

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 1132-2:2001(E)

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

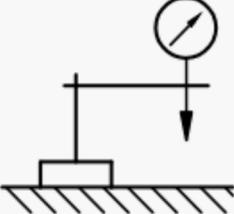
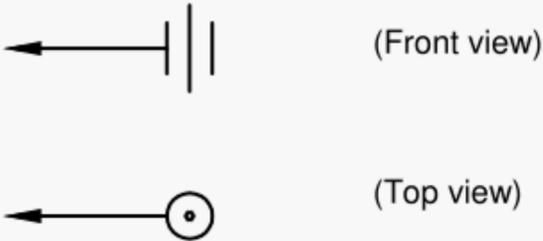
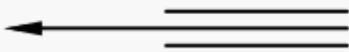
Symbol	Interpretation
	Surface plate (measuring plane)
	Fixed support
	Fixed gauge support
	Indicator or recorder
	Measuring stand with indicator or recorder Symbols for measuring stands can be drawn in different ways in accordance with the measuring equipment used.
	Centred arbor
	Intermittent linear 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
 <p>(Front view)</p> <p>(Top view)</p>	<p>Movable support for indicator moving perpendicular to the measured surface</p>
	<p>Movable support for indicator moving parallel to (along) the measured surface</p>

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 max.	Stylus radius ^b mm min.
	>	≤		
Bore diameter <i>d</i>	—	10	2	0,8
	10	30	2	2,5
	30	—	2	2,5
Outside diameter <i>D</i>	—	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

<i>r_s min</i>		<i>a</i>
>	≤	
—	0,6	<i>r_s max</i> + 0,5
0,6	—	1,2 × <i>r_s max</i>

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

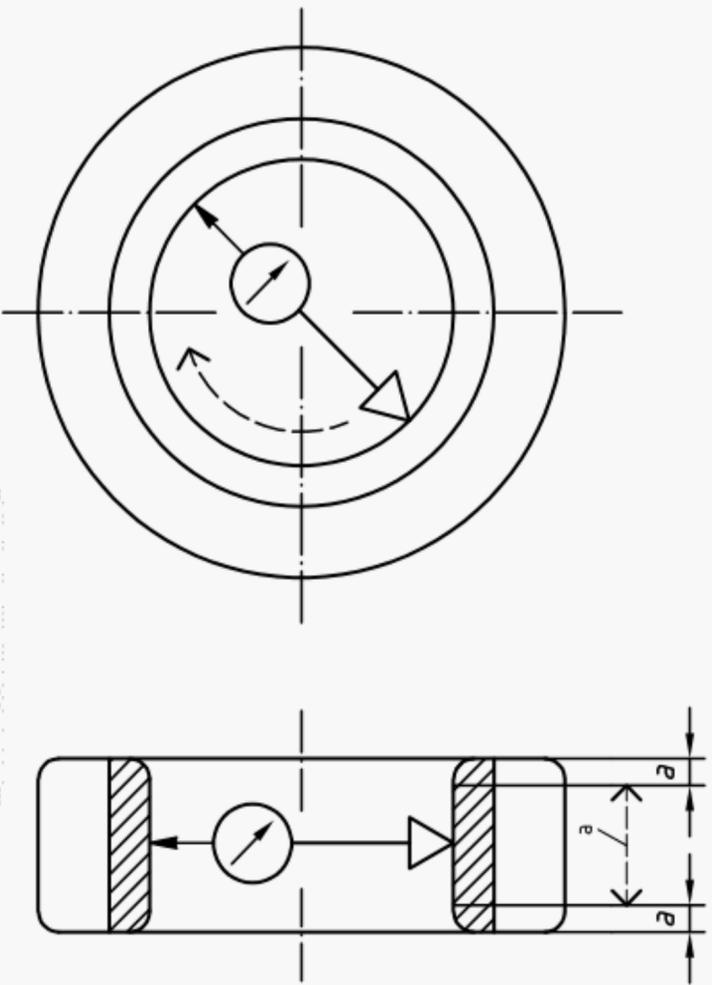
Consideration has not been given to the influence of the accuracy and design of the measuring equipment or to the skill of the operator. These factors sometimes have a significant influence on the resulting measurement or gauged assessment.

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

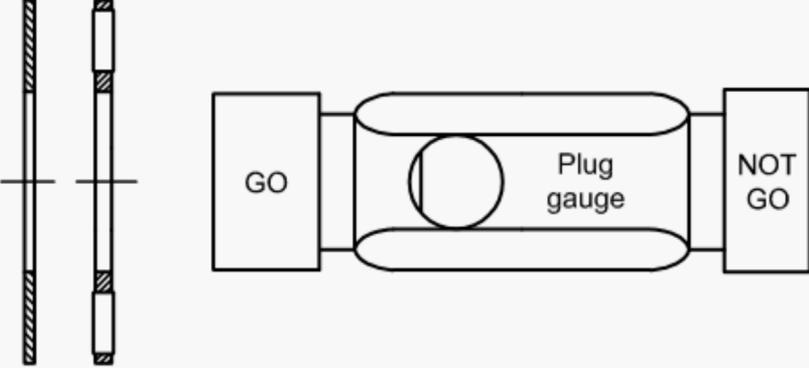
The order of presentation of measuring and gauging principles and methods shall not be regarded as a classification of priority within the prescribed type of measurements.

7 Principles of measuring bore diameter

7.1 Measurement of single bore diameter

Method	Comments
<div style="text-align: center;">  </div> <p>a Measuring zone</p> <p>Zero the gauge indicator to the appropriate size using gauge blocks or a master ring.</p> <p>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.</p> <p>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 $d_{s\ min}$.</p>	<p>This method is applicable to all types of rolling bearing rings, shaft washers and central washers.</p> <p>The single bore diameter, d_{sp} or d_s, is measured directly from the indicator.</p> <p>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.</p> <p>The bearing ring or washer shall be placed with the axis in a vertical position in order to avoid the influences of gravity.</p> <p>The following are arithmetically based on the measurements of $d_{sp\ max}$ and $d_{sp\ min}$:</p> <ul style="list-style-type: none"> 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. <p>The following are arithmetically based on the measurements of d_s, $d_{s\ max}$ and $d_{s\ min}$:</p> <ul style="list-style-type: none"> 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.

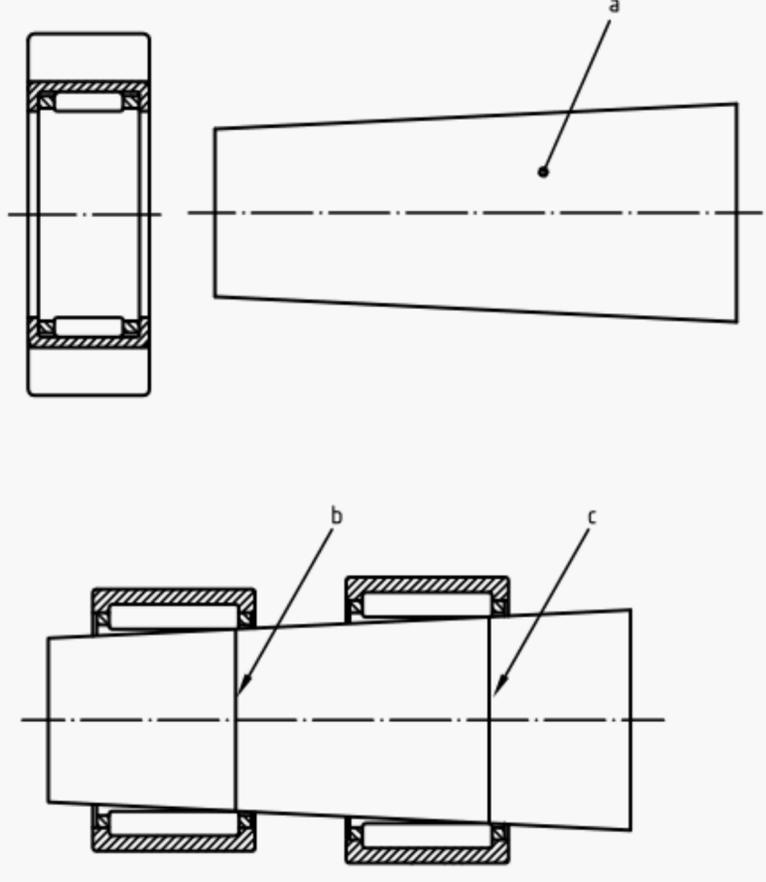
7.2 Functional gauging of smallest single bore diameter of thrust needle roller and cage assembly and thrust washer

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

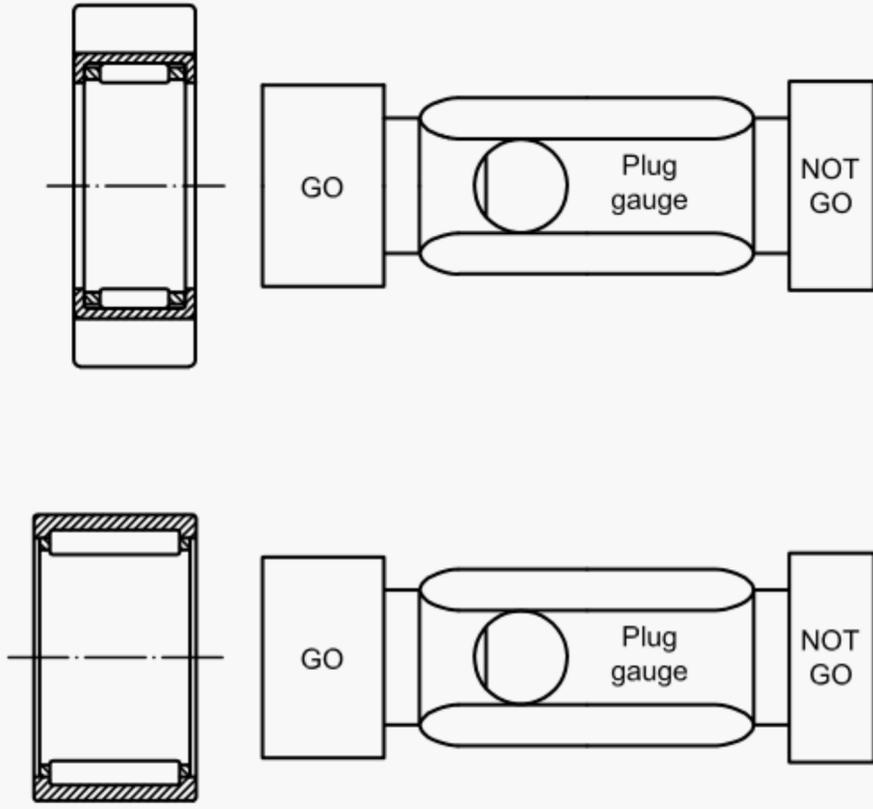
7.3 Measurement of single bore diameter of rolling element complement

Method	Comments																																																			
<div data-bbox="221 511 944 993" data-label="Image"> </div> <p data-bbox="140 1046 836 1090">Fasten the master gauge to a surface plate.</p> <p data-bbox="140 1134 1029 1214">Bearings with machined rings are measured in the free state.</p> <p data-bbox="140 1258 1029 1464">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.</p> <p data-bbox="140 1508 1029 1634">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.</p> <p data-bbox="140 1678 1029 1884">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.</p> <p data-bbox="140 1928 1029 2134">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, $F_{ws \max}$ and $F_{ws \min}$.</p>	<p data-bbox="1055 511 1940 637">This method is applicable to all radial cylindrical roller, needle roller and drawn cup needle roller bearings without inner ring.</p> <p data-bbox="1055 673 1940 799">The single bore diameter of rolling element complement, F_{ws}, is equal to the measurement taken plus the master gauge diameter.</p> <p data-bbox="1055 834 1940 914">The following are arithmetically based on $F_{ws \max}$ and $F_{ws \min}$:</p> <p data-bbox="1102 949 1940 1029">F_{wm} mean bore diameter of rolling element complement;</p> <p data-bbox="1102 1064 1940 1143">Δ_{Fwm} deviation of mean bore diameter of rolling element complement.</p> <p data-bbox="1187 1193 1817 1320">Minimum radial cross-section of ring gauges for drawn cup needle roller bearings</p> <table border="1" data-bbox="1172 1340 1832 2046"> <thead> <tr> <th colspan="2">Nominal ring gauge bore diameter</th> <th>Ring gauge radial cross-section</th> </tr> <tr> <th colspan="2">mm</th> <th>mm</th> </tr> <tr> <th>></th> <th>≤</th> <th>min.^a</th> </tr> </thead> <tbody> <tr> <td>6</td> <td>10</td> <td>10</td> </tr> <tr> <td>10</td> <td>18</td> <td>12</td> </tr> <tr> <td>18</td> <td>30</td> <td>15</td> </tr> <tr> <td>30</td> <td>50</td> <td>18</td> </tr> <tr> <td>50</td> <td>80</td> <td>20</td> </tr> <tr> <td>80</td> <td>120</td> <td>25</td> </tr> <tr> <td>120</td> <td>150</td> <td>30</td> </tr> </tbody> </table> <p data-bbox="1187 1963 1817 2043">^a Larger ring gauge radial cross-sections may be used to assure accurate measurement.</p> <p data-bbox="1300 2155 1704 2199">Radial measuring loads</p> <table border="1" data-bbox="1172 2207 1832 2619"> <thead> <tr> <th colspan="2">F_w</th> <th>Measuring load</th> </tr> <tr> <th colspan="2">mm</th> <th>N</th> </tr> <tr> <th>></th> <th>≤</th> <th>min.</th> </tr> </thead> <tbody> <tr> <td>—</td> <td>30</td> <td>50</td> </tr> <tr> <td>30</td> <td>50</td> <td>60</td> </tr> <tr> <td>50</td> <td>80</td> <td>70</td> </tr> <tr> <td>80</td> <td>—</td> <td>80</td> </tr> </tbody> </table>	Nominal ring gauge bore diameter		Ring gauge radial cross-section	mm		mm	>	≤	min. ^a	6	10	10	10	18	12	18	30	15	30	50	18	50	80	20	80	120	25	120	150	30	F_w		Measuring load	mm		N	>	≤	min.	—	30	50	30	50	60	50	80	70	80	—	80
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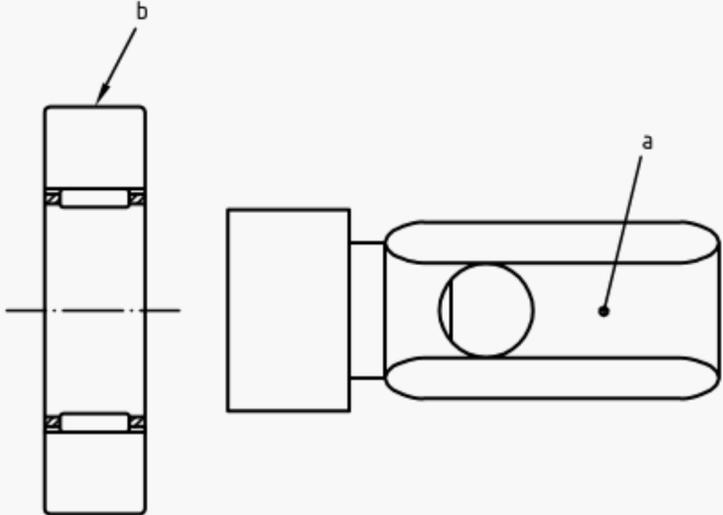
7.4 Measurement of smallest single bore diameter of rolling element complement

Method	Comments																																																			
 <p>a Tapered arbor b Calibrated minimum diameter c Calibrated maximum diameter</p> <p>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.</p> <p>Bearings with machined rings are measured in the free state.</p> <p>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.</p> <p>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.</p> <p>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.</p>	<p>This method is applicable to all radial cylindrical roller, needle roller and drawn cup needle roller bearings without inner ring and with $F_w \leq 150$ mm.</p> <p>This method is used to measure the smallest single bore diameter of rolling element complement, $F_{ws \text{ min}}$. The single bore diameter of rolling element complement, F_{ws}, is not directly measured.</p> <p>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.</p> <p>Minimum radial cross-section of ring gauges for drawn cup needle roller bearings</p> <table border="1" data-bbox="1212 1337 1872 1955"> <thead> <tr> <th colspan="2">Nominal ring gauge bore diameter</th> <th>Ring gauge radial cross-section</th> </tr> <tr> <th colspan="2">mm</th> <th>mm</th> </tr> <tr> <th>></th> <th>≤</th> <th>min.^a</th> </tr> </thead> <tbody> <tr> <td>6</td> <td>10</td> <td>10</td> </tr> <tr> <td>10</td> <td>18</td> <td>12</td> </tr> <tr> <td>18</td> <td>30</td> <td>15</td> </tr> <tr> <td>30</td> <td>50</td> <td>18</td> </tr> <tr> <td>50</td> <td>80</td> <td>20</td> </tr> <tr> <td>80</td> <td>120</td> <td>25</td> </tr> <tr> <td>120</td> <td>150</td> <td>30</td> </tr> </tbody> </table> <p>^a Larger ring gauge radial cross-sections may be used to assure accurate measurement.</p> <p>Axial seating loads for measuring with tapered arbor</p> <table border="1" data-bbox="1212 2219 1872 2646"> <thead> <tr> <th colspan="2">F_w</th> <th>Axial load^a</th> </tr> <tr> <th colspan="2">mm</th> <th>N</th> </tr> <tr> <th>></th> <th>≤</th> <th></th> </tr> </thead> <tbody> <tr> <td>8</td> <td>15</td> <td>10</td> </tr> <tr> <td>15</td> <td>30</td> <td>15</td> </tr> <tr> <td>30</td> <td>80</td> <td>30</td> </tr> <tr> <td>80</td> <td>150</td> <td>50</td> </tr> </tbody> </table> <p>^a Heavier loads may be used provided the measurement is not influenced.</p>	Nominal ring gauge bore diameter		Ring gauge radial cross-section	mm		mm	>	≤	min. ^a	6	10	10	10	18	12	18	30	15	30	50	18	50	80	20	80	120	25	120	150	30	F_w		Axial load ^a	mm		N	>	≤		8	15	10	15	30	15	30	80	30	80	150	50
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120	150	30																																																		
F_w		Axial load ^a																																																		
mm		N																																																		
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8	15	10																																																		
15	30	15																																																		
30	80	30																																																		
80	150	50																																																		

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

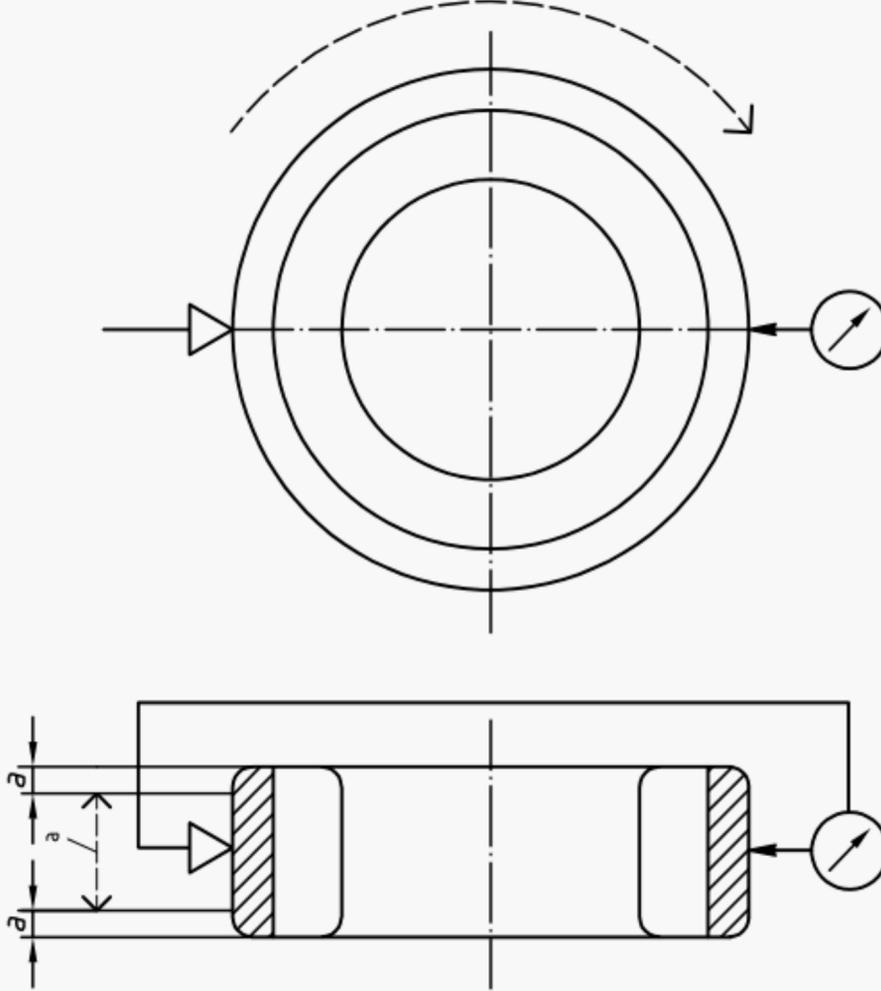
Method	Comments																														
 <p>The bore diameter of the rolling element complement, F_w, is gauged with GO and NOT GO plug gauges.</p> <p>Bearings with machined rings are measured in the free state.</p> <p>For drawn cup needle roller bearings, first press the bearing into a hardened 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.</p> <p>The bore diameter of the rolling element complement is then gauged with GO and NOT GO plug gauges.</p> <p>The GO plug gauge size is the minimum bore diameter of the rolling element complement.</p> <p>The NOT GO plug gauge size is larger than the maximum bore diameter of the rolling element complement by 0,002 mm.</p>	<p>This method is applicable to all radial cylindrical roller, needle roller and drawn cup needle roller bearings without inner ring and with $F_w \leq 150$ mm.</p> <p>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.</p> <p>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 $F_{ws \min}$ is within the tolerance limits.</p> <p style="text-align: center;">Minimum radial cross-section of ring gauges for drawn cup needle roller bearings</p> <table border="1" data-bbox="1172 1414 1836 2105"> <thead> <tr> <th colspan="2" data-bbox="1178 1422 1506 1531">Nominal ring gauge bore diameter</th> <th data-bbox="1510 1422 1830 1531">Ring gauge radial cross-section</th> </tr> <tr> <td colspan="2" data-bbox="1178 1537 1506 1575">mm</td> <td data-bbox="1510 1537 1830 1575">mm</td> </tr> <tr> <td data-bbox="1178 1581 1338 1640">></td> <td data-bbox="1342 1581 1506 1640">\leq</td> <td data-bbox="1510 1581 1830 1640">min. ^a</td> </tr> </thead> <tbody> <tr> <td data-bbox="1178 1646 1338 1699">6</td> <td data-bbox="1342 1646 1506 1699">10</td> <td data-bbox="1510 1646 1830 1699">10</td> </tr> <tr> <td data-bbox="1178 1705 1338 1758">10</td> <td data-bbox="1342 1705 1506 1758">18</td> <td data-bbox="1510 1705 1830 1758">12</td> </tr> <tr> <td data-bbox="1178 1764 1338 1816">18</td> <td data-bbox="1342 1764 1506 1816">30</td> <td data-bbox="1510 1764 1830 1816">15</td> </tr> <tr> <td data-bbox="1178 1822 1338 1875">30</td> <td data-bbox="1342 1822 1506 1875">50</td> <td data-bbox="1510 1822 1830 1875">18</td> </tr> <tr> <td data-bbox="1178 1881 1338 1934">50</td> <td data-bbox="1342 1881 1506 1934">80</td> <td data-bbox="1510 1881 1830 1934">20</td> </tr> <tr> <td data-bbox="1178 1940 1338 1993">80</td> <td data-bbox="1342 1940 1506 1993">120</td> <td data-bbox="1510 1940 1830 1993">25</td> </tr> <tr> <td data-bbox="1178 1999 1338 2052">120</td> <td data-bbox="1342 1999 1506 2052">150</td> <td data-bbox="1510 1999 1830 2052">30</td> </tr> </tbody> </table> <p>^a Larger ring gauge radial cross-sections may be used to assure accuracy.</p>	Nominal ring gauge bore diameter		Ring gauge radial cross-section	mm		mm	>	\leq	min. ^a	6	10	10	10	18	12	18	30	15	30	50	18	50	80	20	80	120	25	120	150	30
Nominal ring gauge bore diameter		Ring gauge radial cross-section																													
mm		mm																													
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6	10	10																													
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18	30	15																													
30	50	18																													
50	80	20																													
80	120	25																													
120	150	30																													

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

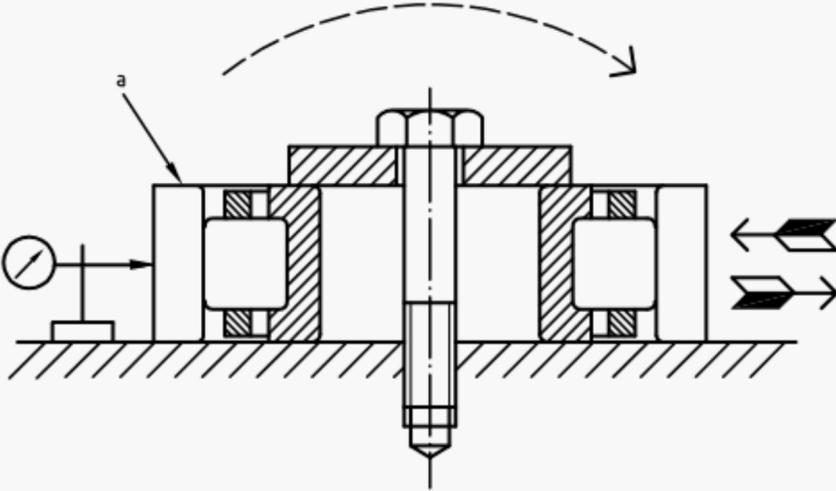
Method	Comments
<div style="text-align: center;">  </div> <p>a Plug gauge b Housing ring gauge</p> <p>Place the radial needle roller and cage assembly in a ring gauge having an outer raceway dimension as specified in ISO 3030. The ring gauge size is equal to the lower deviation of tolerance class G6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

8 Principles of measuring outside diameter

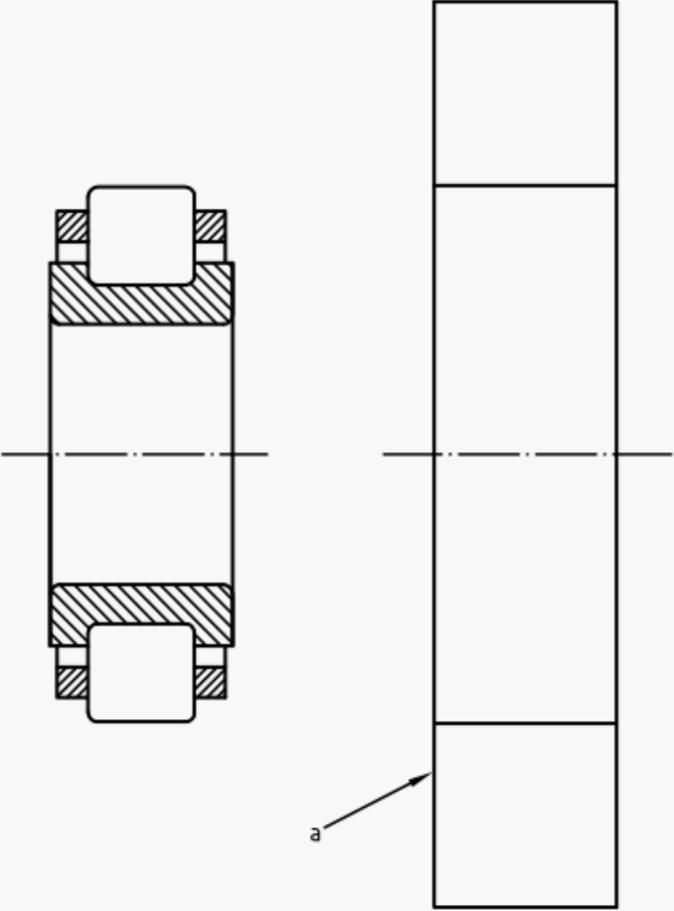
8.1 Measurement of single outside diameter

Method	Comments
 <p>a Measuring zone</p> <p>Zero the gauge indicator to the appropriate size using gauge blocks or a master.</p> <p>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.</p> <p>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 $D_{s\ min}$.</p>	<p>This method is applicable to all types of rolling bearing rings, shaft washers and housing washers.</p> <p>The single outside diameter, D_{sp} or D_s, is measured directly from the indicator.</p> <p>The bearing ring or washer shall be placed with the axis in a vertical position to avoid the influences of gravity.</p> <p>The following are arithmetically based on the measurement of $D_{sp\ max}$ and $D_{sp\ min}$:</p> <p>D_{mp} mean outside diameter in a single plane;</p> <p>Δ_{Dmp} deviation of mean outside diameter in a single plane;</p> <p>V_{Dmp} variation of mean outside diameter.</p> <p>The following are arithmetically based on the measurement of D_s, $D_{s\ max}$ and $D_{s\ min}$:</p> <p>D_m mean outside diameter;</p> <p>Δ_{Dm} deviation of mean outside diameter;</p> <p>Δ_{Ds} deviation of a single outside diameter;</p> <p>V_{Ds} variation of outside diameter.</p>

8.2 Measurement of single outside diameter of rolling element complement

Method	Comments																		
 <p>a Ring gauge</p> <p>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.</p> <p>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.</p> <p>Take indicator readings at the extreme radial positions of the ring gauge. Repeat the measurement on the bearing in several different angular positions.</p> <p>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 $E_{ws \min}$.</p>	<p>This method is applicable to radial cylindrical roller bearings and radial needle roller bearings without outer ring.</p> <p>The single outside diameter of rolling element complement, E_{ws}, will equal the ring gauge bore diameter minus measurements taken.</p> <p>The following are arithmetically based on $E_{ws \max}$ and $E_{ws \min}$:</p> <p>E_{wm} mean outside diameter of rolling element complement;</p> <p>ΔE_{wm} deviation of mean outside diameter of rolling element complement.</p> <p style="text-align: center;">Radial measuring loads</p> <table border="1" data-bbox="1215 1346 1874 1816"> <thead> <tr> <th colspan="2" data-bbox="1215 1346 1544 1472">E_w mm</th> <th data-bbox="1551 1346 1874 1405">Measuring load N</th> </tr> <tr> <th data-bbox="1215 1481 1378 1555">></th> <th data-bbox="1385 1481 1544 1555">\leq</th> <th data-bbox="1551 1481 1874 1555">min.</th> </tr> </thead> <tbody> <tr> <td data-bbox="1215 1564 1378 1637">—</td> <td data-bbox="1385 1564 1544 1637">30</td> <td data-bbox="1551 1564 1874 1637">50</td> </tr> <tr> <td data-bbox="1215 1646 1378 1719">30</td> <td data-bbox="1385 1646 1544 1719">50</td> <td data-bbox="1551 1646 1874 1719">60</td> </tr> <tr> <td data-bbox="1215 1728 1378 1802">50</td> <td data-bbox="1385 1728 1544 1802">80</td> <td data-bbox="1551 1728 1874 1802">70</td> </tr> <tr> <td data-bbox="1215 1811 1378 1884">80</td> <td data-bbox="1385 1811 1544 1884">—</td> <td data-bbox="1551 1811 1874 1884">80</td> </tr> </tbody> </table>	E_w mm		Measuring load N	>	\leq	min.	—	30	50	30	50	60	50	80	70	80	—	80
E_w mm		Measuring load N																	
>	\leq	min.																	
—	30	50																	
30	50	60																	
50	80	70																	
80	—	80																	

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

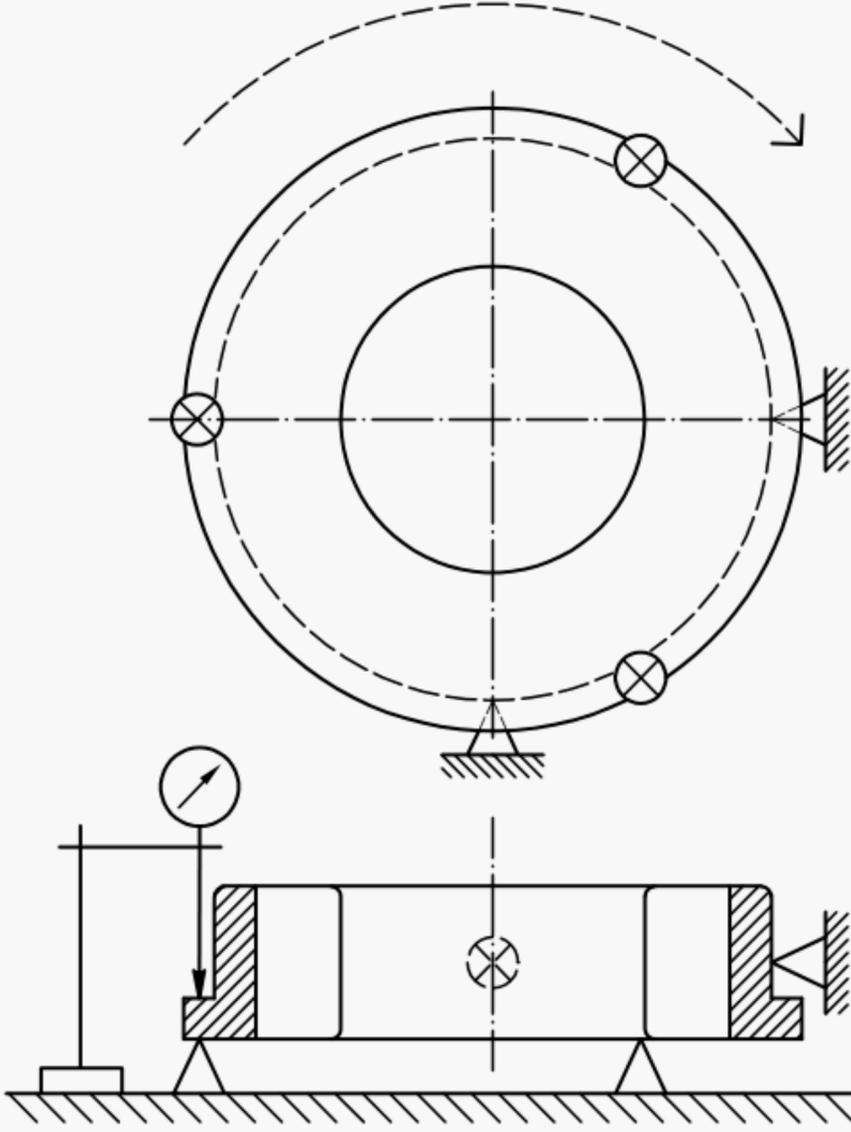
Method	Comments
 <p>a Ring gauge</p> <p>The outside diameter of the rolling element complement, E_w, is gauged with GO and NOT GO ring gauges.</p> <p>The GO ring gauge size is larger than the maximum outside diameter of the rolling element complement by 0,002 mm.</p> <p>The NOT GO ring gauge size is smaller than the minimum outside diameter of the rolling element complement by 0,002 mm.</p>	<p>This method is applicable to radial cylindrical roller bearings and radial needle roller bearings without outer ring.</p> <p>The GO gauge shall pass over the roller complement and the NOT GO gauge shall not pass over the roller complement.</p> <p>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.</p>

9 Principles of measuring width and height

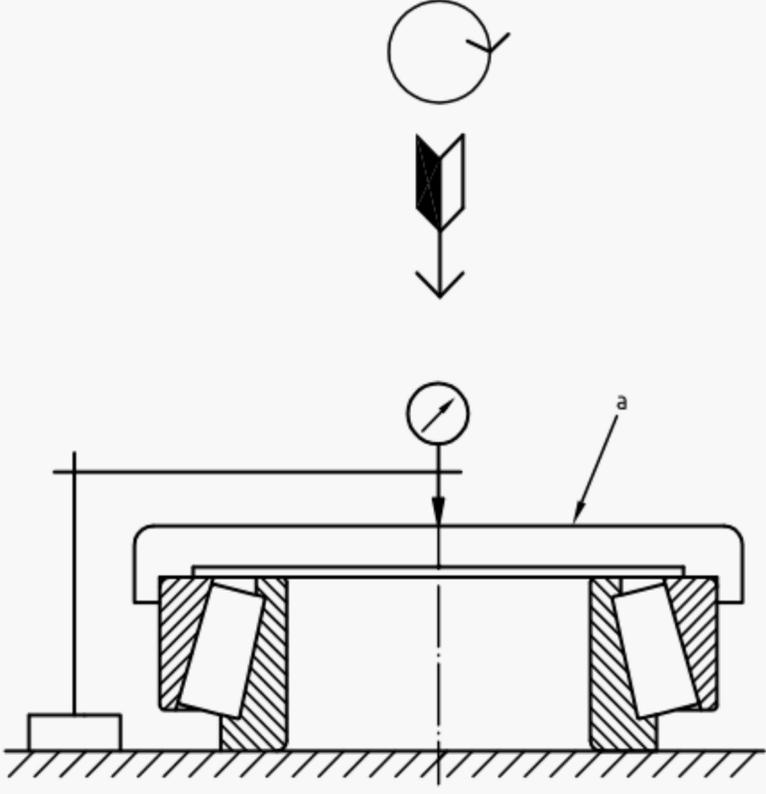
9.1 Measurement of single ring width

Method	Comments
<div data-bbox="251 611 1008 1611" data-label="Image"> </div> <p data-bbox="183 1649 1070 1737">Zero the gauge indicator to the appropriate height from the reference surface using gauge blocks or a master.</p> <p data-bbox="183 1775 1070 1943">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.</p> <p data-bbox="183 1981 1070 2069">Position the indicator against the other face of the ring opposite one fixed support.</p> <p data-bbox="183 2107 1070 2246">Rotate the ring one revolution and measure and record the largest and the smallest single ring width, $B_{s \max}$ and $B_{s \min}$, ($C_{s \max}$ and $C_{s \min}$).</p>	<p data-bbox="1091 605 1985 693">This method is applicable to all types of inner and outer rings of rolling bearings.</p> <p data-bbox="1091 732 1985 820">The single ring width, B_s or C_s, is the actual measurement made at any point on the ring.</p> <p data-bbox="1091 858 1985 946">The following are arithmetically based on the single inner or outer ring width, B_s or C_s:</p> <ul style="list-style-type: none"> <li data-bbox="1144 984 1825 1029">Δ_{B_s} or Δ_{C_s} deviation of a single ring width; <li data-bbox="1144 1067 1687 1111">V_{B_s} or V_{C_s} variation of ring width; <li data-bbox="1144 1149 1602 1193">B_m or C_m mean ring width.

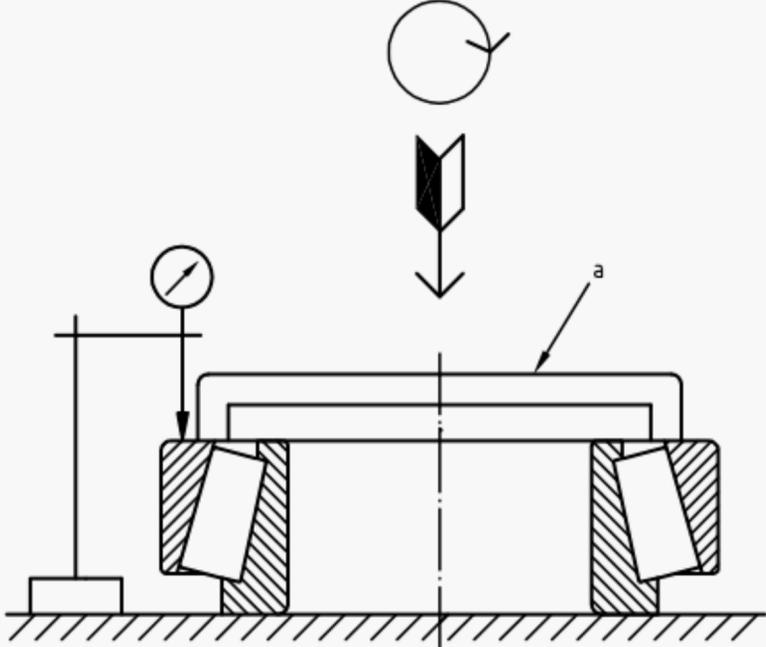
9.2 Measurement of single outer ring flange width

Method	Comments
 <p>Zero the gauge indicator to an appropriate height from the fixed supports using gauge blocks or a master.</p> <p>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.</p> <p>Position the indicator against the flange back face opposite one fixed support.</p> <p>Rotate the outer ring one revolution and measure and record the largest and the smallest single outer ring flange width, $C_{1s \max}$ and $C_{1s \min}$.</p>	<p>This method is applicable to all types of radial rolling bearings with flanges on their outer rings.</p> <p>The single outer ring flange width, C_{1s}, is the actual measurement made at any position on the flange back face.</p> <p>The following are arithmetically based on the single outer ring flange width, C_{1s}:</p> <p>ΔC_{1s} deviation of a single outer ring flange width;</p> <p>$V_{C_{1s}}$ variation of outer ring flange width.</p>

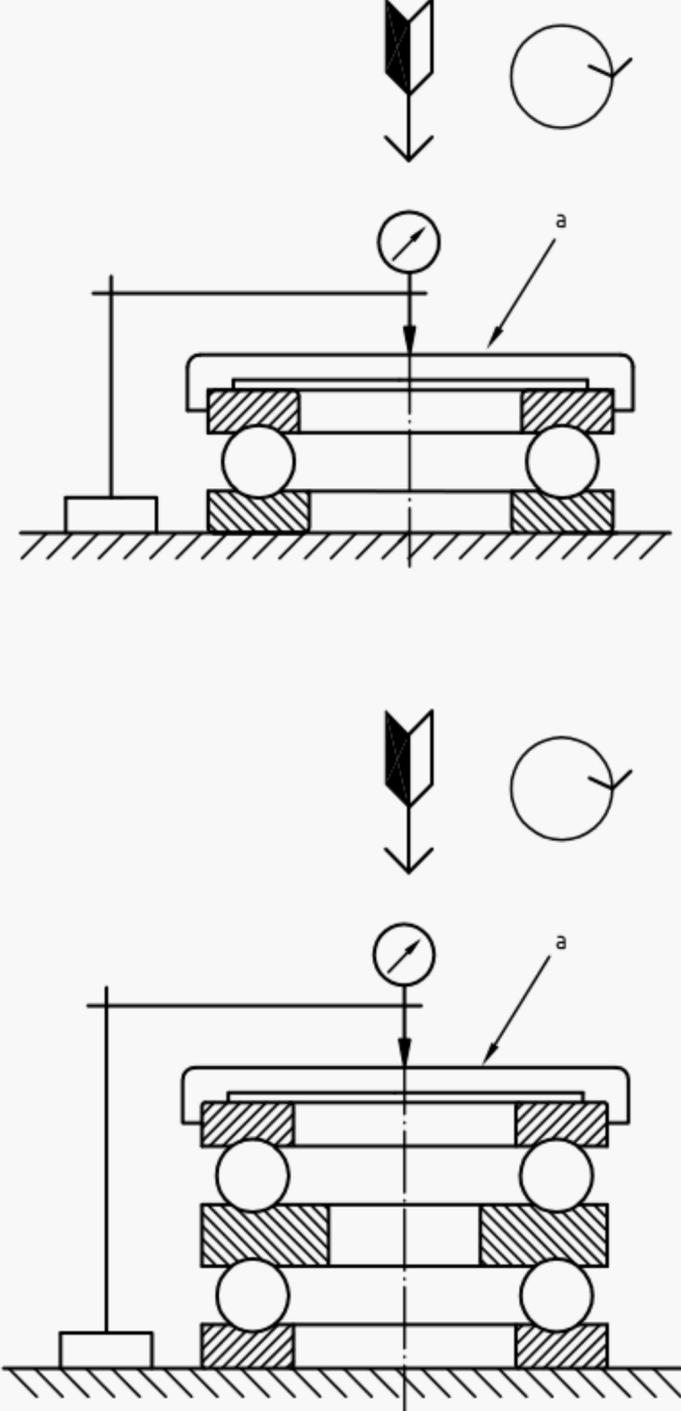
9.3 Measurement of actual bearing width (primary method)

Method	Comments
<div style="text-align: center;">  </div> <p>a Plate</p> <p>Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.</p> <p>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.</p> <p>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.</p> <p>Rotate the outer ring several times, to be sure to reach the minimum width, and take indicator readings.</p>	<p>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.</p> <p>This measurement method excludes the effects of ring face surface flatness.</p> <p>The actual bearing width, T_S, will equal the indicator reading minus the known plate thickness.</p> <p>The deviation of the actual bearing width, ΔT_S, is arithmetically based on the measurement of T_S.</p>

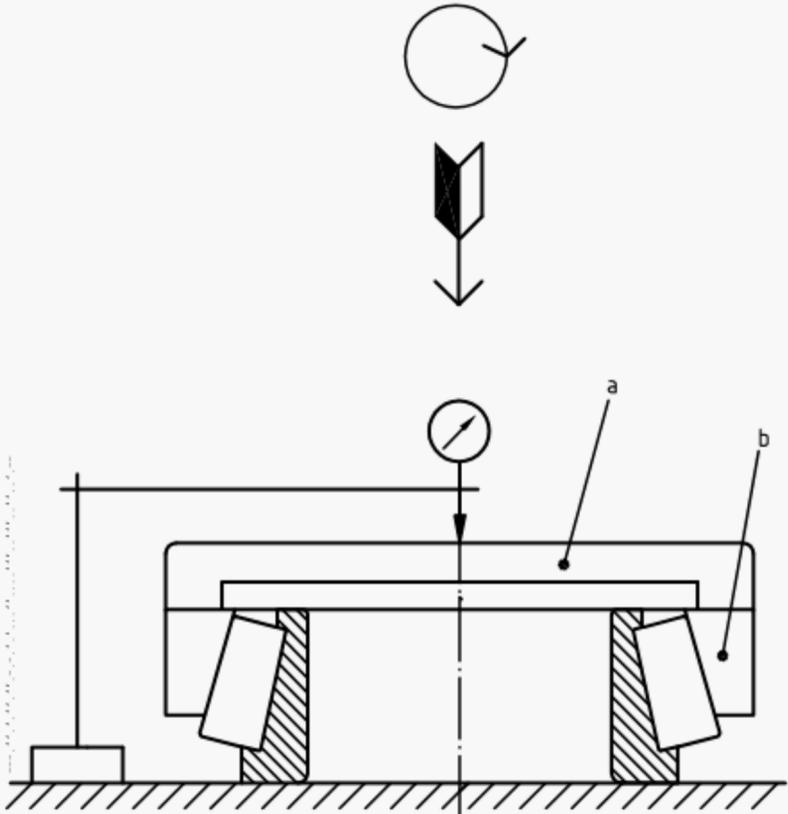
9.4 Measurement of actual bearing width (alternative method)

Method	Comments
 <p>a Stabilizing plate</p> <p>Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.</p> <p>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.</p> <p>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.</p> <p>Position the indicator on the reference face of the outer ring, rotate the outer ring, and take indicator readings.</p> <p>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.</p>	<p>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.</p> <p>The deviation of the actual bearing width, ΔT_S, is arithmetically based on the measurement of T_S.</p> <p>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.</p> <p>For large bearings, the stabilizing plate or ring may be unnecessary.</p> <p>This measurement method includes the effects of surface flatness on the reference face of the outer ring.</p>

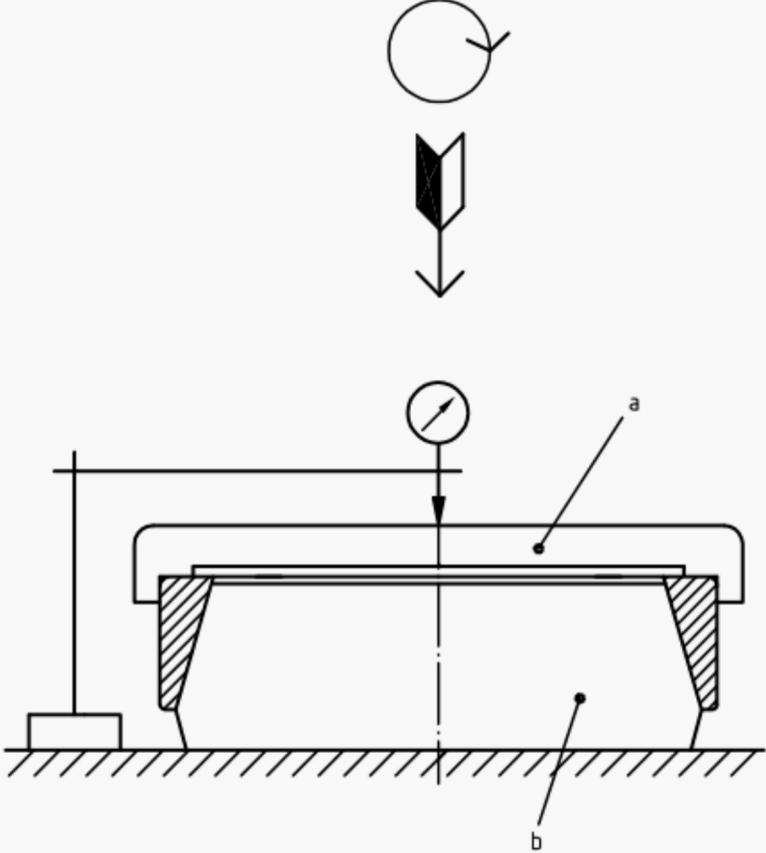
9.5 Measurement of actual bearing height (thrust bearings)

Method	Comments
 <p>a Plate</p> <p>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.</p> <p>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.</p> <p>Rotate the bearing several times, to be sure to reach the smallest height, and take indicator readings.</p>	<p>This method is applicable to all types of thrust bearings including thrust ball, thrust cylindrical roller and thrust tapered roller bearings.</p> <p>The actual bearing height, T_s, will equal the indicator reading minus the known plate thickness.</p> <p>This measurement method excludes the effects of washer face surface flatness.</p> <p>The determination of the deviation of the actual bearing height, ΔT_s, is arithmetically based on the measurement of T_s.</p>

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

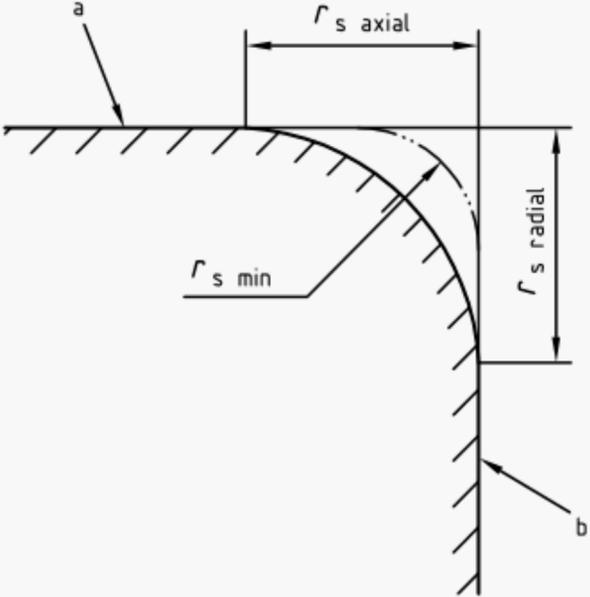
Method	Comments
<div style="text-align: center;">  </div> <p>a Plate</p> <p>b Master outer ring</p> <p>Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.</p> <p>Support the inner subunit on the reference face of the inner ring and ensure the rollers are in contact with the inner ring back face rib and raceway.</p> <p>Place the master outer ring in position on the inner subunit.</p> <p>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.</p> <p>Rotate the master outer ring several times, to be sure to reach the minimum width, and take indicator readings.</p>	<p>This method is applicable to tapered roller bearing inner subunits. It requires the use of a master outer ring.</p> <p>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.</p> <p>This measurement method excludes the effects of ring face surface flatness.</p>

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

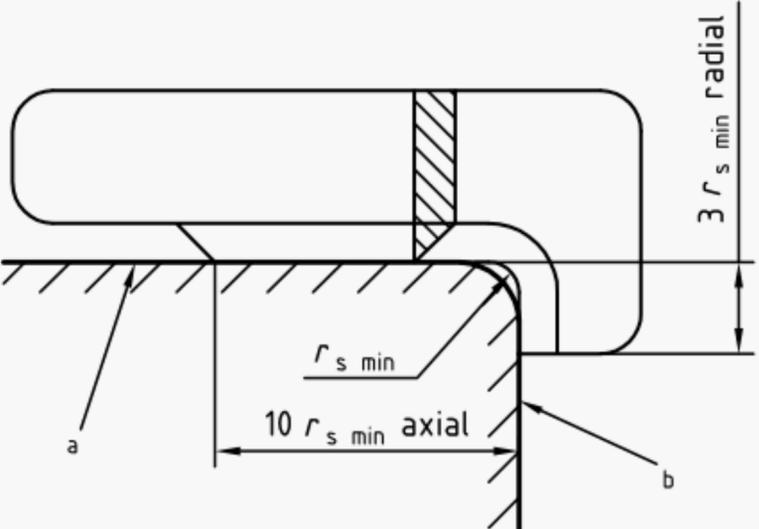
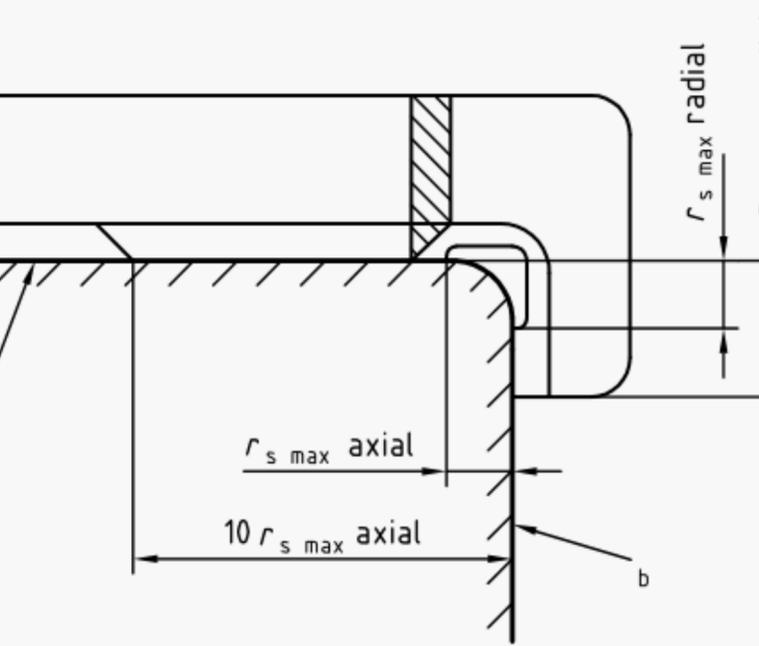
Method	Comments
<div style="text-align: center;">  </div> <p>a Plate</p> <p>b Inner master plug</p> <p>Zero the gauge indicator to an appropriate height from the surface plate using gauge blocks or a master.</p> <p>Support the back face of an inner master plug on the surface plate and place the outer ring in position on the plug.</p> <p>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.</p> <p>Reposition the outer ring several times, to be sure to reach the minimum width, and take indicator reading.</p>	<p>This method is applicable to tapered roller bearing outer rings. It requires the use of an inner master plug.</p> <p>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.</p> <p>This measurement method excludes the effects of ring face surface flatness.</p> <p>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.</p>

10 Principles of measuring ring and washer chamfer dimension

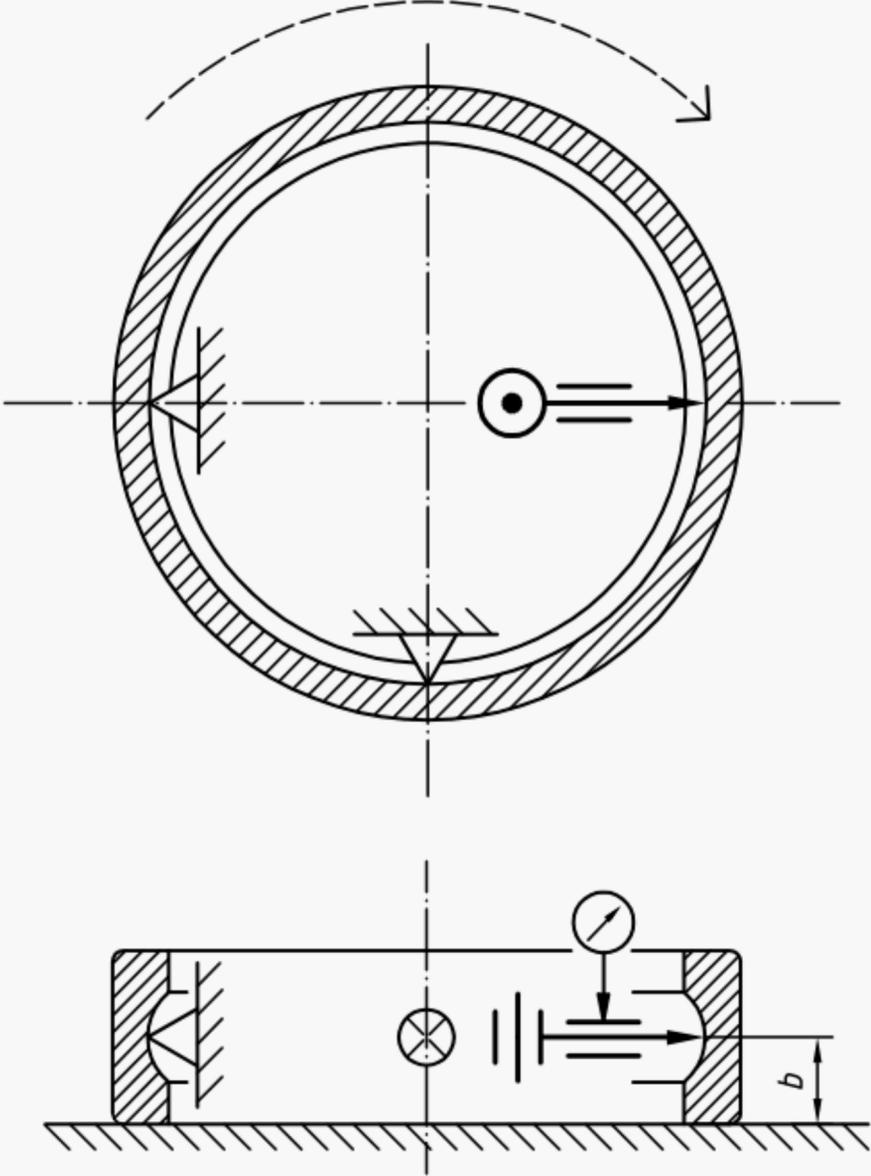
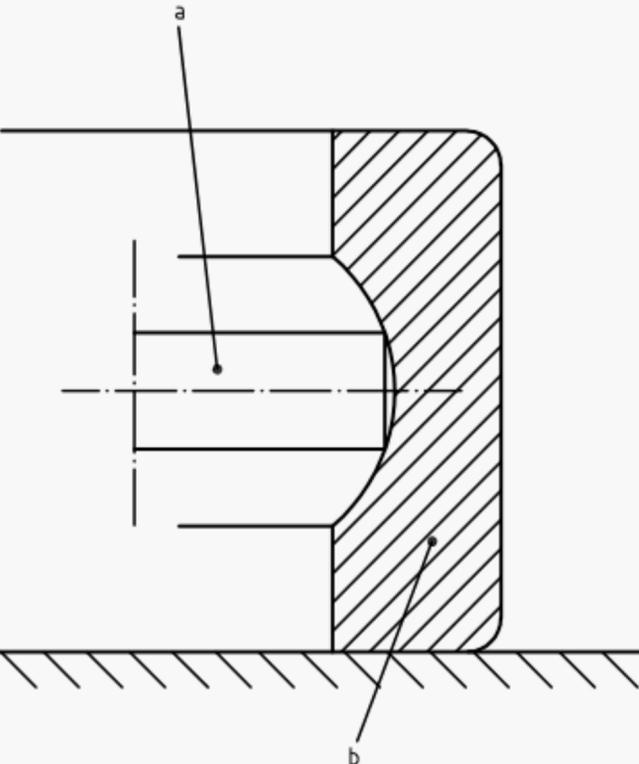
10.1 Measurement of single chamfer dimension (primary method)

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

10.2 Functional gauging of single chamfer dimension (alternative method)

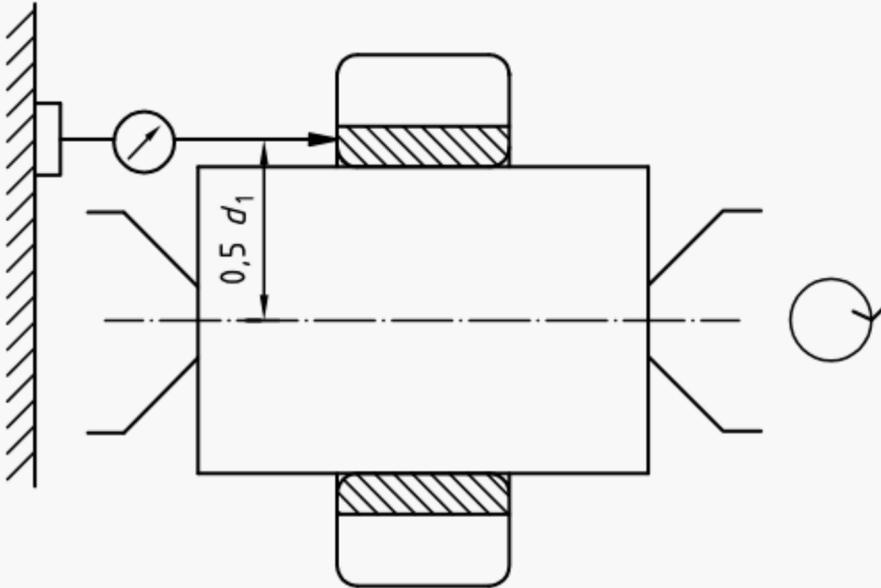
Method	Comments
 <p>The diagram shows a cross-section of a ring or washer with a chamfered edge. A template is placed against the chamfer. The template has a radius labeled $r_{s \text{ min}}$. The axial distance from the face surface to the start of the chamfer is labeled $10 r_{s \text{ min}}$. The radial distance from the diameter surface to the start of the chamfer is labeled $3 r_{s \text{ min}}$. The diameter surface is labeled 'a' and the face surface is labeled 'b'.</p> <p>a Bore or outside diameter surface b Face surface</p>	<p>This method of gauging the radii r_s is applicable to inner and outer rings and thrust washers for all types of rolling bearings.</p> <p>The ring or washer chamfer shall not interfere with the minimum chamfer ($r_{s \text{ min}}$) template.</p> <p>The ring or washer chamfer shall not extend beyond the markings on the maximum chamfer ($r_{s \text{ max}}$) template.</p> <p>NOTE 1 The axial and radial limits of $r_{s \text{ max}}$ may differ.</p> <p>NOTE 2 The method is equally applicable to gauging of radii designated r_1, r_2, etc.</p>
<p>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.</p>  <p>The diagram shows a cross-section of a ring or washer with a chamfered edge. A template is placed against the chamfer. The template has a radius labeled $r_{s \text{ max}}$. The axial distance from the face surface to the start of the chamfer is labeled $10 r_{s \text{ max}}$. The radial distance from the diameter surface to the start of the chamfer is labeled $3 r_{s \text{ max}}$. The diameter surface is labeled 'a' and the face surface is labeled 'b'.</p> <p>a Bore or outside diameter surface b Face surface</p> <p>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.</p>	

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

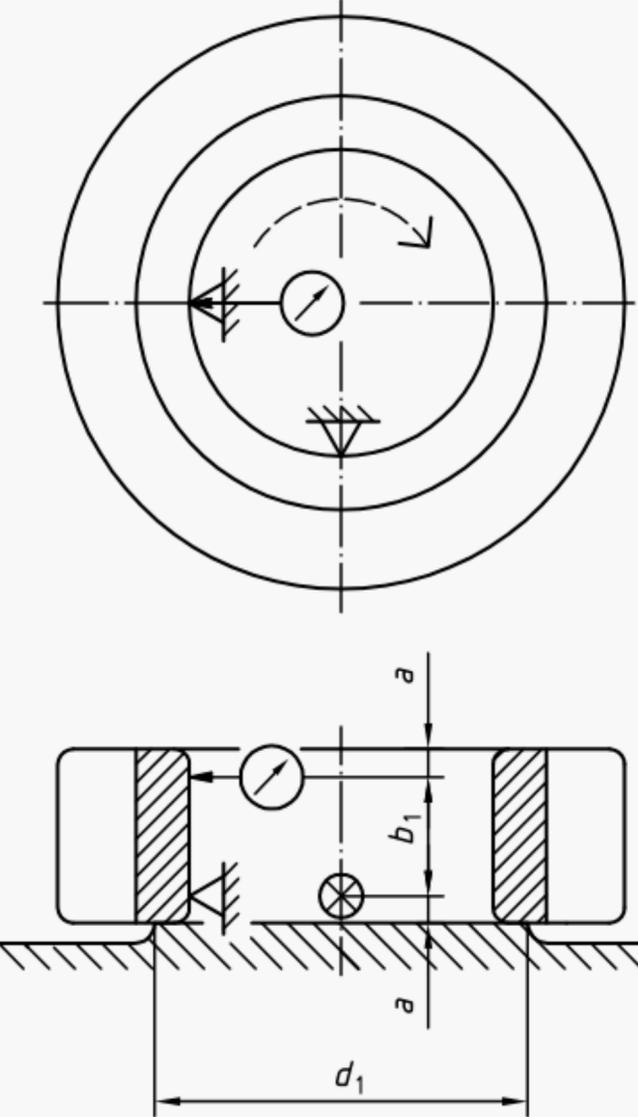
Method	Comments
 <p>Support the reference face of the outer ring on a surface plate, and provide two supports on the raceway surface, set at 90° to each other at the middle of the raceway, to centre the outer ring.</p> <p>Position the gauge head opposite one of the fixed supports and ensure constant pressure of the gauge head against the raceway and in a direction parallel with the ring axis.</p> <p>Take indicator readings while rotating the outer ring one revolution.</p>	<p>This method is applicable to all radial groove ball bearings.</p> <p>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.</p> <p>The height of the gauge head, b, is located at the raceway contact diameter.</p> <p>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).</p>  <p>a Gauge head b Outer ring</p>

12 Principles of measuring surface perpendicularity

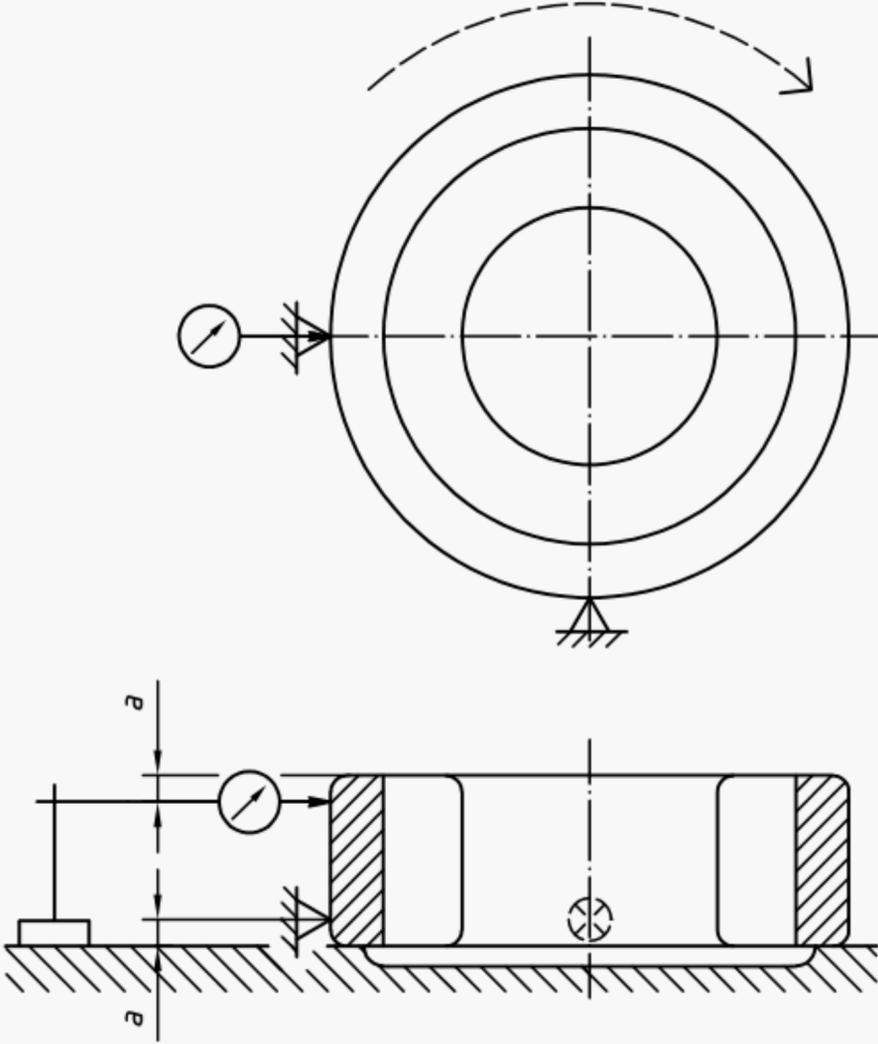
12.1 Measurement of perpendicularity of inner ring face with respect to the bore (method A)

Method	Comments
 <p>Use a precision arbor having a taper of approximately 0,000 2:1 on diameter.</p> <p>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.</p> <p>Take indicator readings while rotating the inner ring one revolution.</p>	<p>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.</p> <p>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.</p> <p>NOTE Care must be taken when mounting the bearing on the arbor that the inner ring bore axis is coaxial with the arbor axis.</p> <p>d_1 mean diameter of inner ring face</p>

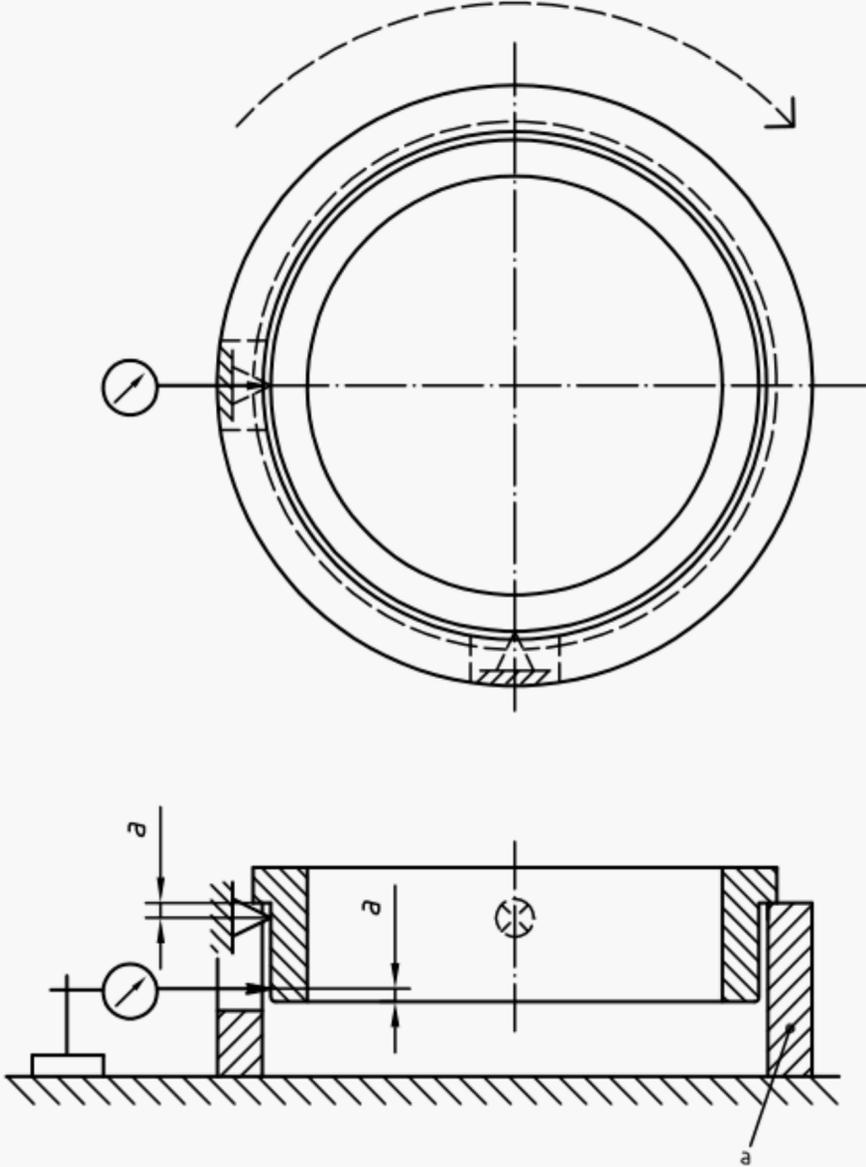
12.2 Measurement of perpendicularity of inner ring face with respect to the bore (method B)

Method	Comments
 <p>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.</p> <p>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.</p> <p>Take indicator readings while rotating the inner ring one revolution.</p>	<p>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.</p> <p>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:</p> $S_d = \frac{S_{dr} \times d_1}{2 \times b_1}$ <p>S_d perpendicularity of inner ring face with respect to the bore</p> <p>S_{dr} difference between maximum indicator reading and minimum indicator reading</p> <p>d_1 mean diameter of inner ring face</p> <p>b_1 axial distance between the indicator and the fixed support directly below it</p>

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

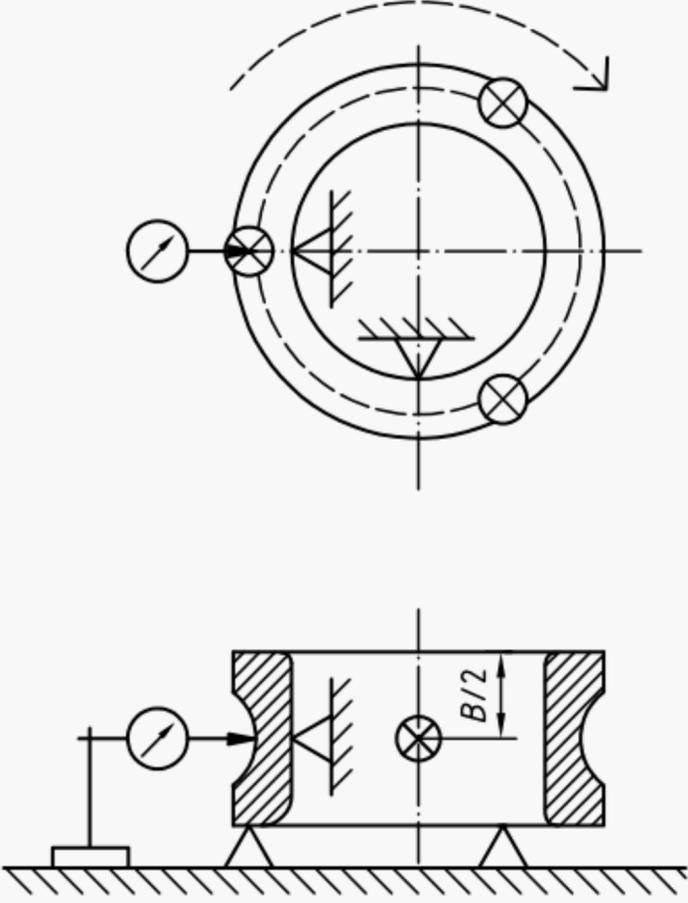
Method	Comments
 <p>Support the reference face of the outer ring on a surface plate leaving the inner ring, if an assembled bearing, free. Locate the outer ring cylindrical outside surface against two supports set at 90° to each other to centre the outer ring.</p> <p>Position the indicator directly above 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.</p> <p>Take indicator readings while rotating the outer ring one revolution.</p>	<p>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.</p> <p>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.</p>

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

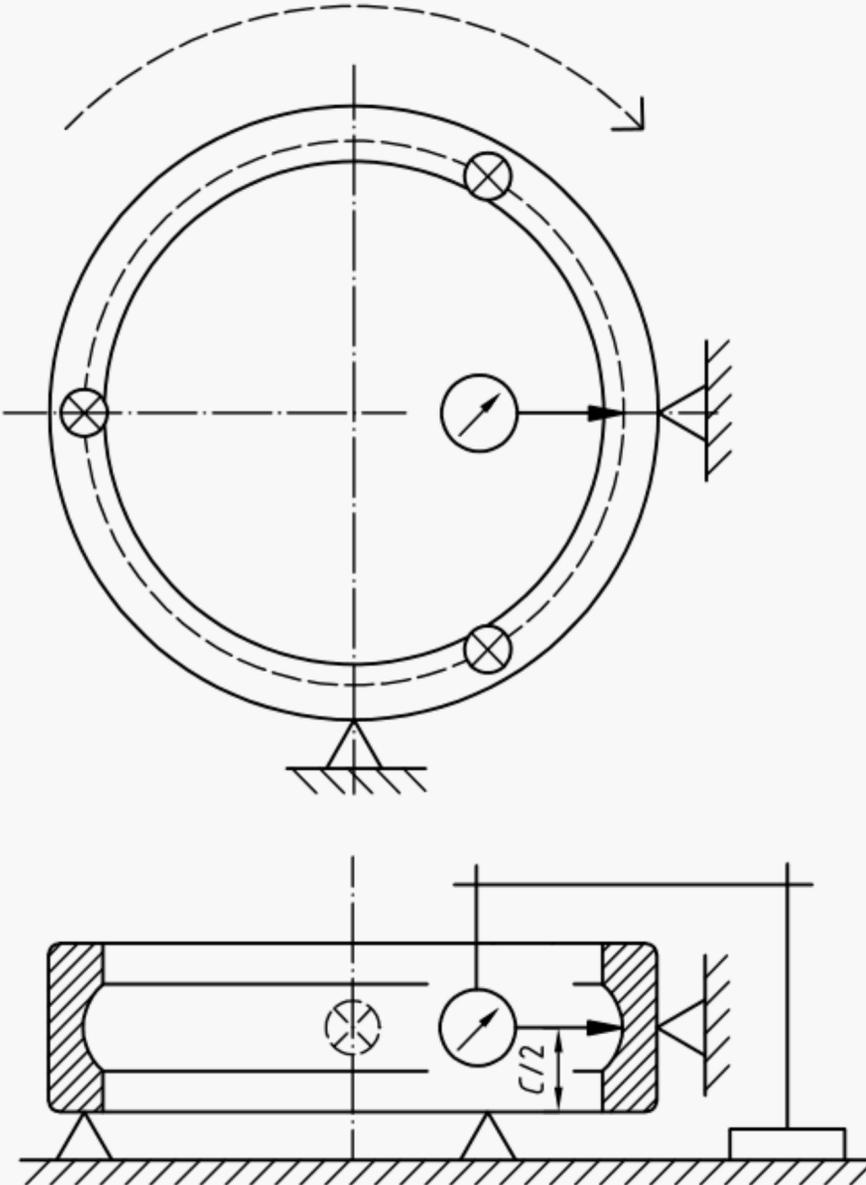
Method	Comments
 <p>a Cylindrical support ring</p> <p>Support the flange back face of the outer ring on the face of a cylindrical support ring, leaving the inner ring, if an assembled bearing, free. The bore diameter of the supporting ring should equal the mean diameter of the flange. Locate the outer ring outside diameter surface against two supports set at 90° to each other to centre the outer ring.</p> <p>NOTE Slots in the support ring permit access for side supports.</p> <p>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.</p> <p>Take indicator readings while rotating the outer ring one revolution.</p>	<p>This method is applicable to all types of radial rolling bearings with flanged outer rings.</p> <p>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.</p>

13 Principles of measuring thickness variation

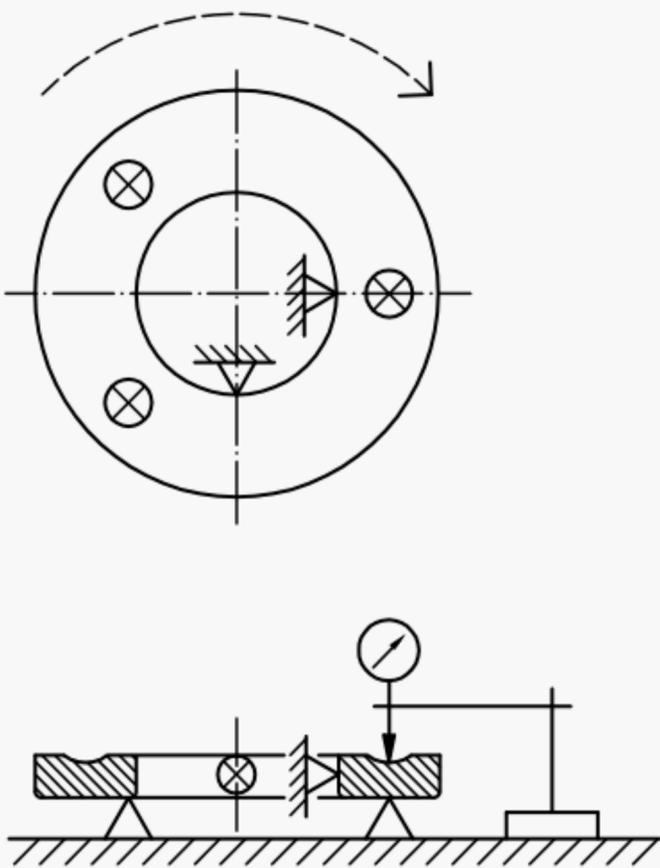
13.1 Measurement of variation in thickness between inner ring raceway and bore

Method	Comments
 <p>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.</p> <p>Position the indicator opposite one bore support.</p> <p>Take indicator readings while rotating the inner ring one revolution.</p>	<p>This method is applicable to all types of radial and angular contact rolling bearing inner rings.</p> <p>The variation in thickness between inner ring raceway and bore, K_i, is the difference between the largest and the smallest indicator readings.</p>

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

Method	Comments
 <p data-bbox="180 1758 1074 2002">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.</p> <p data-bbox="180 2052 1074 2131">Position the indicator opposite one outside diameter support.</p> <p data-bbox="180 2181 1074 2260">Take indicator readings while rotating the outer ring one revolution.</p>	<p data-bbox="1095 514 1987 593">This method is applicable to all types of radial and angular contact rolling bearing outer rings.</p> <p data-bbox="1095 643 1987 767">The variation in thickness between outer ring raceway and outside surface, K_e, is the difference between the largest and the smallest indicator readings.</p>

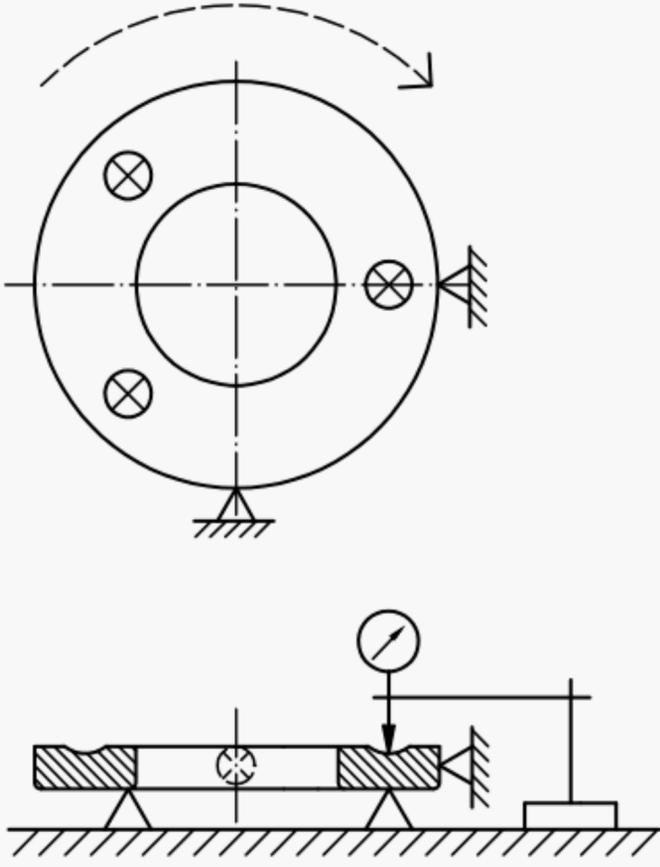
13.3 Measurement of variation in thickness between shaft washer raceway and back face

Method	Comments
 <p>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.</p> <p>Position the indicator against the middle of the raceway directly opposite one fixed support.</p> <p>With the washer in contact with the supports, take indicator readings while rotating the washer one revolution.</p>	<p>This method is applicable to shaft washers with a flat raceway or profiled raceway and flat back face.</p> <p>The variation in thickness between shaft washer raceway and back face, S_i, is the difference between the largest and the smallest indicator readings.</p>

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

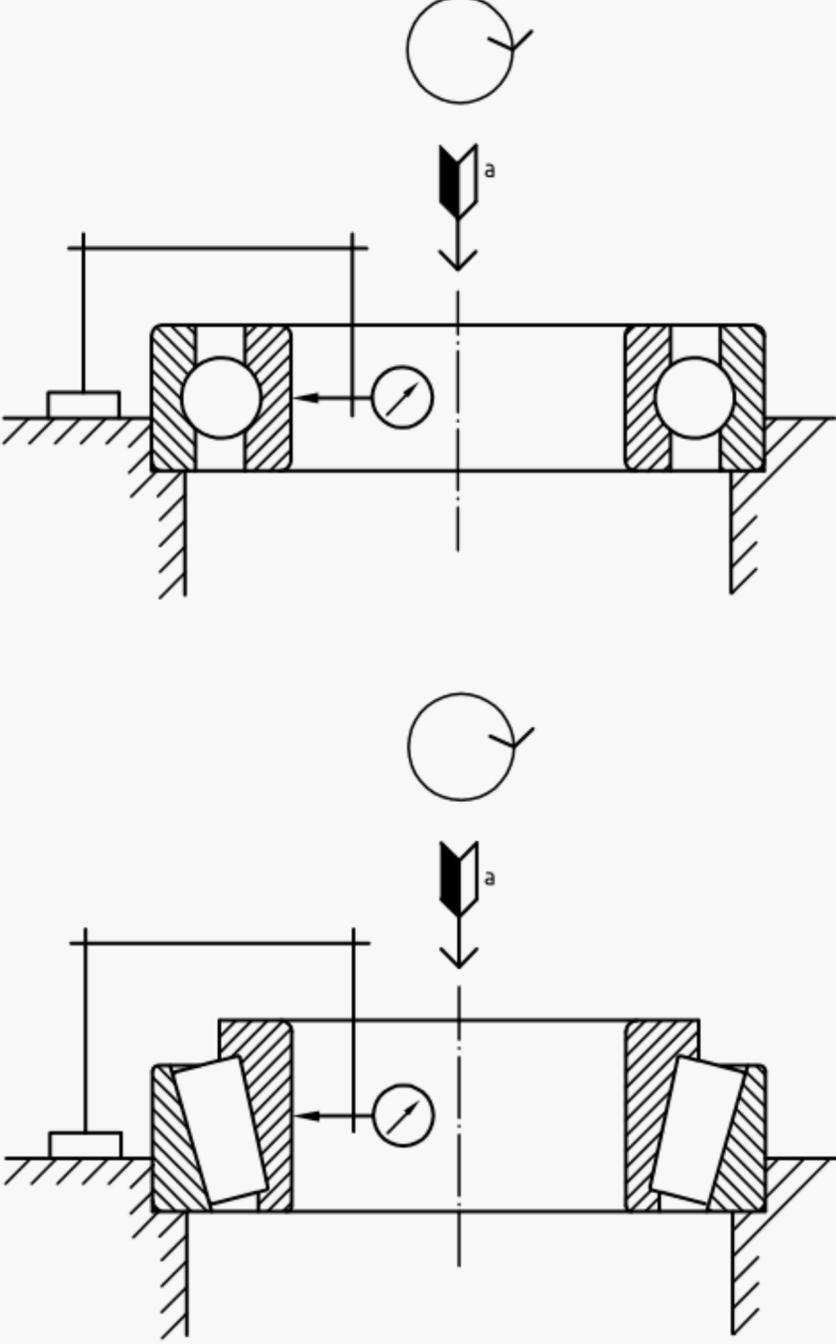
Method	Comments
<div data-bbox="297 543 957 1425" data-label="Image"> </div> <p data-bbox="180 1484 1074 1631">Support a face of the central shaft washer on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the bore surface, set at 90° to each other, to centre the shaft washer.</p> <p data-bbox="180 1690 1074 1764">Position the indicator against the middle of the raceway adjacent to one fixed support.</p> <p data-bbox="180 1822 1074 1925">With the washer in contact with the supports, take indicator readings while rotating the washer one revolution.</p> <p data-bbox="180 1984 1074 2028">Repeat the measurement for the opposite raceway.</p>	<p data-bbox="1095 558 1989 632">This method is applicable to central shaft washers with a profiled raceway on each face.</p> <p data-bbox="1095 690 1989 808">The variation in thickness between shaft washer raceway and back face, S_i, is the difference between the largest and the smallest indicator readings.</p> <p data-bbox="1095 852 1989 926">Each variation of thickness of the back face to raceway is an independent measurement.</p>

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

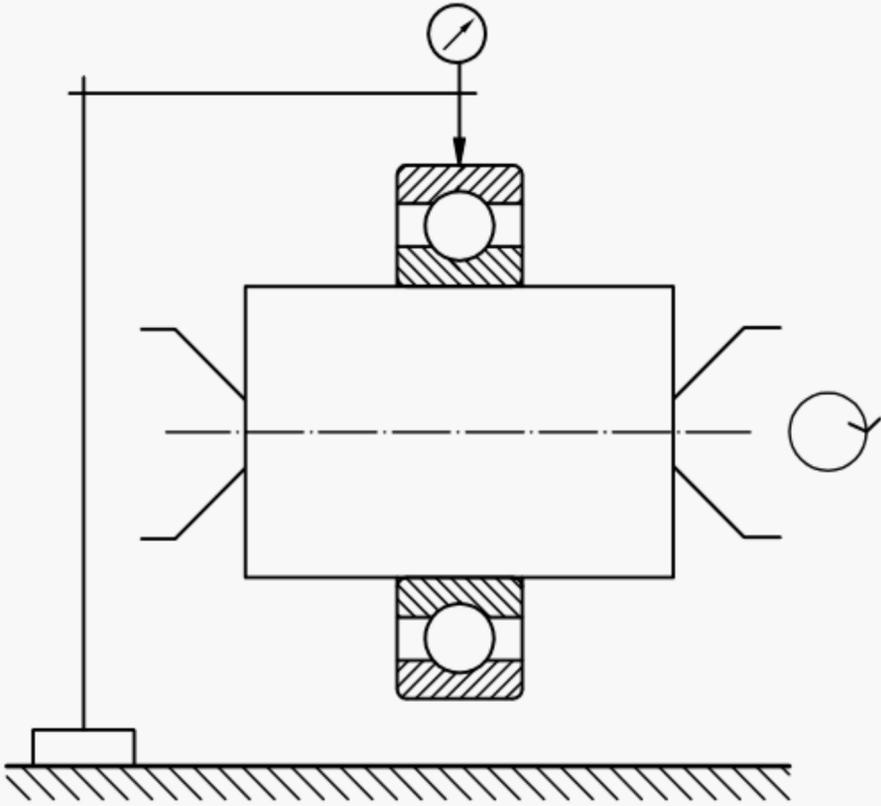
Method	Comments
 <p>Support the flat back face of the housing washer on three equally spaced fixed supports of equal height. Provide two suitable radial supports on the outside surface, set at 90° to each other, to centre the housing washer.</p> <p>Position the indicator against the middle of the raceway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

14 Principles of measuring radial runout

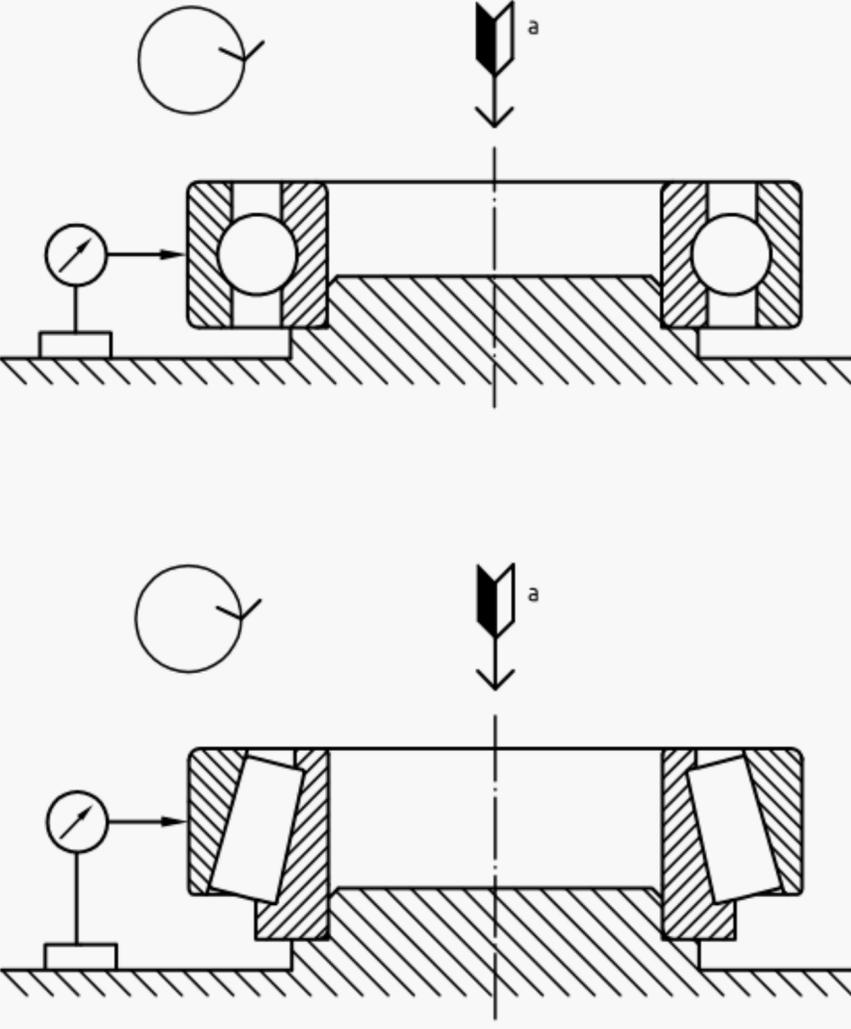
14.1 Measurement of radial runout of inner ring of assembled bearing (primary method)

Method	Comments
 <p>a Load on inner ring</p> <p>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.</p> <p>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.</p>	<p>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.</p> <p>The radial runout of inner ring of assembled bearing, K_{ia}, is the difference between the largest and the smallest indicator readings.</p> <p>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.</p>

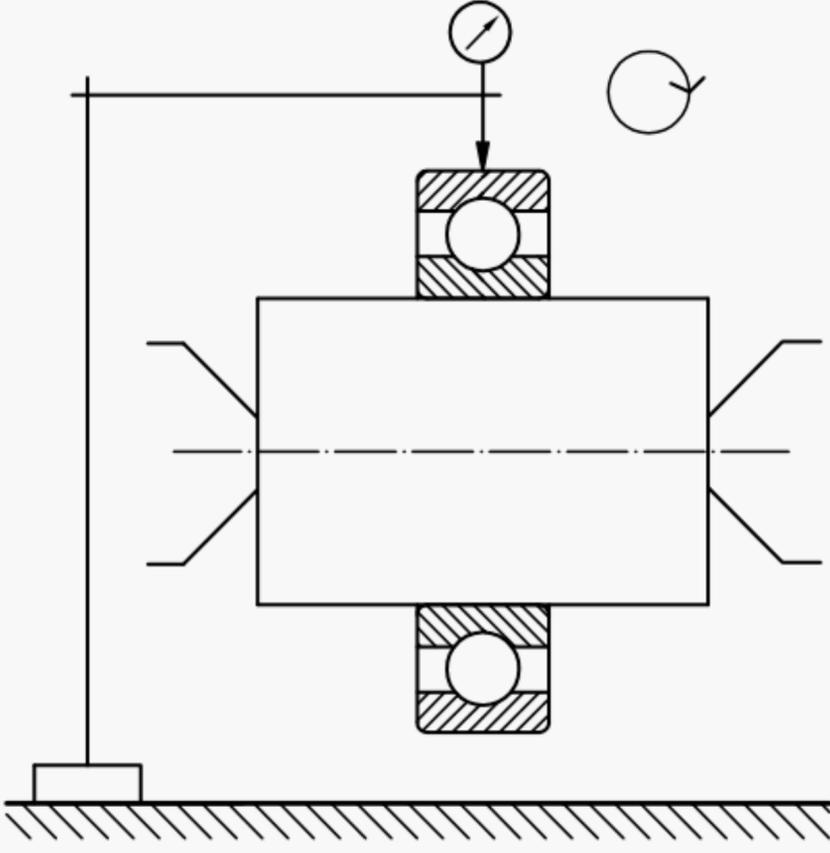
14.2 Measurement of radial runout of inner ring of assembled bearing (alternative method)

Method	Comments
 <p>Use a precision arbor having a taper of approximately 0,000 2:1 on diameter.</p> <p>Mount the bearing assembly on the tapered arbor and place the arbor between two centres so that it can be accurately rotated.</p> <p>Position the indicator against the outside surface of the outer ring as close as possible to the middle of the outer ring raceway.</p> <p>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.</p>	<p>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.</p> <p>The radial runout of inner ring of assembled bearing, K_{ia}, is the difference between the largest and the smallest indicator readings.</p> <p>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.</p>

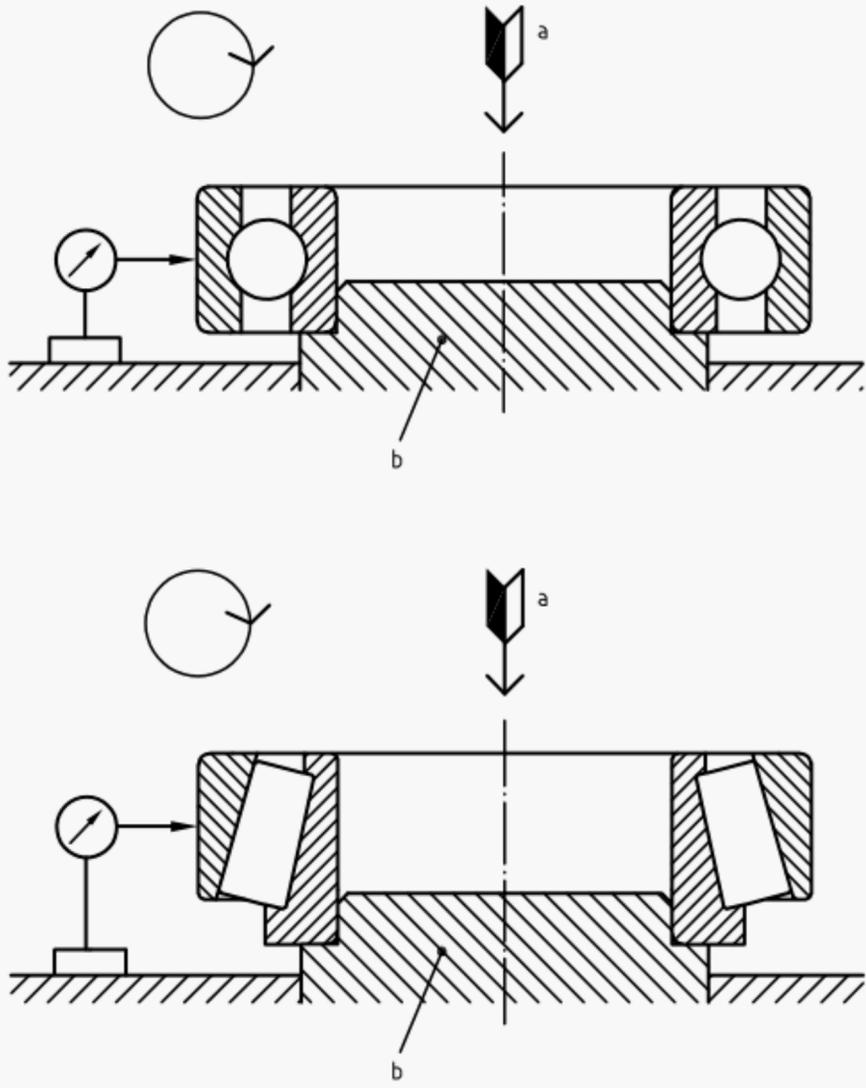
14.3 Measurement of radial runout of outer ring of assembled bearing (primary method)

Method	Comments
 <p>a Load on outer ring</p> <p>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.</p> <p>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.</p>	<p>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.</p> <p>The radial runout of outer ring of assembled bearing, K_{ea}, is the difference between the largest and the smallest indicator readings.</p> <p>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.</p>

14.4 Measurement of radial runout of outer ring of assembled bearing (alternative method)

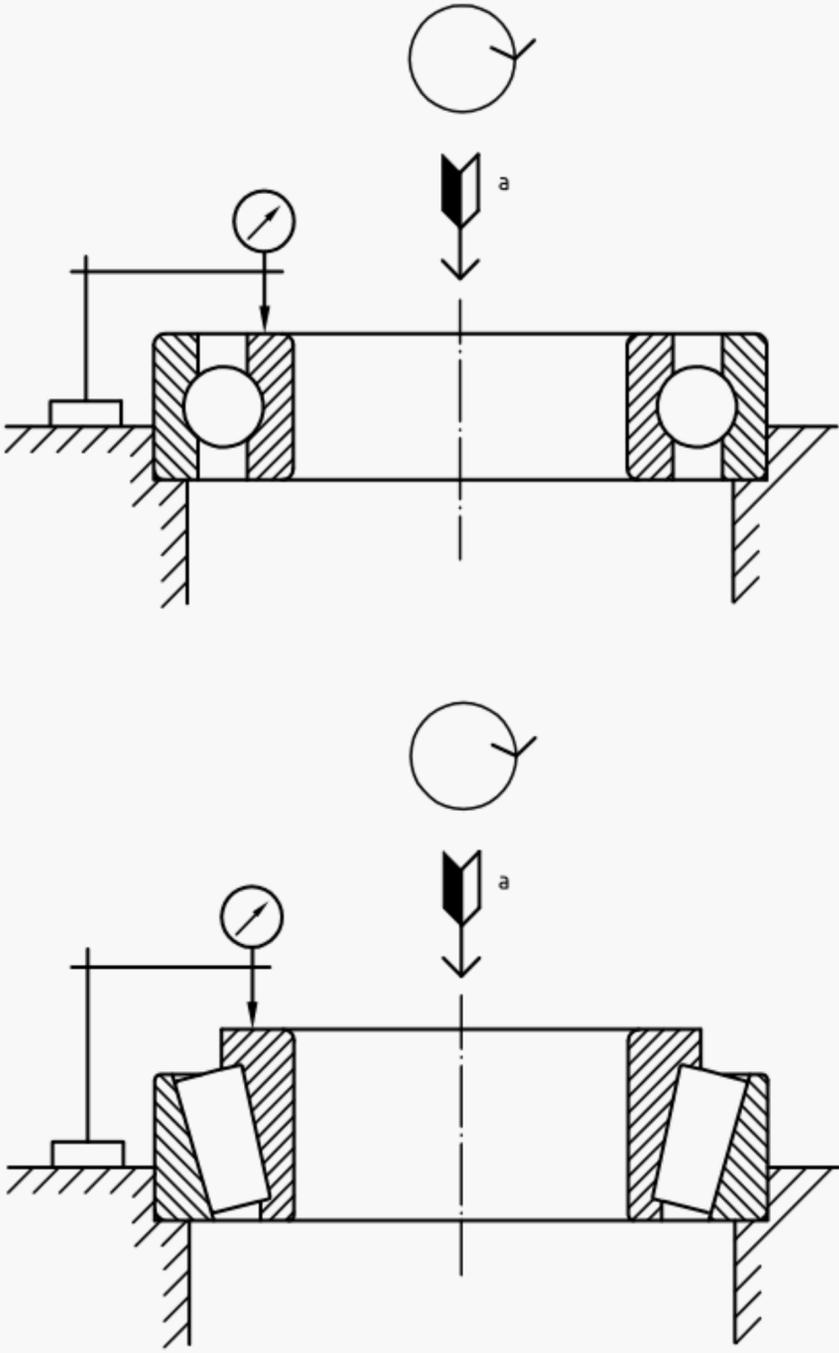
Method	Comments
 <p>Use a precision arbor having a taper of approximately 0,000 2:1 on diameter.</p> <p>Mount the bearing assembly on the tapered arbor and place the arbor between two centres so that it can be accurately rotated.</p> <p>Position the indicator against the outside surface of the outer ring as close as possible to the middle of the outer ring raceway.</p> <p>Hold the inner ring stationary. Take indicator readings while rotating the outer ring one revolution.</p>	<p>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.</p> <p>The radial runout of outer ring of assembled bearing, K_{ea}, is the difference between the largest and the smallest indicator readings.</p> <p>Radial runout of the outer 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.</p>

14.5 Measurement of asynchronous radial runout of inner ring of assembled bearing

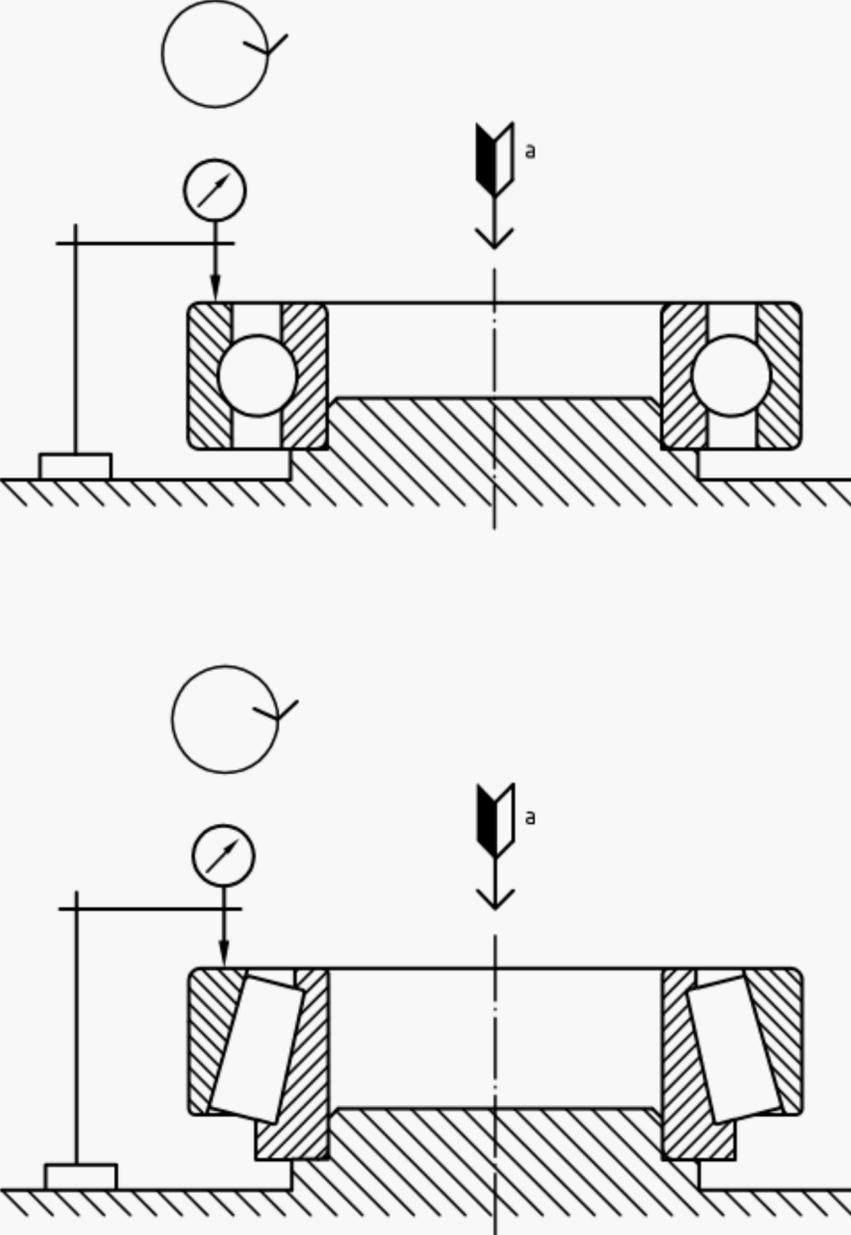
Method	Comments
 <p>a Load on outer ring b Rotatable surface plate</p> <p>Support the reference face of the inner ring on a rotatable surface plate with a pilot for centering in the bore of the ring. Prevent relative rotation between the bearing inner ring and the surface plate. Apply a dynamically stable 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.</p> <p>Position the indicator against the outside surface of the stationary outer ring as close as possible to the middle of the outer ring raceway. While rotating the inner ring (with surface plate) through multiple revolutions in both directions, record the largest indicator readings for each revolution.</p> <p>Reposition the indicator against another radial location on the outside surface of the outer ring and repeat the measurements with multiple revolutions of the inner ring in both directions. Repeat measurements with the indicator repositioned to different radial locations on the outer ring outside surface.</p>	<p>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.</p> <p>The asynchronous radial runout of inner ring of assembled bearing, K_{iaa}, is the range of the largest indicator readings when measured with multiple revolutions of the inner ring and with different fixed points on the outer ring.</p> <p>Measurements should be made with the inner ring rotated through many revolutions in both directions.</p> <p>Asynchronous radial runout 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.</p>

15 Principles of measuring axial runout

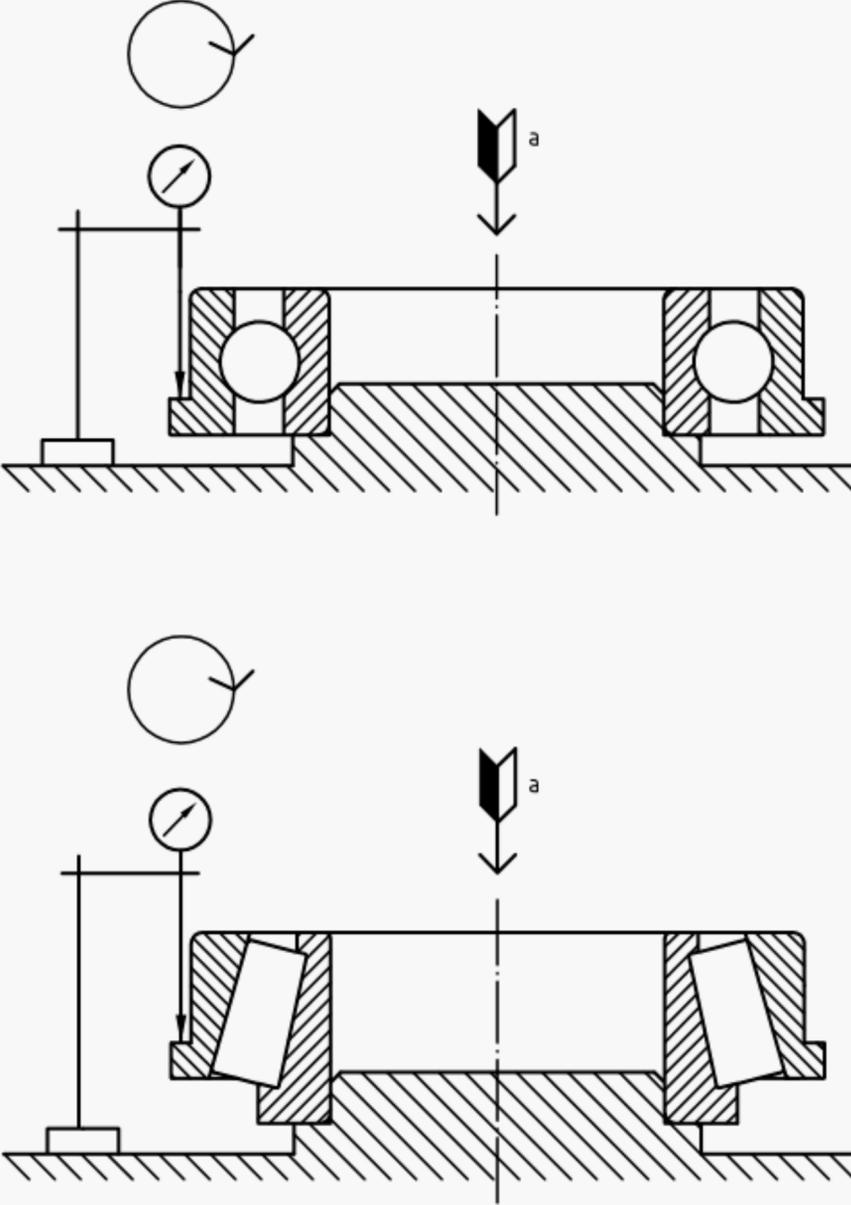
15.1 Measurement of axial runout of inner ring of assembled bearing

Method	Comments
 <p data-bbox="138 2002 463 2043">a Load on inner ring</p> <p data-bbox="138 2090 1034 2419">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.</p> <p data-bbox="138 2463 1034 2584">Position the indicator against the reference face of the inner ring and take indicator readings while rotating the inner ring one revolution.</p>	<p data-bbox="1051 602 1944 767">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.</p> <p data-bbox="1051 811 1944 931">The axial runout of inner ring of assembled bearing, S_{ia}, is the difference between the largest and the smallest indicator readings.</p> <p data-bbox="1051 976 1944 1390">Axial 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.</p>

15.2 Measurement of axial runout of outer ring of assembled bearing

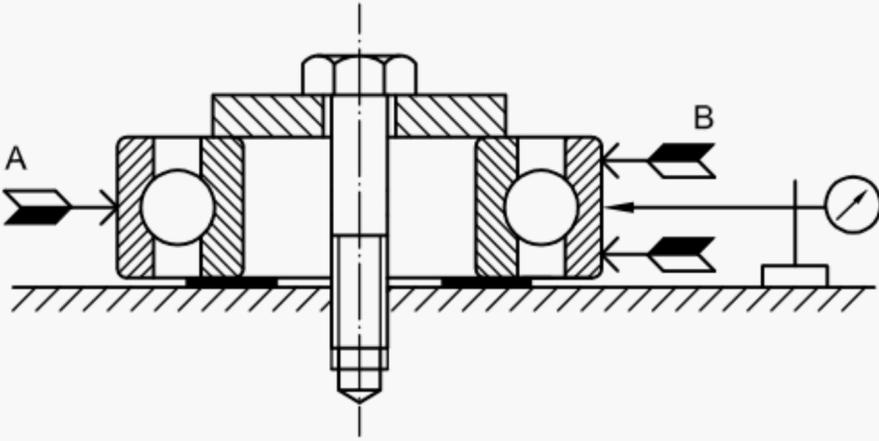
Method	Comments
 <p>a Load on outer ring</p> <p>Support the reference face of the inner ring on a surface plate with a pilot for centering in the bore of the inner ring. Apply a dynamically stable coaxial load, as specified in 5.6, to the reference face of the outer ring in order to ensure contact between 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.</p> <p>Position the indicator against the reference face of the outer ring and take indicator readings while rotating the outer ring one revolution.</p>	<p>This method is applicable to groove ball bearings (including single-row angular contact ball bearings), 4-point-contact ball bearings and tapered roller bearings.</p> <p>The axial runout of outer ring of assembled bearing, S_{ea}, is the difference between the largest and the smallest indicator readings.</p> <p>Axial runout of the outer 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.</p>

15.3 Measurement of axial runout of outer ring flange back face of assembled bearing

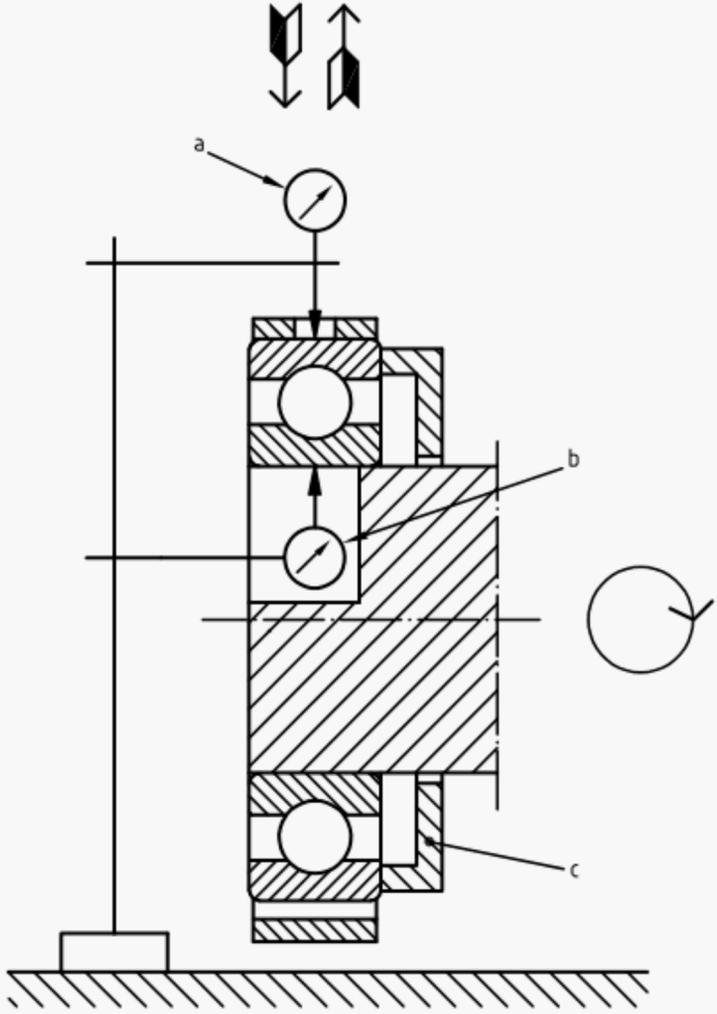
Method	Comments
 <p data-bbox="138 1764 468 1808">a Load on outer ring</p> <p data-bbox="138 1852 1032 2190">Support the reference face of the inner ring on a surface plate with a pilot for centering in the bore of the inner ring. Apply a dynamically stable coaxial load, as specified in 5.6, to the reference 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.</p> <p data-bbox="138 2219 1032 2366">Position the indicator against the outer ring flange back face in the middle of the flange and take indicator readings while rotating the outer ring one revolution.</p>	<p data-bbox="1053 514 1947 676">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 with outer ring flanges.</p> <p data-bbox="1053 720 1947 837">The axial runout of outer ring flange back face of assembled bearing, S_{ea1}, is the difference between the largest and the smallest indicator readings.</p> <p data-bbox="1053 882 1947 1337">Axial runout of the outer ring flange back face 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.</p>

16 Principles of measuring radial clearance

16.1 Measurement of radial internal clearance (method A)

Method	Comments
 <p>Fasten the inner ring of the assembled bearing on a surface plate with a shim inserted between the inner ring face and the surface plate. For spherical roller bearings, the outer ring should be prevented from tilting.</p> <p>Position the indicator against the outer ring outside surface and in line with the middle of the raceway. Hold the outer ring in contact with the rest of the bearing in direction "A", taking care not to lift the opposite side. Axially move the outer ring repeatedly in one direction and then the other and oscillate the ring circumferentially (for the purpose of moving the rolling elements to the bottom of the raceway) until the indicator gives a consistent maximum reading.</p> <p>While continuing to hold the outer ring lightly in contact with the rest of the bearing in direction "A", axially move the outer ring in one direction and then the other without circumferential motion. When the rolling elements pass over the bottom of the raceways, the indicator will show a maximum reading, which is recorded.</p> <p>Without changing the general location of the outer ring, hold it in contact with the bearing in direction "B", taking care not to lift the opposite side. Axially move the outer ring repeatedly in one direction and then the other and oscillate circumferentially (for purpose of moving the rolling elements to the bottom of the raceway) until the indicator gives a consistent minimum reading.</p> <p>Then, while continuing to hold the outer ring lightly in contact with the rest of the bearing in direction "B", axially move the outer ring in one direction and then the other without circumferential motion. When the rolling elements pass over the bottom of the raceway, the indicator will show a minimum reading, which is recorded.</p> <p>Compensate for possible out-of-roundness of the outer ring and inner ring by repeating the same procedure several times at different angular positions.</p>	<p>This method is used for measuring radial internal clearance and is applicable to all radial bearings except single-row angular contact ball bearings and tapered roller bearings.</p> <p>This method is used for measuring the radial internal clearance directly using simple means and without the use of a master bearing.</p> <p>The difference between minimum and maximum measured readings is the measured radial internal clearance. The average of the several sets of measurements is the radial internal clearance, G_r, of the bearing.</p> <p>Since radial internal clearance is defined as being under no load, the measured values must be adjusted to compensate for deflections that may occur during measurement.</p> <p>NOTE If the indicator needle does not pass through a clearly largest and smallest reading, the shim is probably too thin.</p>

16.2 Measurement of radial internal clearance (method B)

Method	Comments																												
<div style="text-align: center;">  </div> <p>a Indicator A b Indicator B c Stop</p> <p>Mount the assembled bearing on a close-fitting rigid arbor. Position indicator "A" against the outer ring outside surface in line with the middle of the raceway. Position indicator "B" against the inner ring bore surface in line with the middle of the raceway. Rotate the inner ring and displace the outer ring radially under a radial measuring load as given in the adjacent table.</p> <p>Record mean readings A_{m1} and B_{m1} of indicators "A" and "B". Reverse the radial measuring load and record the mean readings A_{m2} and B_{m2} of indicators "A" and "B". Record the differences Δ_{Am} and Δ_{Bm} between the two sets of readings.</p> <p>Repeat the measurement in two more positions after turning the outer ring 120° each time (three measuring operations in all).</p>	<p>This method is used for measuring radial internal clearance and is applicable to deep groove ball bearings, radial cylindrical roller bearings, and radial spherical roller bearings.</p> <p>The bearing radial internal clearance, G_r, is the average of the three measurement values.</p> <p>Pre-lubricated bearings and some designs of bearings with seals or shields may adversely affect accuracy of measuring (see 5.8)</p> <p>Since radial internal clearance is defined as being under no load, the measured values must be adjusted to compensate for deflections that may occur during measurement.</p> <p style="text-align: center;">Radial measuring loads</p> <table border="1" data-bbox="1129 1308 1868 2022"> <thead> <tr> <th colspan="2" data-bbox="1129 1308 1498 1484">d mm</th> <th colspan="2" data-bbox="1502 1308 1868 1425">Measuring load, nominal^a N</th> </tr> <tr> <th data-bbox="1129 1490 1315 1581">></th> <th data-bbox="1319 1490 1498 1581">≤</th> <th data-bbox="1502 1490 1687 1581">Ball bearings</th> <th data-bbox="1691 1490 1868 1581">Roller bearings</th> </tr> </thead> <tbody> <tr> <td data-bbox="1129 1587 1315 1649">—</td> <td data-bbox="1319 1587 1498 1649">30</td> <td data-bbox="1502 1587 1687 1649">25</td> <td data-bbox="1691 1587 1868 1649">50</td> </tr> <tr> <td data-bbox="1129 1655 1315 1716">30</td> <td data-bbox="1319 1655 1498 1716">50</td> <td data-bbox="1502 1655 1687 1716">30</td> <td data-bbox="1691 1655 1868 1716">60</td> </tr> <tr> <td data-bbox="1129 1722 1315 1784">50</td> <td data-bbox="1319 1722 1498 1784">80</td> <td data-bbox="1502 1722 1687 1784">35</td> <td data-bbox="1691 1722 1868 1784">70</td> </tr> <tr> <td data-bbox="1129 1790 1315 1852">80</td> <td data-bbox="1319 1790 1498 1852">120</td> <td data-bbox="1502 1790 1687 1852">40</td> <td data-bbox="1691 1790 1868 1852">80</td> </tr> <tr> <td data-bbox="1129 1858 1315 1919">120</td> <td data-bbox="1319 1858 1498 1919">200</td> <td data-bbox="1502 1858 1687 1919">50</td> <td data-bbox="1691 1858 1868 1919">100</td> </tr> </tbody> </table> <p>^a The load must not exceed $0,005C_{0r}$ as defined in ISO 76.</p>	d mm		Measuring load, nominal ^a N		>	≤	Ball bearings	Roller bearings	—	30	25	50	30	50	30	60	50	80	35	70	80	120	40	80	120	200	50	100
d mm		Measuring load, nominal ^a N																											
>	≤	Ball bearings	Roller bearings																										
—	30	25	50																										
30	50	30	60																										
50	80	35	70																										
80	120	40	80																										
120	200	50	100																										

Annex A (normative)

Cross-reference to clauses in ISO 1132-1

Table A.1 — Cross-references and symbols

ISO 1132-2 Clause and method		Symbol	ISO 1132-1 reference
7	Principles of measuring bore diameter		
7.1	Measurement of single bore diameter (including single bore diameter in a single plane)	d_s, d_{sp}	5.1.2, 5.1.3
7.2	Functional gauging of smallest single bore diameter of thrust needle roller and cage assembly and thrust washer	$d_{cs\ min}, d_{s\ min}$ $D_{1s\ min}$	—
7.3	Measurement of single bore diameter of rolling element complement	F_{ws}	5.1.13
7.4	Measurement of smallest single bore diameter of rolling element complement	$F_{ws\ min}$	5.1.14
7.5	Functional gauging of smallest single bore diameter of rolling element complement	$F_{ws\ min}$	—
7.6	Functional gauging of smallest single bore diameter of rolling element complement (radial needle roller and cage assemblies)	$F_{ws\ min}$	—
8	Principles of measuring outside diameter		
8.1	Measurement of single outside diameter (including single outside diameter in a single plane)	D_s, D_{sp}	5.2.2, 5.2.3
8.2	Measurement of single outside diameter of rolling element complement	E_{ws}	5.2.13
8.3	Functional gauging of largest single outside diameter of rolling element complement	$E_{ws\ max}$	—
9	Principles of measuring width and height		
9.1	Measurement of single ring width	B_s, C_s	5.3.2
9.2	Measurement of single outer ring flange width	C_{1s}	5.3.7
9.3	Measurement of actual bearing width (primary method)	T_s	5.3.11
9.4	Measurement of actual bearing width (alternative method)	T_s	5.3.11
9.5	Measurement of actual bearing height (thrust bearings)	T_s	5.3.14
9.6	Measurement of actual effective width of inner subunit (tapered roller bearings)	T_{1s}	5.3.17
9.7	Measurement of actual effective width of outer ring (tapered roller bearings)	T_{2s}	5.3.20
10	Principles of measuring ring and washer chamfer dimension		
10.1	Measurement of single chamfer dimension (primary method)	r_s	5.4.2
10.2	Functional gauging of single chamfer dimension (alternative method)	$r_{s\ max}, r_{s\ min}$	—
11	Principles of measuring raceway parallelism		
11.1	Measurement of parallelism of inner ring raceway with respect to the face	S_i	6.2.1
11.2	Measurement of parallelism of outer ring raceway with respect to the face	S_e	6.2.2

Table A.1 — Cross-references and symbols (continued)

ISO 1132-2 Clause and method		Symbol	ISO 1132-1 reference
12	Principles of measuring surface perpendicularity		
12.1	Measurement of perpendicularity of inner ring face with respect to the bore (method A)	S_d	6.3.1
12.2	Measurement of perpendicularity of inner ring face with respect to the bore (method B)	S_d	6.3.1
12.3	Measurement of perpendicularity of outer ring outside surface with respect to the face	S_D	6.3.2
12.4	Measurement of perpendicularity of outer ring outside surface with respect to the flange back face	S_{D1}	6.3.3
13	Principles of measuring thickness variation		
13.1	Measurement of variation in thickness between inner ring raceway and bore	K_i	6.4.1
13.2	Measurement of variation in thickness between outer ring raceway and outside surface	K_e	6.4.2
13.3	Measurement of variation in thickness between shaft washer raceway and back face	S_i	6.4.3
13.4	Measurement of variation in thickness between raceway and back face of central shaft washer	S_i	6.4.3
13.5	Measurement of variation in thickness between housing washer raceway and back face	S_e	6.4.4
14	Principles of measuring radial runout		
14.1	Measurement of radial runout of inner ring of assembled bearing (primary method)	K_{ia}	7.1.1
14.2	Measurement of radial runout of inner ring of assembled bearing (alternative method)	K_{ia}	7.1.1
14.3	Measurement of radial runout of outer ring of assembled bearing (primary method)	K_{ea}	7.1.2
14.4	Measurement of radial runout of outer ring of assembled bearing (alternative method)	K_{ea}	7.1.2
14.5	Measurement of asynchronous radial runout of inner ring of assembled bearing	K_{iaa}	7.1.3
15	Principles of measuring axial runout		
15.1	Measurement of axial runout of inner ring of assembled bearing	S_{ia}	7.2.1, 7.2.2
15.2	Measurement of axial runout of outer ring of assembled bearing	S_{ea}	7.2.3, 7.2.4
15.3	Measurement of axial runout of outer ring flange back face of assembled bearing	S_{ea1}	7.2.5, 7.2.6
16	Principles of measuring radial clearance		
16.1	Measurement of radial internal clearance (method A)	G_r	8.1.1
16.2	Measurement of radial internal clearance (method B)	G_r	8.1.1

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