BRITISH STANDARD

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ISO 6318:1985

# Assessment of departures from roundness —

## Part 1: Glossary of roundness measurement terms —

## [ISO title: Measurement of roundness — Terms, definitions and parameters of roundness]

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# Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Committee (GME/-) to Technical Committee GME/10 upon which the following bodies were represented:

Department of Trade and Industry (National Engineering Laboratory)
Department of Trade and Industry (National Physical Laboratory)
GAMBICA (BEAMA Ltd.)
Gauge and Tool Makers' Association
Institution of Production Engineers
Loughborough University of Technology
Ministry of Defence
University of Warwick
Coopted member

This British Standard, having been prepared under the direction of the General Mechanical Engineering Standards Committee, was published under the authority of the Board of BSI and comes into effect on 27 February 1987



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# National foreword

This Part of BS 3730, which has been prepared under the direction of the General Mechanical Engineering Standards Committee, is identical with ISO 6318-1985 "*Measurement of roundness — Terms, definitions and parameters of roundness*", published by the International Organization for Standardization (ISO). This Part of BS 3730 is a revision of BS 3730-1:1982 which is withdrawn.

**Terminology and conventions.** The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Wherever the words "International Standard" appear, referring to this standard, they should be read as "this Part of BS 3730".

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**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 5 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.

## Scope and field of application

This International Standard defines metrological terms used in the determination of deviations from roundness.

Figure 2 and Figure 3 illustrate sequential steps involved in roundness measurement.

## Terms and definitions

**1 General terms** (surfaces, planes, axes)

**1.1**
**real surface**

a surface limiting the body separating it from the surrounding medium

See Figure 2

**1.2**
**nominal axis of rotation**

the theoretically exact axis about which the spindle of a perfect instrument rotates

**1.3**
**instantaneous axis of rotation**

the axis about which the spindle of an instrument actually rotates at any instant

NOTE The instantaneous axis of rotation may be continuously varying within the confines of the bearings.

**1.4**
**reference axis of rotation**

the mean of the instantaneous axes about which the spindle of an instrument rotates

**1.5**
**instantaneous error of rotation**

the difference between the position of the instantaneous axis of rotation and the reference axis of rotation

NOTE Errors of rotation of the instrument may comprise radial, axial and tilt components.

**1.6**
**nominal plane of measurement**

a plane perpendicular to the nominal axis of rotation of the instrument

**1.7**
**plane of measurement**

plane perpendicular to the reference axis of rotation and passing through the point of contact of the detecting element of the instrument with the workpiece

**1.8**
**direction of measurement**

the direction along which radial variations are determined. It substantially intersects the axis of rotation of the instrument and it generally lies in the plane of measurement

**1.9**
**axis of workpiece**

a defined straight line about which the relevant part of the workpiece is considered to be round

see Figure 3

NOTE There may be several ways in which the axis can be defined, including:

1) A straight line such that the root mean square value of the distances from it of the defined centres of a representative number of cross-sections has a minimum value.
2) A straight line passing through the defined centres of two separated and defined cross-sections.
3) A straight line which passes through the defined centre of one defined cross-section and is perpendicular to a defined shoulder.
4) A straight line passing through two support centres — this axis is independent of the surface of the workpiece.
5) An axis of two coaxial surfaces of revolution just enclosing the surface irregularities of the workpiece.

**1.10**
**setting-up eccentricity**

the distance in the plane of measurement between the point of intersection therewith of the reference axis of rotation of the instrument and the defined centre of the workpiece profile

**1.11**
**factor of amplification**

the ratio of the output value of the instrument to the displacement of the stylus in the direction of measurement

**2 Profiles**

**2.1**
**real roundness profile**

the profile resulting from the intersection of the real surface of a round workpiece by a plane perpendicular to its defined axis. The concept encompasses every feature of the surface, however small it may be

**2.2**
**profile transformation**

the action of transforming a profile at any stage, as, for example, by a stylus, filter or recorder

**2.3**
**traced profile**

the profile determined by the path followed by the sensing device (the stylus). It may, sometimes, be indistinguishable from the real roundness profile. Measured parameters of roundness are referred to the traced profile

See Figure 2

NOTE It may tend to include or exclude surface roughness according to the dimensions of the stylus.

**2.4**
**modified profile**

the traced profile intentionally modified by an analogue or digital wave filter having defined characteristic

**2.5**
**displayed profile**

the representation of the traced or modified profile displayed by the instrument, for example as a trace, oscilloscope presentation or data log

**3**
**reference circle**

a circle fitting the traced profile of the workpiece in a defined way, to which the departures from roundness and the geometric roundness parameters are referred

**4**
**displayed reference circle**

a circle representing the workpiece reference circle, fitted to the displayed representation of the traced profile in a defined way

NOTE 1 Residual eccentricity left after setting up will result in slight distortion of the displayed representation of the workpiece profile and, in principle, the displayed reference circle should be distorted correspondingly, approximately to the shape known as a limaçon. Electrical methods of plotting the reference circle on a polar graph, and digital representations, often do this automatically. The distortion, having a maximum value given by $E^2/2R$, can generally be neglected if the residual eccentricity, $E$, measured at the display is kept within about 15 % of the mean radius, $R$, of the profile for general testing, and within 7 % for more critical applications.

NOTE 2 Other reference profiles — elliptical, tri-lobe, electric wave filter mean line — may find auxiliary use for analytical purposes.

## 5 Definitions of reference circles to be fitted to the traced profile of the workpiece, and to the displayed representation of the traced profile when adequately centred on the axis of rotation

**5.1**
**least squares mean circle (LSC)**

a circle such that the sum of the squares of the departures from it of the traced or modified profile of the workpiece is a minimum

**5.2**
**minimum circumscribed circle (MCC)**

smallest possible circle that can be fitted around the traced or modified profile of a shaft

**5.3**
**maximum inscribed circle (MIC)**

largest possible circle that can be fitted within the traced or modified profile of a hole

**5.4**
**minimum zone circles (MZC)**

two concentric circles enclosing the traced or modified profile and having the least radial separation

## 6 Terms relating to the circumference

**6.1**
**undulations per revolution; upr**

the number of complete periodic undulations contained in the periphery of the workpiece

NOTE There cannot be less than one complete undulation per 360° or 2π rad.

**6.2**
**sinusoidal undulation number,** $n_s$

the number of dominant or superimposed periodic sinusoidal waves measured during one revolution of the workpiece

**6.3**
**sinusoidal undulation frequency**

sinusoidal undulation number multiplied by revolutions per second of the instrument (expressed in hertz)

**6.4**
**wavelength angle,** $\theta$

the reciprocal of the upr multiplied by 360, when expressed in degrees, or 2π when expressed in radians

See Figure 1

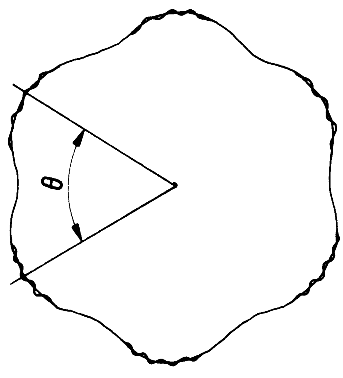



**Figure 1 — wavelength angle**

**6.5**
**circumferential wavelength**

the circumference of the workpiece divided by the upr

## 7 Terms relating to filter function of the apparatus

**7.1**
**wave filter**

a system transmitting a range of sinusoidal frequencies for which the ratio of output to input amplitude is nominally constant, while attenuating (i.e. reducing) the ratio for frequencies lying outside the range at either or both ends

NOTE A characteristic of the electric wave filter is that the ratio is dependent only on frequency, and is independent of amplitude, in contrast to mechanical filtering methods (for example by the stylus) which are influenced by frequency and also by amplitude.

**7.2**
**amplitude transmission characteristic**

ratio of output amplitude to input amplitude plotted for each of a range of sinusoidal frequencies covering the operative range of the apparatus

NOTE The ratio may be expressed as a percentage or in decibels.

**7.3**
**rate of attenuation of filter**

the maximum slope of the transmission characteristic

NOTE 1 The attenuation rate is determined by the design of the filter and is expressed in decibels per octave.

NOTE 2 The rate of attenuation at the 75 % transmission cut-off may also be significant and expressed.

**7.4**
**phase shift**

the displacement, in time or space, between sinusoidal output and input signals of a given frequency

NOTE The phase shift produced by a filter, such as the two C-R[1] filter, is generally dependent on the rate of attenuation at each frequency considered. Phase shift through a phase-corrected (digital) filter can be zero or the same for all frequencies.

**7.5**
**undulation cut-off**

the number of sinusoidal undulations per 360° at the upper or lower end of the passband, where the transmission has been attenuated to 75 % of its maximum (except for 1 upr)

**7.6**
**undulation range of the filter**

the range of undulations lying between the upper and lower undulation cut-off

NOTE The undulation range may be expressed in spatial terms (undulations per 360°) or in temporal terms (frequency in hertz).

## 8 Additional terms

**8.1**
**method divergence**

the numerical difference between two methods of measurement which are both standardized and are nominally but not precisely equal

**8.2**
**measurement between support centres**

method in which the axis used for measurement is the common axis between the support centres formed in the workpiece itself

NOTE In this method the real axis of rotation of the workpiece can lead to differences in the measurement which can be caused by

a) defects of form, orientation, alignment of the centres and the benchmarks;

b) possible eccentricity of the section being checked.

[1] "C" stands for "capacitive", "R" for "resistive".

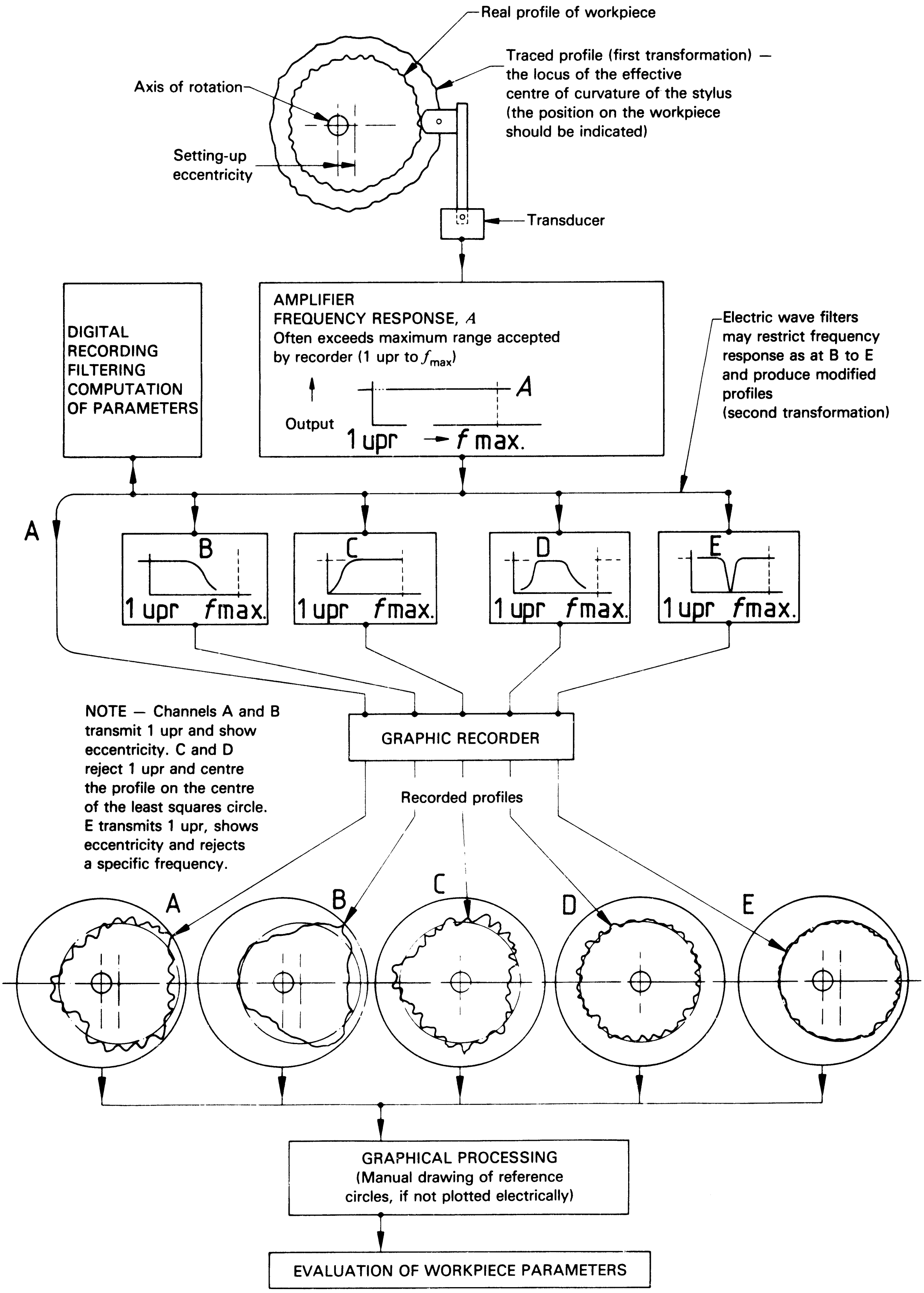


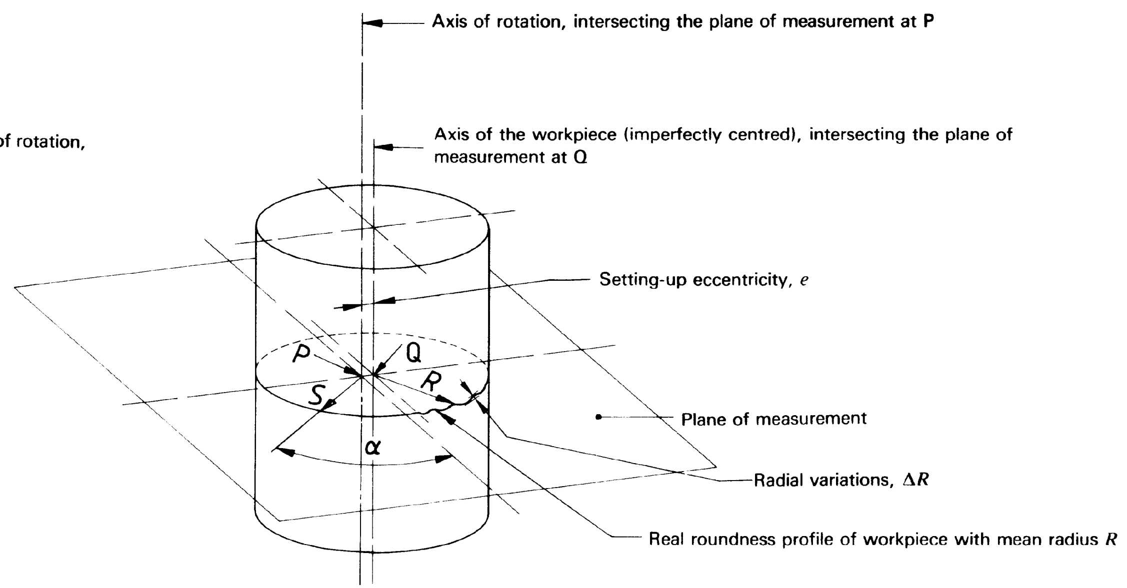

**Figure 2 — Flowchart illustrating an example using the least square circle**

**a) Workpiece**

**Key**

*R* is the mean radius of the real profile of workpiece exhibiting radial variations, $\Delta R$.

$S = f(\alpha)$ is the distance of the real profile from the centre of rotation, P, in any direction, $\alpha$.




**b) Chart**

**Key**

P′ is the centre of the chart.

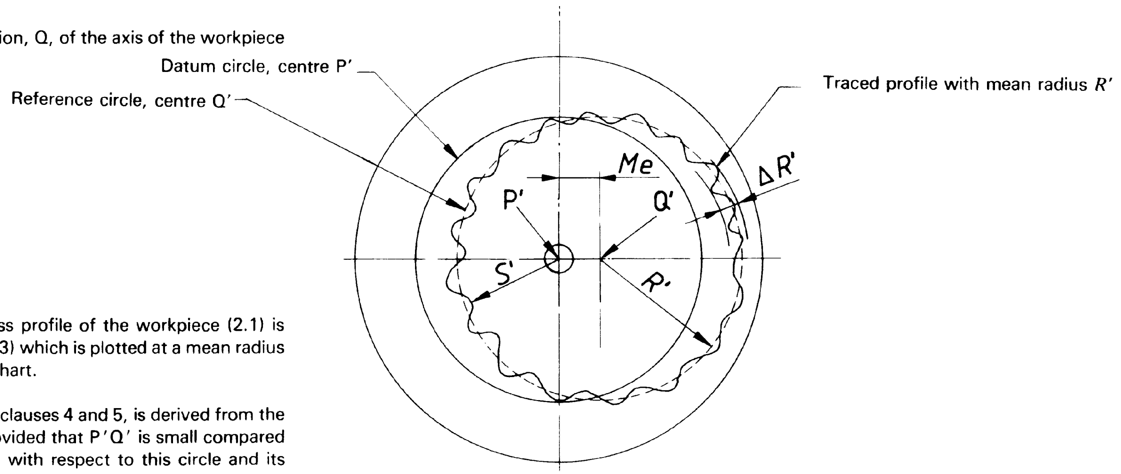
Q′ represents the point of intersection, Q, of the axis of the workpiece with the plane of measurement.

*M* is given from

$P'Q' = M \cdot PQ = Me$

$\Delta R' = M\Delta R$

$S' \ll MS$ and $R' \ll MR$




NOTES

1 On the chart, the real roundness profile of the workpiece (2.1) is represented by the traced profile (2.3) which is plotted at a mean radius *R*′ convenient for the size of the chart.

2 A reference circle, as defined in clauses 4 and 5, is derived from the traced profile of the workpiece. Provided that P′Q′ is small compared with *R*′, parameters are measured with respect to this circle and its centre.

**Figure 3 — Coordinate system for roundness measurement, seen in the domain: a) of a cylindrical workpiece; b) of its graphical representation**

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