutions	0.000 75
Any larger interval	0.001

Table 3 **Limits of error for dials with scale divisions of 0.000 1 in**

Interval of reading	Error in reading over stated interval
	in
Any half revolution	0.000 1
Any one revolution	0.000 15
Any two revolutions	0.000 25
Total travel	0.000 7

Table 4 **Limits of error for dials with scale divisions of 0.01 mm**

Interval of reading	Error in reading over stated interval
	mm
Any 0.1 mm	0.005
Any half revolution	0.007 5
Any one revolution	0.01
Any two revolutions	0.015
Any larger interval	0.020

10 Packing

The gauge shall be packed in a suitable carton or box which will protect the mechanism against shock due to possible rough handling in transport.

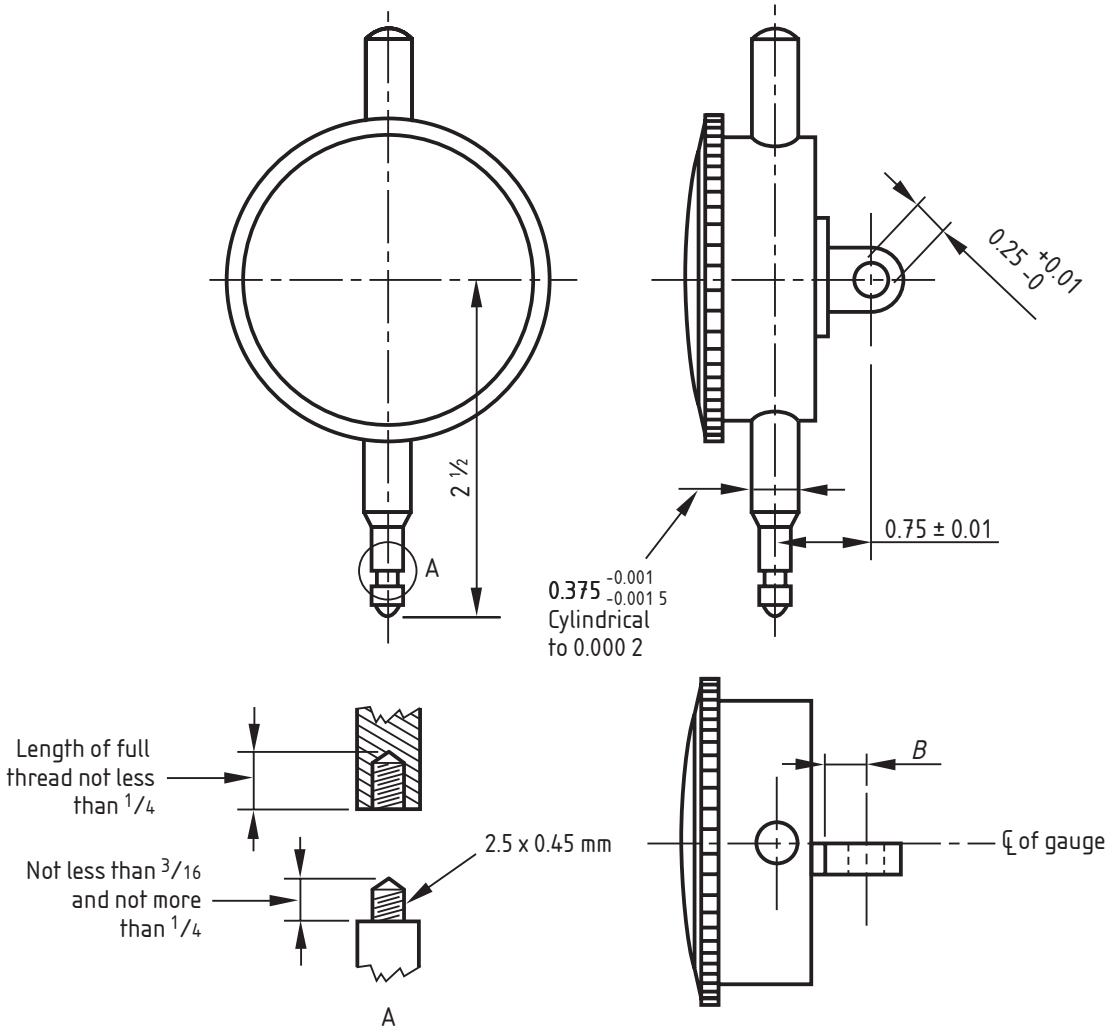
11 Marking

Each gauge shall be legibly and permanently marked with the number of this British Standard, i.e. BS 907:2008[1)], and with the manufacturer's or vendor's name or trade mark.

1) Marking BS 907:2008 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Annex A (informative) Recommended dimensions for dial gauges

Figure A.1 **Dial gauge dimensions**



All dimensions in inches unless otherwise stated.

NOTE 1 Side faces of lug to be finished flat and parallel, the flat surface to extend from the centre of the hole towards the gauge (dimension B) for not less than 5/16 in.

NOTE 2 Lug to be offset so that if the gauge is viewed from the back the right hand face of the lug coincides with the vertical centre plane of the gauge.

Annex B (informative) Notes on methods of testing dial gauges

B.1 Repeatability of reading

For limits of error see **9.2**. The accuracy to which a dial gauge will repeat its readings can be tested by one of the following methods.

a) Having clamped the gauge firmly in a suitable rigid fixture over a flat steel base, roll a true cylinder under the contact-point a number of times from various directions and note the readings. Repeat the test at two or three positions along the range of the gauge. Pass the cylinder through at varying speeds, both slowly and rather abruptly.

b) Allow the contact-point to rest directly upon the flat base below and to note the constancy of the reading obtained when the plunger is lowered on to the base both slowly and abruptly, and when an attempt is made to rotate the plunger first in one direction and then in the other.

B.2 Discrimination

It is important that a dial gauge should be free from any trace of "stickiness" or backlash, particularly when it is used for detecting small errors in alignments, or for testing the accuracy of the centering of a workpiece mounted in a machine. The most practical way of testing a dial gauge for this type of defect is to mount it in a rigid fixture with the end of its plunger in contact with the surface of a slightly eccentric precision mandrel mounted between centres. The actual amount of the eccentricity of the mandrel can be determined beforehand by means of a known sensitive indicator set to read on its surface. For preference the eccentricity should be of the order of only 0.025 mm for 0.01 mm gauges, 0.001 in for 0.001 in gauges and 0.000 2 in for 0.000 1 in gauges. When a dial gauge is tested against such a mandrel it should indicate the amount of eccentricity present to within the accuracy stated in **9.3**.

B.3 Calibration

The calibration of a dial gauge is usually carried out in a fixture in which the gauge is held rigidly opposite and in line with a calibrated micrometer head, or above and normal to a base plate on to which gauge blocks can be wrung. In either case a series of readings is taken at suitable intervals throughout the range of the gauge. If the gauge has a limited range of only two or three turns of its pointer, the readings can be taken at intervals of a tenth of a turn throughout the whole range. Where this is not practical, i.e. in the case of gauges with longer ranges, a limited number of readings may be taken at the interval of one-tenth of a turn during each revolution of the pointer. For example, in the case of a gauge having 100 divisions of 0.001 in and a range of 0.5 in (five turns of the pointer), the readings could be distributed in the manner shown in Table B.1. Each of the readings shown in Table B.1 represents the mean error, found on the instrument tested, at that particular point of observation, the unit being 0.000 1 in, i.e. one tenth of a division.

NOTE Large errors, as shown in Table B.1, are not typical of dial gauges but have been chosen for purposes of clear illustration.

By setting out the readings in this manner, it is a simple matter to compare the results with the limits of error given in Table 2 for this particular type of gauge. It can be seen that the error over none of the 0.01 in intervals tested, i.e. between any two adjacent readings, exceeds the tolerance of 0.000 25 in specified for that interval. On the other hand, over intervals of half a turn, i.e. 50 divisions, the corresponding tolerance of 0.000 5 in is exceeded over the following tested positions:

Turn I	10 to 60	error + 0.000 7 in
Turn III	0 to 50	error + 0.000 6 in
Turn III	60 to Turn IV, 10	error – 0.000 9 in
Turn IV	10 to 60	error + 0.000 8 in.

Over one turn or two turns or any longer interval, the errors are all within the tolerances allowed.

This gauge would be regarded as unsatisfactory on account of the large errors found over some of the half-turn intervals tested.

It is interesting to note that this particular gauge possesses a type of periodic error which is not infrequently met with in this class of measuring tool. To illustrate this point, the results of a test carried out on this gauge at every 10 divisions throughout its range are shown in Figure B.1. It can be seen that the errors in each successive turn are of similar undulatory character. This type of error usually arises from centering errors in the teeth of the pinion to which the pointer is attached, or from the fact that the axis of rotation of the pointer is not truly central with the dial.

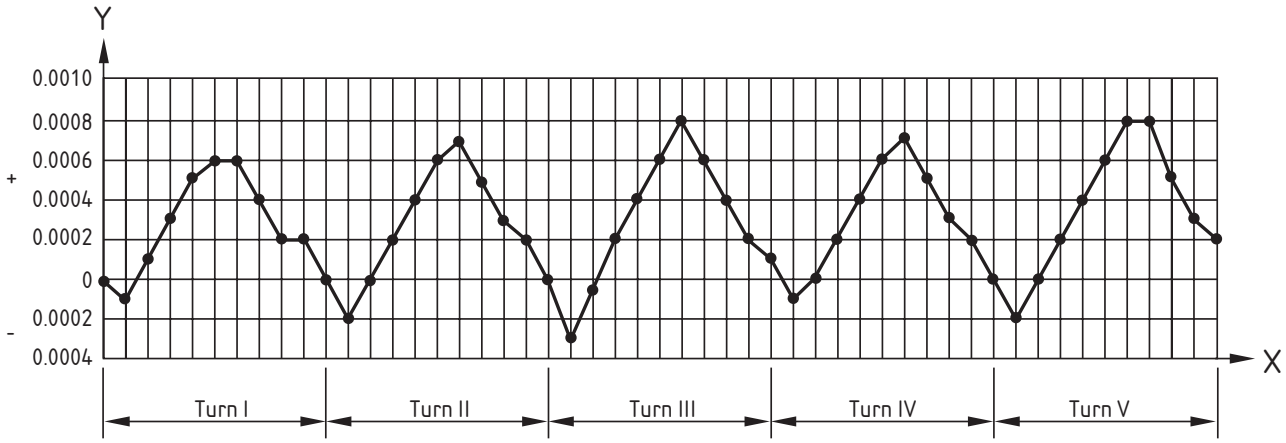
The abbreviated test described above is sufficient to detect this type of periodic error by reason of the large errors found in some of the readings of half-turn intervals.

Where there is any dispute regarding accuracy, the gauge block method should be used, in which case the arithmetical mean of a series of at least five measurements over each of the points in dispute should be taken.

Table B.1 **Error of reading of dial gauge given in units of 0.000 1 in**

Divisions of dial	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
Turn I	0	– 1	+ 1	—	—	—	+ 6	+ 4	+ 2	—
Turn II	—	—	0	+ 2	+ 4	—	—	—	+ 3	+ 2
Turn III	0	—	—	—	+ 4	+ 6	+ 8	—	—	—
Turn IV	+ 1	– 1	0	—	—	—	+ 7	+ 5	+ 3	—
Turn V	—	—	0	+ 2	+ 4	—	—	—	+ 5	+ 3

Figure B.1 **Calibration curve of a dial gauge illustrating periodic error**



Key

Y Error in reading (inches)

Annex C (informative) Notes on the care and use of dial gauges

C.1 General care

Although dial gauges are made robust for workshop use their mechanism is similar to that of a clock, and any fall or sharp blow might damage the pivots or upset the alignment of the bearings. If it is found at any time that the movement is not smooth, the gauge should be checked by a competent instrument maker or be returned to the makers for adjustment.

C.2 Oiling

It is important that the plunger is not oiled or greased. It is intended to work dry. The plunger is made quite a close fit in its bush and is returned to its zero position by means of a comparatively light spring. Even a thin oil will pick up dirt which could cause the plunger to stick.

C.3 General use

Dial gauges should preferably be used as comparators and not as direct measuring instruments. For example, a workpiece of 6.35 mm diameter might be tested with a dial gauge by setting the gauge to zero, raising the spindle to admit the workpiece and then taking a reading. This method, however, would give an accuracy of measurement only within the tolerances allowed in the specification for the longer intervals of reading.

On the other hand, if the gauge is used as a comparator by observing, first of all the reading when set on a 6.35 mm standard plug or gauge block and comparing this reading with the one obtained on the workpiece, thus determining the size of the latter by difference, the accuracy of measurement will be higher than that obtained by the first method.

C.4 Clamping

Dial gauges are usually supplied with means for alternative methods of fixing, namely:

a) by means of a back lug; or

b) by means of the steel stem.

When method a) is used it is necessary for the clamp to be quite tight, since slip could otherwise occur and false readings result. When method b) is adopted it is important that care is taken not to apply too great a clamping force as this might cause the plunger to jam in the stem; it is important that the hole in the fixture which is to take the stem is smoothly finished and truly circular and a good fit on the stem. The stem is purposely made cylindrical to fine limits of accuracy, and the hole in the fixture should be correspondingly accurate. If the hole is not true and smooth, there could be a tendency to nip the stem across a diameter, thus distorting it and causing the plunger to bind or even lock.

C.5 Stands

It is essential that any stand in which a dial gauge is used is very rigid if accurate readings are to be obtained.

C.6 Use of plunger lifting lever

Where the plunger is raised by means of a lever to allow the workpiece to be inserted under the contact point it ought not be released so that the point hits the workpiece with force. The use of a dial gauge in this way for any length of time will bring about a distortion of the teeth of the rack of the plunger at the point where the mechanism is suddenly arrested in its movement. Furthermore, such use might cause the pointer to slip on its spindle, with consequent inaccuracy of reading, particularly if the gauge is one of high magnification, i.e. 0.01 mm or 0.000 1 in.

C.7 Contact points

A variety of contact point types are supplied by the makers for use according to the nature of the workpiece to be tested. Ball points are those most commonly used. Constant use of a ball point can cause wear, and any resulting flat on the ball might cause errors of contact resulting in inaccurate readings.

Particular care should be exercised when using flat contacts of diameters between, say, 6 mm or ¼ in and 13 mm or ½ in. It is essential that the flat surface of such contacts are truly square to the plunger and parallel to the measuring surface of the fixture if accurate readings are to be obtained.

C.8 Choice of an appropriate type of gauge

In choosing a dial gauge for a certain purpose, one should be selected with a magnification which is ample in relation to the accuracy required on the workpiece under test. For example, if the tolerance on the workpiece is ± 0.001 in then a 0.001 in gauge is not the most suitable as the movement of the pointer would be too small for accurate reading. For such a case a 0.000 1 in gauge should be selected.

The dial gauge should be calibrated and the calibration uncertainty incorporated into the overall measurement uncertainty. The overall measurement uncertainty should be taken into account when proving conformance or non-conformance of the workpiece under test with the specified tolerance. The workpiece under test meets specification if the measured value is within the tolerance band specified, taking into account the uncertainty of measurement according to BS EN ISO 14253-1.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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*

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