INTERNATIONAL STANDARD

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Rolling bearings — Tolerances —

Part 2: **Measuring and gauging principles and methods**

Roulements — Tolérances —

Partie 2: Principes et méthodes de mesurage et de vérification par calibre

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 1132 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 1132-2 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*.

This first edition of ISO 1132-2 cancels and replaces ISO/TR 9274:1991, in the form of a technical revision thereof.

ISO 1132 consists of the following parts, under the general title *Rolling bearings — Tolerances*:

— *Part 1: Terms and definitions*

— *Part 2: Measuring and gauging principles and methods*

Annex A forms a normative part of this part of ISO 1132.

Rolling bearings — Tolerances —

Part 2: Measuring and gauging principles and methods

1 Scope

This part of ISO 1132 establishes guidelines for measurement of dimensions, running accuracy and internal clearance of rolling bearings. The purpose is to outline the fundamentals of various measuring and gauging principles which may be used in order to clarify and comply with the definitions of ISO 1132-1 and ISO 5593.

The measuring and gauging methods described in this part of ISO 1132 may differ amongst themselves and do not provide for a unique interpretation. It is recognized that there are other adequate measuring and gauging methods and that technical development may result in even more convenient methods. Therefore, this part of ISO 1132 does not imply any obligation to apply any particular method. However, the methods specified may be referred to in cases of dispute.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 1132. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 1132 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1:1975, *Standard reference temperature for industrial length measurements*.

ISO 76:1987, *Rolling bearings — Static load ratings.*

ISO 104:—[1)], *Rolling bearings — Thrust bearings — Boundary dimensions, general plan*.

ISO 286-2:1988, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*.

ISO 1132-1:2000, *Rolling bearings — Tolerances — Part 1: Terms and definitions*.

ISO 3030:1996, *Rolling bearings — Radial needle roller and cage assemblies — Dimensions and tolerances*.

ISO 3031:2000, *Rolling bearings — Thrust needle roller and cage assemblies, thrust washers — Boundary dimensions and tolerances*.

ISO 3245:1997, *Rolling bearings — Needle roller bearings, drawn cup without inner rings — Boundary dimensions and tolerances.*

1) To be published. (Revision of ISO 104:1994)

ISO 4291:1985, *Methods for the assessment of departure from roundness — Measurement of variations in radius*.

ISO 5593:1997, *Rolling bearings — Vocabulary*.

ISO 15241:2001, *Rolling bearings — Symbols for quantities*.

3 Terms and definitions

For the purpose of this part of ISO 1132, the terms and definitions given in ISO 1132-1 and ISO 5593 apply. The following additional terms and definitions are used throughout this part of ISO 1132. An index of methods with their respective symbols, as specified in ISO 1132-1, is included in annex A.

3.1
measurement
set of operations having the object of determining the dimension(s) or variation of a feature

3.2
gauge
device of defined geometric form and size used to assess the conformance of a feature of a work piece to a dimensional specification.

NOTE The device could give only “GO” and/or “NOT GO” information (e.g. plug gauge).

3.3
gauging
inspection of size and/or form by means of a gauge

3.4
measuring and gauging principle
fundamental geometric basis for the measurement or gauging of the considered geometric characteristic

3.5
measuring and gauging method
practical application of a principle by the use of different types of measuring and gauging equipment and operations

3.6
measuring and gauging equipment
technical device used to perform a specific method of measuring (e.g. calibrated indicator)

3.7
measuring force
force applied by the stylus of an indicator or a recorder to the feature being measured

3.8
measuring load
external force applied to the specimen being measured in order to accomplish the measurement

4 Symbols

For the purposes of this part of ISO 1132, the symbols given in ISO 15241 and the following apply.

The symbols (except those for tolerances) shown in the figures and the values given in the tables denote nominal dimensions unless specified otherwise. Additionally, the drawing symbols given in Table 1 are applied throughout this part of ISO 1132.

Table 1 — Drawing symbols

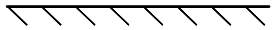
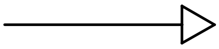
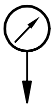
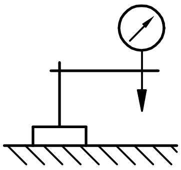
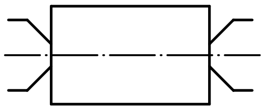
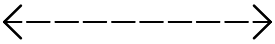
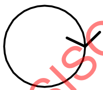
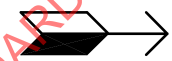
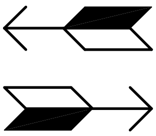
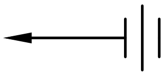
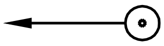
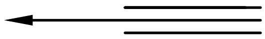
Symbol	Interpretation
	Surface plate (measuring plane)
 (Front view)  (Top view)	Fixed support
	Fixed gauge support
 (Front view)  (Top view)	Indicator or recorder
	Measuring stand with indicator or recorder Symbols for measuring stands can be drawn in different ways in accordance with the measuring equipment used.
	Centred arbor
	Intermittent linear traverse
	Turning against fixed support(s)
	Rotation about centre
	Loading, direction of loading
	Loading alternately in opposite directions

Table 1 — Drawing symbols *(continued)*

Symbol	Interpretation
 (Front view)  (Top view)	Movable support for indicator moving perpendicular to the measured surface
	Movable support for indicator moving parallel to (along) the measured surface

5 General conditions

5.1 Measuring equipment

Measurements of the various dimensions, runouts and clearances can be performed on different types of measuring equipment and with differing degrees of accuracy. The principles described are commonly used by bearing manufacturers and users and generally they provide an accuracy sufficient for practical purposes. It is recommended that the total measuring inaccuracy should not exceed 10 % of the actual tolerance zone. However, the measuring and gauging methods may not always fully check the indicated requirements. Whether or not such methods are sufficient and acceptable depends on the magnitude of the actual deviations from the ideal dimension or form and the inspection circumstances.

Bearing manufacturers frequently use specially designed measuring equipment for individual components, as well as for assemblies, to increase speed and accuracy of measurement. Should the dimensional or geometrical errors appear to exceed those in the relevant specifications, when using equipment as indicated in any of the methods in this part of ISO 1132, the matter should be referred to the bearing manufacturer.

5.2 Masters and indicators

Dimensions are determined by comparing the actual component with appropriate gauge blocks or masters whose calibration is traceable through national standards organizations to the length of the international prototype as defined in ISO 1. For such comparison, a calibrated indicator of appropriate sensitivity is used.

5.3 Arbors

In all cases when the arbor method of measuring runout is used, the rotational accuracy of the arbor shall be determined so that subsequent bearing measurements may be suitably corrected for any appreciable arbor inaccuracy. A precision arbor having a taper of approximately 0,000 2:1 on diameter shall be used.

In cases when an arbor is used to measure the bore diameter of a roller complement, a precision arbor having a taper of approximately 0,000 5:1 on diameter shall be used.

5.4 Temperature

Before any measurements are made, the part to be measured, the measuring equipment and master shall be brought to the temperature of the room in which the measurements are to be made. The recommended room temperature is 20 °C, see ISO 1. Care shall be taken to avoid heat transfer to the component or assembled bearing during measurement.

5.5 Measuring force and radius of measuring stylus

To avoid undue deflection of thin rings, the measuring force shall be minimized. If significant distortion is present, a load deflection factor shall be introduced to correct the measured value to the free unloaded value. The maximum measuring force and minimum radius of the measuring stylus are given in Table 2.

Table 2 — Maximum measuring forces and minimum radii of measuring stylus

Bearing feature	Nominal size range mm		Measuring force [a] N	Stylus radius [b] mm
	>	⩽	max.	min.
Bore diameter *d*	—	10	2	0,8
	10	30	2	2,5
	30	—	2	2,5
Outside diameter *D*	—	30	2	2,5
	30	—	2	2,5

[a] The maximum measuring force is intended to give repeatable measurements without distortion of the specimen. Where distortion occurs, a lower measuring force may be used.

[b] Smaller radii may be used with an appropriate reduction in the measuring force applied.

5.6 Coaxial measuring load

To maintain bearing assemblies in their proper relative positions, the coaxial measuring load given in Tables 3 and 4 should be applied for the methods where specified.

Table 3 — Coaxial measuring loads for radial ball bearings and angular contact ball bearings with contact angles ⩽ 30°

Outside diameter mm		Coaxial load on the bearing N
>	⩽	min.
—	30	5
30	50	10
50	80	20
80	120	35
120	180	70
180	—	140

Table 4 — Coaxial measuring loads for tapered roller bearings, angular contact ball bearings with contact angles > 30° and thrust bearings

Outside diameter mm		Coaxial load on the bearing N
>	⩽	min.
—	30	40
30	50	80
50	80	120
80	120	150
120	—	150

5.7 Measurement zone

The limits for deviations of a bore or an outside diameter are applicable to measurements in radial planes situated at a distance greater than "a" from the side face or flange face of the ring. The values of "a" are given in Table 5.

Only the maximum material size applies outside the measurement zone.

Table 5 — Measurement zone limits

Dimensions in millimetres

$r_{s\,min}$		a
>	⩽	
—	0,6	$r_{s\,max} + 0,5$
0,6	—	$1,2 \times r_{s\,max}$

5.8 Preparation before measuring

Any grease or corrosion inhibitor adhering to the bearing shall be removed if it is likely to affect the measured results. Before measuring, the bearing should be lubricated with a low viscosity oil.

The accuracy of measurements may be adversely affected for pre-lubricated bearings and some designs of sealed and shielded bearings. To eliminate any discrepancy, the measurements shall be made with open bearings, i.e. after removing the seals/shields and/or lubricant.

NOTE Immediately after completion of the measurements, the bearing should be protected with a corrosion inhibitor.

5.9 Reference face for measurements

The reference face is designated by the bearing manufacturer and is usually the datum for measurements.

NOTE The reference face for the measurement of a ring is generally taken as the unmarked face. In the case of symmetrical rings when it is not possible to identify the reference face, the tolerances are deemed to apply relative to either face.

The reference face of a shaft washer and housing washer of a thrust bearing is that face intended to support axial load and is generally opposite the raceway.

In the case of single-row angular contact ball bearing rings and tapered roller bearing rings, the reference face is the “back face” which is intended to support axial load.

For bearings with flanged outer rings, the reference face is the flange face intended to support axial load.

6 Measuring and gauging principles and methods

6.1 General

Principles for measuring and gauging are shown for the applicable definitions in ISO 1132-1. Methods are described as they apply to various bearing types in clauses 7 to 16 of this part of ISO 1132. Where more than one method is shown, a primary method is identified. Many terms in ISO 1132-1 are derivatives of measured features and they are so identified in the comments.

Measurements of geometrical accuracy (e.g. deviation from circular, cylindrical and spherical form) are as specified in ISO 4291.

6.2 Format of clauses

The format of clauses 7 to 16 is arranged in three parts.

a) The title identifying the principle and method including the clause numbering.

b) The left hand column entitled “Method” shows:

- a figure illustrating the method;
- essential characteristics of the method;
- the readings to be taken;
- required repetitions.

c) The right hand column entitled “Comments” is used for supplementary information, e.g.:

- a particular application;
- any restrictions in application;
- any particular sources of error;
- any particular requirements as to equipment;
- examples of equipment;
- treatment of readings obtained.

6.3 Caution

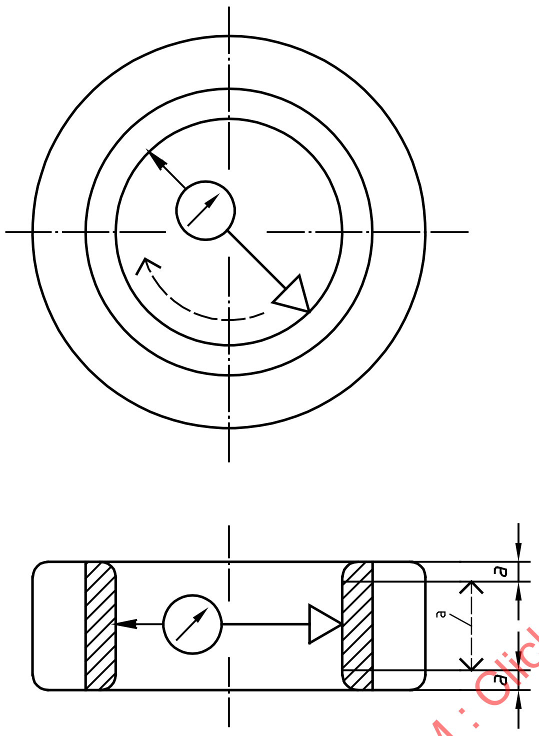
Consideration has not been given to the influence of the accuracy and design of the measuring equipment or to the skill of the operator. These factors sometimes have a significant influence on the resulting measurement or gauged assessment.

The measuring and gauging principles and methods are not illustrated in detail and are not intended for application on end-product drawings.

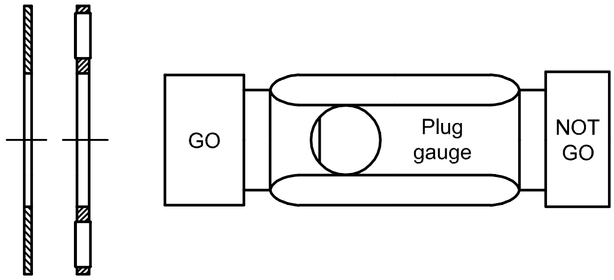
The order of presentation of measuring and gauging principles and methods shall not be regarded as a classification of priority within the prescribed type of measurements.

7 Principles of measuring bore diameter

7.1 Measurement of single bore diameter

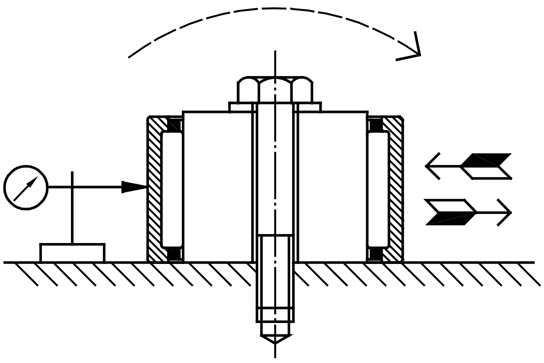
Method	Comments
 a Measuring zone Zero the gauge indicator to the appropriate size using gauge blocks or a master ring. In several angular directions and in a single radial plane, measure and record the largest and the smallest single bore diameters, $d_{sp\ max}$ and $d_{sp\ min}$, within the measuring zone as specified in 5.7. Repeat angular measurements and recordings in several radial planes to determine the largest and the smallest single bore diameter of an individual ring, $d_{s\ max}$ and $d_{s\ min}$.	This method is applicable to all types of rolling bearing rings, shaft washers and central washers. The single bore diameter, d_{sp} or d_s, is measured directly from the indicator. This method is also applicable in measuring a separable cylindrical or needle roller bearing outer ring bore diameter, providing the gauge point clear the raceway lead-in chamfers. The bearing ring or washer shall be placed with the axis in a vertical position in order to avoid the influences of gravity. The following are arithmetically based on the measurements of $d_{sp\ max}$ and $d_{sp\ min}$: d_{mp} mean bore diameter in a single plane; Δ_{dmp} deviation of mean bore diameter in a single plane; V_{dsp} variation of bore diameter in a single plane; V_{dmp} variation of mean bore diameter. The following are arithmetically based on the measurements of d_s, $d_{s\ max}$ and $d_{s\ min}$: d_m mean bore diameter; Δ_{dm} deviation of mean bore diameter; Δ_{ds} deviation of a single bore diameter; V_{ds} variation of bore diameter.

7.2 Functional gauging of smallest single bore diameter of thrust needle roller and cage assembly and thrust washer

Method	Comments
 The bore diameter of a free thrust needle roller and cage assembly or free thrust washer is gauged with GO and NOT GO plug gauges. The GO plug gauge size is the thrust needle roller and cage assembly or thrust washer minimum bore diameter, $d_{cs\ min}$ or $d_{s\ min}$, respectively, as specified in ISO 3031. The NOT GO plug gauge size is the thrust needle roller and cage assembly or thrust washer maximum bore diameter specified in ISO 3031.	This method is applicable to thrust needle roller and cage assemblies and thrust washers specified in ISO 3031. This method may also be used to gauge the smallest bore diameter of housing washers, $D_{1s\ min}$, specified in ISO 104. The assembly or washer shall fall freely from the GO plug gauge under its own weight. The NOT GO plug gauge should not enter the bore of the assembly or washer. Where the NOT GO plug gauge can be forced through the bore, the assembly or washer shall not fall from the gauge under its own weight. Plug gauges are used to verify the limits of size and do not directly measure the bore diameter. NOTE The thrust needle roller and cage assembly and corresponding thrust washer require different plug gauges due to their respective tolerances.

7.3 Measurement of single bore diameter of rolling element complement

Method



Fasten the master gauge to a surface plate.

Bearings with machined rings are measured in the free state.

For drawn cup needle roller bearings, first press the bearing into a hardened steel ring gauge of bore diameter specified in ISO 3245. The minimum radial cross-section of the ring gauge is shown in the adjacent table.

Position the bearing on the master gauge and apply the indicator in the radial direction to the approximate middle of the width on the ring outside surface.

Measure the amount of movement of the outer ring in the radial direction by applying sufficient load on the outer ring in the same radial direction as that of the indicator and in the opposite radial direction. The radial load to be applied is shown in the adjacent table.

Record indicator readings at the extreme radial positions of the outer ring. Rotate the bearing and repeat the measurement in several different angular positions to determine the largest and the smallest readings, $F_{\text{ws max}}$ and $F_{\text{ws min}}$.

Comments

This method is applicable to all radial cylindrical roller, needle roller and drawn cup needle roller bearings without inner ring.

The single bore diameter of rolling element complement, F_{ws}, is equal to the measurement taken plus the master gauge diameter.

The following are arithmetically based on $F_{\text{ws max}}$ and $F_{\text{ws min}}$:

F_{wm} mean bore diameter of rolling element complement;

$\Delta_{F\text{wm}}$ deviation of mean bore diameter of rolling element complement.

Minimum radial cross-section of ring gauges for drawn cup needle roller bearings

Nominal ring gauge bore diameter mm		Ring gauge radial cross-section mm
>	⩽	min. [a]
6	10	10
10	18	12
18	30	15
30	50	18
50	80	20
80	120	25
120	150	30

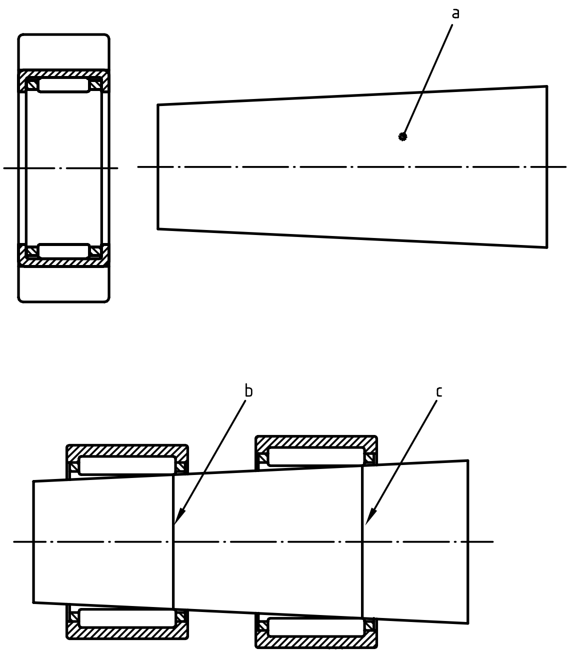
[a] Larger ring gauge radial cross-sections may be used to assure accurate measurement.

Radial measuring loads

F_{w} mm		Measuring load N
>	⩽	min.
—	30	50
30	50	60
50	80	70
80	—	80

7.4 Measurement of smallest single bore diameter of rolling element complement

Method



a Tapered arbor

b Calibrated minimum diameter

c Calibrated maximum diameter

The bore diameter of the rolling element complement is measured with a full circular, calibrated tapered arbor spanning the range of the bore size and having a taper of approximately 0,000 5:1.

Bearings with machined rings are measured in the free state.

For drawn cup needle roller bearings, first press the bearing into a hardened steel ring gauge of bore diameter specified in ISO 3245. The minimum radial cross-section of the ring gauge is shown in the adjacent table.

Seat the tapered arbor in the bearing bore with a slight oscillating motion so as to remove the radial clearance and align the rollers while not expanding the bearing. An axial load for seating the arbor is shown in the adjacent table. Withdraw the arbor and measure its diameter at the location where the roller complement rested against the largest arbor diameter.

NOTE A thin coating of preserving agent applied to the bearing before measurement will indicate the precise stopping point of the rolling elements on the arbor.

Comments

This method is applicable to all radial cylindrical roller, needle roller and drawn cup needle roller bearings without inner ring and with $F_w \leqslant 150$ mm.

This method is used to measure the smallest single bore diameter of rolling element complement, $F_{ws\ min}$. The single bore diameter of rolling element complement, F_{ws}, is not directly measured.

This method may be used as a gauging technique. The arbor is marked on the diameter at the limits of the tolerance range of the bearing bore diameter. The tolerance limits of the bore diameter of a rolling element complement are met if the diameter of the arbor at the contact location of the roller complement exceeds the minimum diameter calibration marking and does not exceed the maximum diameter calibration marking.

Minimum radial cross-section of ring gauges for drawn cup needle roller bearings

Nominal ring gauge bore diameter mm		Ring gauge radial cross-section mm
>	⩽	min. [a]
6	10	10
10	18	12
18	30	15
30	50	18
50	80	20
80	120	25
120	150	30

a Larger ring gauge radial cross-sections may be used to assure accurate measurement.

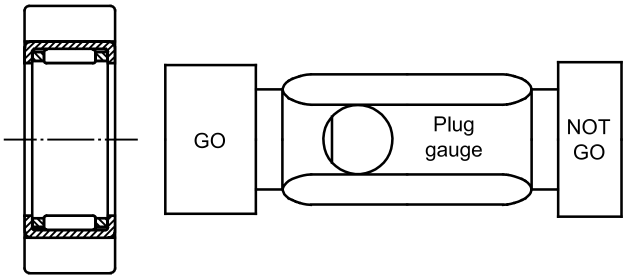
Axial seating loads for measuring with tapered arbor

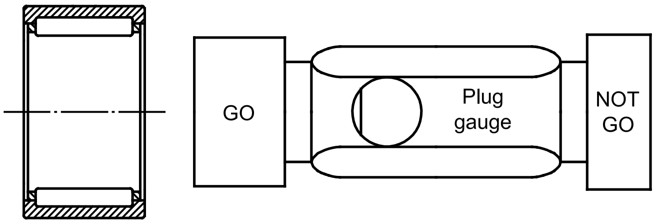
F_w mm		Axial load [a] N
>	⩽	
8	15	10
15	30	15
30	80	30
80	150	50

a Heavier loads may be used provided the measurement is not influenced.

7.5 Functional gauging of smallest single bore diameter of rolling element complement

Method





The bore diameter of the rolling element complement, F_{w}, is gauged with GO and NOT GO plug gauges.

Bearings with machined rings are measured in the free state.

For drawn cup needle roller bearings, first press the bearing into a hardened steel ring gauge of bore diameter specified in ISO 3245. The minimum radial cross-section of the ring gauge is shown in the adjacent table.

The bore diameter of the rolling element complement is then gauged with GO and NOT GO plug gauges.

The GO plug gauge size is the minimum bore diameter of the rolling element complement.

The NOT GO plug gauge size is larger than the maximum bore diameter of the rolling element complement by 0,002 mm.

Comments

This method is applicable to all radial cylindrical roller, needle roller and drawn cup needle roller bearings without inner ring and with $F_{\mathrm{w}} \leqslant 150$ mm.

The bearing, while under its own weight (and in the case of drawn cup bearings, while mounted in a ring gauge and under the combined weight of the ring and bearing), shall fall freely over the GO plug gauge and shall not fall freely over the NOT GO plug gauge.

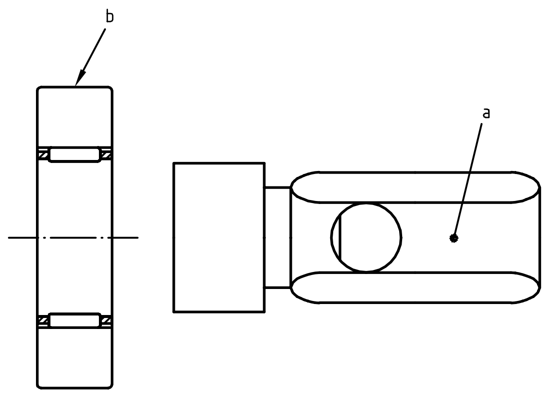
Plug gauges are used to verify limits of size and do not directly measure the single bore diameter of rolling element complement, F_{ws}. This method of gauging determines if the range of $F_{\mathrm{ws\,min}}$ is within the tolerance limits.

Minimum radial cross-section of ring gauges for drawn cup needle roller bearings

Nominal ring gauge bore diameter mm >	Nominal ring gauge bore diameter mm ⩽	Ring gauge radial cross-section mm min. [a]
6	10	10
10	18	12
18	30	15
30	50	18
50	80	20
80	120	25
120	150	30

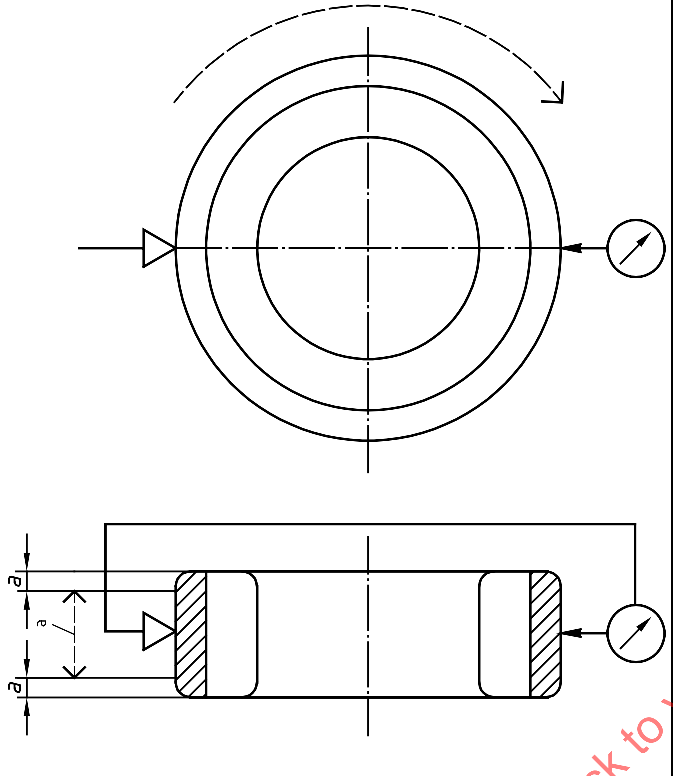
a Larger ring gauge radial cross-sections may be used to assure accuracy.

7.6 Functional gauging of smallest single bore diameter of rolling element complement (radial needle roller and cage assemblies)

Method	Comments
 a Plug gauge b Housing ring gauge Place the radial needle roller and cage assembly in a ring gauge having an outer raceway dimension as specified in ISO 3030. The ring gauge size is equal to the lower deviation of tolerance class G6 (see ISO 286-2) applied to the nominal outside diameter of the rolling element complement, E_w. Insert a plug gauge having a dimension equal to the nominal bore diameter of the rolling element complement, F_w, as specified in ISO 3030. The radial needle roller and cage assembly shall rotate freely when the ring and plug gauges are rotated relative to each other.	This method is applicable to radial needle roller and cage assemblies. The bore and outside diameters of the rolling element complement, F_{ws} and E_{ws}, are not directly measured.

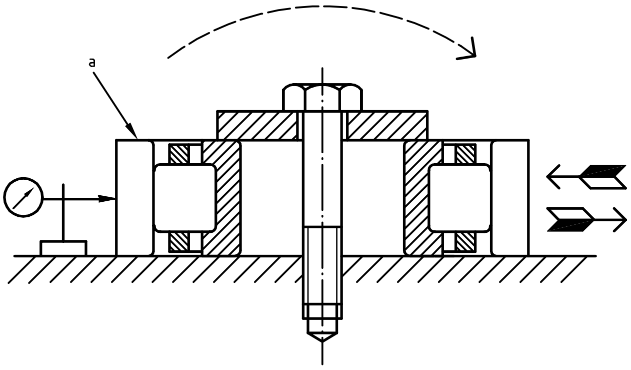
8 Principles of measuring outside diameter

8.1 Measurement of single outside diameter

Method	Comments
 a Measuring zone Zero the gauge indicator to the appropriate size using gauge blocks or a master. In several angular directions and in a single radial plane, measure and record the largest and the smallest single outside diameters, $D_{sp\ max}$ and $D_{sp\ min}$, within the measuring zone as specified in 5.7. Repeat and record measurements in several radial planes to determine the largest and the smallest single outside diameter of an individual ring, $D_{s\ max}$ and $D_{s\ min}$.	This method is applicable to all types of rolling bearing rings, shaft washers and housing washers. The single outside diameter, D_{sp} or D_s, is measured directly from the indicator. The bearing ring or washer shall be placed with the axis in a vertical position to avoid the influences of gravity. The following are arithmetically based on the measurement of $D_{sp\ max}$ and $D_{sp\ min}$: D_{mp} mean outside diameter in a single plane; Δ_{Dmp} deviation of mean outside diameter in a single plane; V_{Dmp} variation of mean outside diameter. The following are arithmetically based on the measurement of D_s, $D_{s\ max}$ and $D_{s\ min}$: D_m mean outside diameter; Δ_{Dm} deviation of mean outside diameter; Δ_{Ds} deviation of a single outside diameter; V_{Ds} variation of outside diameter.

8.2 Measurement of single outside diameter of rolling element complement

Method



a Ring gauge

Fasten the inner ring of the assembled bearing without outer ring on a surface plate. Mount a ring gauge over the outside diameter of the rolling element complement. Apply the indicator to the ring gauge outside diameter surface opposite the middle of the inner ring width.

Measure the amount of movement of the ring gauge in the radial direction by alternately applying sufficient load on the ring gauge in the same radial direction as that of the indicator and in the opposite radial direction. The radial load to be applied is shown in the adjacent table.

Take indicator readings at the extreme radial positions of the ring gauge. Repeat the measurement on the bearing in several different angular positions.

Take indicator readings at the extreme radial positions of the bearing. Repeat the measurement on the bearing in several different angular positions to determine the largest and the smallest readings, $E_{ws\,max}$ and $E_{ws\,min}$.

Comments

This method is applicable to radial cylindrical roller bearings and radial needle roller bearings without outer ring.

The single outside diameter of rolling element complement, E_{ws}, will equal the ring gauge bore diameter minus measurements taken.

The following are arithmetically based on $E_{ws\,max}$ and $E_{ws\,min}$:

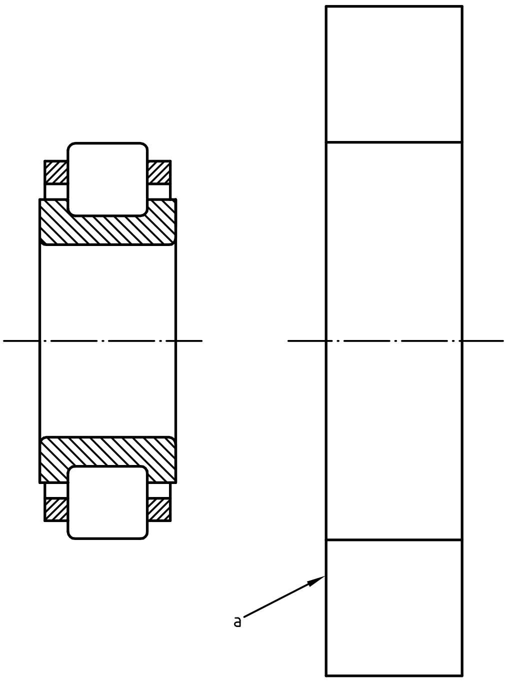
E_{wm} mean outside diameter of rolling element complement;

Δ_{Ewm} deviation of mean outside diameter of rolling element complement.

Radial measuring loads

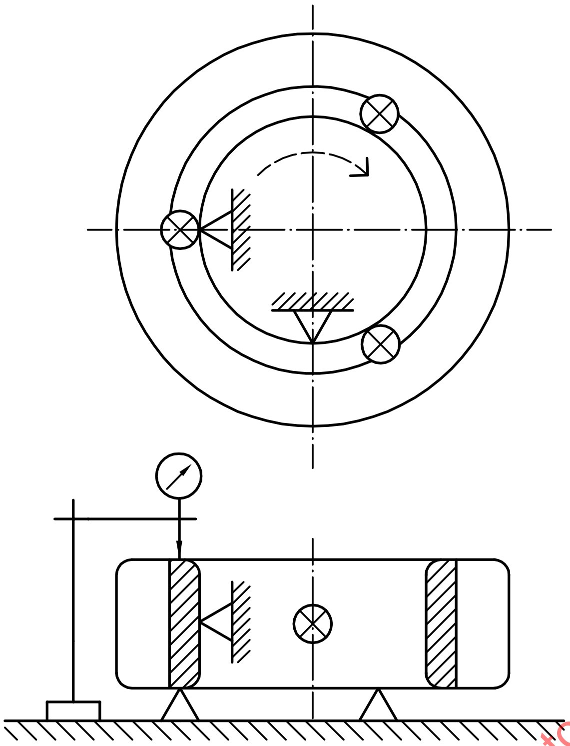
E_w mm		**Measuring load** N
>	⩽	min.
—	30	50
30	50	60
50	80	70
80	—	80

8.3 Functional gauging of largest single outside diameter of rolling element complement

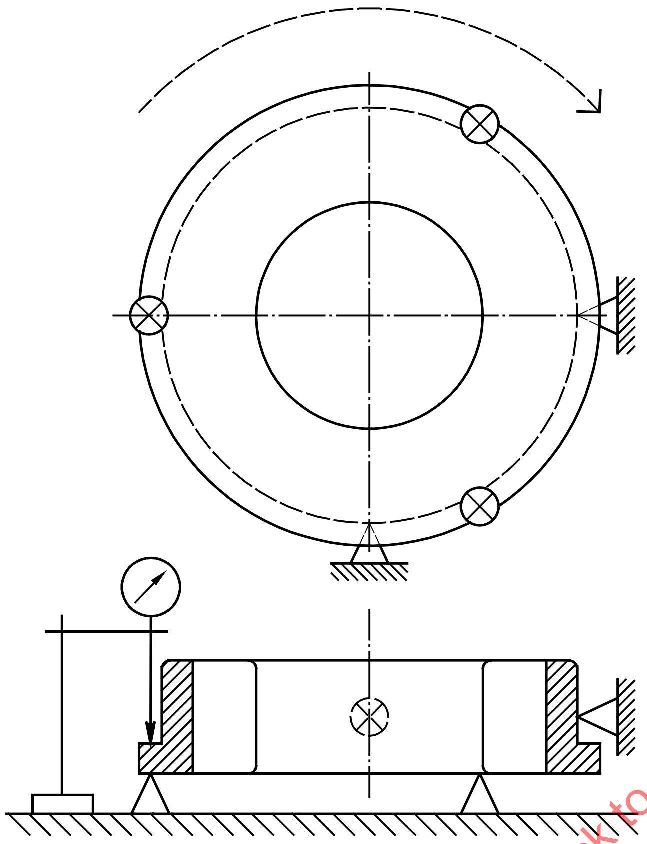
Method	Comments
 [a] Ring gauge The outside diameter of the rolling element complement, E_w, is gauged with GO and NOT GO ring gauges. The GO ring gauge size is larger than the maximum outside diameter of the rolling element complement by 0,002 mm. The NOT GO ring gauge size is smaller than the minimum outside diameter of the rolling element complement by 0,002 mm.	This method is applicable to radial cylindrical roller bearings and radial needle roller bearings without outer ring. The GO gauge shall pass over the roller complement and the NOT GO gauge shall not pass over the roller complement. The ring gauge is used to verify the limits of size and does not directly measure the single outside diameter of the rolling element complement, E_{ws}. This method of gauging determines if the range of $E_{ws\ max}$ is within the tolerance limits.

9 Principles of measuring width and height

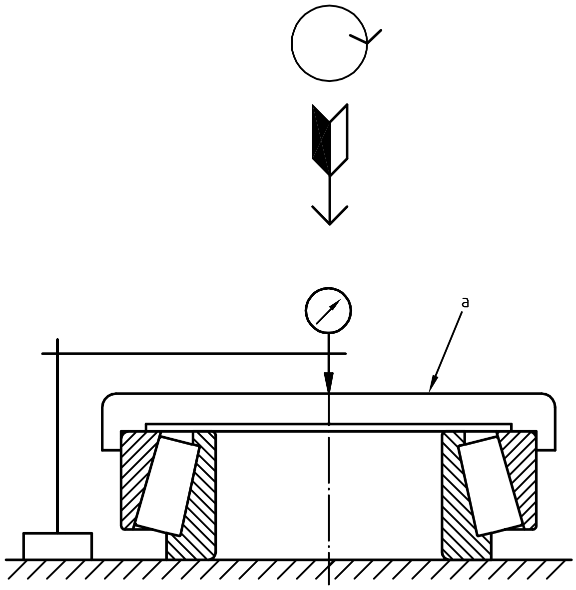
9.1 Measurement of single ring width

Method	Comments
 Zero the gauge indicator to the appropriate height from the reference surface using gauge blocks or a master. Support one face of the ring on three equally spaced fixed supports of equal height and provide two suitable radial supports on the bore surface set at 90° to each other to centre the ring. Position the indicator against the other face of the ring opposite one fixed support. Rotate the ring one revolution and measure and record the largest and the smallest single ring width, $B_{\mathrm{s\,max}}$ and $B_{\mathrm{s\,min}}$ ($C_{\mathrm{s\,max}}$ and $C_{\mathrm{s\,min}}$).	This method is applicable to all types of inner and outer rings of rolling bearings. The single ring width, B_{s} or C_{s}, is the actual measurement made at any point on the ring. The following are arithmetically based on the single inner or outer ring width, B_{s} or C_{s}: $\Delta_{B\mathrm{s}}$ or $\Delta_{C\mathrm{s}}$ deviation of a single ring width; $V_{B\mathrm{s}}$ or $V_{C\mathrm{s}}$ variation of ring width; B_{m} or C_{m} mean ring width.

9.2 Measurement of single outer ring flange width

Method	Comments
 Zero the gauge indicator to an appropriate height from the fixed supports using gauge blocks or a master. Support the flange front face of the outer ring on three equally spaced fixed supports of equal height and provide two suitable radial supports on the bearing outside surface set at 90° to each other to centre the outer ring. Position the indicator against the flange back face opposite one fixed support. Rotate the outer ring one revolution and measure and record the largest and the smallest single outer ring flange width, $C_{1s\,max}$ and $C_{1s\,min}$.	This method is applicable to all types of radial rolling bearings with flanges on their outer rings. The single outer ring flange width, C_{1s}, is the actual measurement made at any position on the flange back face. The following are arithmetically based on the single outer ring flange width, C_{1s}: Δ_{C1s} deviation of a single outer ring flange width; V_{C1s} variation of outer ring flange width.

9.3 Measurement of actual bearing width (primary method)

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>


a Plate

Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.

Support the bearing on the reference face of the inner ring and ensure that the rolling elements are in contact with the raceways. For tapered roller bearings, ensure the rolling elements are in contact with the inner ring back face rib and the raceways.

Place a plate of known thickness on the reference face of the outer ring, apply a dynamically stable coaxial load, as specified in 5.6, and position the indicator over the centre of the plate.

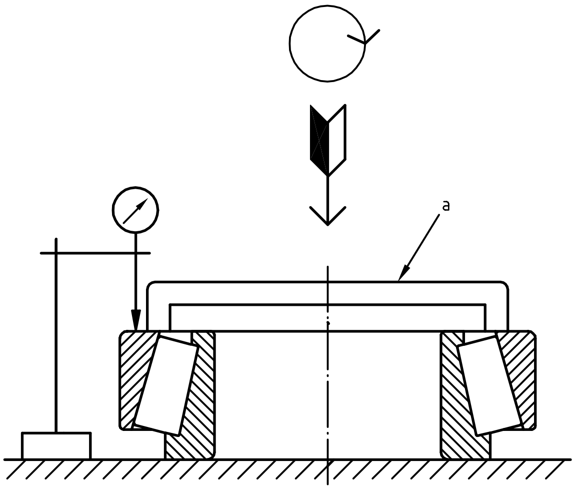
Rotate the outer ring several times, to be sure to reach the minimum width, and take indicator readings.
</td><td>
This method is the primary method for measuring actual bearing width in radial or angular contact bearings where one inner ring face and one outer ring face bound the bearing width. It is applicable to tapered roller bearings, single-row angular contact spherical roller bearings, single-row angular contact ball bearings and single-row thrust spherical roller bearings.

This measurement method excludes the effects of ring face surface flatness.

The actual bearing width, T_{s}, will equal the indicator reading minus the known plate thickness.

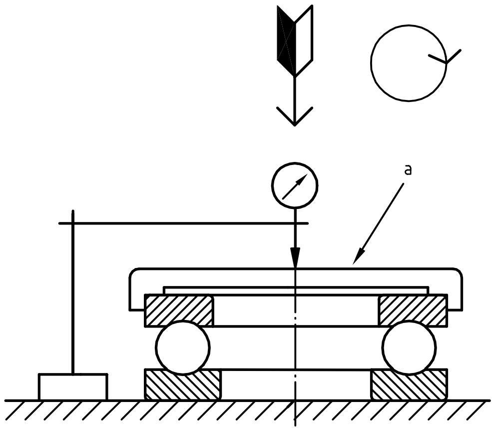
The deviation of the actual bearing width, Δ_{Ts}, is arithmetically based on the measurement of T_{s}.
</td></tr>
</table>

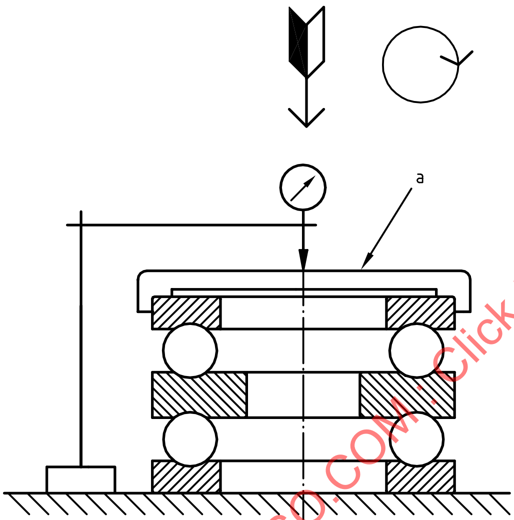
9.4 Measurement of actual bearing width (alternative method)

Method	Comments
 [a] Stabilizing plate Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master. Support the bearing on the reference face of the inner ring and ensure that the rolling elements are in contact with the raceways. For tapered roller bearings, ensure the rolling elements are in contact with the inner ring back face rib and the raceways. Place a stabilizing plate or ring on the reference face of the outer ring and apply a dynamically stable coaxial load as specified in 5.6. Position the indicator on the reference face of the outer ring, rotate the outer ring, and take indicator readings. Repeat readings at several circumferential and radial positions on the outer ring back face to determine the value of the actual bearing width, T_s.	This method is applicable to bearings where one inner ring face and one outer ring face bound the bearing width. It is applicable to tapered roller bearings, single-row angular contact spherical roller bearings, single-row angular contact ball bearings and single-row thrust spherical roller bearings. The deviation of the actual bearing width, Δ_{Ts}, is arithmetically based on the measurement of T_s. This method is an alternative method for measuring actual bearing width, T_s. The actual bearing width is the average of the measurements taken directly from the indicator. For large bearings, the stabilizing plate or ring may be unnecessary. This measurement method includes the effects of surface flatness on the reference face of the outer ring.

9.5 Measurement of actual bearing height (thrust bearings)

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>





[a] Plate

Support the bearing on a surface plate. Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.

Place a plate of known thickness on the bearing assembly, apply a dynamically stable coaxial load, as specified in 5.6, and position the indicator over the centre of the plate.

Rotate the bearing several times, to be sure to reach the smallest height, and take indicator readings.

</td><td>

This method is applicable to all types of thrust bearings including thrust ball, thrust cylindrical roller and thrust tapered roller bearings.

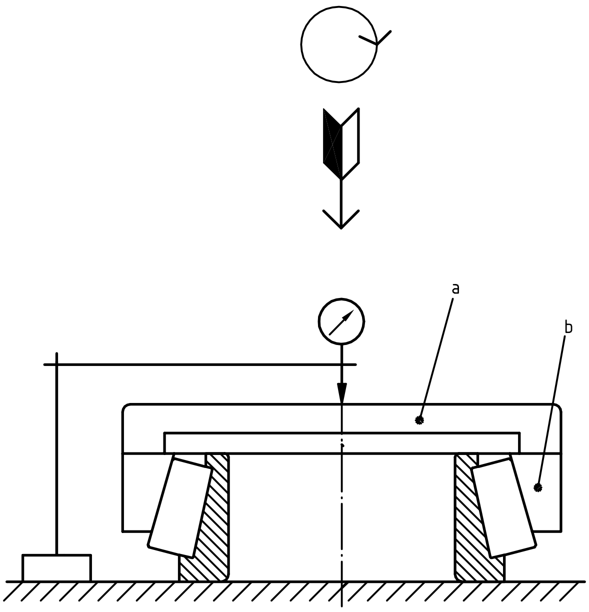
The actual bearing height, T_s, will equal the indicator reading minus the known plate thickness.

This measurement method excludes the effects of washer face surface flatness.

The determination of the deviation of the actual bearing height, Δ_{Ts}, is arithmetically based on the measurement of T_s.

</td></tr>
</table>

9.6 Measurement of actual effective width of inner subunit (tapered roller bearings)

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>


a Plate

b Master outer ring

Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.

Support the inner subunit on the reference face of the inner ring and ensure the rollers are in contact with the inner ring back face rib and raceway.

Place the master outer ring in position on the inner subunit.

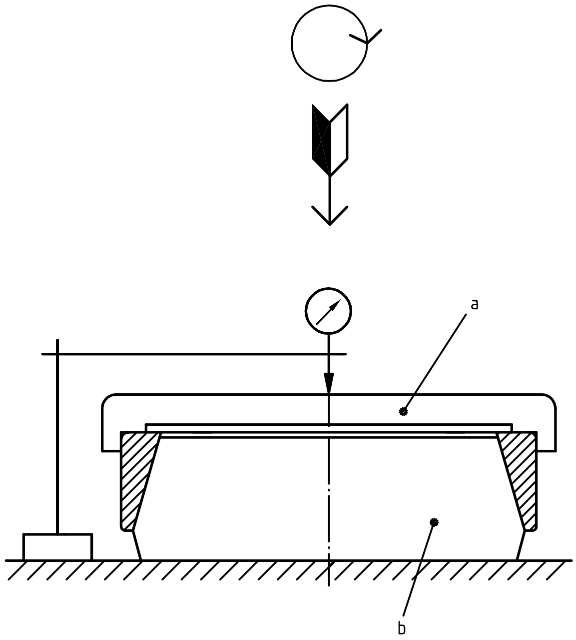
Place a plate of known thickness on the master outer ring back face, apply a dynamically stable coaxial load, as specified in 5.6, and position the indicator over the centre of the plate.

Rotate the master outer ring several times, to be sure to reach the minimum width, and take indicator readings.
</td><td>
This method is applicable to tapered roller bearing inner subunits. It requires the use of a master outer ring.

The actual effective width of the inner subunit, T_{1s}, is based on the height of the master outer ring and is equal to the indicator reading minus the known plate thickness.

This measurement method excludes the effects of ring face surface flatness.
</td></tr>
</table>

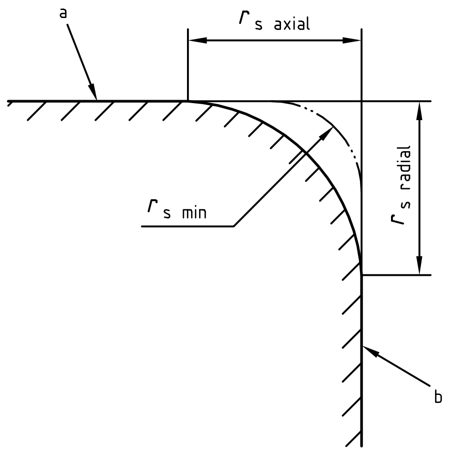
9.7 Measurement of actual effective width of outer ring (tapered roller bearings)

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>


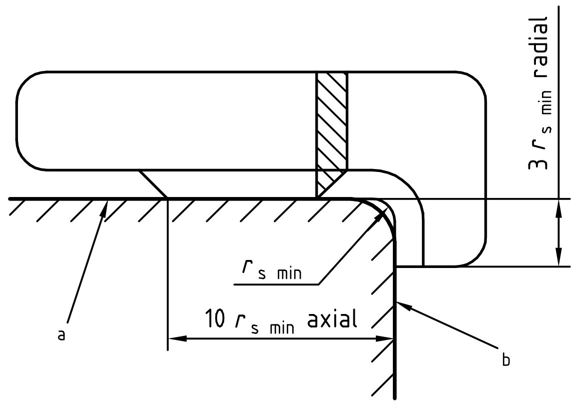
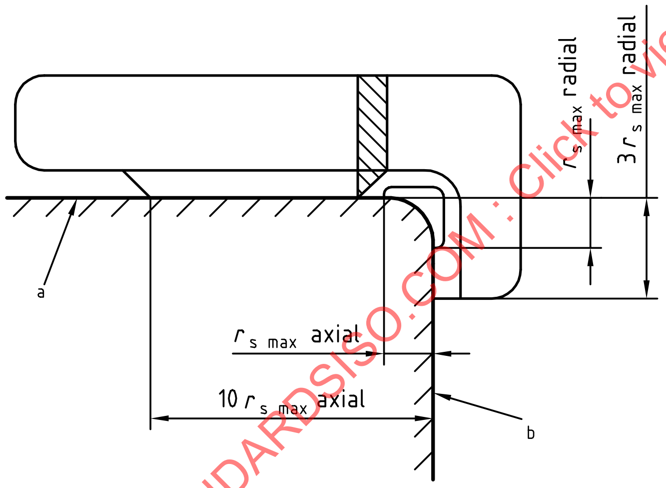
a Plate
b Inner master plug
Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.
Support the back face of an inner master plug on the surface plate and place the outer ring in position on the plug.
Place a plate of known thickness on the back face of the outer ring, apply a dynamically stable coaxial load, as specified in 5.6, and position the indicator over the centre of the plate.
Reposition the outer ring several times, to be sure to reach the minimum width, and take indicator reading.
</td><td>
This method is applicable to tapered roller bearing outer rings. It requires the use of an inner master plug.
The actual effective width of the outer ring, T_{2s}, is based on the height of the inner master plug and is equal to the indicator reading minus the known plate thickness.
This measurement method excludes the effects of ring face surface flatness.
Where necessary, a calibrated inner subunit (sub-assembly of inner ring, cage and rolling elements) may be used in place of an inner master plug.
</td></tr>
</table>

10 Principles of measuring ring and washer chamfer dimension

10.1 Measurement of single chamfer dimension (primary method)

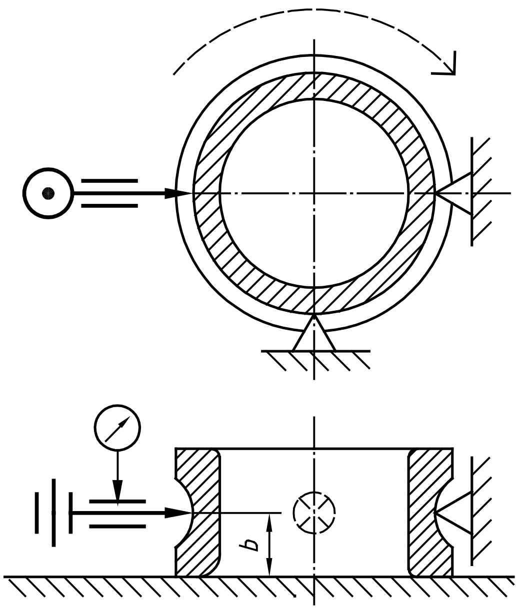
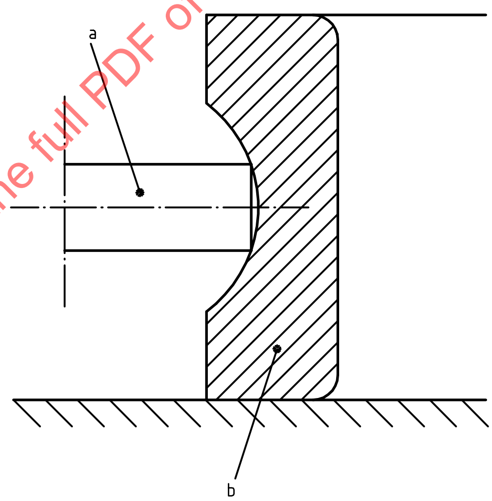
Method	Comments
 a Bore or outside diameter surface b Face surface Draw the chamfer profile with a profile projector using a magnification of at least × 20. Extend the profile generatrix of the diameter surface and the face surface up to the point of intersection. From the point of intersection, measure the horizontal and vertical distances to the beginning of the diameter and face surfaces. Draw in a circular arc with a radius equal to $r_{s\ min}$. If the nominal radial and axial chamfer distances are different, use the smaller of the two chamfer distances.	This method of measuring the radii r_s is applicable to inner and outer rings and thrust washers for all types of rolling bearings. The ring chamfer shall not extend beyond the circular arc having the radius $r_{s\ min}$. NOTE 1 The axial and radial limits of $r_{s\ max}$ may differ. NOTE 2 The method is equally applicable to measurement of radii designated r_1, r_2, etc.

10.2 Functional gauging of single chamfer dimension (alternative method)

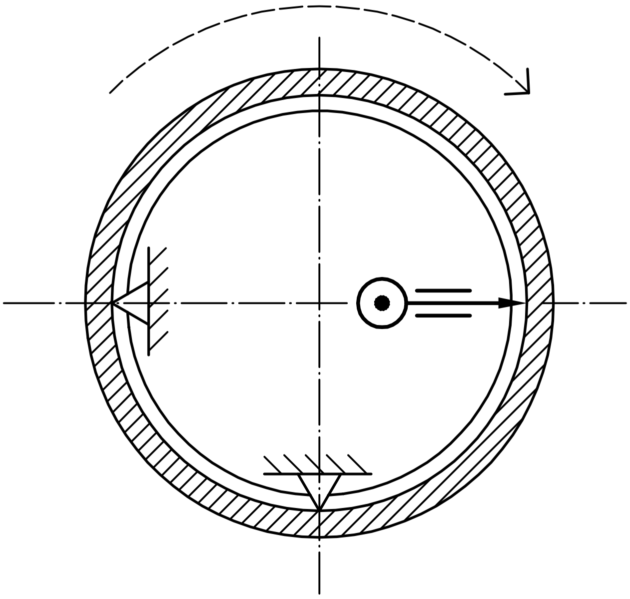
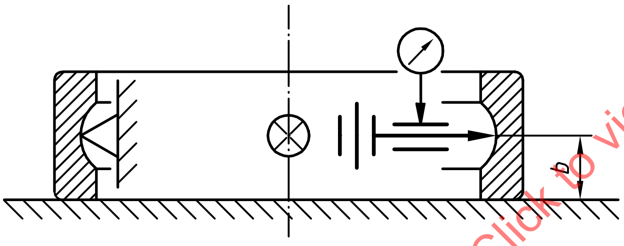
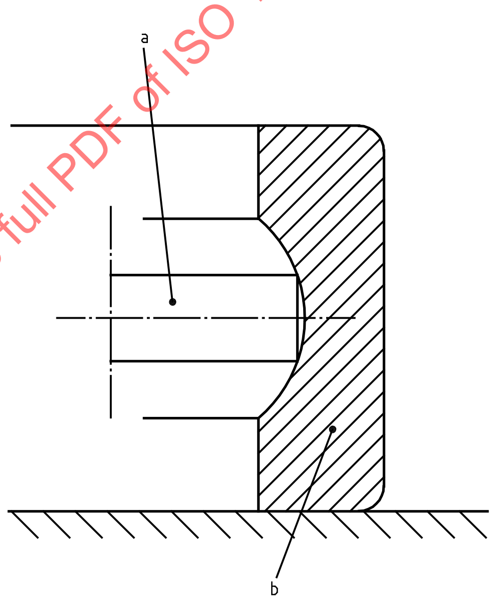
Method	Comments
 a Bore or outside diameter surface b Face surface Place the minimum chamfer template against the ring or washer. The template should rest on both the diameter surface and the face surface. Compare the ring or washer chamfer with the profile of the template.  a Bore or outside diameter surface b Face surface Place the maximum chamfer template against the ring or washer. The template should rest on both the diameter surface and the face surface. Compare the ring or washer chamfer with the markings of the template.	This method of gauging the radii r_s is applicable to inner and outer rings and thrust washers for all types of rolling bearings. The ring or washer chamfer shall not interfere with the minimum chamfer ($r_{s\,min}$) template. The ring or washer chamfer shall not extend beyond the markings on the maximum chamfer ($r_{s\,max}$) template. NOTE 1 The axial and radial limits of $r_{s\,max}$ may differ. NOTE 2 The method is equally applicable to gauging of radii designated r_1, r_2, etc.

11 Principles of measuring raceway parallelism

11.1 Measurement of parallelism of inner ring raceway with respect to the face

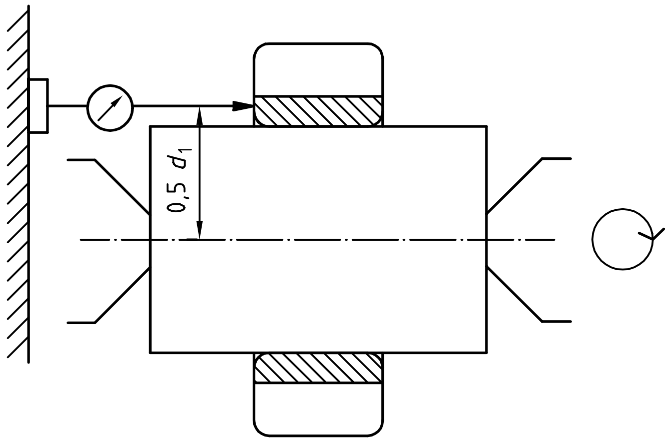
Method	Comments
 Support the reference face of the inner ring on a surface plate, and provide two supports on the raceway surface, set at 90° to each other at the middle of the raceway, to centre the inner ring. Position the gauge head opposite one of the fixed supports and ensure constant pressure of the gauge head against the raceway and in a direction parallel with the ring axis. Take indicator readings while rotating the inner ring one revolution.	This method is applicable to all radial groove ball bearings. The parallelism of inner ring raceway with respect to the face, S_i, is the difference between the largest and the smallest indicator readings. The height of the gauge head, b, is located at the raceway contact diameter. In practice, the axial movement of the gauge head is improved by using a head that spans the curvature of the raceway (see diagram below).  a Gauge head b Inner ring

11.2 Measurement of parallelism of outer ring raceway with respect to the face

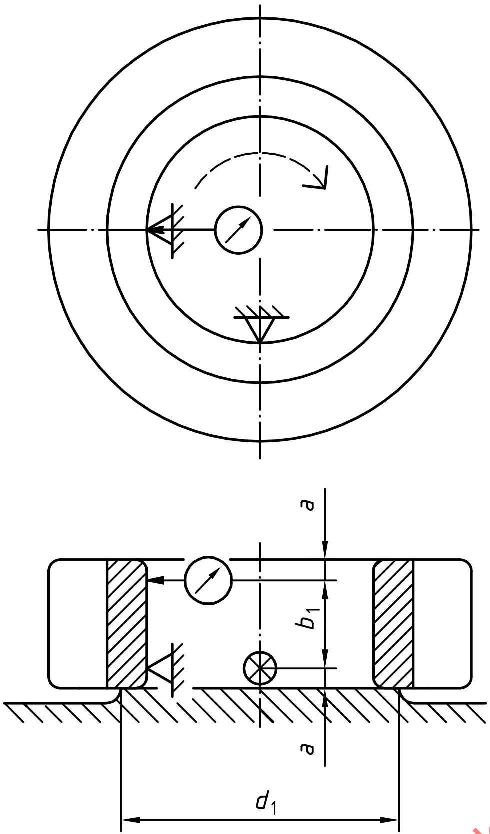
Method	Comments
  Support the reference face of the outer ring on a surface plate, and provide two supports on the raceway surface, set at 90° to each other at the middle of the raceway, to centre the outer ring. Position the gauge head opposite one of the fixed supports and ensure constant pressure of the gauge head against the raceway and in a direction parallel with the ring axis. Take indicator readings while rotating the outer ring one revolution.	This method is applicable to all radial groove ball bearings. The parallelism of outer ring raceway with respect to the reference face, S_e, is the difference between the largest and the smallest indicator readings. The height of the gauge head, b, is located at the raceway contact diameter. In practice, the axial movement of the gauge head is improved by using a head that spans the curvature of the raceway (see diagram below).  [a] Gauge head [b] Outer ring

12 Principles of measuring surface perpendicularity

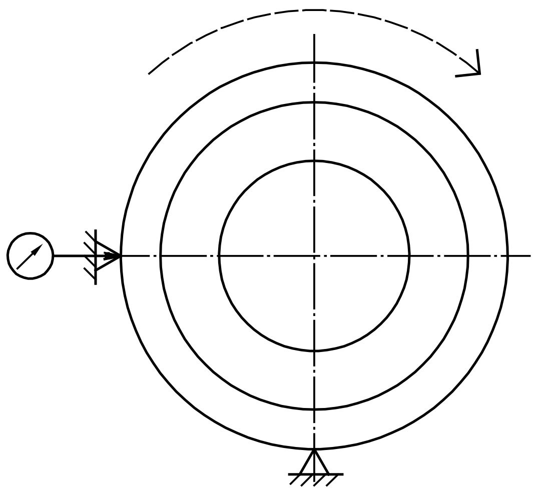
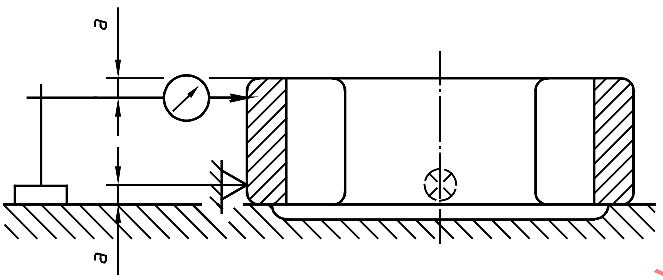
12.1 Measurement of perpendicularity of inner ring face with respect to the bore (method A)

Method	Comments
 Use a precision arbor having a taper of approximately 0,000 2:1 on diameter. Mount the bearing assembly on the tapered arbor and place the arbor between two centres so that it can be accurately rotated. Position the indicator against the reference face of the inner ring at a radial distance from the arbor axis of half the mean diameter of the face. Take indicator readings while rotating the inner ring one revolution.	This method is applicable to radial rolling bearings and their inner rings. It is most applicable to inner rings with an inner ring bore diameter-to-width ratio of less than four. The perpendicularity of the inner ring face with respect to the bore, S_d, is the difference between the largest and the smallest indicator readings. NOTE Care must be taken when mounting the bearing on the arbor that the inner ring bore axis is coaxial with the arbor axis. d_1 mean diameter of inner ring face

12.2 Measurement of perpendicularity of inner ring face with respect to the bore (method B)

Method	Comments
 Support the reference face of the inner ring on a surface plate, leaving the outer ring, if an assembled bearing, free and locate the inner ring bore surface against two supports set at 90° to each other to centre the inner ring. Position the indicator directly above one support. The indicator and the two supports are axially located at the extremes of the measurement zone based on the chamfer size as specified in 5.7. Take indicator readings while rotating the inner ring one revolution.	This method is applicable to all types of radial rolling bearings and their inner rings. It is primarily applicable to large rings, where measurements are affected by bearing weight, or inner rings with a bore diameter-to-width ratio equal to or greater than four. This method of measurement defines the deviation of the bore with respect to the face and is converted to deviation of the face with respect to the bore, S_d, by calculation thus: $$S_d = \frac{S_{dr} \times d_1}{2 \times b_1}$$ S_d perpendicularity of inner ring face with respect to the bore S_{dr} difference between maximum indicator reading and minimum indicator reading d_1 mean diameter of inner ring face b_1 axial distance between the indicator and the fixed support directly below it

12.3 Measurement of perpendicularity of outer ring outside surface with respect to the face

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>


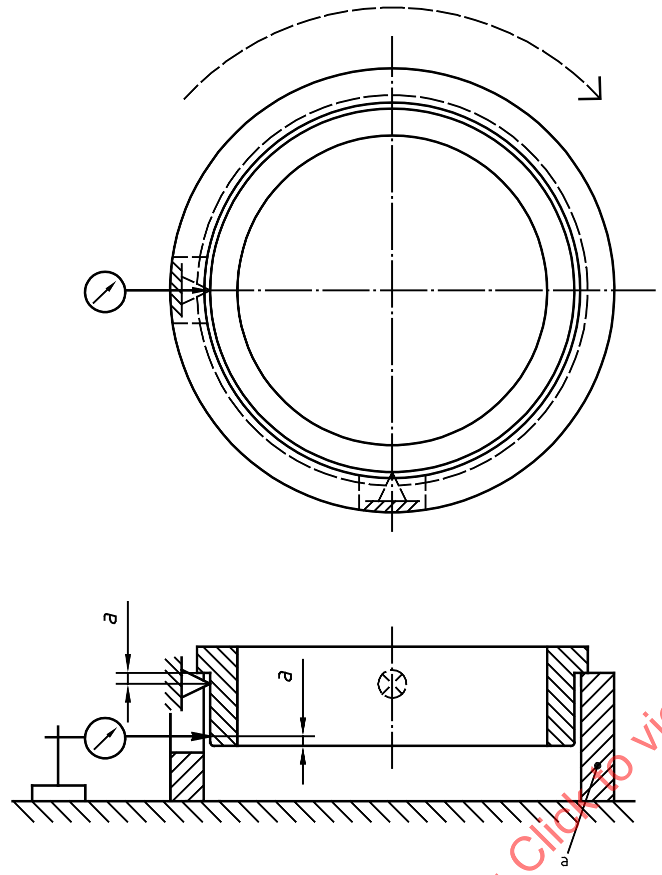
Support the reference face of the outer ring on a surface plate leaving the inner ring, if an assembled bearing, free. Locate the outer ring cylindrical outside surface against two supports set at 90° to each other to centre the outer ring.

Position the indicator directly above one support. The indicator and the two supports are axially located at the extremes of the measurement zone based on the chamfer size as specified in 5.7.

Take indicator readings while rotating the outer ring one revolution.</td><td>This method is applicable to all types of radial rolling bearings and their outer rings. It is particularly applicable to large rings, where measurements are affected by bearing weight, or rings with a diameter-to-width ratio equal to or greater than four.

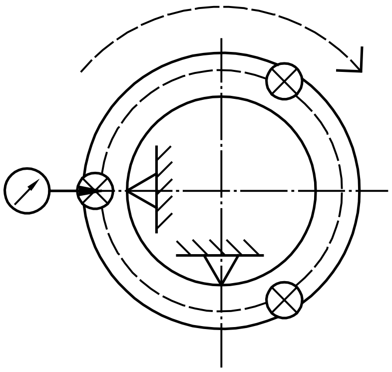
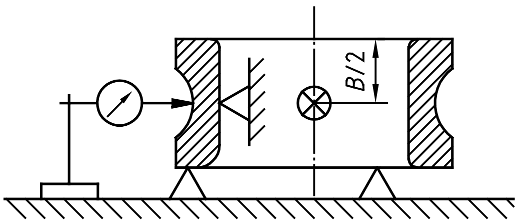
The perpendicularity of outer ring outside surface with respect to the face, S_D, is the difference between the largest and the smallest indicator readings.</td></tr>
</table>

12.4 Measurement of perpendicularity of outer ring outside surface with respect to the flange back face

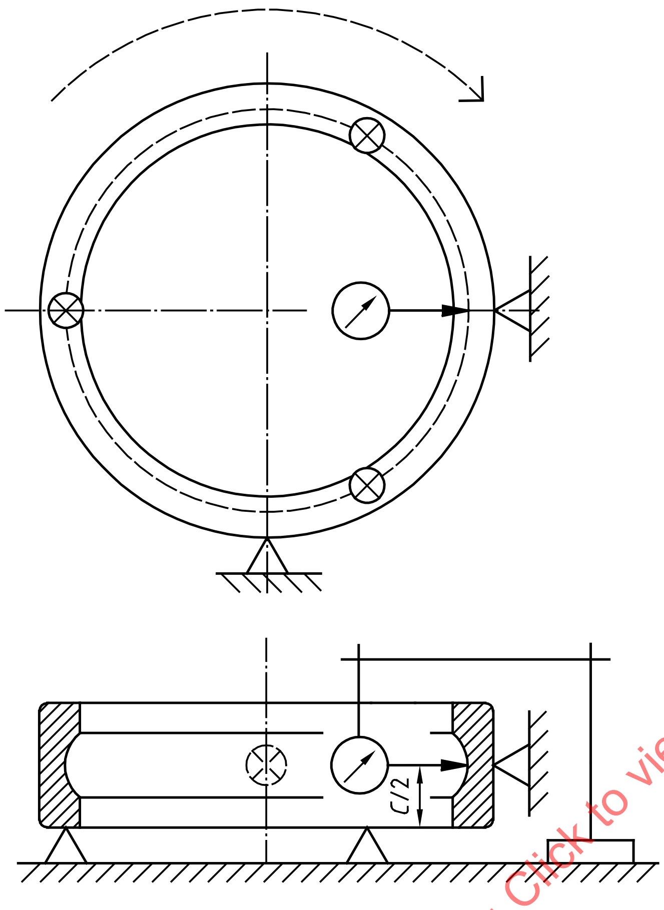
Method	Comments
 [a] Cylindrical support ring Support the flange back face of the outer ring on the face of a cylindrical support ring, leaving the inner ring, if an assembled bearing, free. The bore diameter of the supporting ring should equal the mean diameter of the flange. Locate the outer ring outside diameter surface against two supports set at 90° to each other to centre the outer ring. NOTE Slots in the support ring permit access for side supports. Position the indicator directly below one support. The indicator and the two supports are axially located at the extremes of the measuring zone based on the chamfer size as specified in 5.7. Take indicator readings while rotating the outer ring one revolution.	This method is applicable to all types of radial rolling bearings with flanged outer rings. The perpendicularity of outer ring outside surface with respect to the flange back face, S_{D1}, is the difference between the largest and the smallest indicator readings.

13 Principles of measuring thickness variation

13.1 Measurement of variation in thickness between inner ring raceway and bore

Method	Comments
  Support one face of the inner ring on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the bore surface set at 90° to each other, at an axial distance of $B/2$, or opposite the middle of the raceway, to centre the inner ring. Position the indicator opposite one bore support. Take indicator readings while rotating the inner ring one revolution.	This method is applicable to all types of radial and angular contact rolling bearing inner rings. The variation in thickness between inner ring raceway and bore, K_{i}, is the difference between the largest and the smallest indicator readings.

13.2 Measurement of variation in thickness between outer ring raceway and outside surface

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>

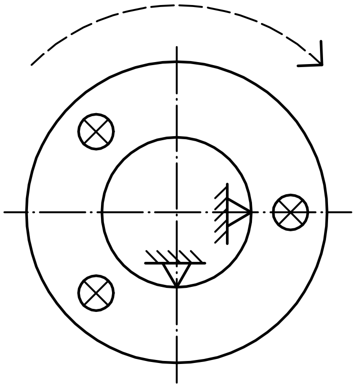
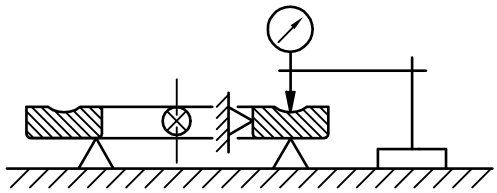
Support one face of the outer ring on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the outside surface set at 90° to each other, at an axial distance of $C/2$, or opposite the middle of the raceway, to centre the inner ring.

Position the indicator opposite one outside diameter support.

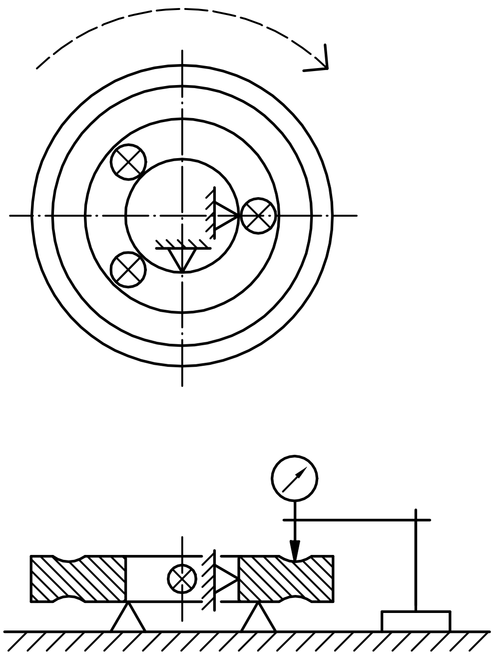
Take indicator readings while rotating the outer ring one revolution.</td><td>This method is applicable to all types of radial and angular contact rolling bearing outer rings.

The variation in thickness between outer ring raceway and outside surface, K_e, is the difference between the largest and the smallest indicator readings.</td></tr>
</table>

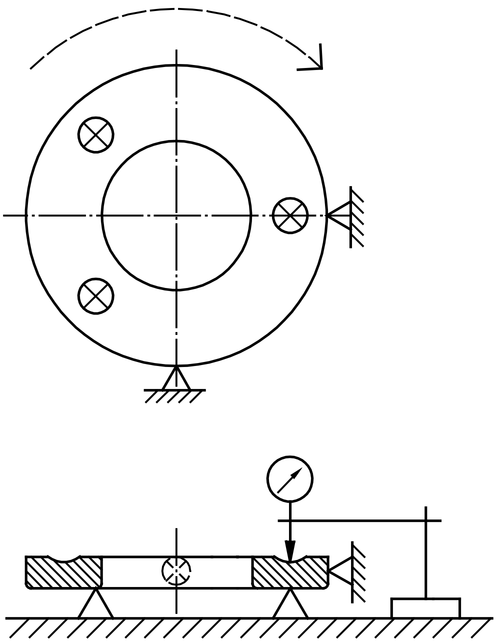
13.3 Measurement of variation in thickness between shaft washer raceway and back face

Method	Comments
  Support the flat back face of the shaft washer on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the bore surface, set at 90° to each other, to centre the shaft washer. Position the indicator against the middle of the raceway directly opposite one fixed support. With the washer in contact with the supports, take indicator readings while rotating the washer one revolution.	This method is applicable to shaft washers with a flat raceway or profiled raceway and flat back face. The variation in thickness between shaft washer raceway and back face, S_i, is the difference between the largest and the smallest indicator readings.

13.4 Measurement of variation in thickness between raceway and back face of central shaft washer

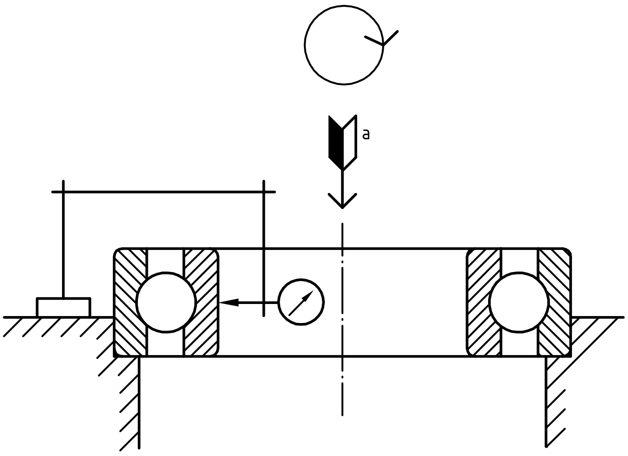
Method	Comments
 Support a face of the central shaft washer on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the bore surface, set at 90° to each other, to centre the shaft washer. Position the indicator against the middle of the raceway adjacent to one fixed support. With the washer in contact with the supports, take indicator readings while rotating the washer one revolution. Repeat the measurement for the opposite raceway.	This method is applicable to central shaft washers with a profiled raceway on each face. The variation in thickness between shaft washer raceway and back face, S_i, is the difference between the largest and the smallest indicator readings. Each variation of thickness of the back face to raceway is an independent measurement.

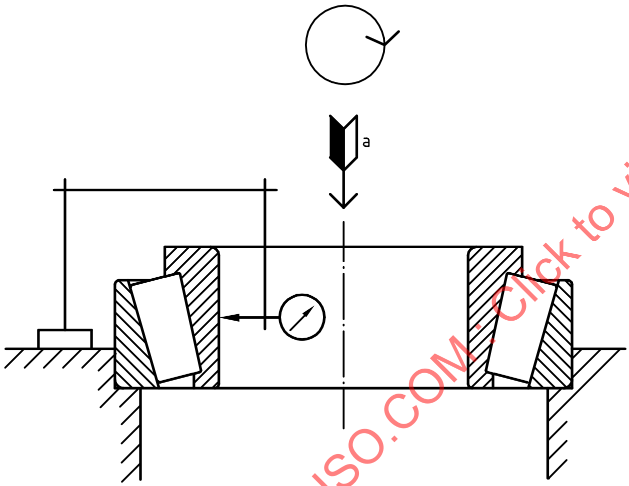
13.5 Measurement of variation in thickness between housing washer raceway and back face

Method	Comments
 Support the flat back face of the housing washer on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the outside surface, set at 90° to each other, to centre the housing washer. Position the indicator against the middle of the raceway directly opposite one fixed support. With the washer in contact with the supports, take indicator readings while rotating the washer one revolution.	This method is applicable to housing washers with a flat raceway or profiled raceway and flat back face. The variation in thickness between housing washer raceway and back face, S_e, is the difference between the largest and the smallest indicator readings.

14 Principles of measuring radial runout

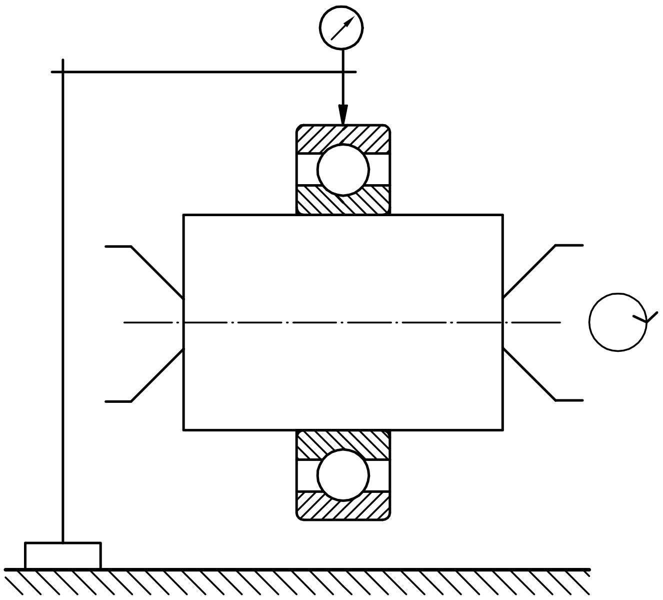
14.1 Measurement of radial runout of inner ring of assembled bearing (primary method)

<table>
<tr><th>Method</th><th>Comments</th></tr>
<tr><td>


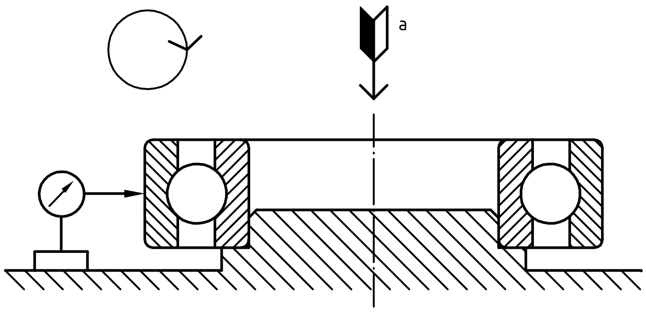
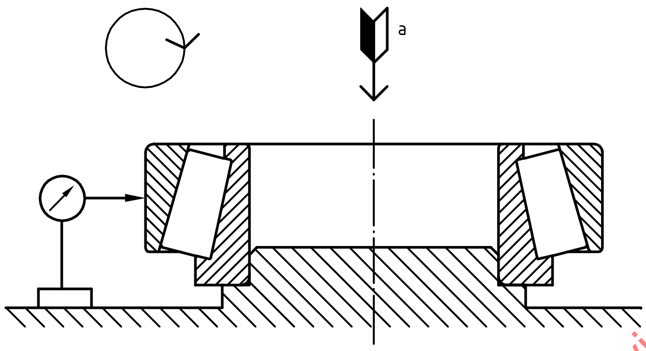


[a] Load on inner ring
Support the reference face of the outer ring on a surface plate with a pilot for centering the outside diameter of the ring. Apply a dynamically stable coaxial load, as specified in 5.6, to the reference face of the inner ring in order to ensure contact between rolling elements and raceways. For tapered roller bearings, ensure the rolling elements are in contact with the inner ring back face rib and the raceways.
Position the indicator against the bore surface of the inner ring as close as possible to the middle of the inner ring raceway. Take indicator readings while rotating the inner ring one revolution.
</td><td>
This method is applicable to radial groove ball bearings (including single-row angular contact ball bearings), 4-point-contact ball bearings and tapered roller bearings.
The radial runout of inner ring of assembled bearing, K_{ia}, is the difference between the largest and the smallest indicator readings.
Radial runout of the inner ring of an assembled bearing is the result of several factors (e.g. variation of rolling element diameter, raceway imperfections and waviness, variation of contact angle, reference face/surface flatness and lubricant contaminant). Accurate measurement is difficult, particularly in higher precision classes of bearings. In cases of dispute, the producer and the user may agree on a more specific method, which may include the measurement of individual components as specified in 11.1, 11.2, 13.1 and 13.2.
</td></tr>
</table>

14.2 Measurement of radial runout of inner ring of assembled bearing (alternative method)

Method	Comments
 Use a precision arbor having a taper of approximately 0,000 2:1 on diameter. Mount the bearing assembly on the tapered arbor and place the arbor between two centres so that it can be accurately rotated. Position the indicator against the outside surface of the outer ring as close as possible to the middle of the outer ring raceway. Hold the outer ring to prevent rotation but ensure its weight is supported by the rolling elements. Take indicator readings while rotating the arbor one revolution.	This method is applicable to radial groove ball bearings (except single-row angular contact ball bearings), radial cylindrical roller, spherical roller and needle roller bearings. The radial runout of inner ring of assembled bearing, K_{ia}, is the difference between the largest and the smallest indicator readings. Radial runout of the inner ring of an assembled bearing is the result of several factors (e.g. variation of rolling element diameter, raceway imperfections and waviness, variation of contact angle, reference face/surface flatness and lubricant contaminant). Accurate measurement is difficult, particularly in higher precision classes of bearings. In cases of dispute, the producer and the user may agree on a more specific method, which may include the measurement of individual components as specified in 11.1, 11.2, 13.1 and 13.2.

14.3 Measurement of radial runout of outer ring of assembled bearing (primary method)

Method	Comments
  [a] Load on outer ring Support the reference face of the inner ring on a surface plate with a pilot for centering the bore of the ring. Apply a dynamically stable coaxial load, as specified in 5.6, to the reference face of the outer ring in order to ensure contact between rolling elements and raceways. For tapered roller bearings, ensure the rolling elements are in contact with the inner ring back face rib and the raceways. Position the indicator against the outside surface of the outer ring as close as possible to the middle of the outer ring raceway and take indicator readings while rotating the outer ring one revolution.	This method is applicable to radial groove ball bearings (including single-row angular contact ball bearings), 4-point-contact ball bearings and tapered roller bearings. The radial runout of outer ring of assembled bearing, K_{ea}, is the difference between the largest and the smallest indicator readings. Radial runout of the outer ring of an assembled bearing is the result of several factors (e.g. variation of rolling element size, raceway imperfections and waviness, variation of contact angle, reference face/surface flatness and lubricant contaminant). Accurate measurement is difficult, particularly in higher precision classes of bearings. In cases of dispute, the producer and the user may agree on a more specific method, which may include the measurement of individual components as specified in 11.1, 11.2, 13.1 and 13.2.