

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 7451 : 1997

Instruments for the assessment of
departure from roundness—
Measurement of variations in radius

ICS 17.040.30

Descriptors : roundness measurement, measuring instruments

Reference number : JIS B 7451 : 1997 (E)

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently JIS B 7451 : 1991 is replaced with JIS B 7451 : 1997.

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Date of Establishment: 1991-08-01

Date of Revision: 1997-11-20

Date of Public Notice in Official Gazette: 1997-11-20

Investigated by: Japanese Industrial Standards Committee
Divisional Council on FA

JIS B 7451 : 1997, First English edition published in 1998-06

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

Instrument for the assessment of departure from roundness —Measurement of variations in radius

Introduction This Japanese Industrial Standard is based on **ISO 4291**, *Methods for the assessment of departure from roundness—Measurement of variations in radius* published in 1985 as the 1st edition and **ISO 6318**, *Measurement of roundness—Terms, definitions and parameters of roundness* without changing the technical contents as for the corresponding parts to the International Standards and adding the contents not specified in the corresponding International Standards (Tolerance on rotational accuracy). Moreover, the items (mechanism of lading stand, magnification, stability of measuring instrument, inspection and marking) which are not included in the corresponding International Standards are added.

1 Scope This Japanese Industrial Standard specifies the contact type instruments for the assessment of departure from roundness (hereafter referred to as “measuring instrument”) for the purpose of measuring the variations in radius in peripheral direction of circular shape of workpiece by means of contact detector.

Remarks : Methods for the assessment of roundness by means of the roundness measuring instruments not based on the body of this Standard are shown in Annex 1 (normative).

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The latest editions of them apply.

JIS B 0621 *Definitions and designations of geometrical deviations*

JIS B 7430 *Optical flats*

JIS B 7506 *Gauge blocks*

JIS Z 8103 *Glossary of terms used in instrumentation*

3 Definitions and symbols For the purpose of this Standard, the definitions given in **JIS B 0621** and **JIS Z 8103**, and the following definitions apply.

The symbol is given in the parentheses following each term.

- a) **detector revolving type** Type of measuring instrument having such mechanism that the lading-goods stand is fixed and the detector revolves (see Attached Fig. 1).
- b) **lading-good stand rotating type** Type of measuring instrument having such mechanism that the detector is fixed and the lading-goods table rotates (see Attached Fig. 2).
- c) **detector** Device consisting of the mechanism detecting the measured roundness curve and the transducer.
- d) **stylus** A part of detector which touches direct the workpiece to be measured.

- e) **measuring force** Static force of stylus to act to the measuring surface.
- f) **rotational accuracy** The rotation accuracy of the rotary device shall be as follows:
 - 1) **rotational accuracy in radial direction** The accuracy of rotational device expressed with the value of roundness obtained by measuring the standard of spherical, hemispherical or cylindrical shape (hereafter referred to as “standard for rotational accuracy inspection”).
 - 2) **rotational accuracy in axial direction** The accuracy of rotational device expressed with the value of flatness relating to one periphery obtained by measuring the optical flat.
- g) **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.
- h) **measured roundness profile** The locus of the centre of the stylus tip when the stylus travels along the real roundness profile of a workpiece. This stylus has the defined shape and measuring force.
- i) **roundness profile** The profile obtained in such a way that, with respect to the measured roundness profile of digital type or analogue type, the components larger than the defined undulation per revolution are removed by a low-pass filter of phase compensation type or 2CR type and, furthermore, the coordinate transformation is given to the centre of selected central definition method.
 The profile obtained by removing the components smaller than the defined undulation per revolution from this roundness profile by a high-pass filter of phase compensation type or 2CR type is also included.
- j) **reference circle** A geometric circle fitting the measured roundness profile or roundness of the workpiece in a defined way (e.g. least square).
- k) **undulation per revolution (upr)** The number of undulation like sinusoidal wave contained in one periphery of the workpiece.
- l) **cut-off value of roundness profile (fc)** The undulation per revolution at which the gain of the low-pass filter and the high-pass filter have been attenuated to 75 % (hereafter referred to as “cut-off value”).
- m) **magnification calibrator** The calibrator capable of giving statically the displacement of correct dimension by using screw threads and lever, screw threads and wedge, etc.
- n) **standard for calibration** A cylindrical instrument having one or more small plane(s) or curved surface(s) on the periphery for giving a dynamic and a certain displacement to the measuring instrument.

4 Type The types of the measuring instruments shall be divided into detector revolving type and lading table rotating type according to the rotational mechanisms.

5 Structure

5.1 Constitution of measuring instrument The measuring instrument shall be constituted by detector, stylus, rotary apparatus, feed apparatus, lading stand, amplifier, filter, arithmetic and logic unit, indicator, recorder, etc. (see Attached Fig. 1 and Attached Fig. 2). The standard for test for measuring the rotation accuracy in radius direction should preferably be appended.

Remarks : Example of constitutional layout of measuring instrument is shown in Fig. 1.

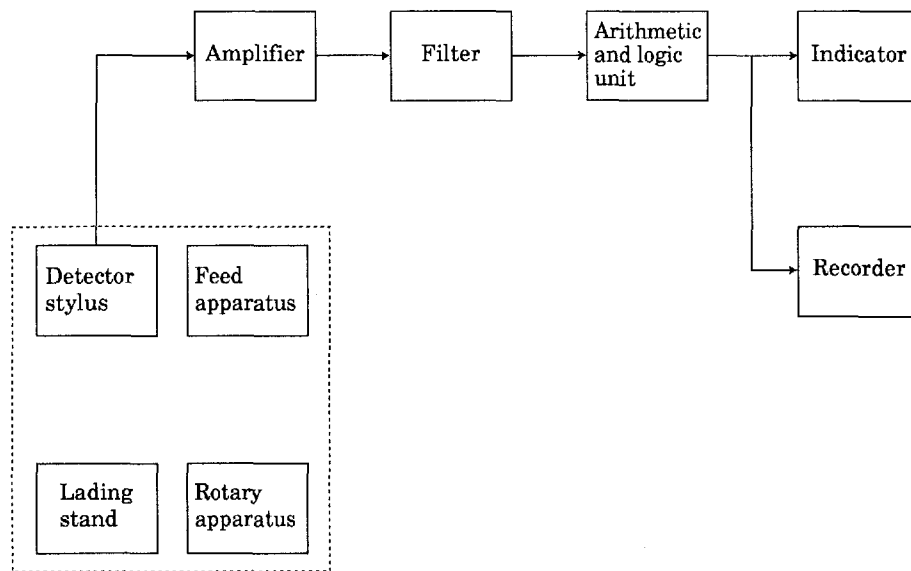


Fig. 1 Example of constitutional layout of measuring instrument

5.2 Stylus The shape of tip part of stylus should preferably be as follows.

- a) The tip part is to be spherical shape, toroidal (hatchet) shape, cylindrical shape or ovoidal shape (see Fig. 2).
- b) The radius of curvature of tip part (nominal value of r indicated in Fig. 2) should preferably take 0.25 mm, 0.8 mm, 2.5 mm, 8 mm, and 25 mm as standard values and the tolerance on the radius of curvature of tip part shall be $\pm 30\%$ of each nominal value.

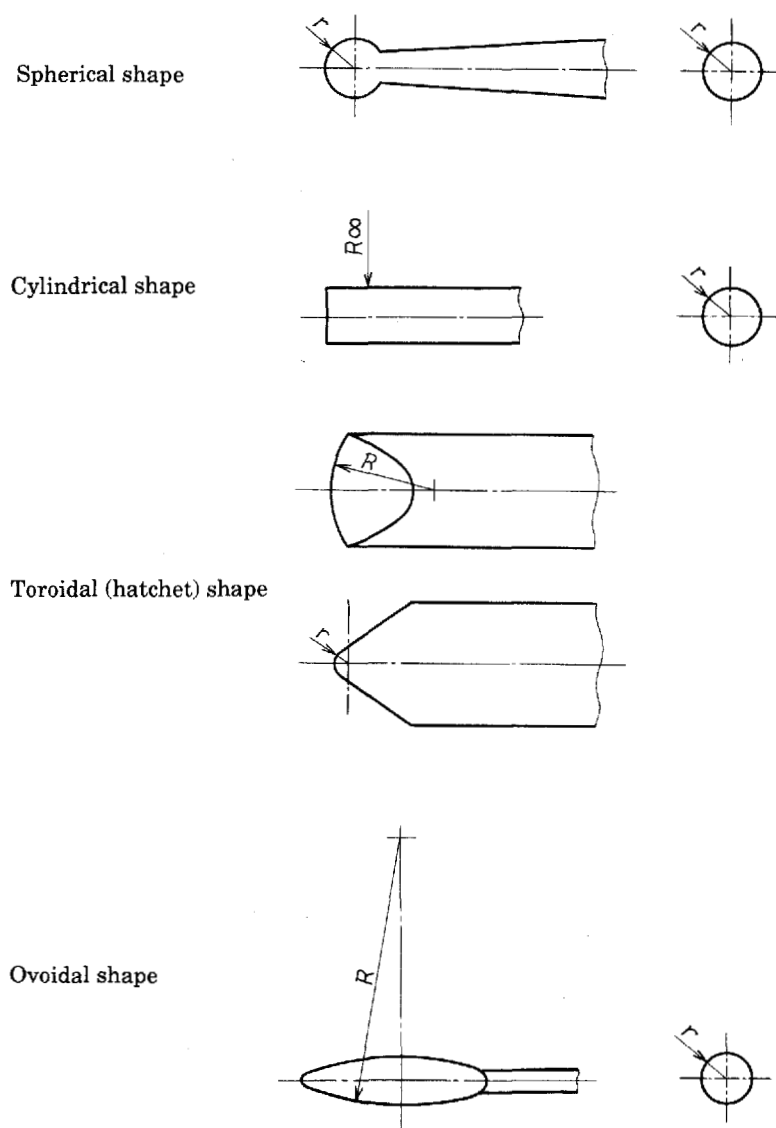


Fig. 2 Example of shape of tip part of stylus

Reference : The tip part of stylus is generally steel, hard metal, diamond, sapphire, ceramic, etc. However, that for measuring of soft substance is made of materials of plastics series in many cases.

5.3 Lading stand The lading stand shall have micro-regulation mechanism for making centre of measuring section of workpiece coincide with the rotary shaft centre of rotary apparatus.

5.4 Filter The constitution of filter and cut-off value shall be as follows.

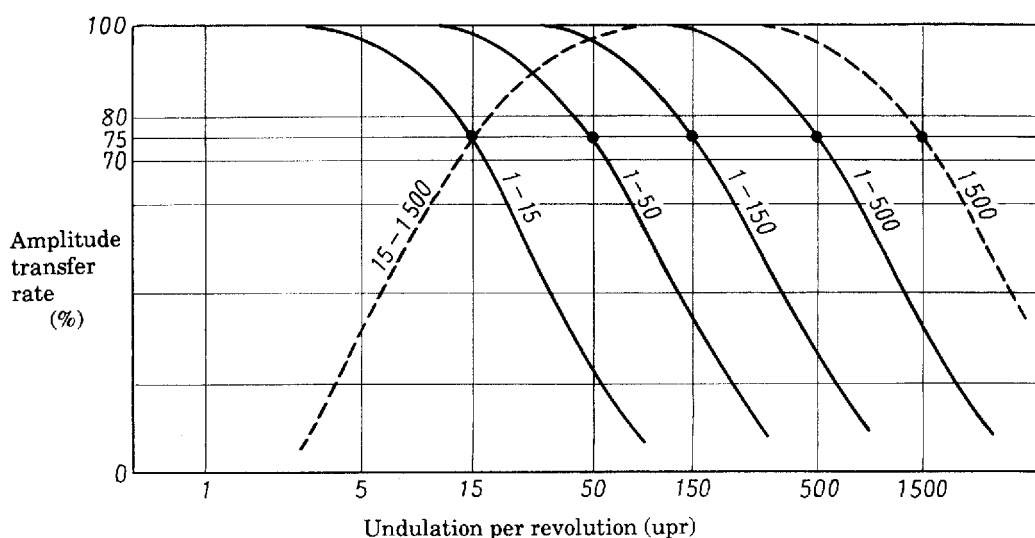
5.4.1 Constitution of filter The filter is of the phase compensation type or the constitution that connected in series with two sets of R-C circuits equal in time constant, and have transmission characteristics of Fig. 4.

5.4.2 Cut-off value of filter and the combination The cut-off value of filter and the combination are to be selected from Table 1.

Table 1 Cut-off value of filter and the combination

Classification of filter	Cut-off value and the combination (upr)
Low-pass filter	15 50 150 500 (1 500)
High-pass filter	(15) (50) (150)
Bandwidth filter (combination of low-pass filter and high-pass filter)	(15-150) (15-500) (50-500) (15-1 500) (50-1 500) (150-1 500)

- Remarks 1 The cut-off value and the combinations shown in () indicate that it may be not necessarily selected.
- 2 The relation of amplitude transfer rate of filter having various cut-off values and the undulation per revolution is shown in Fig. 3.

**Fig. 3 Relation of amplitude transfer rate of filter and undulation per revolution**

6 Performance

6.1 Measuring force The permissible tolerance between the measuring force and its nominal value⁽¹⁾ shall be $\pm 30\%$ of the nominal value. The measuring force shall not exceed 250 mN.

Note (1) Nominal value of the measuring force is the approximate value which indicates the measuring force of the measuring instrument.

6.2 Rotational accuracy The rotational accuracy of each type of measuring instrument shall not be more than the value given in Table 2.

Table 2 Indication of rotational accuracy

Type of measuring instrument	Measuring direction	Method of indication of rotational accuracy	Rotational accuracy (μm)
Detector revolving type	Radial direction	Measured value of rotational accuracy	1.0
	Axial direction	Measured value of rotational accuracy at the position of 50 mm of diameter	2.0
Lading stand rotating type	Radial direction	Rotational accuracy obtained by the following formula: $P = A + B \cdot H$ where, P : rotational accuracy in radial direction (μm) A : rotational accuracy at the height on lading stand surface (μm) B : inherent constant determined according to measuring instruments H : height from the lading stand surface (mm)	$0.24 + 0.002H$
	Axial direction	Measured value of rotational accuracy at the position of 50 mm of diameter	2.0

Remarks 1 For the cut-off value, 50 (μm) shall be the standard.

2 Rotational accuracy shall be measured in the inspection environment and specific condition shown in 6.1 of the body.

6.3 Magnification The permissible tolerance on the relative error of magnification shall be $\pm 6\%$ of the nominal value⁽²⁾.

Note ⁽²⁾ Nominal value of magnification is the value which indicates the magnification rate of the measuring instrument and it shall be selected from Table 3.

Table 3 Nominal value of magnification

Number series of nominal value of magnification	1, 2, 5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, 10 000, 20 000, 50 000, 100 000, 200 000
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6.4 Transmission characteristics of filter When the attenuation rate of the filter is -12 dB/oct , the transmission characteristics of the low-pass filter and the high-pass filter shall lie between respective two transmission curves shown in Fig. 4. The amplitude transfer rate at the cut-off value of each filter shall be 75 %.

The tolerance on the transmission characteristic shall be that the deviation from the ideal characteristic is within $\pm 5\%$ with respect to each cut-off value.

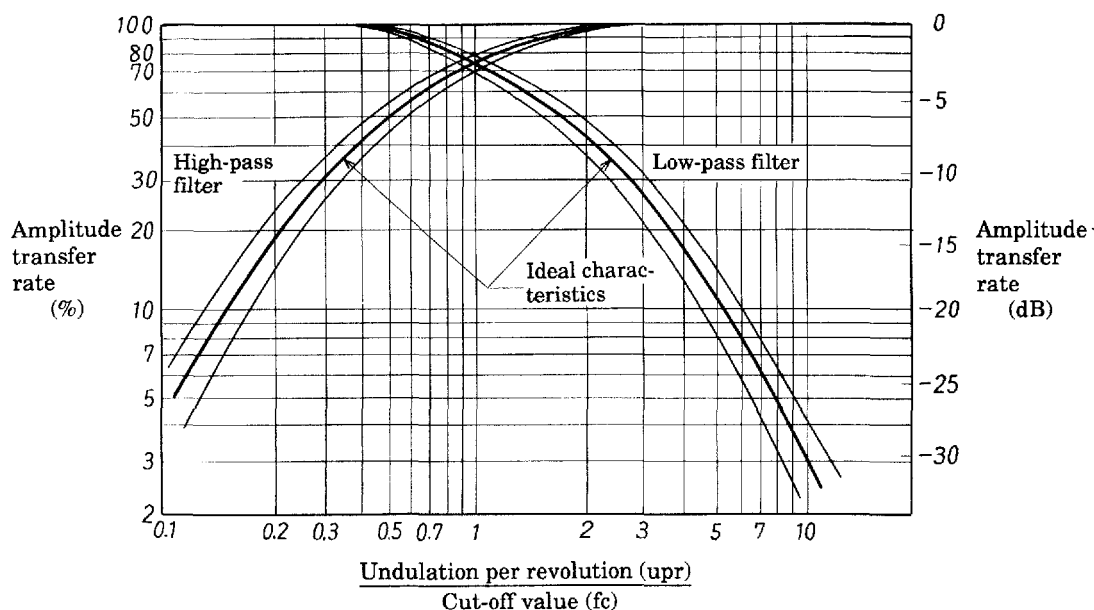


Fig. 4 Transmission characteristics of filter

6.5 Stability of measuring instrument The stability of the measuring instrument shall be that the indicated value shall not fluctuate by 5 % or more during 1 h after passing 10 min from putting the power source in the measuring instrument.

6.6 Error due to variation of voltage of power source The error caused by the variation of the power source voltage shall be that the measured value does not fluctuate exceeding ± 5 % when using for the measuring instrument the a.c. power source of 50 Hz or 60 Hz and making the input voltage fluctuate by ± 10 % with respect to the rated voltage of the measuring instrument.

7 Inspection

7.1 Inspection environment The environment at the time of inspection of the measuring instruments shall be as follows:

7.1.1 Temperature $(20 \pm 2)^\circ\text{C}$ provided that there is no rapid change of temperature during the test.

7.1.2 Humidity (50 ± 10) %

7.1.3 Voltage of power source Within ± 1.5 % of the rated voltage provided that it is within ± 10 % of the rated voltage in the inspection on the variation of the indicated value caused by the variation of the power source voltage.

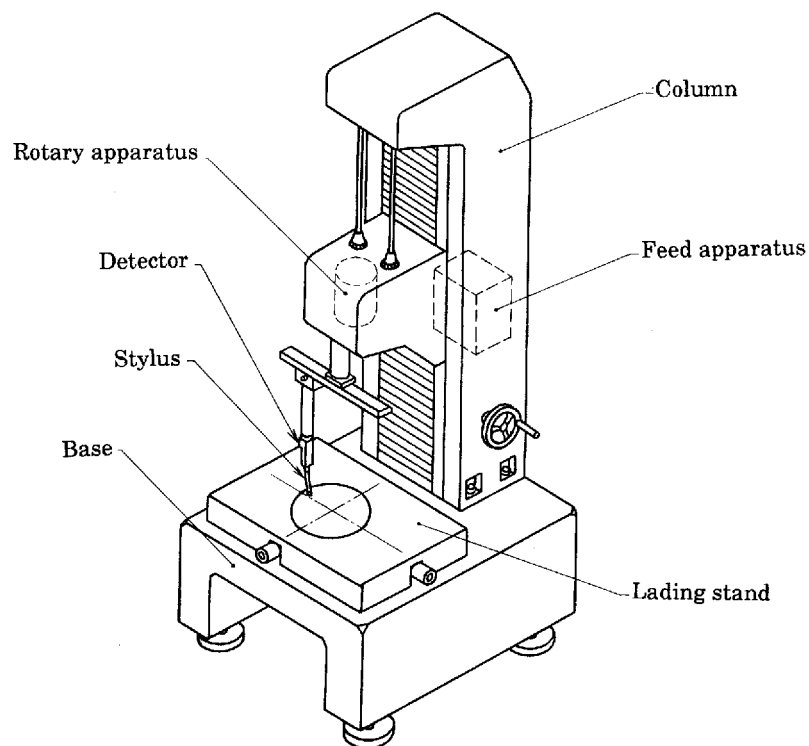
7.2 Inspection items The items are shown in Attached Table 1.

7.3 Inspection methods The measuring instruments shall be inspected in accordance with the methods specified in Attached Table 1 and the results shall conform to the tolerances specified respectively.

8 Marking

8.1 Marking to measuring instrument The measuring instrument shall be marked with the following matters:

- a) Name of measuring instrument
- b) Manufacturer's name or its abbreviation
- c) Manufacturing number
- d) Type of power source voltage used and rated voltage



Remarks : This figure is the explanatory figure.

Attached Fig. 1 Detector rotary type roundness measuring instrument