

Method for

Determining departures from roundness by measuring variations in radius

[ISO title: Methods for the assessment of departure from
roundness — Measurement of variations in radius]

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- GAMBICA (BEAMA Ltd.)
- Gauge and Tool Makers' Association
- Institution of Production Engineers
- Loughborough University of Technology
- Ministry of Defence
- University of Warwick
- Coopted member

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National foreword

This British Standard, which has been prepared under the direction of the General Mechanical Engineering Standards Committee, is identical with ISO 4291:1985 “*Methods for the assessment of departure from roundness — Measurement of variations in radius*”, published by the International Organization for Standardization (ISO).

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.

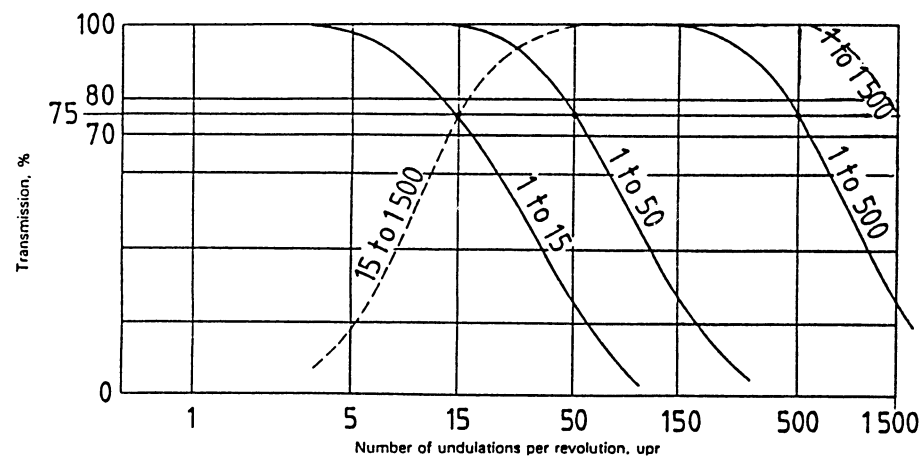
The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words “International Standard” appear, referring to this standard, they should be read as “British Standard”.

Cross-reference

International Standard	Corresponding British Standard
ISO 6318:1985	BS 3730 <i>Assessment of departures from roundness</i> Part 1:1987 <i>Glossary of roundness measurement terms</i> (Identical)

Textual error. When adopting the text of the International Standard, an error in Figure 5 was discovered. It has been marked in the text and has been reported to ISO in a proposal to amend the text of the International Standard.



A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover 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.

1 Scope and field of application

This International Standard specifies a method for determining departures from roundness by measuring variations in radius by means of contact (stylus) instruments.

It establishes

- a) types of instruments and general requirements;
- b) recommendations for the use of instruments;
- c) procedures for calibration of instruments and verification of their characteristics.

This International Standard applies to the assessment of the departures from ideal roundness of a workpiece through the medium of a profile transformation, obtained under reference conditions, expressed with respect to any one of the following centres:

- a) centre of the least squares circle;
- b) centre of the minimum zone circle;
- c) centre of the minimum circumscribed circle;
- d) centre of the maximum inscribed circle.

Each of these centres may have its own particular application. The position of the least squares centre can be calculated from a simple explicit equation given in Annex F.

Departures from roundness of the measured profile, procedure, calibration and determination of systematic errors of rotation are dealt with in Annex A to Annex D, respectively. Annex E gives rules for plotting and reading polar graphs.

NOTE 1 Profile transformation is defined in ISO 6318.

NOTE 2 Reference conditions include the stylus, frequency limitations of an electric wave filter (if used), permissible eccentricity of the graphical or digital representation of the profile (generally 7 % to 15 % of its mean radius, see Annex E), the position of the measured section or sections relative to some feature of the workpiece.

2 Reference

ISO 6318, *Measurement of roundness — Terms, definitions and parameters of roundness*.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 6318 apply.

4 Instruments

4.1 Instrument types and general requirements

Instruments of the stylus type employed for the determination of departures from ideal roundness may be of one of two types:

- a) a stylus and transducer rotating round a stationary workpiece;
- b) a rotating workpiece engaged by a stationary stylus and transducer.

According to the nature of the output information, instruments for the measurement of roundness fall into two groups:

- a) profile recording;
- b) with direct display of the values of the parameters.

Both groups may be combined in one instrument.

Stylus instruments should comply with the requirements of 4.1.1 to 4.1.3.

4.1.1 Stylus types and dimensions

The surface characteristics of the part under examination are of primary importance in the choice of stylus. Variations to meet different requirements, depending upon the nature and magnitude of the irregularities which are to be taken into account, are permitted as shown in Figure 1 to Figure 4 (see also clause B.3).

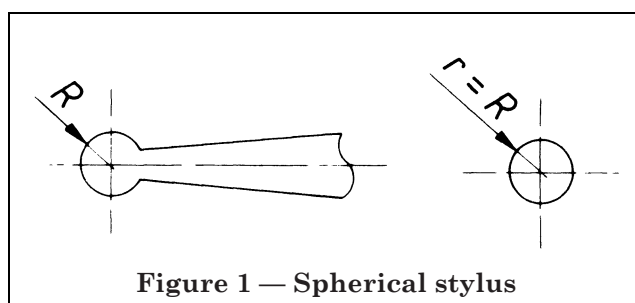


Figure 1 — Spherical stylus

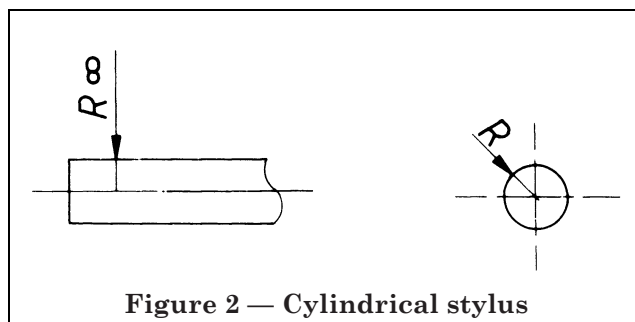


Figure 2 — Cylindrical stylus

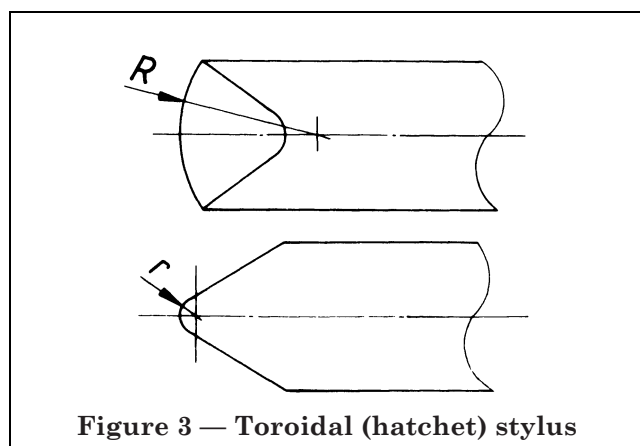


Figure 3 — Toroidal (hatchet) stylus

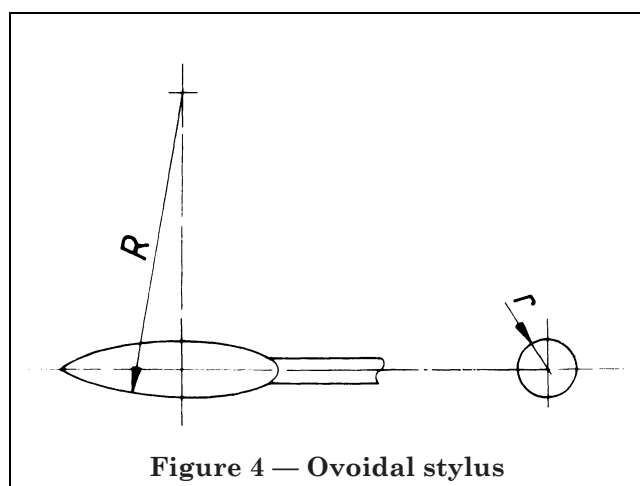


Figure 4 — Ovoidal stylus

The dimensions r and R of the various styli shall be selected from the following values:

— 0,25; 0,8; 2,5; 8 and 25 mm.

4.1.2 Stylus static force

The force shall be adjustable up to 0,25 N and in use shall be adjusted down to the lowest value that will ensure continuous contact between the stylus and the surface being measured.

4.1.3 Instrument response for sinusoidal undulations

The range of periodic sinusoidal undulations per revolution (upr) (i.e. per 360°) of the workpiece to which the instrument responds shall be terminated by values taken from the table.

Table — Limiting values of upr

Filters transmitting from 1 upr up to	Filters rejecting below
15	15
50	50
150	150
500	
1 500	

The response at the rated termination of the band shall be 75 % of the maximum transmission within the band except for 1 upr which represents direct mechanical coupling between input and output, [See note 2c).]

The transmission characteristics of the filter shall be equivalent to those produced by two independent C-R¹⁾ networks of equal time constant (see Figure 5). These curves show only the amplitude attenuation characteristics and do not take phase shift into account. A phase corrected filter of known characteristics giving the same rate of attenuation may be used provided that these characteristics are indicated in the test report.

NOTE 1 When a filter attenuating high frequencies is required, the two C-R form will generally be acceptable, distortion of the transmitted profile due to phase shift of the high relative to the low frequencies being generally unimportant.

When a filter attenuating low frequencies is required, distortion due to phase shift may be more significant and have to be taken into account, or avoided by using a phase corrected filter.

NOTE 2a) It is necessary to distinguish clearly between the undulations per revolution (i.e. per 360°) of the workpiece and the response of electronic circuits in the instrument in hertz.²⁾

The frequency, in hertz, generated by the instrument will be given by the number of sinusoidal undulations per 360° of the workpiece multiplied by the number of revolutions per second of the spindle.

NOTE 2b) Eccentricity will count as 1 upr. A sinusoidal component of 1 upr will be found when the periphery of the workpiece is assessed from a centre other than the centre of the least squares circle.

NOTE 2c) When electronic circuits of instruments are required to respond down to 1 upr, they are often made responsive down to zero frequency (0 Hz), this being a natural way of avoiding phase distortion and permitting calibration by static means.

4.2 Instrument errors

4.2.1 Overall instrument error

This is the difference between the value of the parameter indicated, displayed or recorded by the instrument and the true value of this parameter. The value of this error is determined when measuring a test piece. The overall instrument error shall be expressed as a percentage of the upper limiting value of the measuring range used. This error comprises systematic and random components from the spindle error, electric noise, vibration, magnification, etc.

¹⁾ "C" stand for "capacitive", "R" for "resistive".

²⁾ 1 Hz = 1 cycle per second

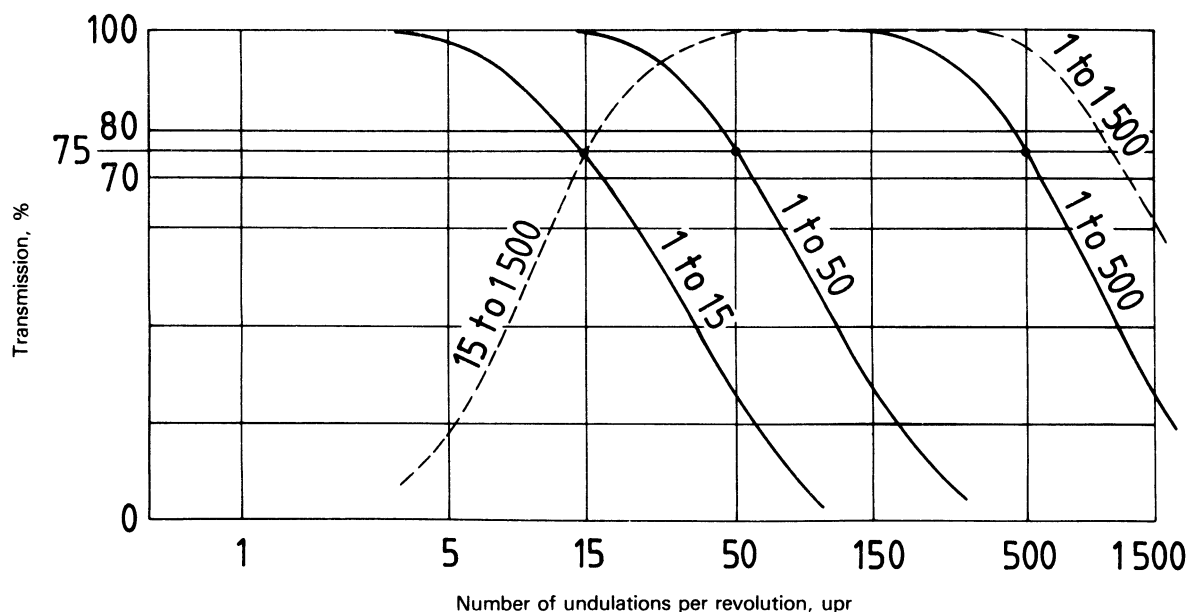


Figure 5 — Typical transmissions showing rate of attenuation given by two independent C-R networks of equal time constant^a

^a See national foreword for details of textual error.

4.2.2 Errors of rotation of the instrument

The errors of rotation are determined under reference conditions at assigned positions of measurement:

- a) radial instrument error — the value of the roundness parameter which would be indicated by the instrument when measuring a perfectly round and perfectly centred section of a test piece, in a direction perpendicular to the reference axis of rotation;
- b) axial instrument error — the value derived from the zonal parameter displayed by the instrument when measuring on a perfectly flat test piece set perfectly perpendicular to the reference axis of rotation.

NOTE The components of errors of rotation are vector quantities and should not therefore be algebraically added to the measured value of a roundness parameter in an attempt to allow for errors of rotation.

4.2.3 Statements of errors of rotation

The rotating member can exhibit, within the confines of its bearings, combinations of

- a) radial displacements parallel to itself;
- b) axial displacements parallel to itself;
- c) tilt.

The magnitude of the radial instrument error, measured at the stylus, depends on the position of the measurement plane along the axis of rotation. The magnitude of the axial instrument error depends on the radius at which the flat test piece is measured. The axial and radial positions selected for test shall therefore be stated.

The radial instrument error shall be expressed at two stated and well separated positions along the axis or at one position together with the rate of change of the radial instrument error along the axis.

The axial instrument error shall be expressed on the axis and at one stated radius.

Annex A Departure from roundness of the measured profile of the workpiece

In this International Standard, the departure from ideal roundness is assessed as the difference between the largest and the smallest radii of the measured profile of the workpiece, measured from one or other of the following centres:

- a) least squares centre (LSC) — the centre of the least squares mean circle (see Figure 6);
- b) minimum zone centre (MZC) — the centre of the minimum zone circle (see Figure 7).
- c) minimum circumscribed circle centre (MCC) — the centre of the minimum circumscribed circle for external surfaces (see Figure 8);

- d) maximum inscribed circle centre (MIC) — the centre of the maximum inscribed circle for internal surfaces (see Figure 9).

The largest and smallest radii, in each case, are commonly used to define a concentric zone. The width of the zone may be designated by ΔZ , with a subscript denoting its centre. For the purposes of this International Standard, the following subscripts are used:

least squares	subscript q, thus ΔZ_q
minimum width	subscript z, thus ΔZ_z
minimum circumscribed	subscript c, thus ΔZ_c
maximum inscribed	subscript i, thus ΔZ_i

NOTE The use of circles drawn on the chart to represent circles fitting the profile of the workpiece assumes that the workpiece is sufficiently well centred on the axis of the instrument (see B.1.1, Figure 10 and Annex F).

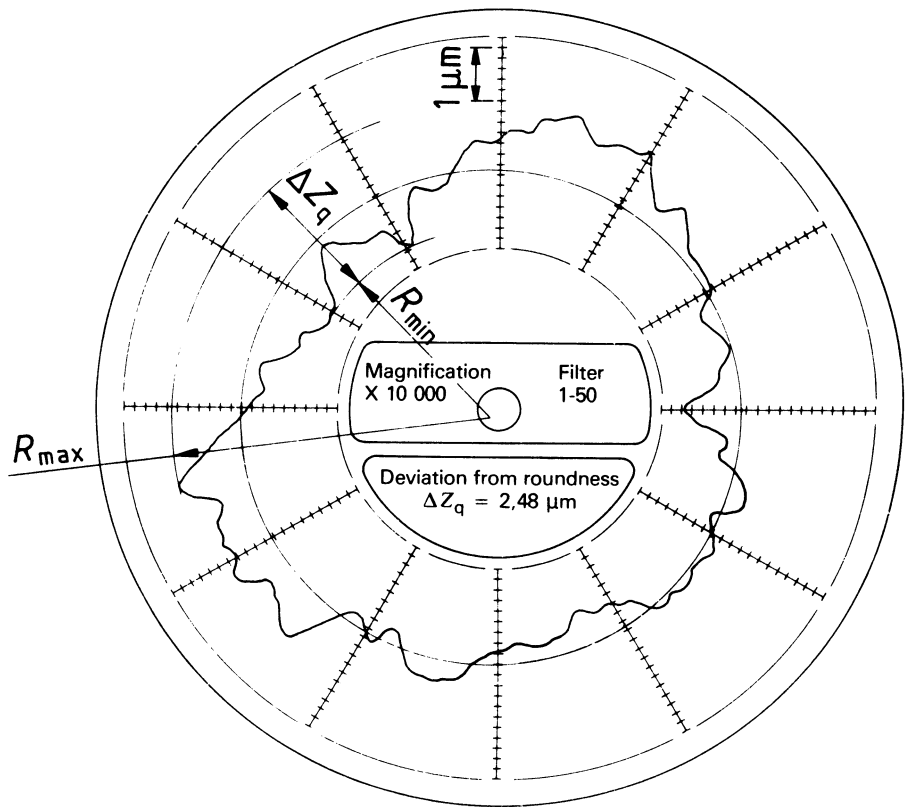


Figure 6 — Assessment of roundness from least squares centre, ΔZ_q