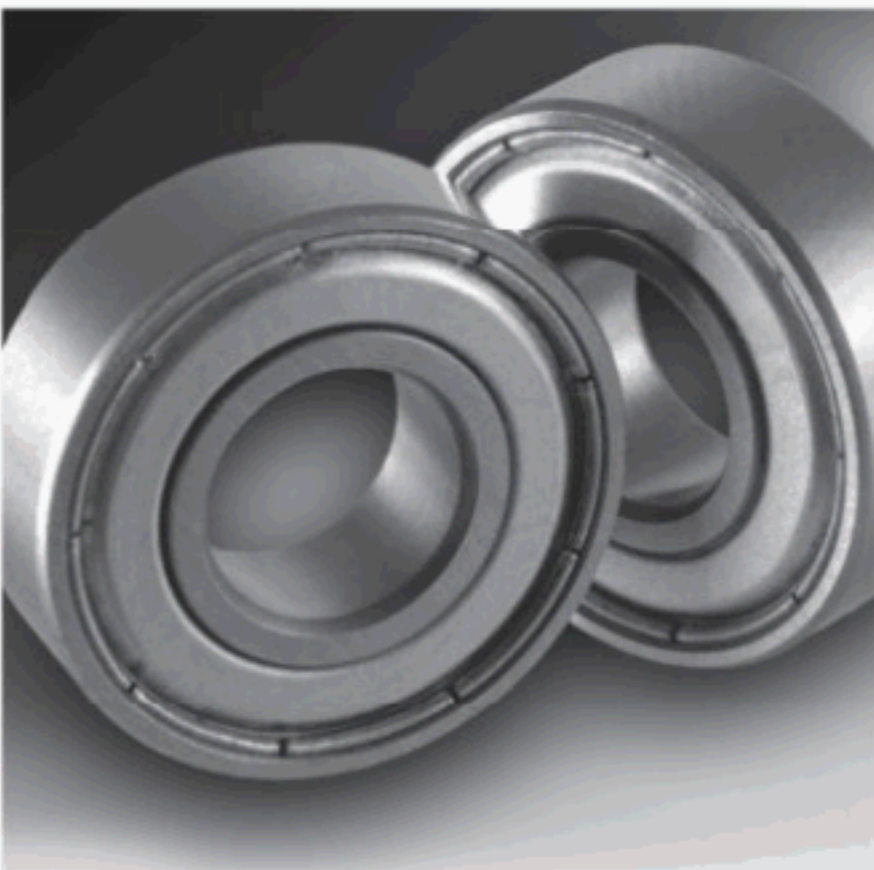


ANSI/ABMA Std. 4:1994 (Reaffirmed 2013)

**AMERICAN NATIONAL STANDARD**

***ABMA Standard***



# **Tolerance definitions and gauging practices for ball and roller bearings**

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Manufacturers Association**

**ANSI/ABMA Std. 4:1994**

**Reaffirmed 2013**

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## **FOREWORD**

(This foreword is not part of ANSI/ABMA Standard 4, Tolerance Definitions and Gauging Practices for Ball and Roller Bearings.)

This American National Standard defines the terms used in other ANSI/ABMA standards specifying tolerances for boundary dimensions, running accuracy and internal clearance for rolling bearings. In addition, it specifies general conditions under which these tolerances apply and provides measurement and gauging methods for the measurement of dimensions, running accuracy and internal clearance of rolling bearings. Symbols for a number of the concepts defined in this standard are established.

This standard has been revised to conform with International Standards developed by the members of the International Organization for Standardization (ISO). In particular, the language and intent of ISO 1132 (Rolling bearings - Tolerances - Definitions), ISO 5593 (Rolling bearings - Vocabulary) and ISO Technical Report 9274 (Rolling bearings - Measuring and gauging principles and methods) have been followed.

Copies of ISO standards concerning rolling element (anti-friction) bearings are available from the American National Standards Institute.

Suggestions for the improvement of this standard gained through experience with its use will be welcomed. These should be sent to the American National Standards Institute, Inc., 11 West 42nd Street, 13th Floor, New York, NY 10036.

The officers of Accredited Standards Committee B3 operating under the American National Standards Institute procedures and the organizations represented at the time this standard was submitted are as follows:

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American Bearing Manufacturers Association

Hydraulic Institute

Association for Manufacturing Technology

Society of Tribologists and Lubrication Engineers

U.S. Department of Defense, DISC

U.S. Department of the Navy

**ABMA (formerly AFBMA) Standards  
for  
Ball and Roller Bearings**

- 1 - Terminology for Anti-Friction Ball and Roller Bearings and Parts**
- 4 - Tolerance Definitions and Gauging Practices for Ball and Roller Bearings**
- 7 - Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings)  
Conforming to Basic Boundary Plans**
- 8.1 - Mounting Accessories, Metric Design**
- 8.2 - Mounting Accessories, Inch Design**
- 9 - Load Ratings and Fatigue Life for Ball Bearings**
- 10 - Metal Balls**
- 11 - Load Ratings and Fatigue Life for Roller Bearings**
- 12.1 - Instrument Ball Bearings, Metric Design**
- 12.2 - Instrument Ball Bearings, Inch Design**
- 13 - Rolling Bearing Vibration and Noise (Methods of Measuring)**
- 14 - Housings for Bearings with Spherical Outside Surfaces**
- 15 - Ball Bearings with Spherical Outside Surfaces and Extended Inner Ring Width (Includes Eccentric  
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- 16.1 - Airframe Ball, Roller, and Needle Roller Bearings, Metric Design**
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- 25.2 - Rolling Bearings, Linear Motion, Recirculating Ball, Sleeve Type - Inch Series**
- 26.2 - Thin Section Ball Bearings - Inch Design**

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# American National Standard ABMA Standard Tolerance Definitions and Gauging Practices for Ball and Roller Bearings

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# Tolerance Definitions and Gauging Practices for Ball and Roller Bearings

## 1. Scope

This standard includes:

(1) Terms and definitions of tolerances for the boundary dimensions, running accuracy and internal clearance of ball and roller bearings listed in other ANSI/ABMA and ISO standards.

(2) Description of methods of measuring, which are commonly used by bearing users and which, as a rule, give an accuracy sufficient for practical purposes.

## 2. Terms and definitions

### 2.1 General

**2.1.1 Applicability of tolerances:** The tolerances apply exclusively to the concept of boundary dimensions, running accuracy and internal clearance defined in sections 2.2, 2.3 and 2.4 of this standard.

**2.1.2 Absolute dimensions:** At a temperature of  $+20^{\circ}\text{C}$  ( $+68^{\circ}\text{F}$ ) and provided that the bearing parts are completely unstressed by external forces, including measuring loads and the gravitational force on the part itself, a boundary dimension of a bearing or bearing part shall not deviate from the nominal dimension by more than the tolerances to be applied. In order to assure correlation between the bearing dimensions and the absolute unit of length, the gauges and measuring instruments shall, at suitable intervals, be adjusted or calibrated by means of master gauges, whose calibration is traceable to those used by the National Institute of Standards and Technology.

**2.1.3 Tolerance terms:** All specified tolerances apply to the finished bearing or component.

The term "nominal size" (diameter, width height), "deviation", and "tolerance" conform with those defined in ANSI Standard B4.2, Preferred Metric Limits and Fits. Figure 1 illustrates those and other terms.

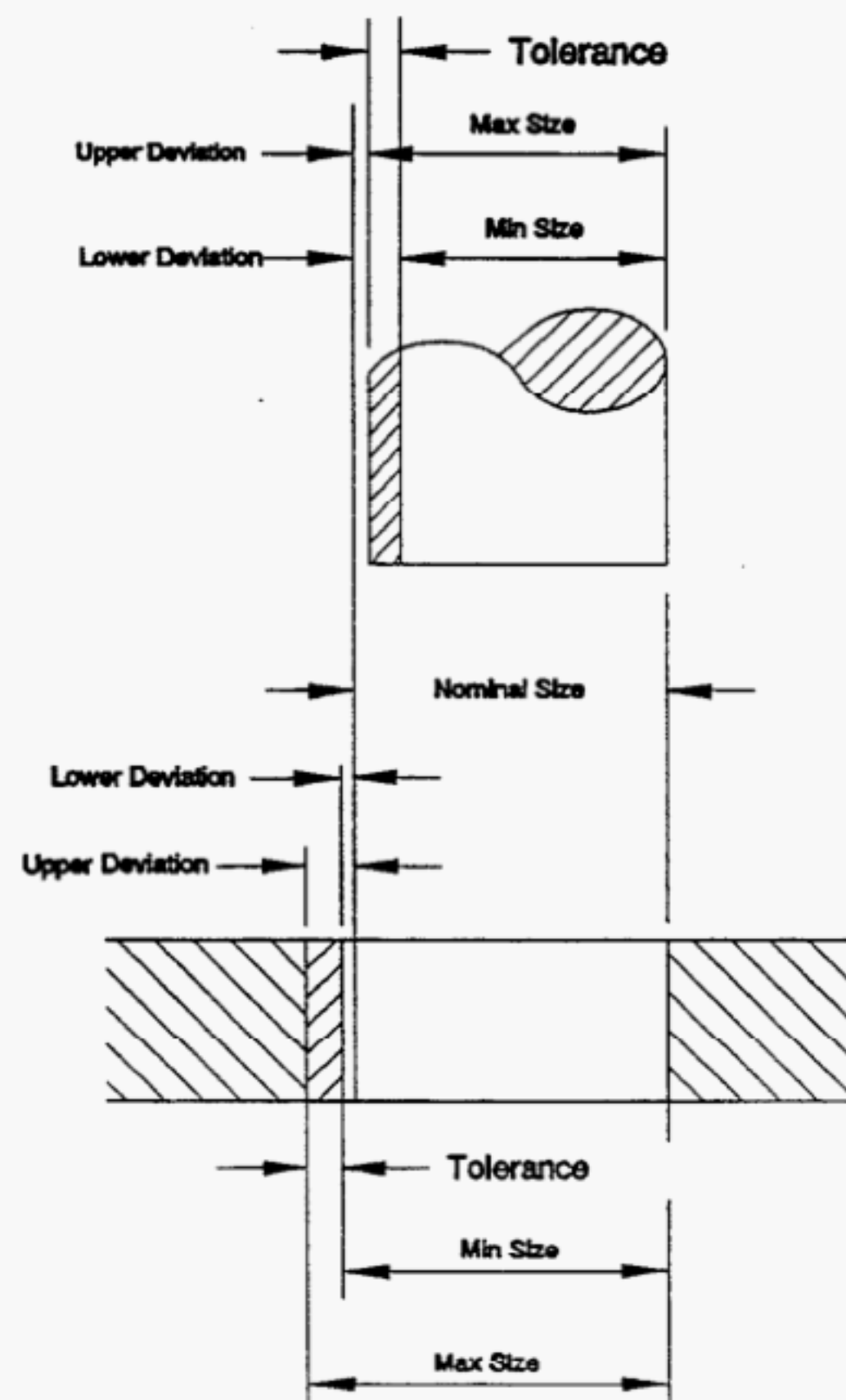


Figure 1  
Illustration of definitions

## **2.1.4 Axes, planes, etc.**

### **2.1.4.1 inner ring (or shaft washer) axis:**

Axis of the cylinder inscribed in a basically cylindrical bore or of the cone inscribed in a basically tapered bore. The inner ring (or shaft washer) axis is also the bearing axis.

### **2.1.4.2 outer ring (or housing washer) axis:**

Axis of the cylinder circumscribed around a basically cylindrical outside surface.

**2.1.4.3 radial plane:** Plane perpendicular to the bearing or ring axis. It is, however, acceptable to consider radial planes referred to in the definitions as being parallel with the plane tangential to the reference face of a ring or the back face of a thrust bearing washer.

**2.1.4.4 radial direction:** Direction through the bearing or ring axis in a radial plane.

**2.1.4.5 axial plane:** Plane containing the bearing or ring axis.

**2.1.4.6 axial direction:** Direction parallel with the bearing or ring axis. It is, however, acceptable to consider axial directions referred to in the definitions as being perpendicular to the plane tangential to the reference face of a ring or back face of a thrust bearing washer.

**2.1.4.7 reference face:** Face so designated by the manufacturer of the bearings and which may be the datum for measurements.

NOTE - The reference face for measurement is generally taken as the unmarked face. In case of symmetrical rings when it is not possible to identify the reference face, the tolerances are deemed to comply relative to either face, but not both. The reference face of a shaft and housing washer of a thrust bearing is that face intended to support axial load and is generally opposite the raceway face. 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.

**2.1.4.8 outer ring flange back face:** That side of an outer ring flange which is intended to support axial load.

**2.1.4.9 middle of raceway:** Point or line on a raceway surface, halfway between the two edges of the raceway.

**2.1.4.10 raceway contact diameter:** Diameter of the theoretical circle through the nominal points of contact between the rolling elements and raceway.

NOTE - For roller bearings, the nominal point of contact is generally at the middle of the roller.

**2.1.4.11 diameter deviation near ring faces:** In radial planes, nearer the face of a ring than 1.2 times the maximum (axial direction) ring chamfer, only the maximum material limits apply.

## **2.2 Boundary dimensions**

Diameter (width, height) variations and mean diameters (width, height) defined in this section are the differences and arithmetical means of the actual largest and smallest single dimensions, not of the permissible limits for the single dimensions.

### **2.2.1 Bore diameter**

**2.2.1.1 nominal bore diameter,  $d$ :** Diameter of the cylinder containing the theoretical bore surface of a cylindrical bore. Diameter, in a designated radial plane, of the cone containing the theoretical bore surface of a tapered bore.

NOTE - For rolling bearings, the nominal bore diameter is generally the reference value (basic diameter) for deviations of the actual bore surface.

**2.2.1.2 single bore diameter,  $d_s$ :** Distance between two parallel tangents to the line of intersection of the actual bore surface and a radial plane.



**2.2.1.3 deviation of a single bore diameter,  $\Delta_{ds}$  (of a basically cylindrical bore):** Difference between a single bore diameter and the nominal bore diameter.

**2.2.1.4 bore diameter variation,  $V_{ds}$  (of a basically cylindrical bore):** Difference between the largest and the smallest of the single bore diameters of an individual ring.

**2.2.1.5 mean bore diameter,  $d_m$  (of a basically cylindrical bore):** Arithmetical mean of the largest and the smallest of the single bore diameters of an individual ring.

**2.2.1.6 mean bore diameter deviation,  $\Delta_{dm}$  (of a basically cylindrical bore):** Difference between the mean bore diameter and the nominal bore diameter.

**2.2.1.7 single plane mean bore diameter,  $d_{mp}$ :** Arithmetical mean of the largest and smallest of the single bore diameters in a single radial plane. This diameter,  $d_{mp}$ , measured at the middle of the ring, is used for classification purposes.

**2.2.1.8 single plane mean bore diameter deviation,  $\Delta_{dmp}$  (of a basically cylindrical bore):** Difference between a single plane mean bore diameter and the nominal bore diameter.

**2.2.1.9 bore diameter variation in a single radial plane,  $V_{dp}$ :** Difference between the largest and the smallest of the single bore diameters in a single radial plane. This is also referred to as bore out-of-roundness.

**2.2.1.10 mean bore diameter variation,  $V_{dmp}$  (of a basically cylindrical bore):** Difference between the largest and the smallest of the single plane mean bore diameters of an individual ring. This is also referred to as bore taper.

**2.2.1.11 bore diameter,  $F_w$  (of the rolling element complement of an outer ring assembly, or a rolling element and cage assembly within a ring gauge):** Diameter of the cylinder inscribed within the rolling element complement.

## **2.2.2 Outside diameter**

**2.2.2.1 nominal outside diameter,  $D$  (of the single bore diameters of a basically cylindrical outside surface):** Diameter of the cylinder containing the theoretical outside surface.

NOTE - For rolling bearings, the nominal outside diameter is generally the reference value (basic diameter) for deviations of the actual outside surface.

**2.2.2.2 single outside diameter,  $D_s$ :** Distance between two parallel tangents to the line of intersection of the actual outside surface and a radial plane.

**2.2.2.3 deviation of a single outside diameter,  $\Delta_{Ds}$  (of a basically cylindrical outside surface):** Difference between a single outside diameter and the nominal outside diameter.

**2.2.2.4 outside diameter variation,  $V_{Ds}$  (of a basically cylindrical outside surface):** Difference between the largest and the smallest of the single outside diameters of an individual ring.

**2.2.2.5 mean outside diameter,  $D_m$  (of a basically cylindrical outside surface):** Arithmetical mean of the largest and the smallest of the single outside diameters of an individual ring.

**2.2.2.6 mean outside diameter deviation,  $\Delta_{Dm}$  (of a basically cylindrical surface):** Difference between the mean outside diameter and the nominal outside diameter.

**2.2.2.7 single plane mean outside diameter,  $D_{mp}$ :** Arithmetical mean of the largest and the smallest of the single outside diameters in a single radial plane. This diameter,  $D_{mp}$ , measured at the middle of the ring, is used for classification purposes.

**2.2.2.8 single plane mean outside diameter deviation,  $\Delta_{Dmp}$  (of a basically cylindrical outside surface):** Difference between a single plane mean outside diameter and the nominal outside diameter.

**2.2.2.9 outside diameter variation in a single radial plane,  $V_{dp}$ :** Difference between the largest and the smallest of the single outside diameters in a single radial plane. This is also referred to as outside diameter out-of-roundness.

**2.2.2.10 mean outside diameter variation  $V_{Dmp}$  (of a basically cylindrical outside surface):** Difference between the largest and the smallest of the single plane mean outside diameters of an individual ring. This is also referred to as outside diameter taper.

**2.2.2.11 outside diameter,  $E_w$  (of the rolling element complement of an inner ring assembly, or a rolling element and cage assembly over a plug gauge):** Diameter of the cylinder circumscribed around the rolling element complement.

## **2.2.3 Form**

**2.2.3.1 deviation from circular form (of a basically circular line on a surface):** Greatest radial distance between the circle inscribed in the line (inside surface) or circumscribed around the line (outside surface) and any point on the line.

**2.2.3.2 deviation from cylindrical form (of a basically cylindrical surface):** Greatest radial distance, in any radial plane, between the cylinder inscribed in the surface (inside surface) or circumscribed around the surface (outside surface) and any point on the surface.

**2.2.3.3 deviation from spherical form (of a basically spherical surface):** Greatest radial distance, in any equatorial plane, between the sphere inscribed in the surface (inside surface) or circumscribed around the surface (outside surface) and any point on the surface.

## **2.2.4 Width and height**

**2.2.4.1 nominal ring width,  $B$  (inner ring) or  $C$  (outer ring):** Distance between the two theoretical side faces of a ring.

**NOTE -** For rolling bearings, the nominal width is generally the reference value (basic dimension) for deviations of the actual width.

**2.2.4.2 single ring width,  $B_s$  or  $C_s$ :** Distance between the points of intersection of the two actual side faces of a ring and a straight line perpendicular to the plane tangential to the reference face of the ring.

**2.2.4.3 deviation of a single ring width,  $\Delta_{Bs}$  or  $\Delta_{Cs}$ :** Difference between a single ring width and the nominal ring width.

**2.2.4.4 ring width variation,  $V_{Bs}$  or  $V_{Cs}$ :** Difference between the largest and the smallest of the single widths of an individual ring.

**2.2.4.5 mean ring width,  $B_m$  or  $C_m$ :** Arithmetical mean of the largest and the smallest of the single widths of an individual ring.

**2.2.4.6 nominal outer ring flange width,  $C_1$ :** Distance between the two theoretical side faces of a flange.

**2.2.4.7 single width of an outer ring flange,  $C_{1s}$ :** Distance between the points of intersection of the two actual side faces of a flange and a straight line perpendicular to the plane tangential to the reference face of the flange.

**2.2.4.8 deviation of a single outer ring flange width,  $\Delta_{C1s}$ :** Difference between a single flange width and the nominal flange width.



**2.2.4.9 outer ring flange width variation,  $V_{C1s}$ :** Difference between the largest and the smallest of the single widths of an individual flange.

**2.2.4.10 mean outer ring flange width,  $C_{1m}$ :** Arithmetical mean of the largest and the smallest of the single flange widths of an individual ring.

**2.2.4.11 nominal bearing width, B, C, or T (radial bearing):** Distance between the two theoretical ring faces designated to bound the bearing width.

NOTE - The nominal bearing width is generally the reference value (basic dimension) for deviations of the actual bearing width. Symbol B is used where the nominal width is the distance between the inner ring faces, as well as where inner and outer rings are equally wide and their faces nominally flush. Symbol C is used where the nominal width is the distance between the outer ring faces (providing symbol B is not applicable). Symbol T is used where the nominal width is the distance between one inner ring face and the outer ring face on the opposite side.

**2.2.4.12 actual bearing width,  $T_s$  (radial bearing where one inner ring face and one outer ring face are designated to bound the bearing width):** Distance between the points of intersection of the bearing axis and the two planes tangential to the actual ring faces designated to bound the bearing width.

NOTE - For a single row tapered roller bearing this is the distance between the points of intersection of the bearing axis and two planes, one tangential to the actual back face of the cone and one tangential to that of the cup, the cone and cup raceways and the cone back face rib being in contact with all the rollers.

**2.2.4.13 deviation of the actual bearing width,  $\Delta_{T_s}$  (radial bearings where one inner ring face and one outer ring face are designated to bound the bearing width):** Difference between the actual bearing width

and the nominal bearing width.

**2.2.4.14 nominal bearing height, T (thrust bearing):** Distance between the two theoretical washer back faces designated to bound the bearing height.

NOTE - The nominal bearing height is generally the reference value (basic dimension) for deviations of the actual bearing height.

**2.2.4.15 actual bearing height,  $T_s$  (thrust bearing):** Distance between the points of intersection of the bearing axis and the two planes tangential to the actual washer back faces designated to bound the bearing height.

**2.2.4.16 deviation of the actual bearing height,  $\Delta_{T_s}$  (thrust bearing):** Difference between the actual bearing height and the nominal bearing height.

## **2.2.5 Ring chamfer dimension**

### **2.2.5.1 single chamfer dimension, $r_s, r_{1s}$**

**2.2.5.1.1 radial dimension:** Actual distance, in a single axial plane, from the imaginary sharp ring corner to the intersection of the chamfer surface and the ring face.

**2.2.5.1.2 axial dimension:** Actual distance, in a single axial plane, from the imaginary sharp ring corner to the intersection of the chamfer surface and the bore or outside surface of the ring.

**2.2.5.2 smallest single chamfer dimension,  $r_{s \min}, r_{1s \min}$  (minimum limit):** In addition to defining the smallest permissible radial and axial single chamfer dimension, this is the radius of an imaginary circular arc, in an axial plane, tangential to the ring face and the bore or outside surface of the ring, beyond which no ring material is allowed to project.

**2.2.5.3 largest single chamfer dimension,  $r_{s \max}, r_{1s \max}$  (maximum limit):** The largest permissible radial or axial single chamfer dimension.

## 2.3 Running accuracy

### 2.3.1 Radial runout

**2.3.1.1 inner ring raceway to bore thickness variation,  $K_i$  (radial bearing):** Difference between the largest and the smallest of the radial distances between the bore surface and the middle of a raceway on the outside of the ring.

**2.3.1.2 radial runout of assembled bearing inner ring,  $K_{ia}$  (radial bearing):** Difference between the largest and the smallest of the radial distances between the bore surface of the inner ring, in different angular positions of this ring, and a point in a fixed position relative to the outer ring. At the angular position of the point mentioned, or on each side and close to it, rolling elements are to be in contact with both the inner and outer ring raceways or (in a tapered roller bearing) the cone back face rib, the bearing parts being otherwise in normal relative positions.

NOTE -  $K_{ia}$  is the result of several factors and accurate measurement is difficult. In practice, the manufacturer may instead revert to the inspection of  $K_i$ , which is the major factor. (See 2.3.1.1)

**2.3.1.3 outer ring raceway to outside surface thickness variation,  $K_e$  (radial bearing)** Difference between the largest and the smallest of the radial distances between the outside surface and the middle of a raceway on the inside of the ring.

**2.3.1.4 radial runout of assembled bearing outer ring,  $K_{ea}$  (radial bearing):** Difference between the largest and the smallest of the radial distances between the outside surface of the outer ring, in different angular positions of this ring, and a point in a fixed position relative to the inner ring. At the angular position of the point mentioned, or on each side and close to it, rolling elements are to be in contact with both the inner and outer ring raceways and (in a tapered roller bearing) the cone back face rib, the bearing parts being

otherwise in normal relative positions.

NOTE -  $K_{ea}$  is the result of several factors and accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of  $K_e$ , which is the major factor. (See 2.3.1.3)

**2.3.1.5 asynchronous radial runout of assembled bearing inner ring,  $K_{iaa}$  (radial bearing):** Difference between the largest and the smallest of the radial distances between a fixed point on the outside surface of the outer ring relative to any fixed point on the bore surface of the inner ring when measured with multiple inner ring revolutions, in either direction, and with the rolling elements in contact with both inner and outer ring raceways and (in a tapered roller bearing) the cone back face rib, the bearing parts being otherwise in normal relative positions. This is also referred to as non-repetitive radial run out.

### 2.3.2 Face runout with raceway

**2.3.2.1 raceway parallelism with face,  $S_i$  or  $S_e$  (inner or outer ring, reference or back face):** Difference between the largest and the smallest of the axial distances between the plane tangential to the reference or back face and the middle of the raceway.

**2.3.2.2 washer raceway to back face thickness variation,  $S_i$  or  $S_e$  (thrust bearing shaft or housing washer, flat back face):** Difference between the largest and the smallest of the axial distances between the back face and the middle of a raceway on the opposite side of the washer.

**2.3.2.2.1 washer raceway to side face thickness variation,  $S_i$  (double direction thrust bearing shaft washer):** Difference between the largest and the smallest of the axial distances between the side face and the middle of a raceway on the opposite side of the washer.



**2.3.2.3 assembled bearing inner ring face runout with raceway,  $S_{ia}$  (groove type radial ball bearing):** Difference between the largest and the smallest of the axial distances between the reference face of the inner ring, in different relative angular positions of this ring, at a radial distance from the inner ring axis equal to half the inner ring raceway contact diameter, and a point in a fixed position relative to the outer ring. The inner and outer ring raceways are to be in contact with all the balls.

NOTE -  $S_{ia}$  is the result of several factors and accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of  $S_i$ , which is the major factor. (See 2.3.2.1)

**2.3.2.4 assembled bearing cone back face runout with raceway,  $S_{ia}$  (tapered roller bearing):** Difference between the largest and smallest of the axial distances between the cone back face, in different angular positions of the cone, at a radial distance from the cone axis equal to half the cone raceway contact diameter, and a point in a fixed position relative to the cup. The cone and cup raceways and the cone back face rib are to be in contact with all the rollers, the bearing parts being otherwise in normal relative positions.

NOTE -  $S_{ia}$  is the result of several factors and accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of  $S_i$ , which is the major factor. (See 2.3.2.1)

**2.3.2.5 assembled bearing outer ring face runout with raceway,  $S_{ea}$  (groove type radial ball bearing):** Difference between the largest and the smallest of the axial distances between the reference face of the outer ring, in different relative angular positions of this ring, at a radial distance from the outer ring axis equal to half the outer ring raceway contact diameter, and a point in a fixed position relative to the inner ring. The inner and outer ring raceways are to be in contact with all the balls.

NOTE -  $S_{ea}$  is the result of several factors and accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of  $S_e$ , which is the major factor. (See 2.3.2.1)

**2.3.2.6 assembled bearing outer ring flange back face runout with raceway,  $S_{ea1}$  (radial bearing):** Difference between the largest and smallest of the axial distances between the outer ring flange back face, in different relative angular positions of this ring, at a radial distance from the outer ring axis equal to half the flange back face mean diameter, and a point in a fixed position relative to the inner ring. The inner and outer ring raceways are to be in contact with all the rolling elements.

**2.3.2.7 assembled bearing cup back face runout with raceway,  $S_{ea}$  (tapered roller bearing):** Difference between the largest and the smallest of the axial distances between the cup back face, in different angular positions of the cup, at a radial distance from the cup axis equal to half the cup raceway contact diameter, and a point in a fixed position relative to the cone. The cone and cup raceways and the cone back face rib are to be in contact with all the rollers, the bearing parts being otherwise in normal relative positions.

NOTE -  $S_{ea}$  is the result of several factors and accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of  $S_e$ , which is the major factor. (See 2.3.2.1)

### **2.3.3 Face runout with bore**

**2.3.3.1 face runout with bore,  $S_d$  (inner ring, reference or back face):** Difference between the largest and the smallest of the axial distances between a plane perpendicular to the ring axis and the reference or back face of the ring, at a radial distance from the axis of half the inner ring raceway contact diameter.



### 2.3.4 Outside surface inclination

**2.3.4.1 variation of the outside surface generatrix inclination with face,  $S_D$  (outer ring basically cylindrical surface, reference or back face):** Total variation of the relative position, in a radial direction parallel with the plane tangential to the reference or back face of the outer ring, of points on the same generatrix of the outside surface at a distance from the side faces of the ring equal to 1.2 times the maximum limit of the axial chamfer dimension.

**2.3.4.2 variation of bearing outside surface generatrix inclination with flange back face,  $S_{D1}$ :** Total variation of the relative position, in a radial direction parallel with the plane tangential to the outer ring flange back face, of points on the same generatrix of the bearing outside surface at a distance from the side face of the ring and from the back face of the flange equal to 1.2 times the maximum limit of the axial chamfer dimension.

### 2.4 Internal clearance

#### 2.4.1 Radial clearance

**2.4.1.1 radial internal clearance,  $G_r$  (bearing capable of taking purely radial load, non-preloaded):** The arithmetical mean of the radial distances through which one of the rings may be displaced relative to the other, from one eccentric extreme position to the diametrically opposite extreme position, in different angular directions and without being subjected to any external load. The mean value includes displacements with the rings in different angular positions relative to each other and with the set of rolling elements in different angular positions in relation to the rings.

NOTE - At each limiting eccentric position of the rings in relation to each other, their relative axial position, and the position of the rolling elements relative to the raceways, are to be such that the one ring has actually assumed the extreme eccentric position in

relation to the other ring.

**2.4.1.2 theoretical radial internal clearance (radial contact bearing):** Outer ring raceway diameter minus the inner ring raceway diameter minus twice the rolling element diameter.

NOTE - For a master bearing, i.e. a bearing having negligible form errors, the clearance defined in 2.4.1.1 is identical to the theoretical clearance, providing that a rolling element is positioned in line with the angular direction of displacement.

#### 2.4.2 Axial clearance

**2.4.2.1 axial internal clearance,  $G_a$  (bearing or bearing set capable of taking axial load in both directions, non-preloaded):** The arithmetical mean of the axial distances through which one of the rings or ring sets may be displaced relative to the other, from one axial extreme position to the opposite extreme position and without being subjected to any external load. The mean value includes displacements with the rings or ring sets in different angular positions relative to each other and with the set of rolling elements in different angular positions in relation to the rings or ring sets.

NOTE - At each limiting axial position of the rings or ring sets in relation to each other, their relative radial position, and the position of the rolling elements relative to the raceways, are to be such that the one ring or ring set has actually assumed the extreme axial position in relation to the other ring or ring set.

## 3. Measuring and gauging practices

### 3.1 General

#### 3.1.1 Measuring equipment

Measurements of the various dimensions and runouts can be performed on different kinds of measuring equipment and with different

degrees of accuracy. The methods described are commonly used by bearing users and which, as a rule, 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 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 standard, the matter should be referred to the bearing manufacturer.

### 3.1.2 Masters and indicators

Determination of dimensions is performed by comparing the actual part with appropriate gauge blocks or masters whose calibration is traceable to those used by the National Institute of Standards and Technology. For such comparison, an indicator, calibrated and of appropriate sensitivity, is used.

### 3.1.3 Arbors

In all cases when arbor methods of measuring of runout are used, the rotational accuracy of the arbor shall be determined so that subsequent bearing measurements may be suitably corrected for any appreciable arbor inaccuracy.

### 3.1.4 Temperature

Before measurement is 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. Care shall be used to avoid heat transfer to the part or assembled bearing during measurement. The recommended room temperature is +20°C (+68°F).

### 3.1.5 Measuring force and radius of measuring stylus

To avoid undue deflection of thin rings, measuring force shall be minimized, and if significant distortion is present a load deflection factor shall be introduced to correct the measured value to the free unloaded value.

#### 3.1.5.1 Maximum measuring force and minimum radius of measuring stylus

	Nominal range mm		Measuring force N (oz.)	Stylus radius mm (in.)
	over	incl.	max.	min.
Bore diameter d	-	10	2 (7)	0.8 (0.032)
	10	30	2 (7)	2.5 (0.098)
	30	-	3.5 (12)	2.5 (0.098)
Outside diameter D	-	30	2 (7)	2.5 (0.098)
	30	-	2.5 (9)	2.5 (0.098)

Note: Smaller radii may be used with appropriate reduction in applied measuring force.

### 3.1.6 Coaxial measuring load

To maintain the bearing parts in their proper relative positions, the coaxial measuring load in 3.1.6.1 and 3.1.6.2 shall be applied for methods 3.2.3.2, 3.2.5.2, 3.3.4.2, 3.3.6.2, 3.5.1.1 and 3.5.2.1.



### 3.1.6.1 Coaxial loads for groove type ball bearings

Nominal size range of the bearing outside diameter, D mm		Minimum axial load on the bearing N (lbs.)
over	incl.	
-	30	5 (1.1)
30	50	7.5 (1.7)
50	80	15 (3.4)
80	120	35 (7.9)
120	180	70 (16.0)
180	-	140 (31.0)

### 3.1.6.2 Coaxial loads for tapered roller bearings

Nominal size range of the bearing outside diameter, D mm		Minimum axial load on the bearing N (lbs.)
over	incl.	
-	30	40 (9)
30	50	40 (18)
50	80	120 (27)
80	120	150 (34)
120	-	150 (34)

### 3.1.7 Measurement zone

The limits for deviations of a bore or an outside diameter are applicable to measurements in radial planes situated at distances greater than  $1.2 r_{s \max}$  from the side faces of the rings. (See 2.1.4.11)

### 3.1.8 Preparation before measuring

Any grease or corrosion inhibitor adhering to the bearing shall be removed if it is likely to

affect the measurement results. Before measuring, the bearings should be lubricated with a low viscosity oil.

Prelubricated bearings and some designs of bearings with closures may adversely affect accuracy of gauging. If a discrepancy arises, the "referee" method should be the open bearing after removing the closures and/or lubricant.

Note - Immediately after completion of the measurements, the bearings should be protected with a corrosion inhibitor.

### 3.1.9 Measuring and gauging methods

For each characteristic to be measured one or more methods are indicated in sections 3.2 through 3.6.

#### 3.1.9.1 Left hand column - Method

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

#### 3.1.9.2 Right hand column - Comments

- a particular application
- any restrictions in application
- definitions or equations
- interpretations of readings
- factors affecting measuring technique
- reference to alternative methods

### 3.1.10 Cautions

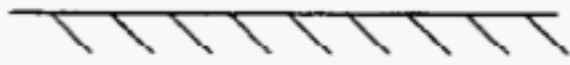
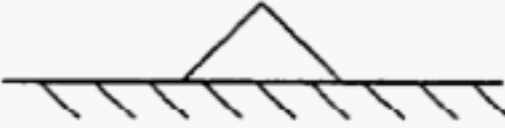

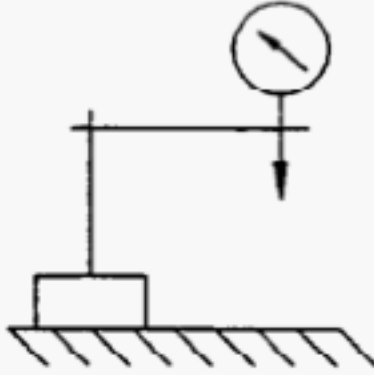
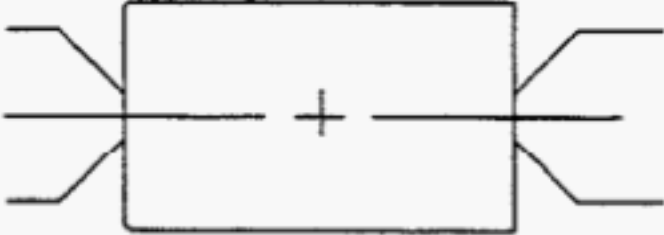
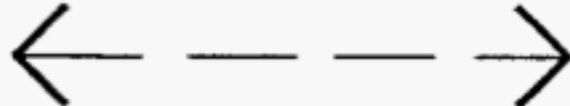
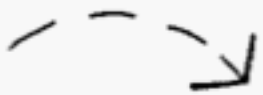



The measuring and gauging methods are not illustrated in detail and are not intended for application on end-product drawings.

The numbering of measuring and gauging methods shall not be regarded as a classification of priority.



### 3.1.11 Symbols

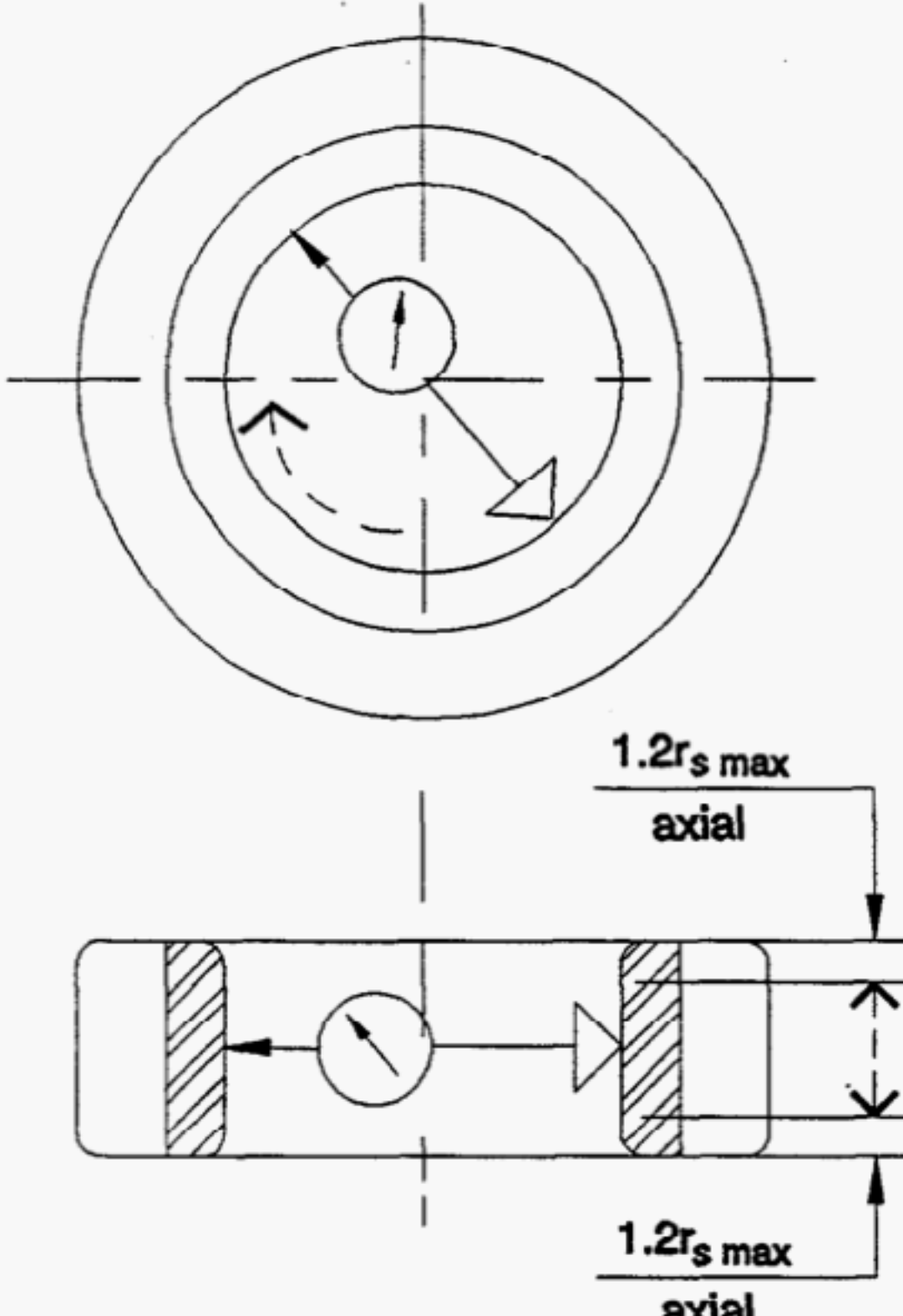
3.1.11.1 The symbols shown below are applied throughout this standard.

Symbol	Interpretation
	Surface plate
	Fixed 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.
	Centered arbor
	Intermittent linear traverse
	Intermittent turning
	Rotation
	Loading, direction of loading
	Loading alternately in opposite directions

## 3.2 Methods of measuring inner ring

### 3.2.1 Bore diameter

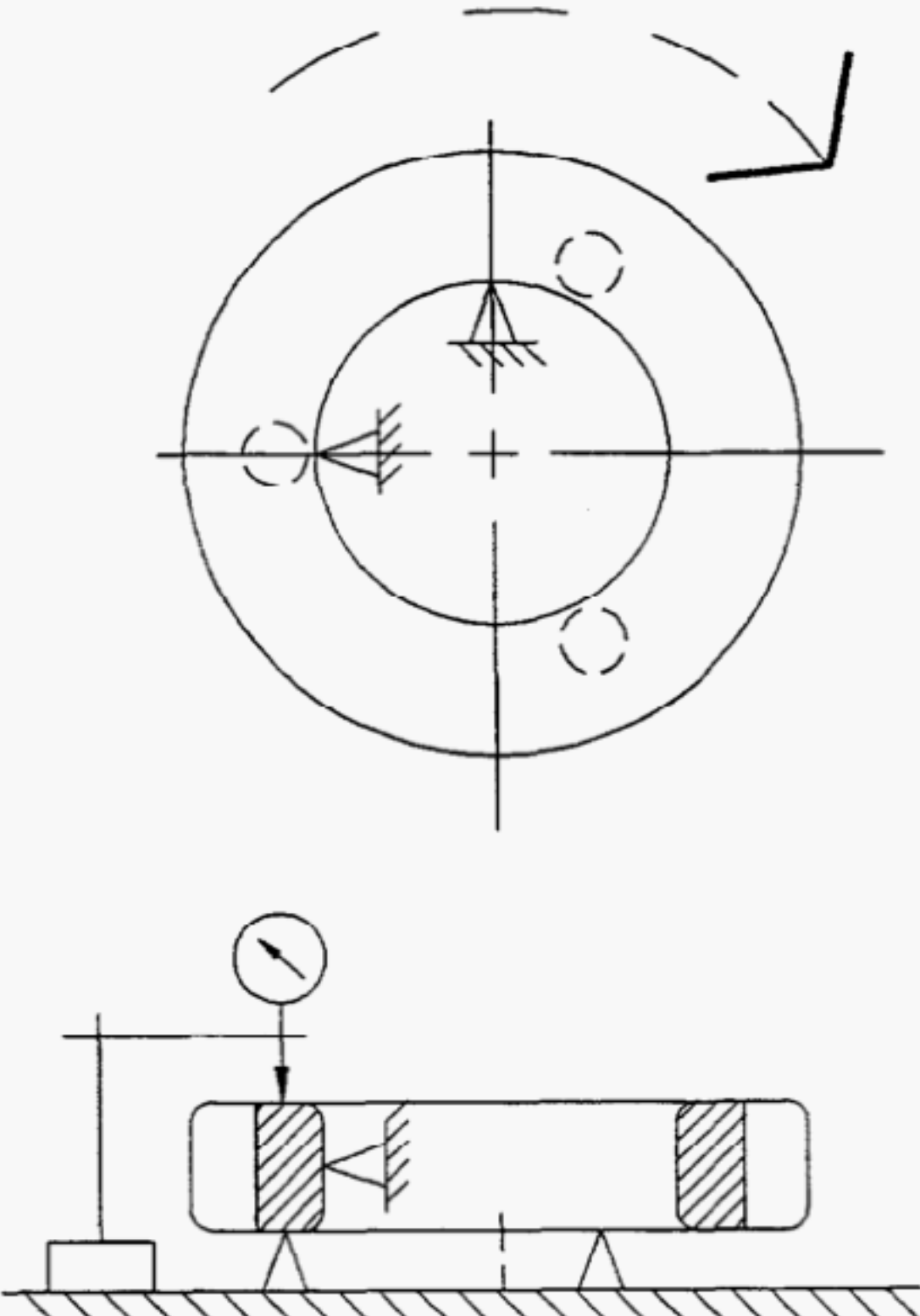
#### 3.2.1.1 Two-point measurement

Method	Comments
 <p>In several angular directions, measure and record minimum and maximum single bore diameters.</p> <p>Repeat angular measurements and recordings in several radial planes.</p>	<p>This method is applicable to all types of rolling bearings and their inner rings, shaft washers and housing washers.</p> <p>If the size or section of the bearing, ring, or washer is such that, with the axis in a horizontal position, the bore measurement is influenced by gravity, the bearing, ring, or washer should be placed with the axis in a vertical position and, if necessary, a lower measuring force is used.</p> $\Delta_{ds} = d_s - d$ <p> <math>\Delta_{ds}</math> = deviation of single bore diameter  <math>d</math> = nominal bore diameter  <math>d_s</math> = single bore diameter </p> $d_{mp} = \frac{d_{s \max} + d_{s \min}}{2}$ <p> <math>d_{mp}</math> = single plane mean bore diameter  <math>\Delta_{dmp} = d_{mp} - d</math> </p> <p> <math>\Delta_{dmp}</math> = single plane mean bore diameter deviation  <math>V_{dp} = d_{s \max} - d_{s \min}</math> </p> <p> <math>V_{dp}</math> = bore diameter variation in a single radial plane  <math>V_{dmp} = d_{mp \max} - d_{mp \min}</math> </p> <p> <math>V_{dmp}</math> = mean bore diameter variation </p> <p>This method is also applicable in measuring a separable cylindrical or needle roller bearing outer ring bore diameter, providing the gauge point clears the raceway lead-in chamfers.</p>

### 3.2 Methods of measuring inner ring

#### 3.2.2 Ring width

##### 3.2.2.1. Two-point measurement

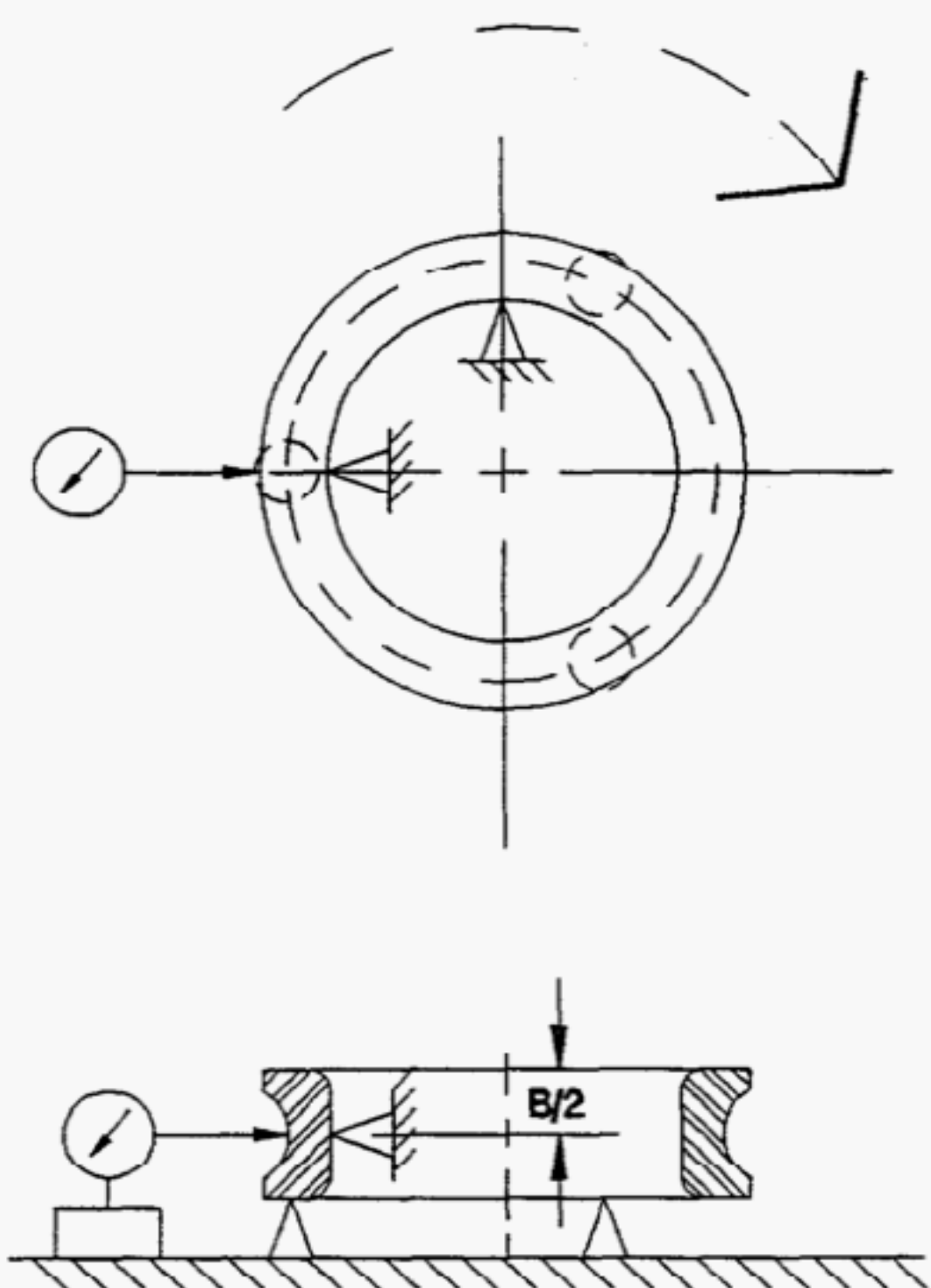
Method	Comments
 <p>Support one face of the inner ring three on three equally spaced fixed axial supports of equal height and provide two suitable radial supports on the bore surfaced at 90° to each other to center the inner ring.</p> <p>Position the indicator against the other face of the inner ring opposite one fixed support.</p> <p>Rotate the inner ring one revolution and measure and record minimum and maximum single inner ring width.</p>	<p>This method is applicable to all types of rolling bearings and their inner rings.</p> $\Delta_{Bs} = B_s - B$ <p><math>\Delta_{Bs}</math> = deviation of single inner ring width  <math>B</math> = nominal inner ring width  <math>B_s</math> = single inner ring width</p> $V_{Bs} = B_{s \max} - B_{s \min}$ <p><math>V_{Bs}</math> = inner ring width variation</p> <p>This method is also applicable in measuring thrust washer thickness.</p>



### 3.2 Methods of measuring inner ring

#### 3.2.3 Radial runout

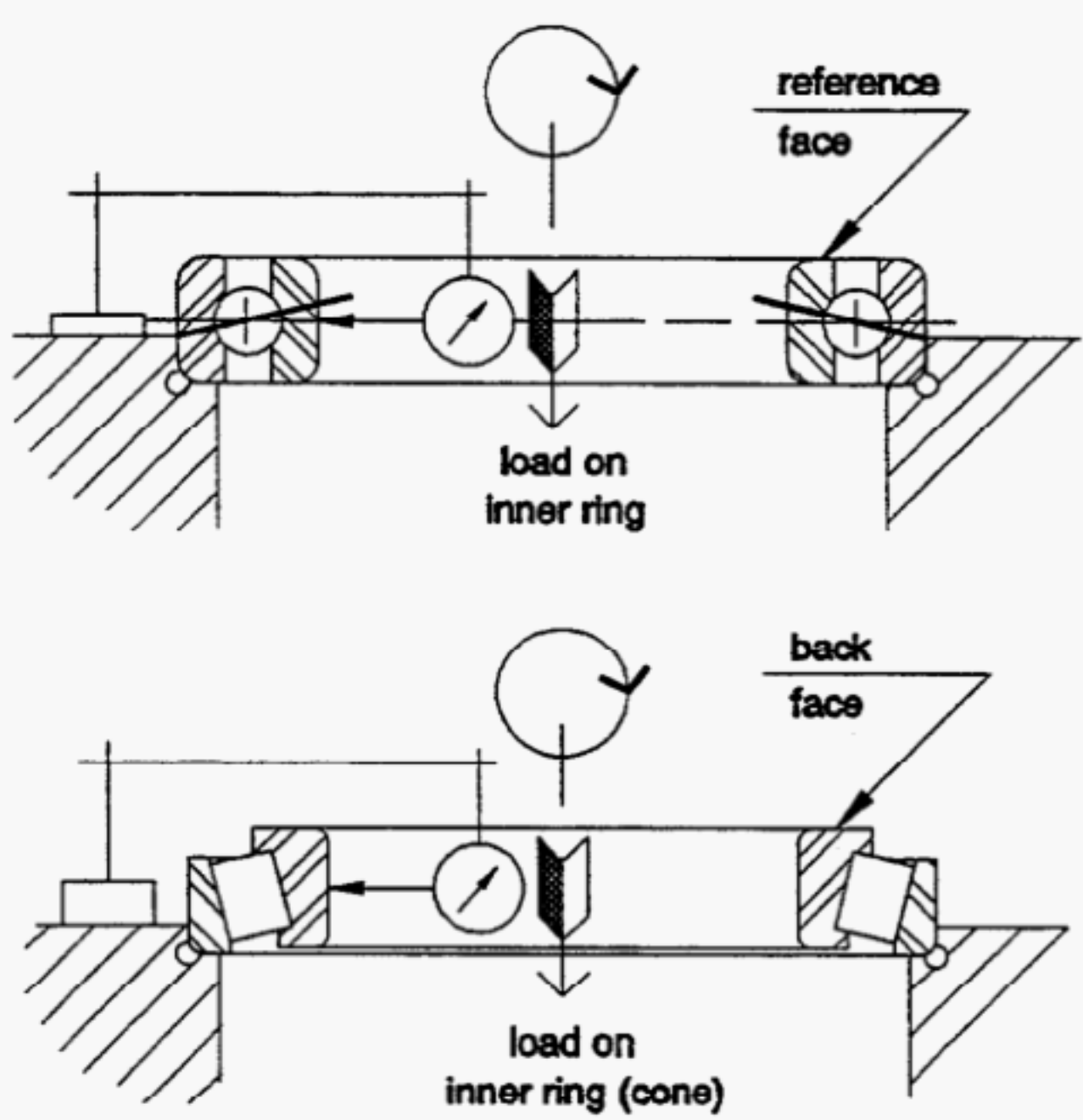
##### 3.2.3.1 Method 1. Measurement of thickness variation

Method	Comments
 <p>Support one face of the inner ring on three equally spaced fixed axial support of equal height and provide two suitable radial supports on the bore surface at <math>90^\circ</math> to each other, at an axial distance of <math>B/2</math>, or opposite the middle of the raceway, to center 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 bearings.</p> <p>The inner ring raceway to bore thickness variation, <math>K_i</math>, is the difference between the largest and the smallest indicator readings.</p> <p>Refer to alternate Method 2 (see 3.2.3.2) or Method 3 (see 3.2.3.3) for measurement of inner ring radial runout of assembled bearing.</p>

### 3.2 Methods of measuring inner ring

#### 3.2.3 Radial runout

##### 3.2.3.2 Method 2. Measurement with fixed outer ring and inner ring rotation

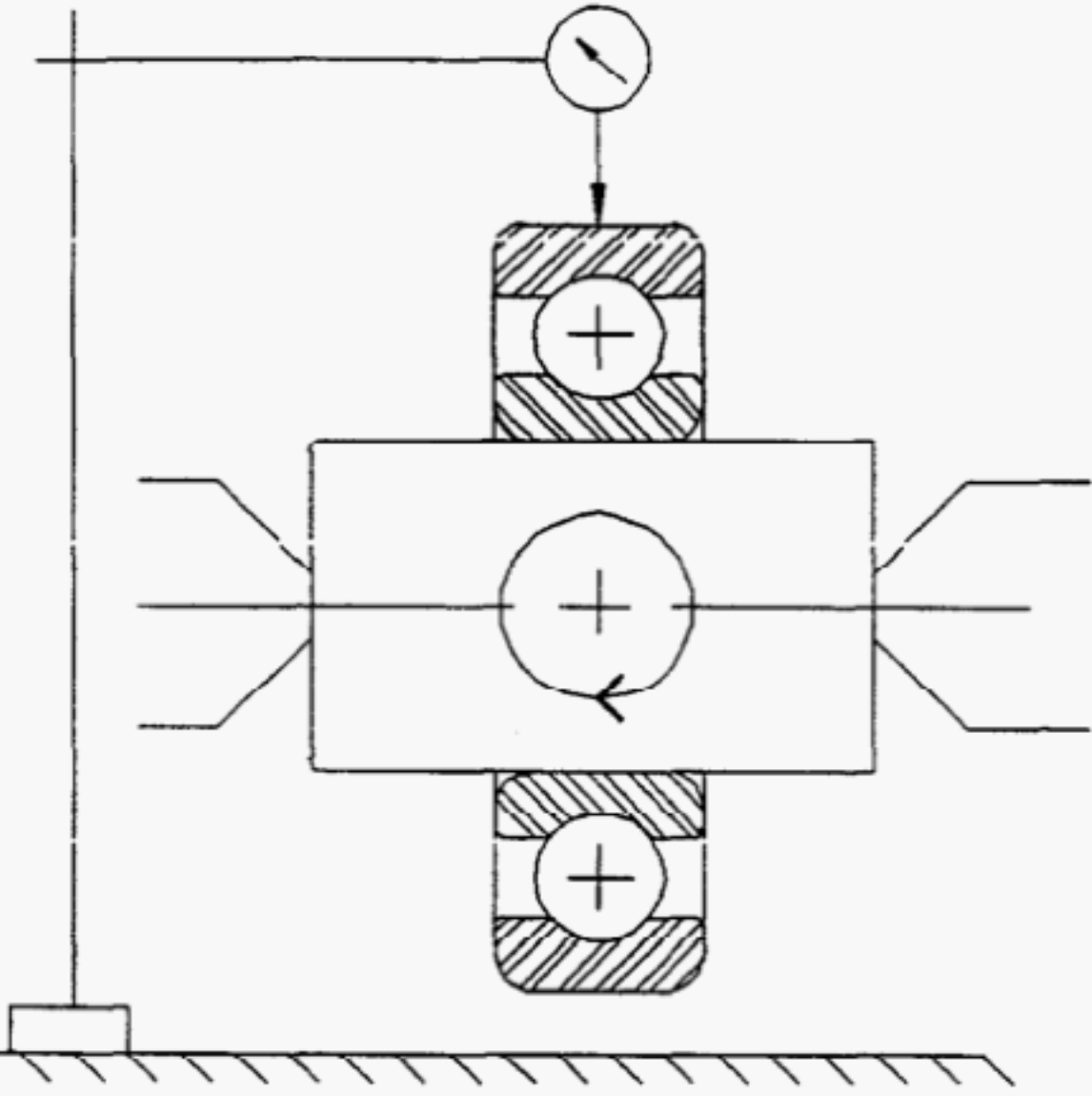
Method	Comments
 <p>Support the outer ring (cup) and apply a dynamically stable coaxial load (see 3.1.6) to the reference face (or cone back face) of the inner ring to ensure contact between rolling elements and raceways. For tapered roller bearings, ensure the rollers are in contact with the cone back face rib. Position an indicator against the bore surface of the inner ring as close as possible to the middle of the inner ring raceway and take indicator readings while rotating the inner ring one revolution.</p>	<p>This method is applicable to groove type ball bearings (including single row angular contact ball bearings) and tapered roller bearings.</p> <p>The radial runout of assembled bearing inner ring, <math>K_{ia}</math>, is the difference between the largest and smallest indicator readings.</p> <p>Radial runout of assembled bearing inner ring (cone) is the result of several factors, e.g. inner ring concentricity, bore roundness, rolling element diameter variation, and rolling element contact angle variation. Accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of inner ring runout, <math>K_i</math>, which is the major factor. Refer to Method 1 (see 3.2.3.1).</p> <p>If this method is not practical relative to the equipment available or bearing type, use alternative Method 3 (see 3.2.3.3).</p>



## 3.2 Methods of measuring inner ring

### 3.2.3 Radial runout

#### 3.2.3.3 Method 3. Measurement with fixed outer ring and inner ring rotation around bore axis

Method	Comments
 <p>Use a precision arbor having a taper of between 0.0001:1 and 0.0002:1 on diameter.</p> <p>Mount the bearing assembly on a tapered arbor and place the arbor between two centers so that it can be accurately rotated. Position the indicator against the outside diameter surface of the outer ring as close as possible to the middle of the outer ring raceway. Hold the outer ring to prevent rotation and 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 groove type ball bearings (except single row angular contact ball bearings) and cylindrical, spherical and needle roller bearings.</p> <p>The radial runout of assembled inner ring, <math>K_{ia}</math>, is the difference between the largest and smallest indicator readings.</p> <p>Radial runout of assembled bearing inner ring is the result of several factors, e.g. inner ring concentricity, bore roundness, and rolling element diameter variation. Accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of inner ring runout, <math>K_i</math>, which is the major factor. Refer to Method 1 (see 3.2.3.1).</p> <p>Refer to Method 2 (see 3.2.3.2) for an alternate method of measuring groove type ball bearings (including single row angular contact ball bearings) and tapered roller bearings.</p>

### 3.2 Methods of measuring inner ring

#### 3.2.4 Face runout with bore

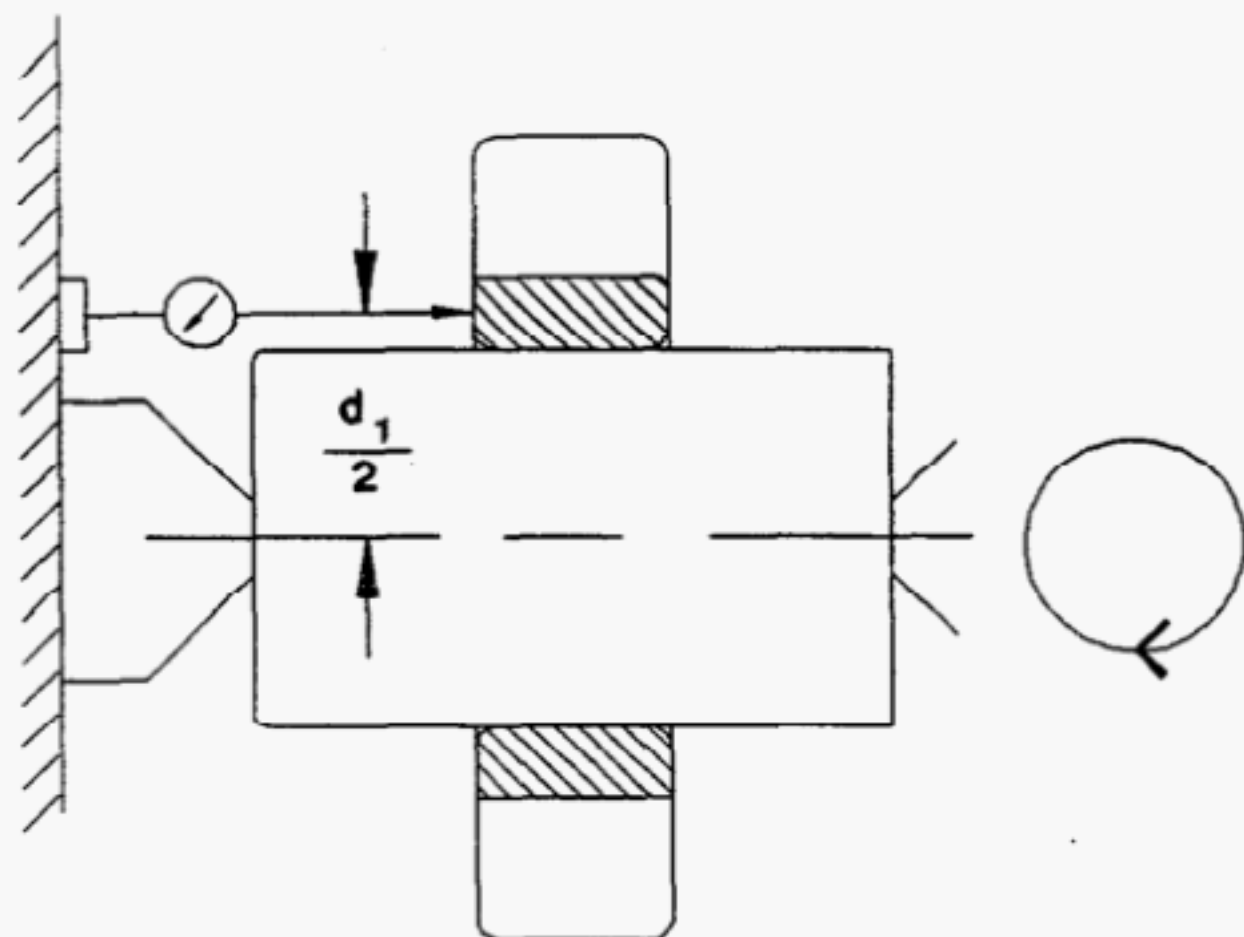
##### 3.2.4.1 Method 1. Measuring with fixed outer ring and inner ring rotation by supporting the face and bore generatrix

Method	Comments
<div data-bbox="458 628 1124 1713" data-label="Image"> </div> <p>Support the inner ring reference face (or back face) 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 center the inner ring. Position an indicator directly above one support.</p> <p>Take indicator readings while rotating the inner ring one revolution.</p>	<p>This method is applicable to all types of rolling bearings and their inner rings.</p> <p>This measurement defines bore runout with reference face and is converted to face runout with bore by calculation.</p> $S_d = \frac{(\text{max reading} - \text{min reading}) \times d_1}{2 \times B_1}$ <p><math>S_d</math> = face runout with bore</p> <p><math>d_1</math> = inner ring raceway contact diameter (for ball bearings) or the center of inner ring cross section for other bearing types.</p> <p><math>B_1</math> = axial distance between the indicator and the bore support directly below it.</p> <p>Note: For calculated values of</p> $\frac{d_1}{2 \times B_1} > 2$ <p>the inner ring is considered face oriented and an upper limit of 2 shall be used for the conversion.</p> <p>If the method is not practical relative to the equipment available, use alternative Method 2 (see 3.2.4.2).</p>

### 3.2 Methods of measuring inner ring

#### 3.2.4 Face runout with bore

##### 3.2.4.2 Method 2. Measuring with fixed outer ring and inner ring rotation around bore axis

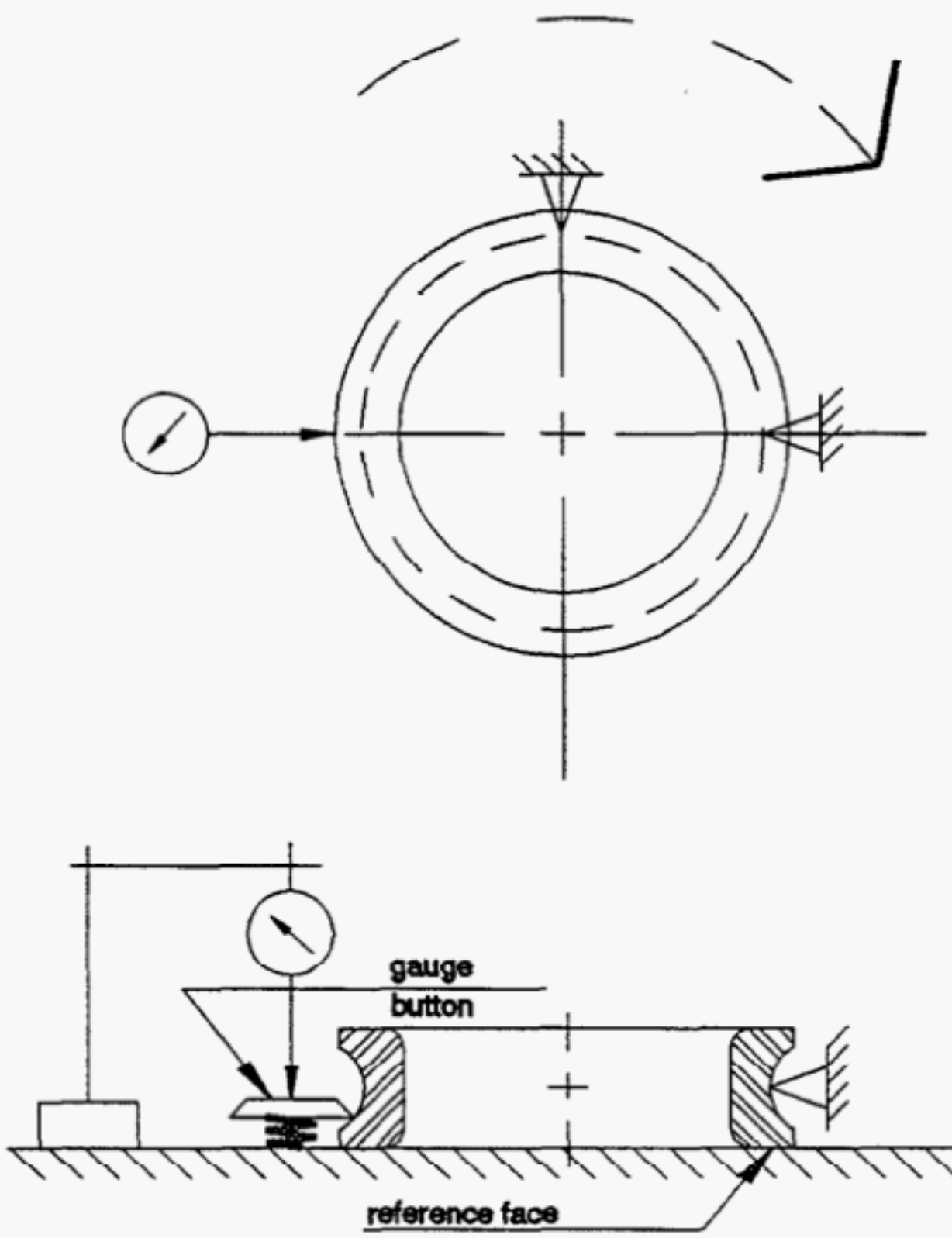
Method	Comments
 <p>Use a precision arbor having a taper of between 0.0001:1 and 0.0002:1 on diameter.</p> <p>Mount the bearing assembly on a tapered arbor and place the arbor between two centers so that it can be accurately rotated. Position the indicator against the reference face (or back face) of the inner ring at a radial distance from the arbor axis to be approximately equal to <math>d_1/2</math>.</p> <p>Take indicator readings while rotating the inner ring one revolution.</p>	<p>This method is applicable to all types of rolling bearings and their inner rings.</p> <p>Face runout with bore, <math>S_a</math>, is the difference between the largest and smallest indicator readings.</p> <p><math>d_1</math> = inner ring raceway contact diameter (for ball bearings) or the center of inner ring cross section for other bearing types.</p> <p>Note: Care must be taken when mounting the bearing on the arbor to preclude loss of accuracy.</p> <p>Refer to Method 1 (see 3.2.4.1) for an alternate method of measuring.</p>



### 3.2 Methods of measuring inner ring

#### 3.2.5 Raceway parallelism with face

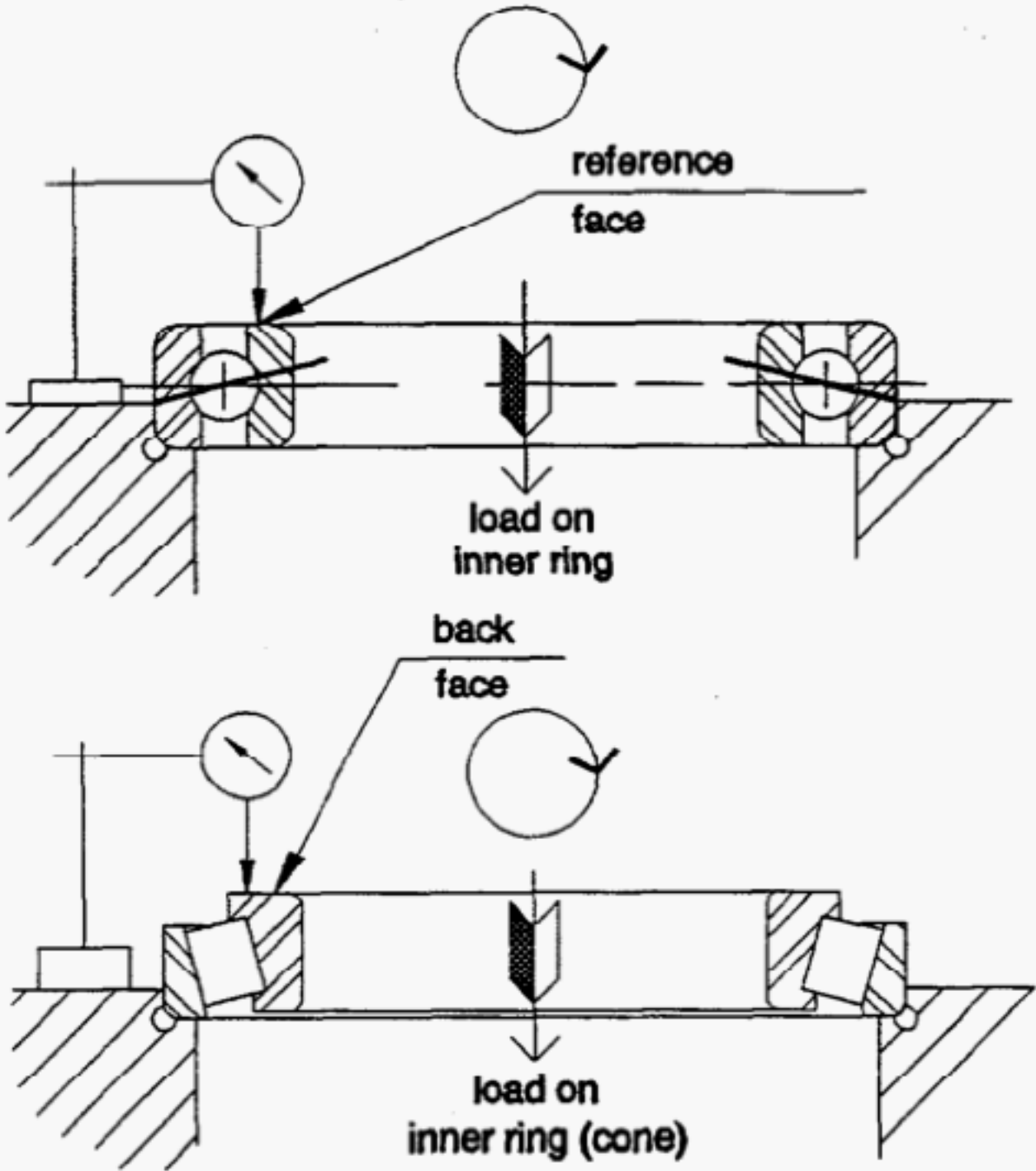
##### 3.2.5.1 Method 1. Measurement of raceway parallelism with face

Method	Comments
 <p>Position the inner ring with its reference face (or back face of a tapered roller bearing) down on a flat gauge plate, and provide two supports on the raceway surface at 90° to each other at the middle of the raceway, to center the inner ring.</p> <p>Position the gauge button diagonally opposite one of the fixed supports and ensure constant pressure of the gauge button against the raceway and in a direction parallel with the ring axis.</p> <p>Take indicator readings while rotating the inner ring one revolution.</p>	<p>This method is applicable to all radial and angular contact ball bearings, tapered roller bearings, and radial and thrust spherical roller bearings.</p> <p>The inner ring raceway parallelism with reference face, <math>S_i</math>, is the difference between the largest and the smallest indicator readings.</p> <p>Refer to Method 2 (see 3.2.5.2) for measurement of inner ring face runout with raceway of an assembled bearing.</p>

### 3.2 Methods of measuring inner ring

#### 3.2.5 Face runout with raceway

##### 3.2.5.2 Method 2. Measurement with fixed outer of inner ring and rotation of inner ring

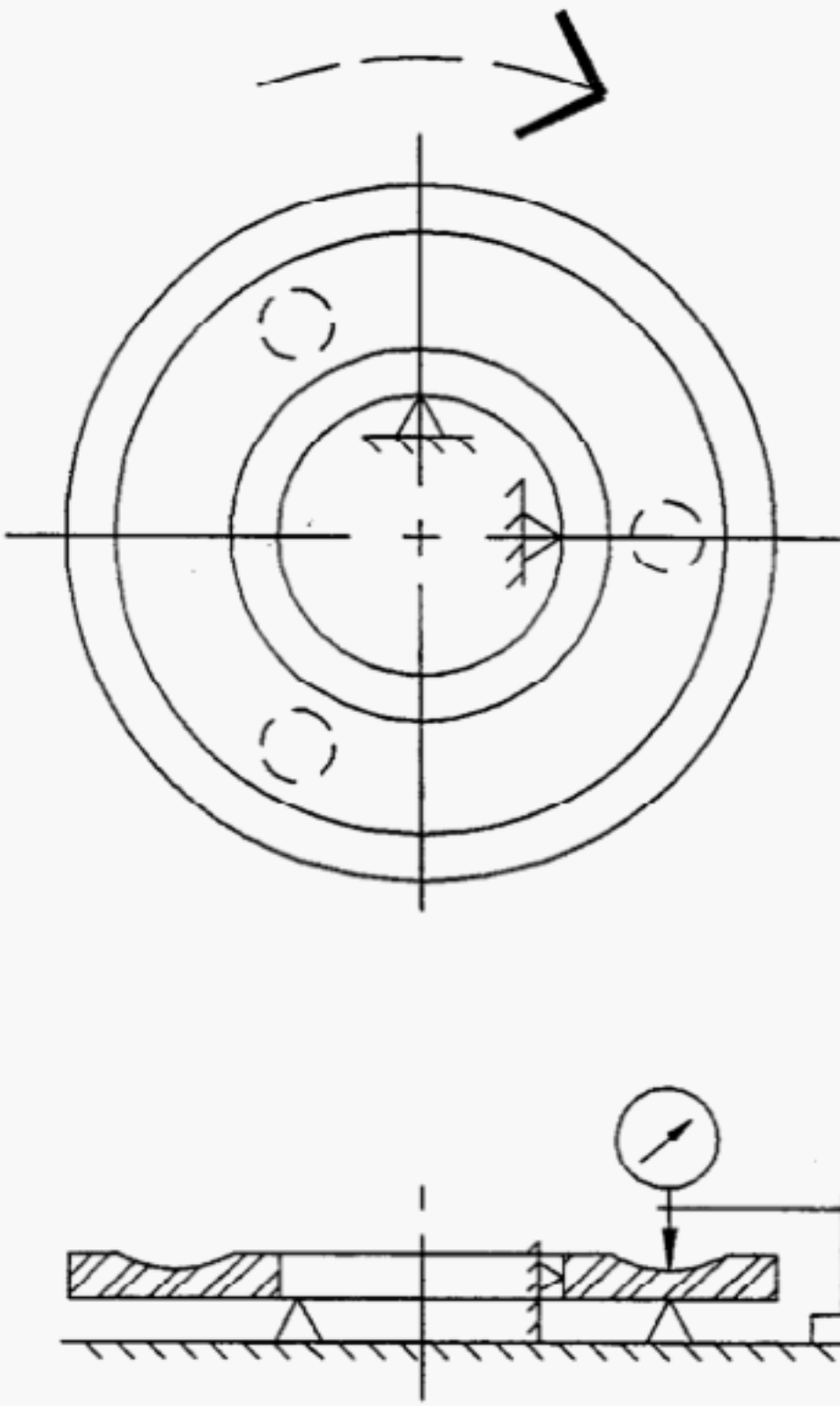
Method	Comments
 <p>Support the outer ring (cup) and apply a dynamically stable coaxial load (see 3.1.6) to the inner ring reference face (or cone back face) to ensure contact between rolling elements and the raceways. For tapered roller bearings, ensure the rollers are in contact with the cone back face.</p> <p>Position the indicator against the inner ring reference face (or cone back face) and take indicator readings while rotating the inner ring one revolution.</p>	<p>This method is applicable to groove type ball bearings including single row angular contact ball bearings and tapered roller bearings.</p> <p>The assembled bearing inner ring face (cone back face) runout with raceway, <math>S_{ia}</math>, is the difference between the largest and smallest indicator readings.</p> <p>Assembled bearing inner ring face (cone back face) runout with raceway is the result of several factors, e.g. rolling element diameter variation, reference face flatness, and contact angle variation. Accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of inner ring raceway parallelism with face, <math>S_i</math>, which is the major factor. Refer to Method 1 (see 3.2.5.1).</p>



### 3.2 Methods of measuring inner ring

#### 3.2.6 Thickness variation of thrust bearing shaft washer

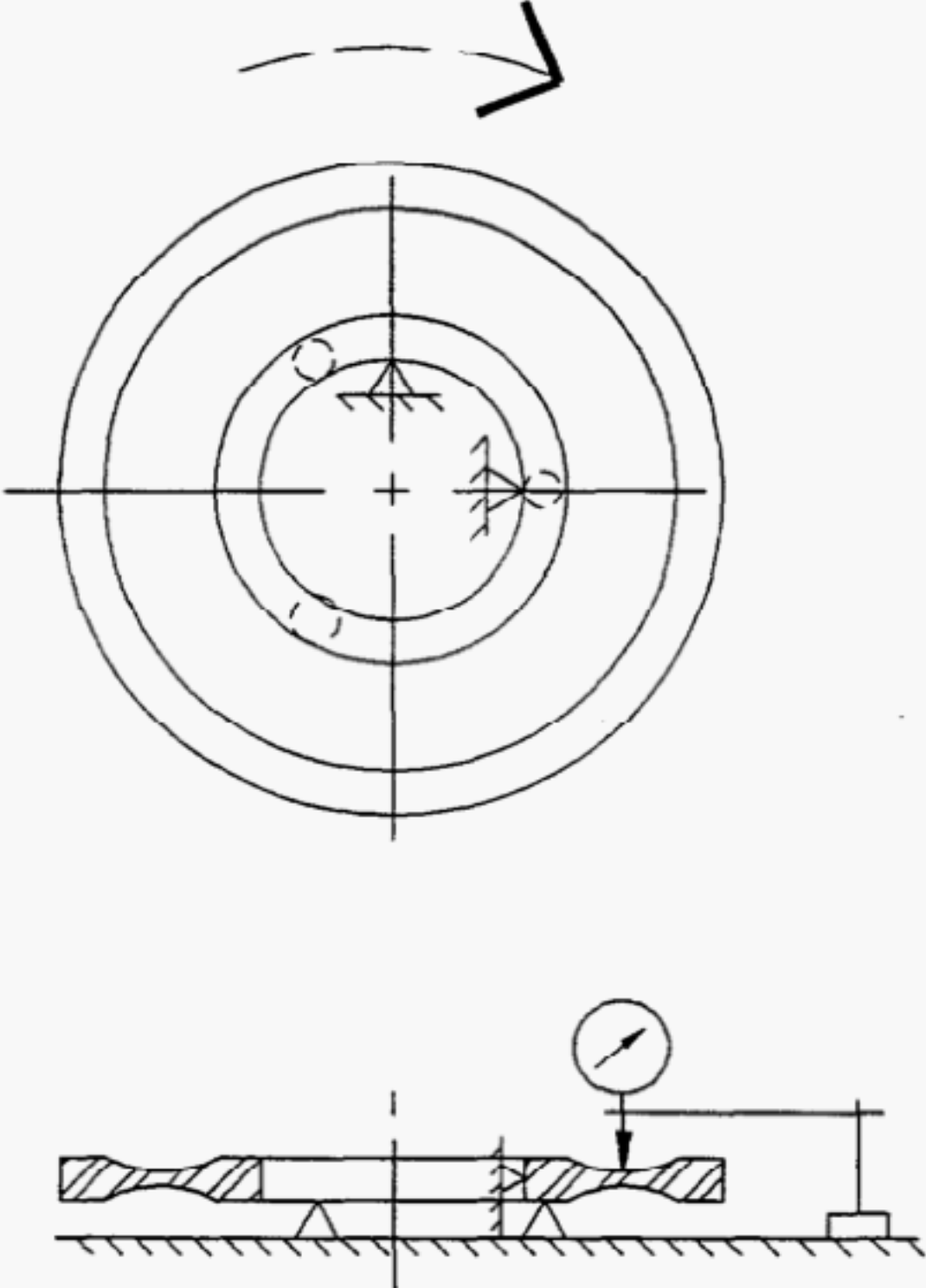
##### 3.2.6.1 Two point measurement between the back face and the raceway

Method	Comments
<div data-bbox="447 556 1059 1585"></div> <p data-bbox="323 1713 1244 1899">Support the flat back face on three equally spaced fixed axial supports of equal height and provide suitable radial supports in the bore surface at 90° to each other to center the shaft washer.</p> <p data-bbox="323 1942 1244 2084">Position the indicator against the middle of the raceway directly opposite one fixed support and take indicator readings while rotating the washer one revolution.</p>	<p data-bbox="1299 556 1976 699">This method is applicable to flat raceways or profiled raceways with flat back faces.</p> <p data-bbox="1299 742 1976 928">The washer raceway to back face thickness variation, <math>S_i</math>, is the difference between the largest and smallest indicator reading.</p>

### 3.2 Methods of measuring inner ring

#### 3.2.7 Thickness variation of thrust bearing shaft washer

##### 3.2.7.1 Two point measurement between the side face and raceway of a double direction thrust washer

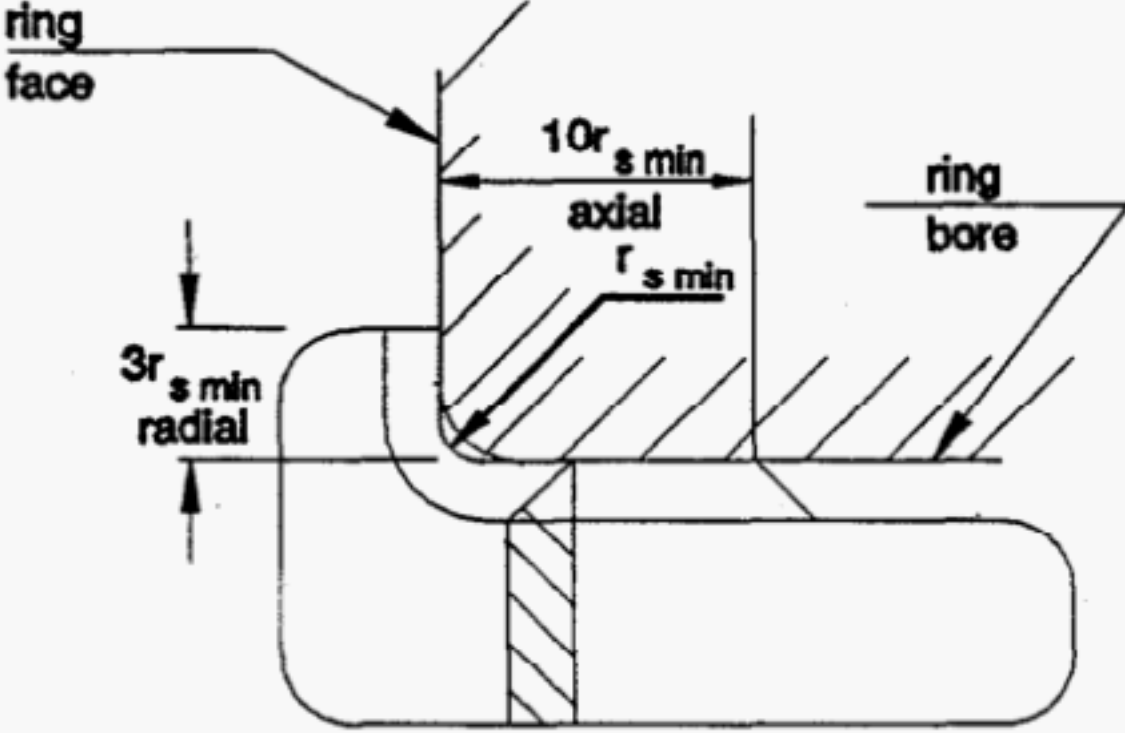
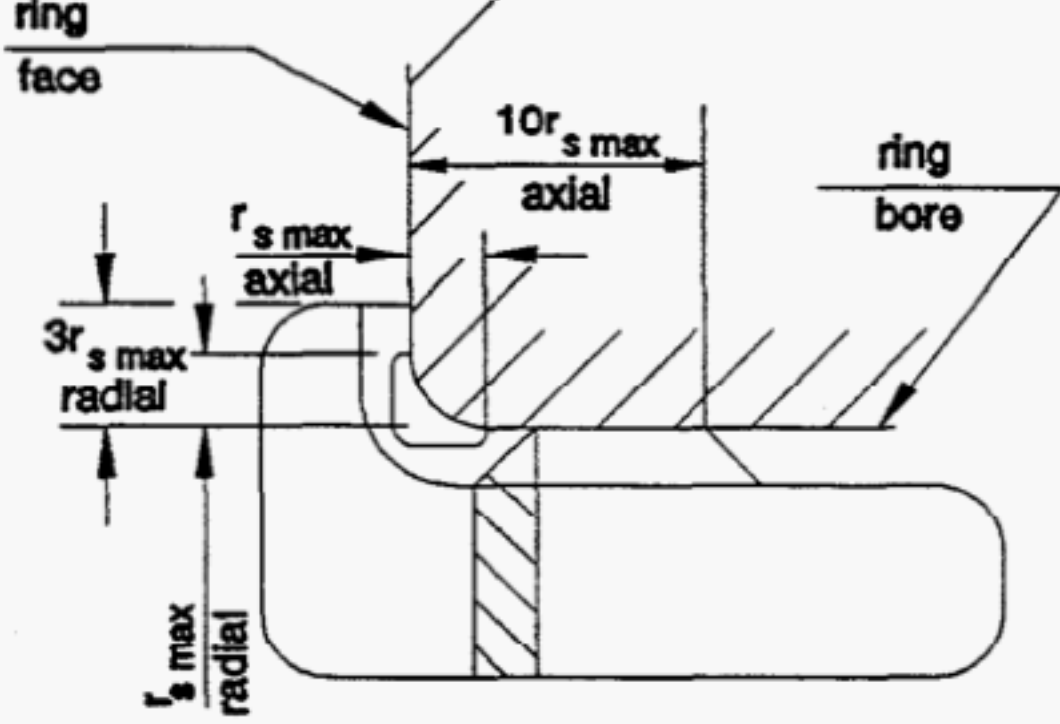
Method	Comments
 <p>Support a side face on three equally spaced fixed axial supports of equal height and provide suitable radial supports in the bore surface at 90° to each other to center the shaft washer.</p> <p>Position the indicator against the middle of the raceway adjacent to one fixed support and take indicator readings while rotating the washer one revolution.</p> <p>Repeat the measurement on the opposite side.</p>	<p>This method is applicable to thrust washers with non-flat side faces.</p> <p>The washer raceway to side face thickness variation, <math>S_i</math>, is the difference between the largest and smallest indicator readings.</p> <p>Each side face to raceway thickness variation is an independent measurement.</p>



### 3.2 Methods of measuring inner ring

#### 3.2.8 Chamfer dimensions comparison with a template

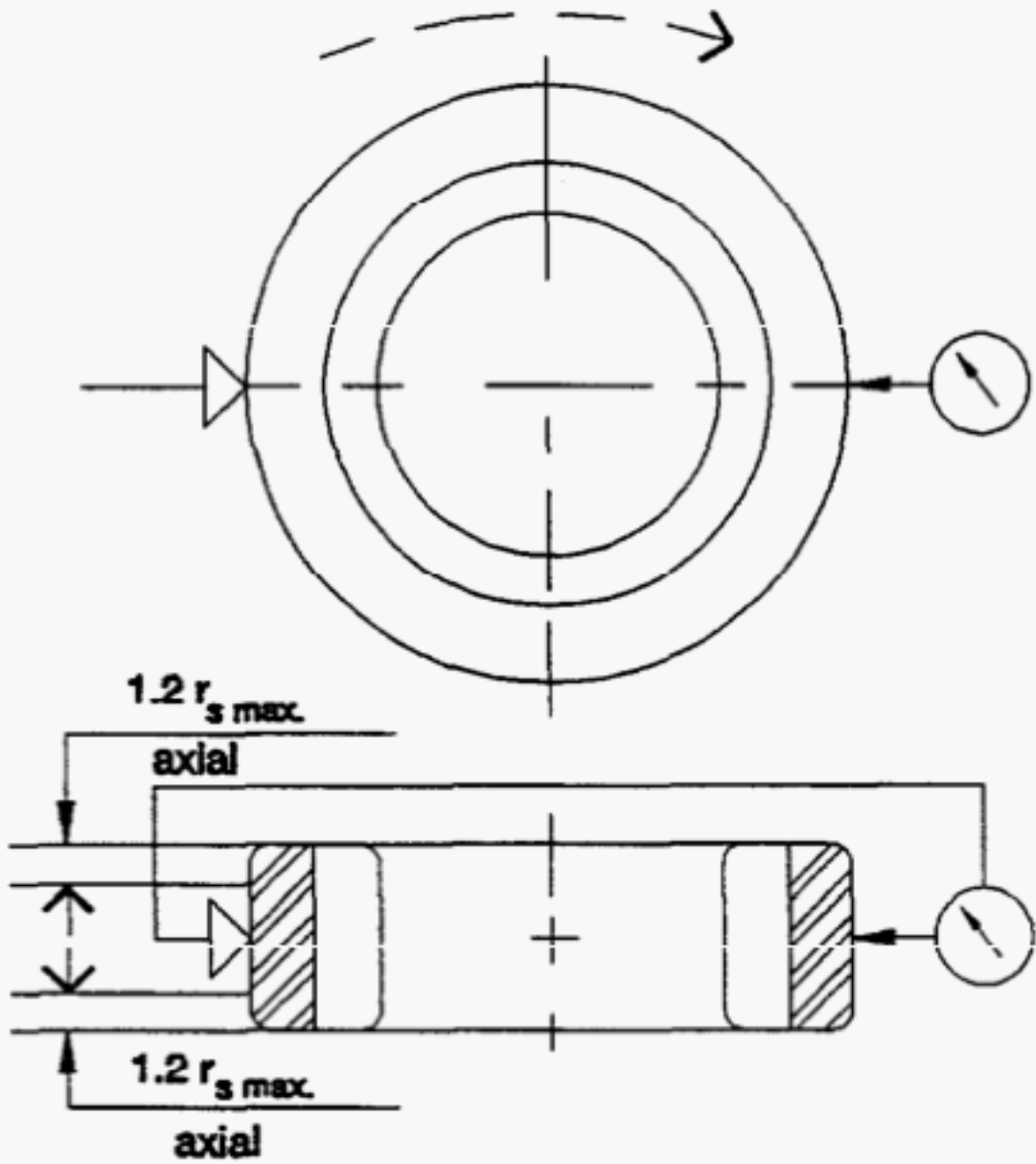
##### 3.2.8.1 Gauging by comparison with a template

Method	Comments
 <p>The diagram shows a cross-section of an inner ring with a chamfer. A template is placed against the ring face and the ring bore. The template has a radial dimension of <math>3r_{s \min}</math> and an axial dimension of <math>10r_{s \min}</math>. The ring bore is labeled 'ring bore' and the ring face is labeled 'ring face'.</p> <p>Place the minimum chamfer template on the inner ring. The template should rest on both the bore surface and the face surface of the inner ring. Compare the inner ring bore chamfer with the profile of the template.</p>  <p>The diagram shows a cross-section of an inner ring with a chamfer. A template is placed against the ring face and the ring bore. The template has a radial dimension of <math>3r_{s \max}</math> and an axial dimension of <math>10r_{s \max}</math>. The ring bore is labeled 'ring bore' and the ring face is labeled 'ring face'.</p> <p>Place the maximum chamfer template on the inner ring. The template should rest on both the bore surface and the face surface of the inner ring. Compare the inner ring bore chamfer with the markings of the template.</p>	<p>This method is applicable to all types of rolling bearings and their inner rings.</p> <p>The inner ring bore chamfer must not interfere with the minimum chamfer (<math>r_{s \min}</math>) template.</p> <p>The inner ring bore chamfer must not extend beyond the markings on the maximum chamfer (<math>r_{s \max}</math>) template.</p> <p>Where the outer ring outside diameter chamfer differs from the inner ring bore chamfer, the symbol <math>r_1</math> is used.</p> <p>Note: The axial and radial limits of <math>r_{s \max}</math> may differ.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.1 Outside diameter

##### 3.3.1.1 Method 1. Two-point measurement

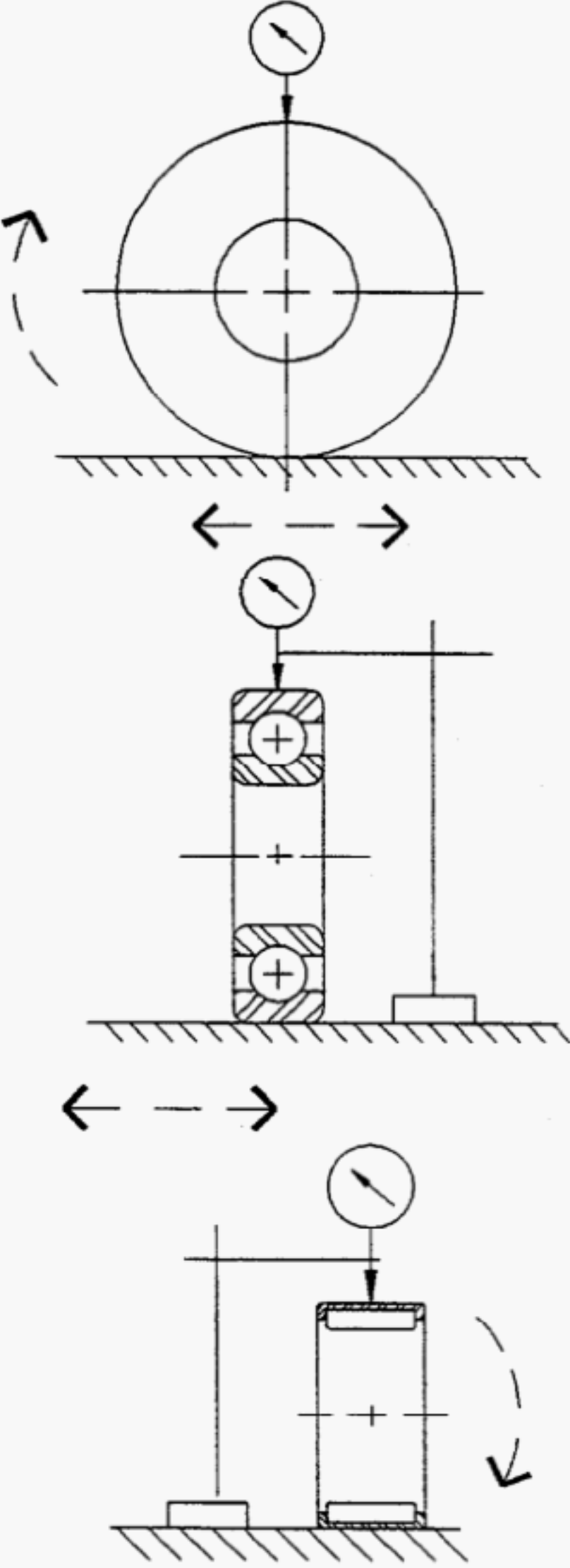
Method	Comments
 <p>In several angular directions, measure and record minimum and maximum single outside diameters.</p> <p>Repeat angular measurements and recordings in several radial planes.</p>	<p>This method is applicable to all types of rolling bearings and their outer rings, shaft washers and housing washers.</p> <p>If the size or section of the bearing, ring, or washer is such that, with the axis in a horizontal position, the outside diameter measurement is influenced by gravity, the bearing, ring, or washer should be placed with the axis in a vertical position and, if necessary, use a lower measuring force.</p> $\Delta_{Ds} = D_s - D$ <p> <math>\Delta_{Ds}</math> = deviation of single outside diameter  <math>D</math> = nominal outside diameter  <math>D_s</math> = single outside diameter </p> $D_{mp} = \frac{D_{s \max} + D_{s \min}}{2}$ <p><math>D_{mp}</math> = single plane mean outside diameter</p> $\Delta_{Dmp} = D_{mp} - D$ <p><math>\Delta_{Dmp}</math> = single plane mean outside diameter deviation</p> $V_{Dp} = D_{s \max} - D_{s \min}$ <p><math>V_{Dp}</math> = outside diameter variation in a single radial plane</p> $V_{Dmp} = D_{mp \max} - D_{mp \min}$ <p><math>V_{Dmp}</math> = mean outside diameter variation</p> <p>This method is also applicable in measuring a separable cylindrical or needle roller bearing inner ring outside diameter, providing the gauge point clears the raceway lead-in chamfers; and also the outside diameter of thrust needle and cage assemblies.</p>



### 3.3 Methods of measuring outer ring

#### 3.3.1 Outside diameter

##### 3.3.1.2 Method 2. Measurement of height

Method	Comments
 <p>Place the bearing or a bearing ring or washer on a surface plate. Position an indicator against the outside surface of the ring as shown.</p> <p>In several angular directions, measure and record minimum and maximum single outside diameters.</p> <p>Repeat angular measurements and recordings in several radial planes.</p>	<p>This method is applicable to all types of rolling bearings and their outer rings, shaft washers and housing washers. As this is not a two-point method of measurement, Method 1 (see 3.3.1.1) is the more accurate method. If the size or section of the bearing, ring, or washer is such that, with the bearing axis in a horizontal position, the outside diameter measurement is influenced by gravity, the bearing, ring, or washer should be measured using Method 1 (see 3.3.1.1).</p> $\Delta_{Ds} = D_s - D$ <p> <math>\Delta_{Ds}</math> = deviation of single outside diameter  <math>D</math> = nominal outside diameter  <math>D_s</math> = single outside diameter </p> $d_{mp} = \frac{D_{s \max} + D_{s \min}}{2}$ <p> <math>D_{mp}</math> = single plane mean outside diameter </p> $\Delta_{Dmp} = D_{mp} - D$ <p> <math>\Delta_{Dmp}</math> = single plane mean outside diameter deviation </p> $V_{Dp} = D_{s \max} - D_{s \min}$ <p> <math>V_{Dp}</math> = outside diameter variation in a single radial plane </p> $V_{Dmp} = D_{mp \max} - D_{mp \min}$ <p> <math>V_{Dmp}</math> = mean outside diameter variation </p> <p>This method is also applicable in measuring a separable cylindrical or needle roller bearing inner ring outside surface diameter, providing the gauge point clears the raceway lead-in chamfers; and also the outside diameter of thrust needle and cage assemblies.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.2 Ring width

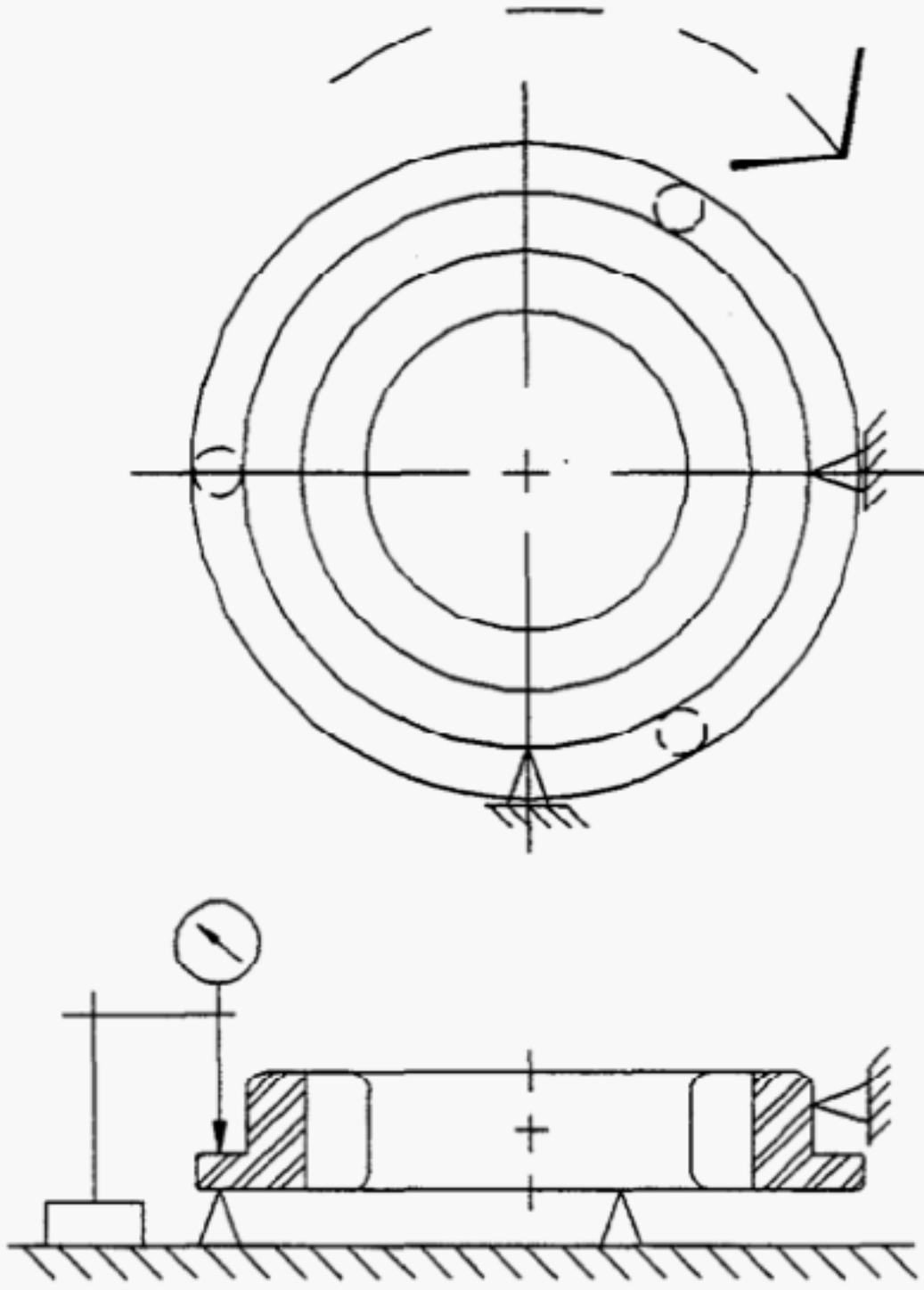
##### 3.3.2.1 Two-point measurement

Method	Comments
<div data-bbox="273 594 1109 1785" data-label="Image"> <p>The diagram consists of two parts. The top part is a cross-sectional view of a bearing. The outer ring is supported by three fixed axial supports (indicated by hatched lines and triangles) and two radial supports (indicated by hatched lines and circles). The inner ring is shown inside the outer ring. The bottom part is a side view of the outer ring. It is supported by three fixed axial supports (indicated by hatched lines and triangles). A dial indicator is positioned against the outer ring, with its probe touching the outer surface. The dial indicator is mounted on a stand.</p> </div> <p>Support one face of the outer ring on three equally spaced fixed axial supports of equal height and provide two suitable radial supports on the outside surface 90° to each other to center the outer ring.</p> <p>Position an indicator against the other face of the outer ring opposite one fixed support.</p> <p>Rotate the outer ring one revolution and measure and record minimum and maximum single outer ring width.</p>	<p>This method is applicable to all types of rolling bearings and their outer rings.</p> $\Delta_{Cs} = C_s - C$ <p><math>\Delta_{Cs}</math> = deviation of single outer ring width  <math>C</math> = nominal outer ring width  <math>C_s</math> = single outer ring width</p> $V_{Cs} = C_{s \max} - C_{s \min}$ <p><math>V_{Cs}</math> = outer ring width variation</p> <p>Note: Symbol B may be used where inner and outer rings are equally wide and their faces normally flush.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.3 Flange width

##### 3.3.3.1 Two-point measurement

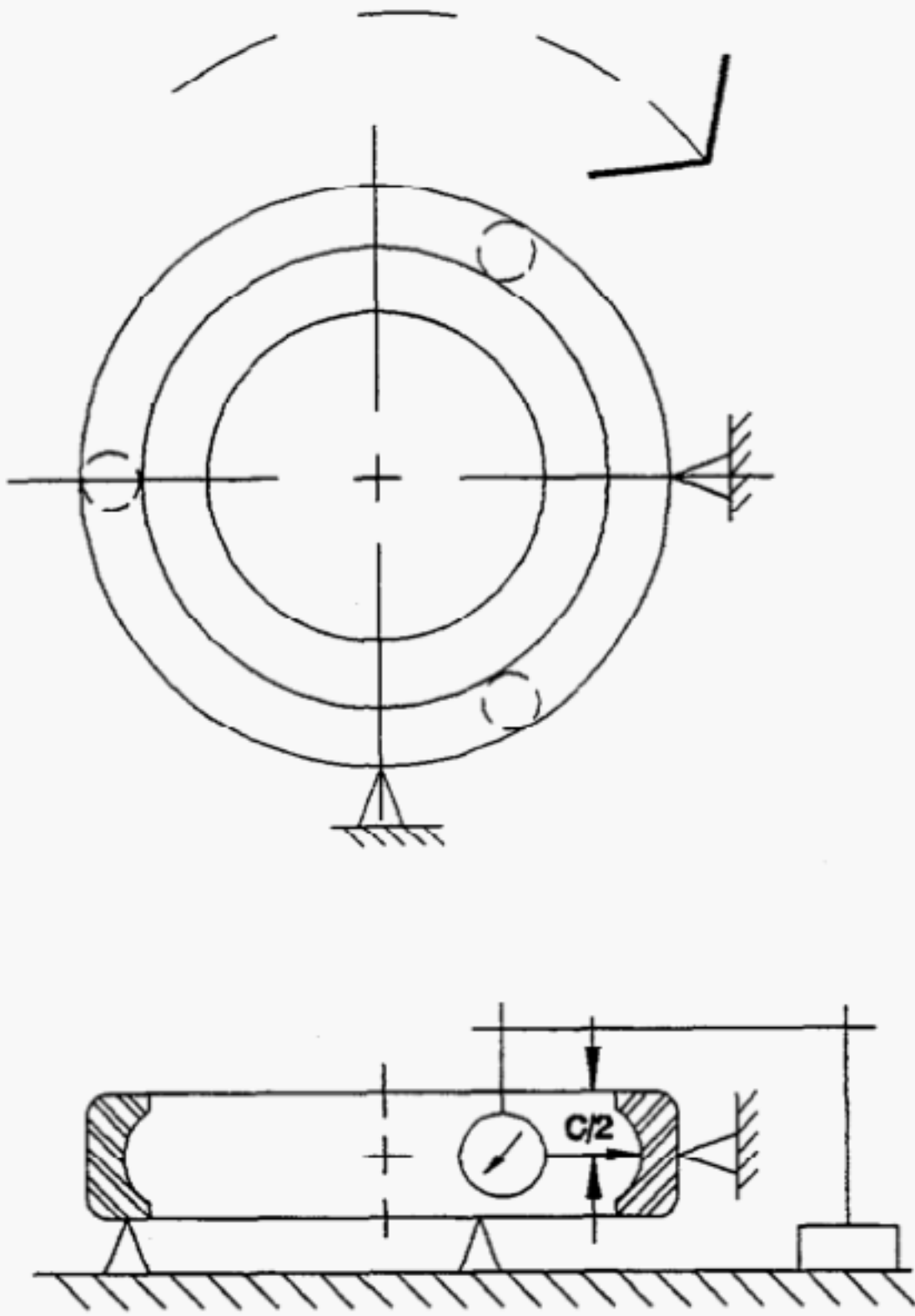
Method	Comments
 <p>Support the outer ring on the flange side face on three equally spaced fixed axial supports of equal height and provide two suitable radial supports on the bearing outside surface at 90° to each other to center the outer ring.</p> <p>Position an indicator against the inside face of the flange opposite one fixed support.</p> <p>Rotate the outer ring one revolution and measure and record minimum and maximum single outer ring flange width.</p>	<p>This method is applicable to all types of rolling bearings and their outer rings.</p> $\Delta_{C_{1s}} = C_{1s} - C_s$ <p><math>\Delta_{C_{1s}}</math> = deviation of single outer ring flange width  <math>C_1</math> = nominal outer ring flange width  <math>C_{1s}</math> = single outer ring flange width</p> $V_{C_{1s}} = C_{1s \max} - C_{1s \min}$ <p><math>V_{C_{1s}}</math> = outer ring flange width variation</p>



### 3.3 Methods of measuring outer ring

#### 3.3.4 Radial runout

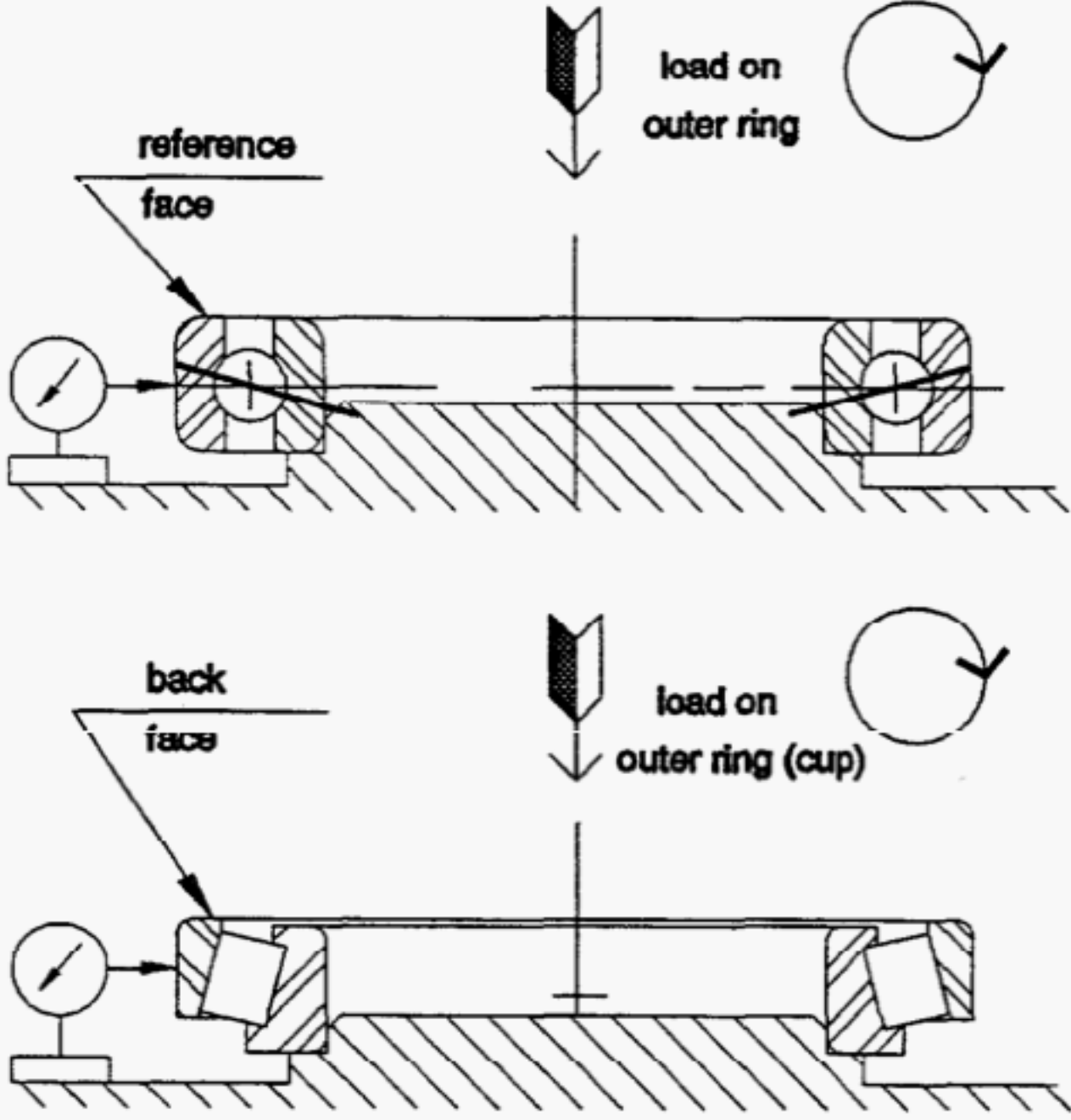
##### 3.3.4.1 Method 1. Measurement of thickness variation

Method	Comments
 <p>Support one face of the outer ring on three equally spaced fixed axial supports of equal height and provide two suitable radial supports on the outside surface at <math>90^\circ</math> to each other, at an axial distance of <math>C/2</math>, or opposite the middle of the raceway, to center the outer ring.</p> <p>Position the indicator opposite one outside diameter support.</p> <p>Take indicator readings while rotating the outer ring one revolution.</p>	<p>This method is applicable to all types of radial and angular contact rolling bearings.</p> <p>The outer ring raceway to outside diameter thickness variation, <math>K_e</math>, the difference between the largest and the smallest indicator readings.</p> <p>Refer to alternate Method 2 (see 3.3.4.2) or Method 3 (see 3.3.4.3) for measurement of outer ring radial runout of assembled bearing.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.4 Radial runout

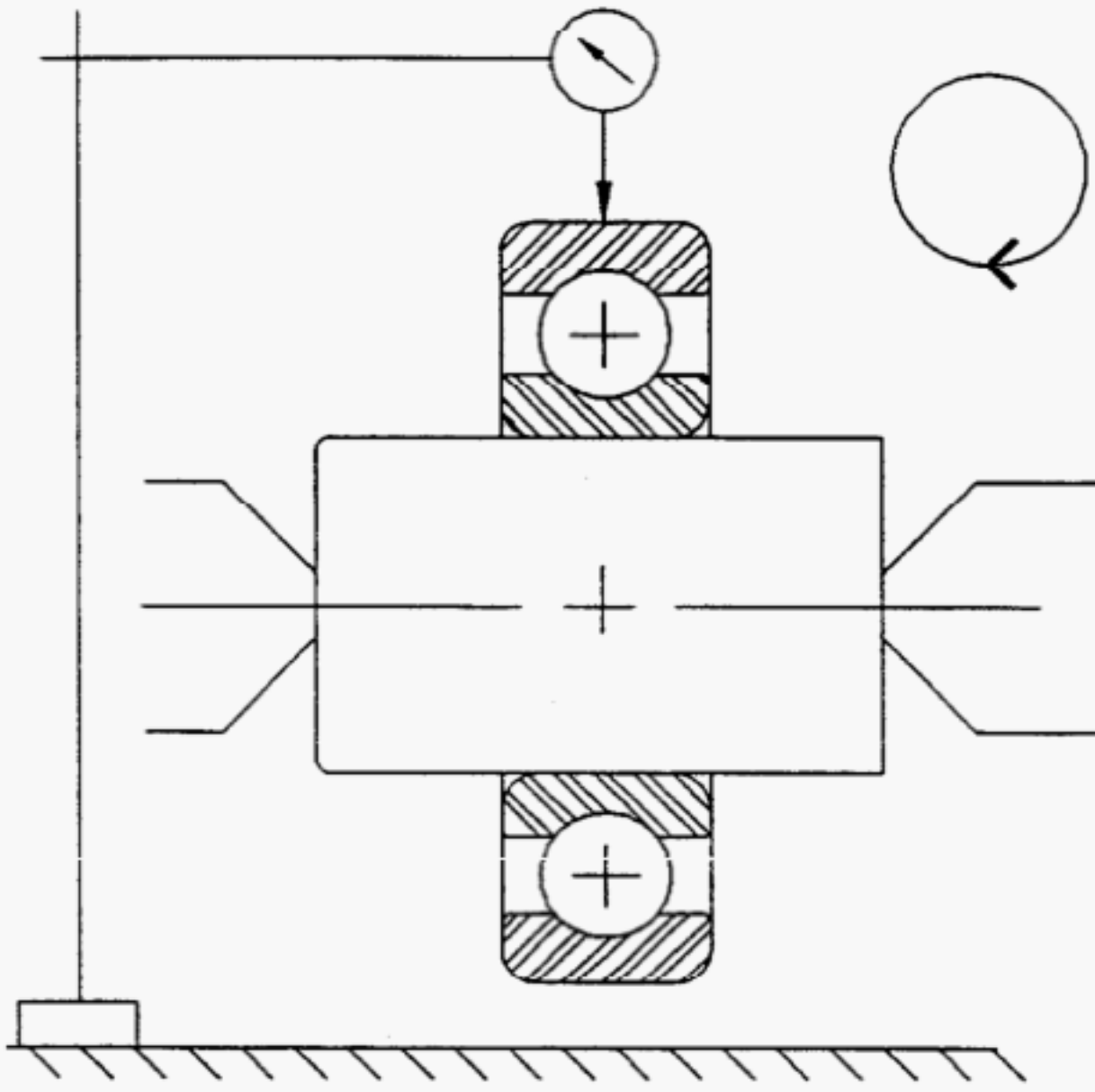
##### 3.3.4.2 Method 2. Measurement with fixed inner ring and outer ring rotation

Method	Comments
 <p>Support the inner ring reference face (or cone back face) on a surface plate with a pilot for centering in the bore of the inner ring (cone) and apply a dynamically stable coaxial load (see 3.1.6) to the reference face of the outer ring (or cup back face) to ensure contact between rolling elements and the raceways. For tapered roller bearings, ensure the rollers are in contact with the cone back face rib.</p> <p>Position an indicator against the outside surface of the outer ring and 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 groove type ball bearings (including single row angular contact ball bearings) and tapered roller bearings.</p> <p>The radial runout of assembled bearing outer ring, <math>K_{ea}</math>, is the difference between the largest and smallest indicator readings.</p> <p>Radial runout of assembled bearing outer ring is the result of several factors, e.g. outer ring concentricity, outer diameter roundness, rolling element diameter variation, and rolling element contact angle variation. Accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of outer ring runout, <math>K_e</math>, which is the major factor. Refer to Method 1 (see 3.3.4.1).</p> <p>If this method is not practical relative to the equipment available or bearing type, use alternative Method 3 (see 3.3.4.3).</p>

### 3.3 Methods of measuring outer ring

#### 3.3.4 Radial runout

##### 3.3.4.3 Method 3. Measurement with fixed inner ring and outer ring rotation around the bore axis

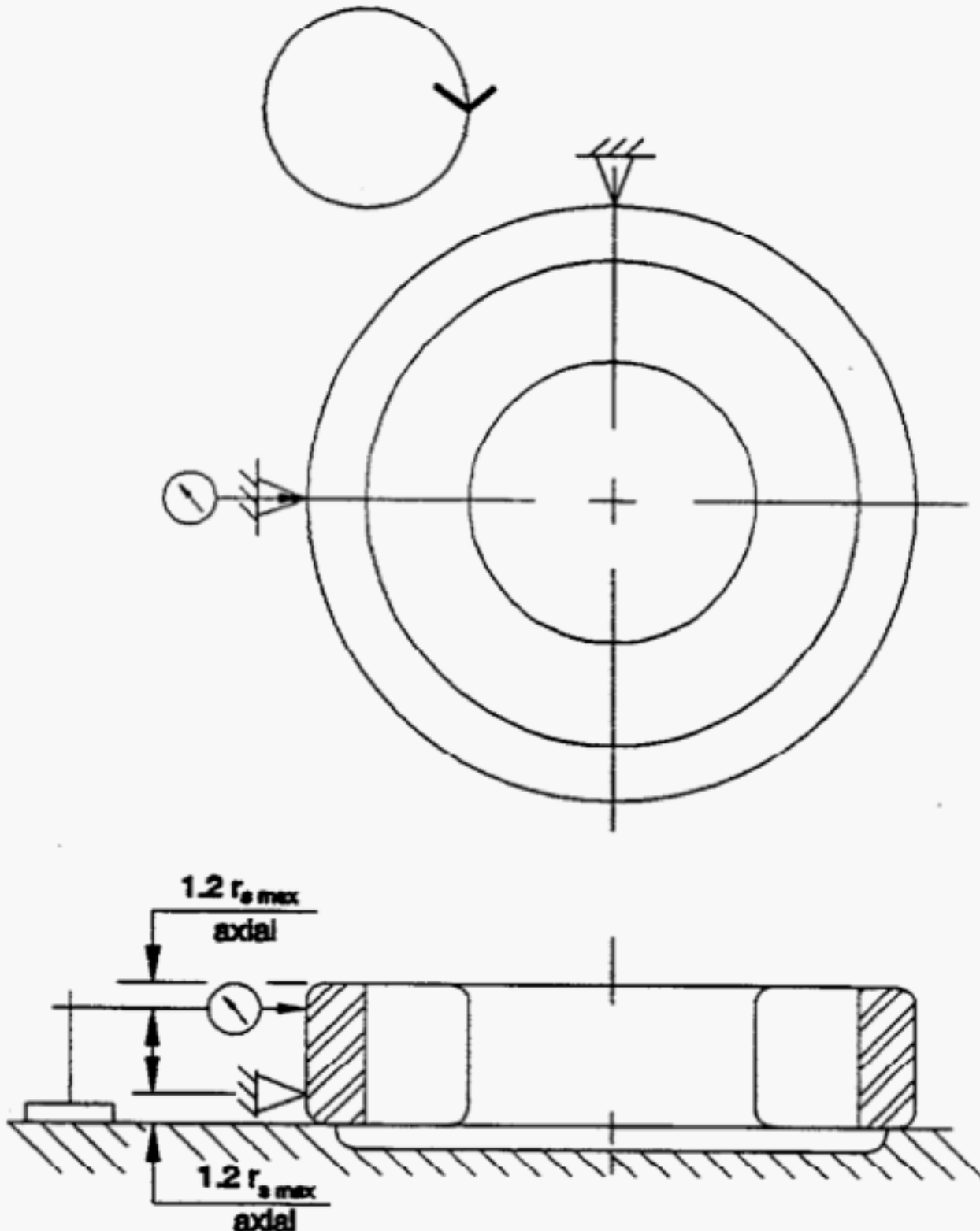
Method	Comments
 <p>Use a precision arbor having a taper of between 0.0001:1 and 0.0002:1 on diameter.</p> <p>Mount the bearing assembly on a tapered arbor and place the arbor between two centers so that it can be accurately rotated. Position the indicator against the outside diameter surface of the outer ring as close possible to the middle of the outer ring raceway. Hold the inner ring stationary. Take indicator reading while rotating the outer ring one revolution.</p>	<p>This method is applicable to groove type ball bearings (except single row angular contact ball bearings) and cylindrical, spherical and needle roller bearings.</p> <p>The radial runout of assembled bearing outer ring, <math>K_{ea}</math>, is the difference between the largest and smallest indicator readings.</p> <p>Radial runout of assembled bearing outer ring is the result of several factors, e.g. outer ring concentricity, O.D. roundness, and rolling element diameter variation. Accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of outer ring runout, <math>K_e</math>, which is the major factor. Refer to Method 1 (see 3.3.4.1).</p> <p>Refer to Method 1 (see 3.3.4.2) for an alternate method of measuring groove type ball bearings (including single row angular contact ball bearings) and tapered roller bearings.</p>



### 3.3 Methods of measuring outer ring

#### 3.3.5 Variation of outside surface

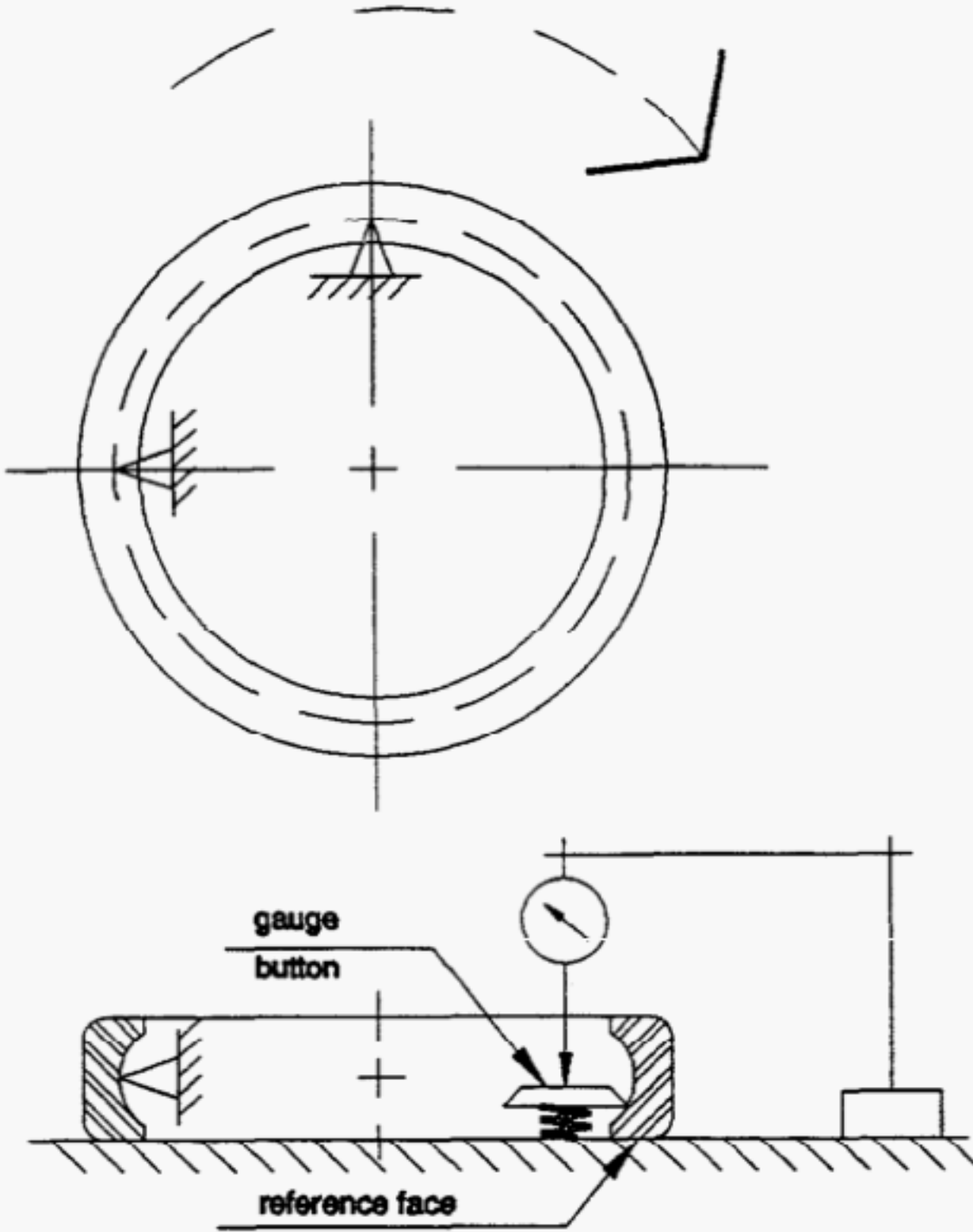
##### 3.3.5.1 Measurement from a fixed point the face and the outside surface generatrix

Method	Comments
 <p>Support the outer ring reference face (or back face) on a surface plate leaving the inner ring, if an assembled bearing, free and locate the outer ring cylindrical surface against two supports set at <math>90^\circ</math> to each other to center the outer ring. Position the indicator directly above one support.</p> <p>Take indicator readings while rotating the outer ring one revolution.</p>	<p>This method is applicable to all types of rolling bearings and their outer rings.</p> <p>The variation of outside surface generatrix inclination with face, <math>S_D</math>, is the difference between the largest and smallest indicator readings.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.6 Raceway parallelism with face

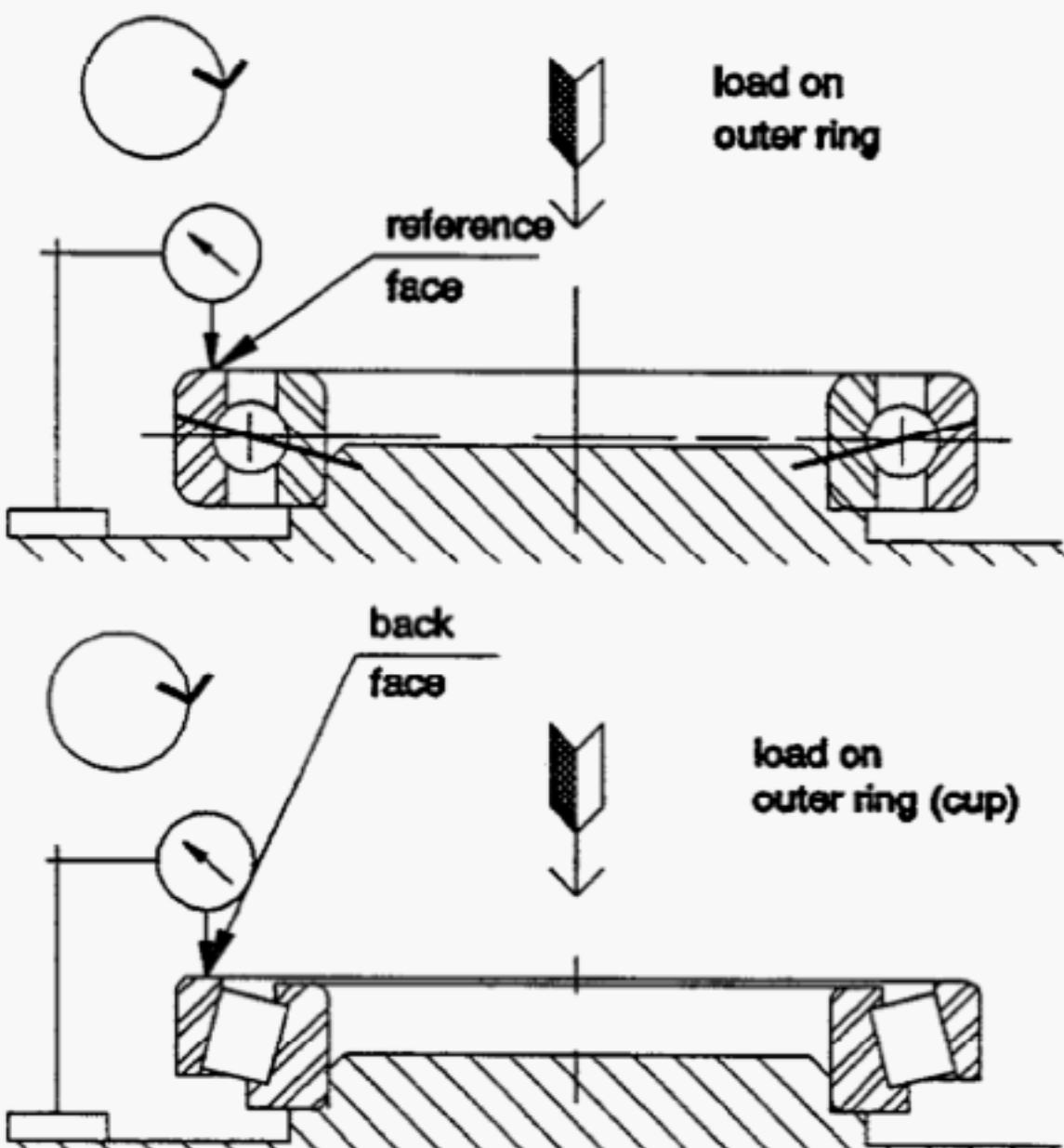
##### 3.3.6.1 Method 1. Measurement of raceway parallelism with face

Method	Comments
 <p>Position the outer ring face (or back face of a tapered roller bearing) down on a flat gauge plate, provide two supports on the raceway surface at 90° to each other at the middle of the raceway, to center the outer ring.</p> <p>Position the gauge button diagonally opposite one of the fixed supports and ensure constant pressure of the gauge button 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 and angular contact ball bearings, tapered roller bearings, and radial and thrust spherical roller bearings.</p> <p>The outer ring raceway parallelism with reference face, <math>S_e</math>, is the difference between the largest and the smallest indicator readings.</p> <p>Refer to Method 2 (see 3.3.6.2) for measurement of outer ring face runout with raceway of an assembled bearing.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.6 Face runout with raceway

##### 3.3.6.2 Method 2. Measurement with fixed inner ring and rotation of outer ring

Method	Comments
 <p>Support the inner ring reference face (or cone back face) on a surface plate with a pilot for centering in the bore of the inner ring (cone) and apply a dynamically stable coaxial load (see 3.1.6) to the reference face (or back face) of the outer ring (cup) to ensure contact between the rolling elements and the raceways. For tapered roller bearings, ensure the rollers are in contact with the cone back face rib.</p> <p>Position the indicator against the outer ring reference face (or cup back face) and take indicator readings while rotating the outer ring one revolution.</p>	<p>This method is applicable to groove type ball bearings, including single row angular contact ball bearings and tapered roller bearings.</p> <p>The assembled bearing outer ring face (cup back face) runout with raceway, <math>S_{ea}</math>, is the difference between the largest and smallest indicator readings.</p> <p>Assembled bearing outer ring face (cup back face) runout with raceway is the result of several factors, e.g. rolling element diameter variation, reference face flatness, and contact angle variation. Accurate measurement is difficult. In practice, the manufacturer may instead revert to the measurement of outer ring raceway parallelism with face, <math>S_e</math>, which is the major factor. Refer to Method 1 (see 3.3.6.1).</p>



### 3.3 Methods of measuring outer ring

#### 3.3.7 Thickness variation of thrust bearing housing washer

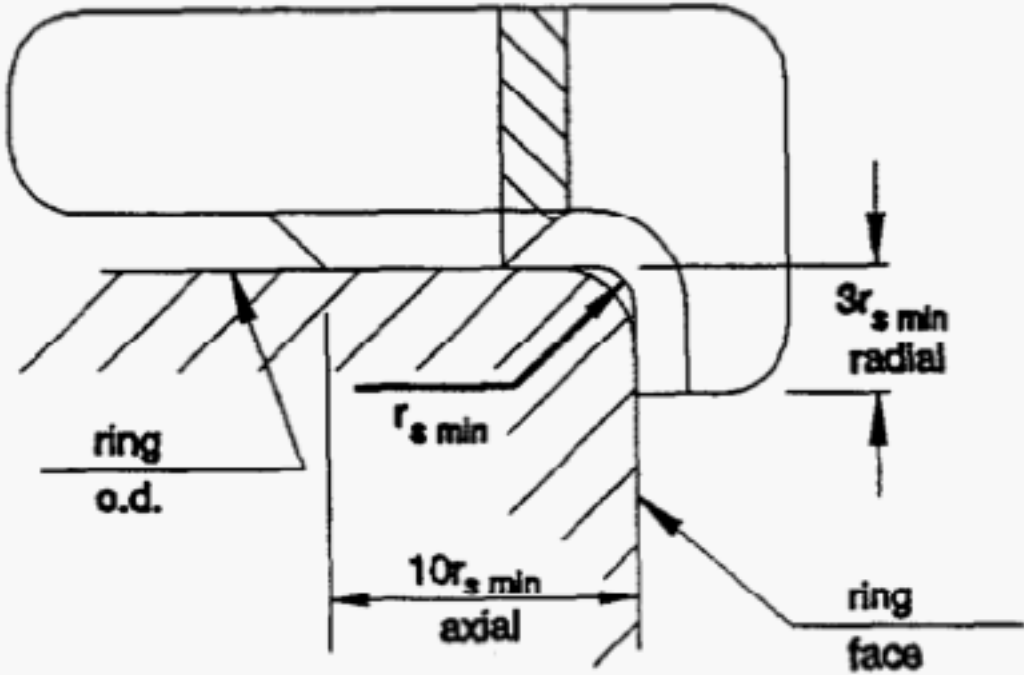
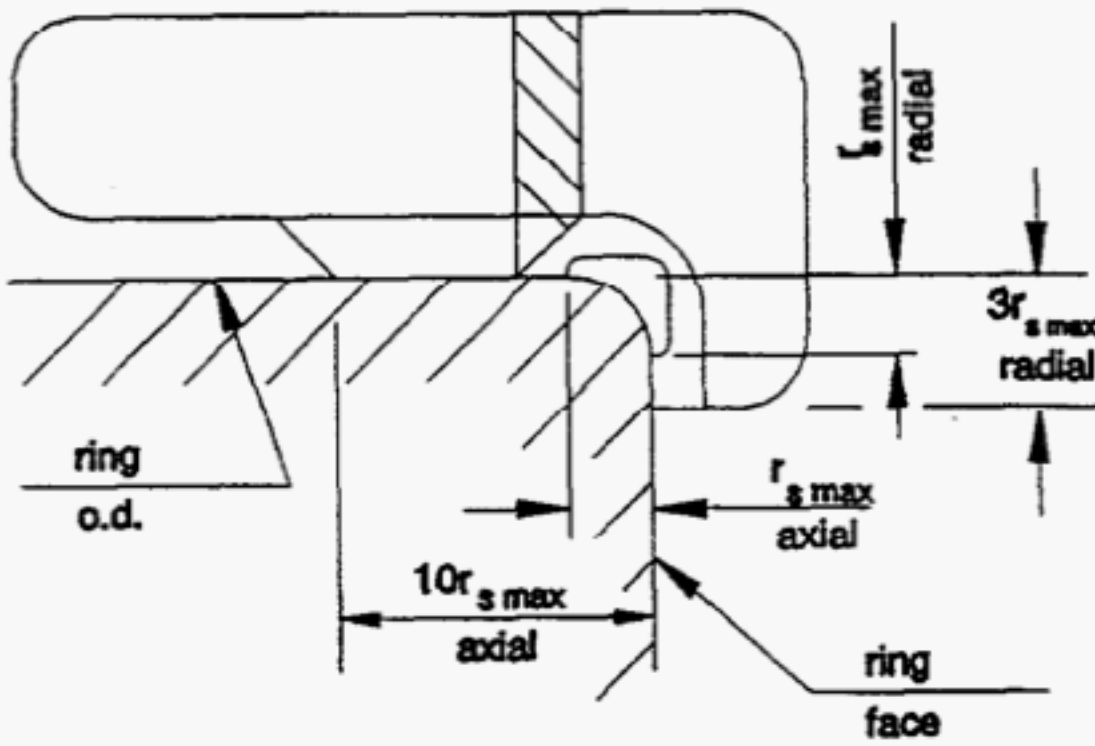
##### 3.3.7.1 Two Point measurement between the back face and the raceway

Method	Comments
<div data-bbox="388 594 987 1399" data-label="Image"> </div> <p data-bbox="246 1450 1159 1630">Support the flat back face on three equally spaced fixed axial supports of equal height and provide suitable radial supports on the 90° to each other to center the housing washer.</p> <p data-bbox="246 1682 1159 1816">Position the indicator against the middle of the raceway directly opposite one fixed support and take indicator readings while rotating the washer one revolution.</p>	<p data-bbox="1214 579 1869 714">This method is applicable to flat raceways or profiled raceways with flat back faces.</p> <p data-bbox="1214 765 1869 945">The washer raceway to back face thickness variation, <math>S_e</math>, is the difference between the largest and smallest indicator readings.</p>

### 3.3 Methods of measuring outer ring

#### 3.3.8 Chamfer dimensions

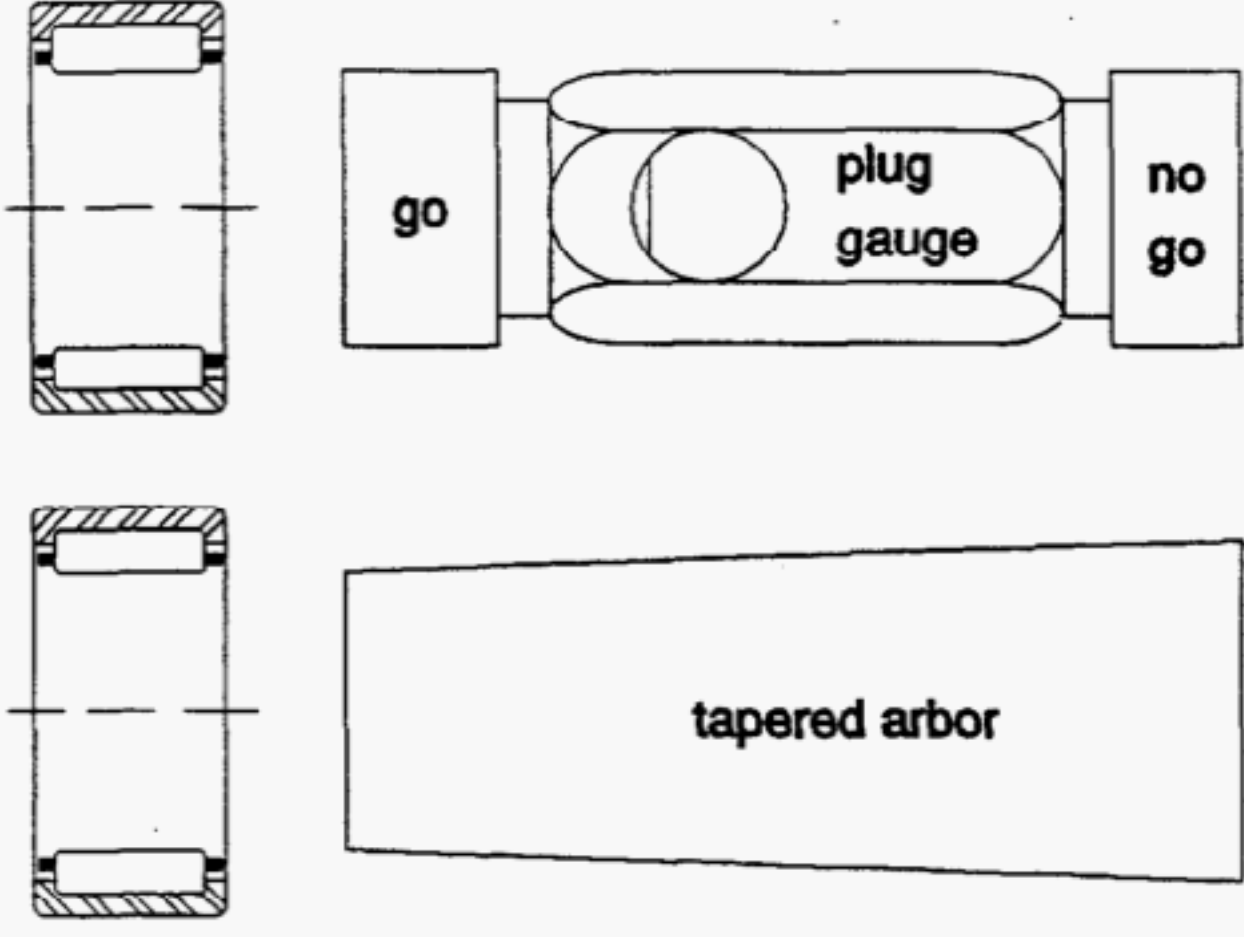
##### 3.3.8.1 Gauging by comparison with a template

Method	Comments
 <p>The diagram shows a cross-section of an outer ring with a chamfer. A template is placed against the outer surface and the face. The template's profile is defined by a minimum radius <math>r_{s \min}</math>. The axial distance from the face to the start of the chamfer is <math>10r_{s \min}</math>. The radial distance from the outer surface to the start of the chamfer is <math>3r_{s \min}</math>. The outer diameter is labeled 'ring o.d.' and the face is labeled 'ring face'.</p> <p>Place the minimum chamfer template on the outer ring. The template should rest on both the outside surface and the face surface of the outer ring. Compare the outer ring outside diameter chamfer with the profile of the template.</p>  <p>The diagram shows a cross-section of an outer ring with a chamfer. A template is placed against the outer surface and the face. The template's profile is defined by a maximum radius <math>r_{s \max}</math>. The axial distance from the face to the start of the chamfer is <math>10r_{s \max}</math>. The radial distance from the outer surface to the start of the chamfer is <math>3r_{s \max}</math>. The outer diameter is labeled 'ring o.d.' and the face is labeled 'ring face'.</p> <p>Place the maximum chamfer template on the outer ring. The template should rest on both the outside surface and the face surface of the outer ring. Compare the outer ring outside diameter chamfer with the markings of the template.</p>	<p>This method is applicable to all types of rolling bearings and their outer rings.</p> <p>The outer ring outside diameter chamfer must not interfere with the minimum chamfer (<math>r_{s \min}</math>) template.</p> <p>The outer ring outside diameter chamfer must not extend beyond the markings on the maximum chamfer (<math>r_{s \max}</math>) template.</p> <p>Where the outer ring outside diameter chamfer differs from the inner ring bore chamfer, the symbol <math>r_1</math> is used.</p> <p>Note: The axial and radial limits of <math>r_{s \max}</math> may differ.</p>

### 3.4 Methods of measuring incomplete cylindrical or needle roller bearings

#### 3.4.1 Roller complement bore diameter

##### 3.4.1.1 Method 1. Functional gauging with outer ring free

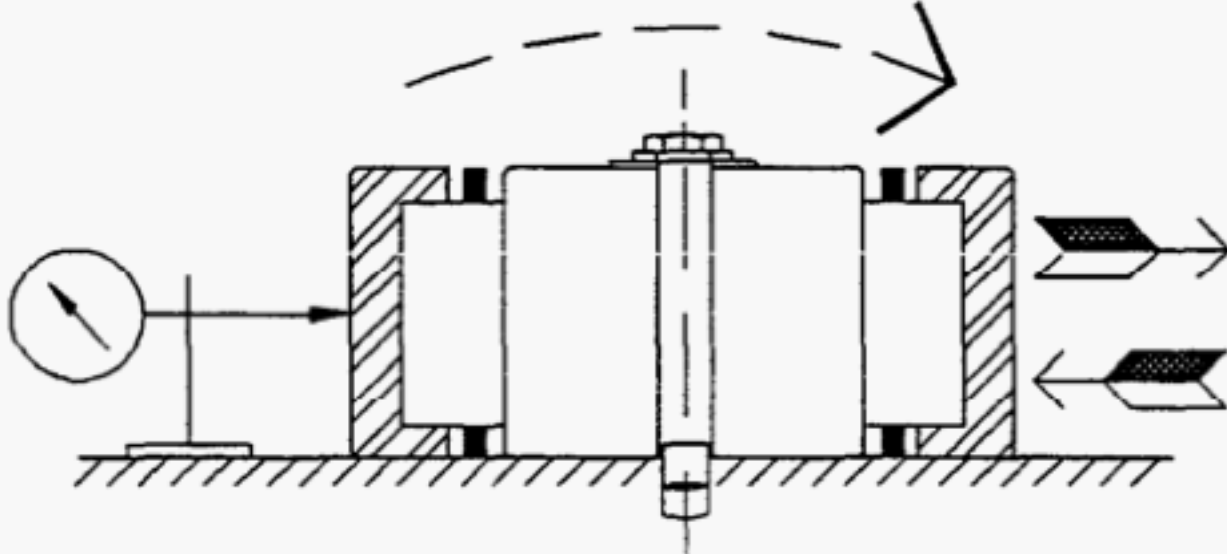
Method	Comments
 <p>The roller complement bore diameter, <math>F_w</math>, is gauged with GO and NO GO plug gauges, or with a calibrated tapered arbor having a taper of 0.0005:1.</p> <p>For metric bearings the GO plug gauge size is the roller complement minimum bore diameter. The NO GO plug gauge size is larger than the roller complement maximum bore diameter by 0.002 mm (0.00008 inch).</p> <p>For inch bearings the GO plug gauge size is smaller than the roller complement minimum bore diameter by 0.0025 mm (0.0001 inch). The NO GO plug gauge size is larger than, the roller complement maximum bore diameter by 0.0025 mm (0.0001 inch).</p>	<p>This method is used for gauging of the roller complement bore diameter of bearings with machined outer ring and without inner ring.</p> <p>The GO plug gauge must pass through the bearing bore and the NO GO plug gauge must not pass through the bearing bore. The roller complement bore diameter, <math>F_w</math>, is not directly measured.</p> <p>When using a tapered arbor, the arbor is seated in the bearing bore so as to remove the radial clearance while not expanding the bearing ring. The arbor is then withdrawn and its diameter measured at the location where the roller complement rested against the maximum arbor diameter. This measurement is the roller complement bore diameter, <math>F_w</math>.</p> <p>Refer to Method 3 (see 3.4.1.3) for the measurement of drawn cup outer ring assemblies.</p>



### 3.4 Methods of measuring incomplete cylindrical or needle roller bearings

#### 3.4.1 Roller complement bore diameter

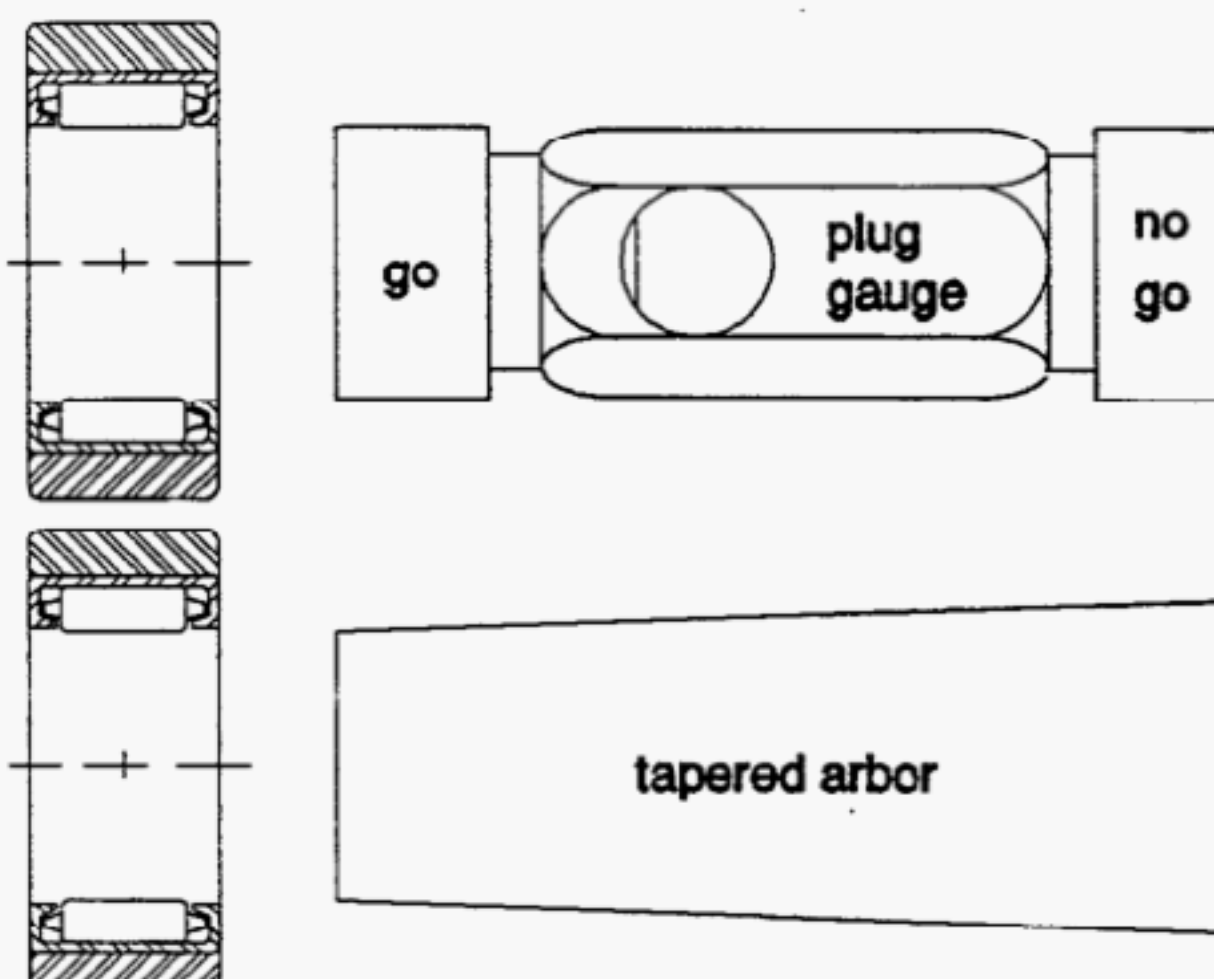
##### 3.4.1.2 Method 2. Measurement of radial displacement over a master gauge

Method	Comments
<div data-bbox="373 688 1192 1059"></div> <p data-bbox="318 1136 1028 1179">Fasten the master gauge on a surface plate.</p> <p data-bbox="318 1228 1247 1365">Position the bearing without inner ring on the master gauge. Apply the indicator on the outside surface in the middle of the outer ring width.</p> <p data-bbox="318 1413 1240 1499">Apply sufficient radial loading alternately on the outer ring in the same radial direction as that of the indicator.</p> <p data-bbox="318 1547 1214 1685">Take indicator readings at the extreme radial positions of the outer ring. Repeat the measurement on the bearing in several different angular positions.</p>	<p data-bbox="1286 625 1935 811">This method is used for gauging of the roller complement bore diameter of bearings with machined outer ring and without inner ring.</p> <p data-bbox="1286 859 1917 1045">The roller complement bore diameter, <math>F_w</math>, will equal the average of the measurements taken plus the master gauge diameter.</p> <p data-bbox="1286 1093 1945 1222">Refer to Method 3 (see 3.4.1.3) for the measurement of drawn cup outer ring assemblies.</p>

### 3.4 Methods of measuring incomplete cylindrical or needle roller bearings

#### 3.4.1 Roller complement bore diameter

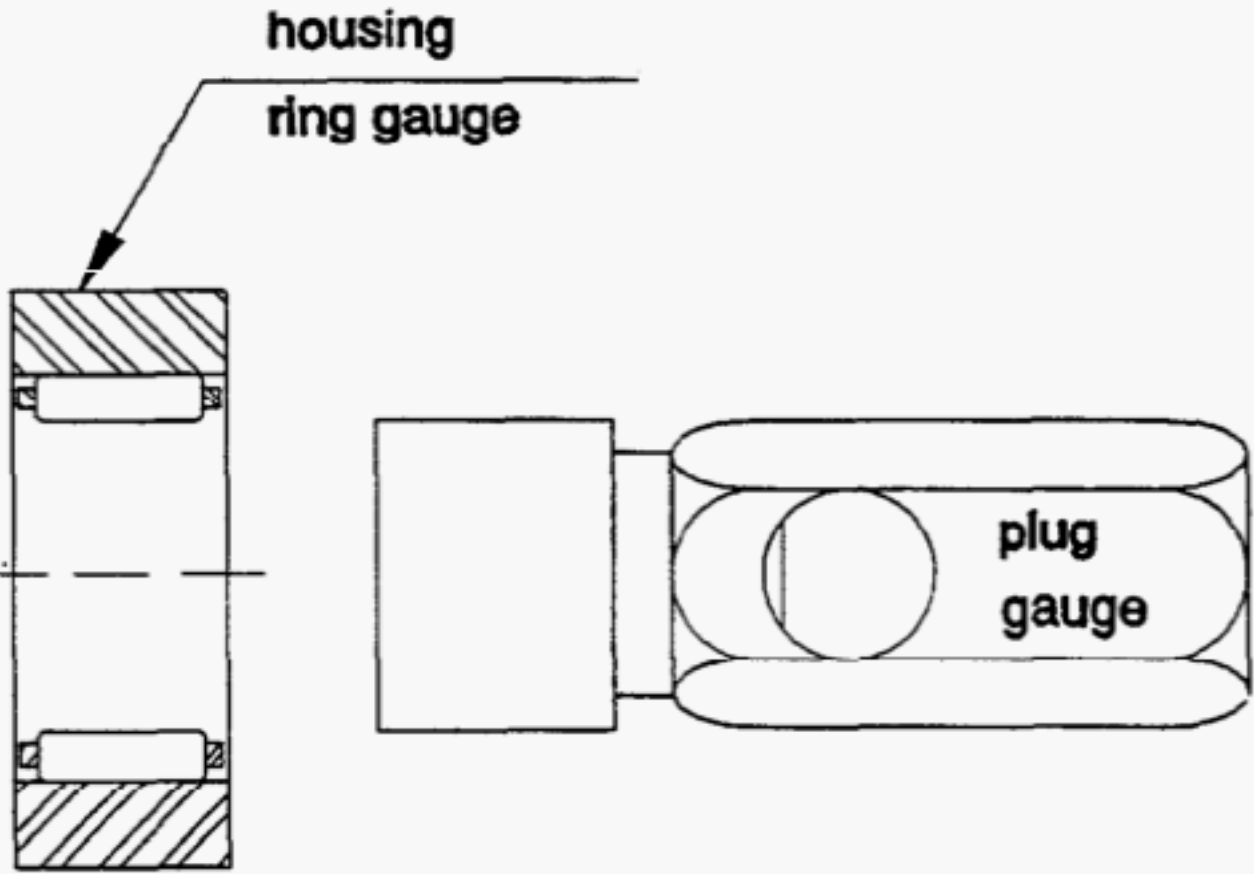
##### 3.4.1.3 Method 3. Functional gauging with outer ring pressed into a ring gauge

Method	Comments																																								
	<p>This method is used for gauging of the roller complement bore diameter of bearings with drawn cup outer ring and without inner ring.</p> <p>The bearing, while mounted in a ring and under the combined weight of the ring and bearing, must fall freely over the GO plug and must not fall freely over the NO GO plug. The roller complement bore diameter, <math>F_w</math>, is not directly measured.</p> <p>When using a tapered arbor, the arbor is seated in the bearing bore so as to remove the radial clearance while not expanding the bearing ring. The arbor is then withdrawn and its diameter measured at the location where the roller complement rested against the maximum arbor diameter. This measurement is the roller complement bore diameter, <math>F_w</math>.</p> <p>Refer to Method 1 (see 3.4.1.1) and Method 2 (see 3.4.1.2) for measurement of machined outer ring assemblies.</p>																																								
<p>First press the bearing into a hardened steel ring gauge of bore diameter specified by ANSI/ABMA Standard 18.1 or 18.2. The recommended minimum radial section of the ring gauge is shown in the adjacent table. The roller complement bore diameter, <math>F_w</math>, is then gauged with GO and NO GO plug gauges or with a calibrated tapered arbor having a taper of 0.0005:1.</p> <p>The GO plug gauge size is the minimum roller complement bore diameter.</p> <p>The NO GO plug gauge size is larger than the maximum roller complement maximum bore diameter by 0.002 mm (0.00008 inch) for metric bearings and 0.0025 mm (0.0001 inch) for inch bearings.</p>	<table><tr><th colspan="2">Ring gauge bore diameter mm</th><th colspan="2">Minimum ring gauge radial section</th></tr><tr><th>over</th><th>incl.</th><th>inch</th><th>mm</th></tr><tr><td>5.0</td><td>9.0</td><td>0.375</td><td>9.5</td></tr><tr><td>9.0</td><td>13.0</td><td>0.437</td><td>11.1</td></tr><tr><td>13.0</td><td>16.1</td><td>0.562</td><td>14.3</td></tr><tr><td>16.1</td><td>38.4</td><td>0.687</td><td>17.5</td></tr><tr><td>38.4</td><td>51.0</td><td>0.812</td><td>20.6</td></tr><tr><td>51.0</td><td>63.8</td><td>0.875</td><td>22.2</td></tr><tr><td>63.8</td><td>89.2</td><td>1.000</td><td>25.4</td></tr><tr><td>89.2</td><td>101.9</td><td>1.125</td><td>28.6</td></tr></table>	Ring gauge bore diameter mm		Minimum ring gauge radial section		over	incl.	inch	mm	5.0	9.0	0.375	9.5	9.0	13.0	0.437	11.1	13.0	16.1	0.562	14.3	16.1	38.4	0.687	17.5	38.4	51.0	0.812	20.6	51.0	63.8	0.875	22.2	63.8	89.2	1.000	25.4	89.2	101.9	1.125	28.6
Ring gauge bore diameter mm		Minimum ring gauge radial section																																							
over	incl.	inch	mm																																						
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63.8	89.2	1.000	25.4																																						
89.2	101.9	1.125	28.6																																						

### 3.4 Methods of measuring incomplete cylindrical or needle roller bearings

#### 3.4.2 Roller complement bore and outside diameters

##### 3.4.2.1 Functional gauging with the assembly placed in the bore of a ring gauge

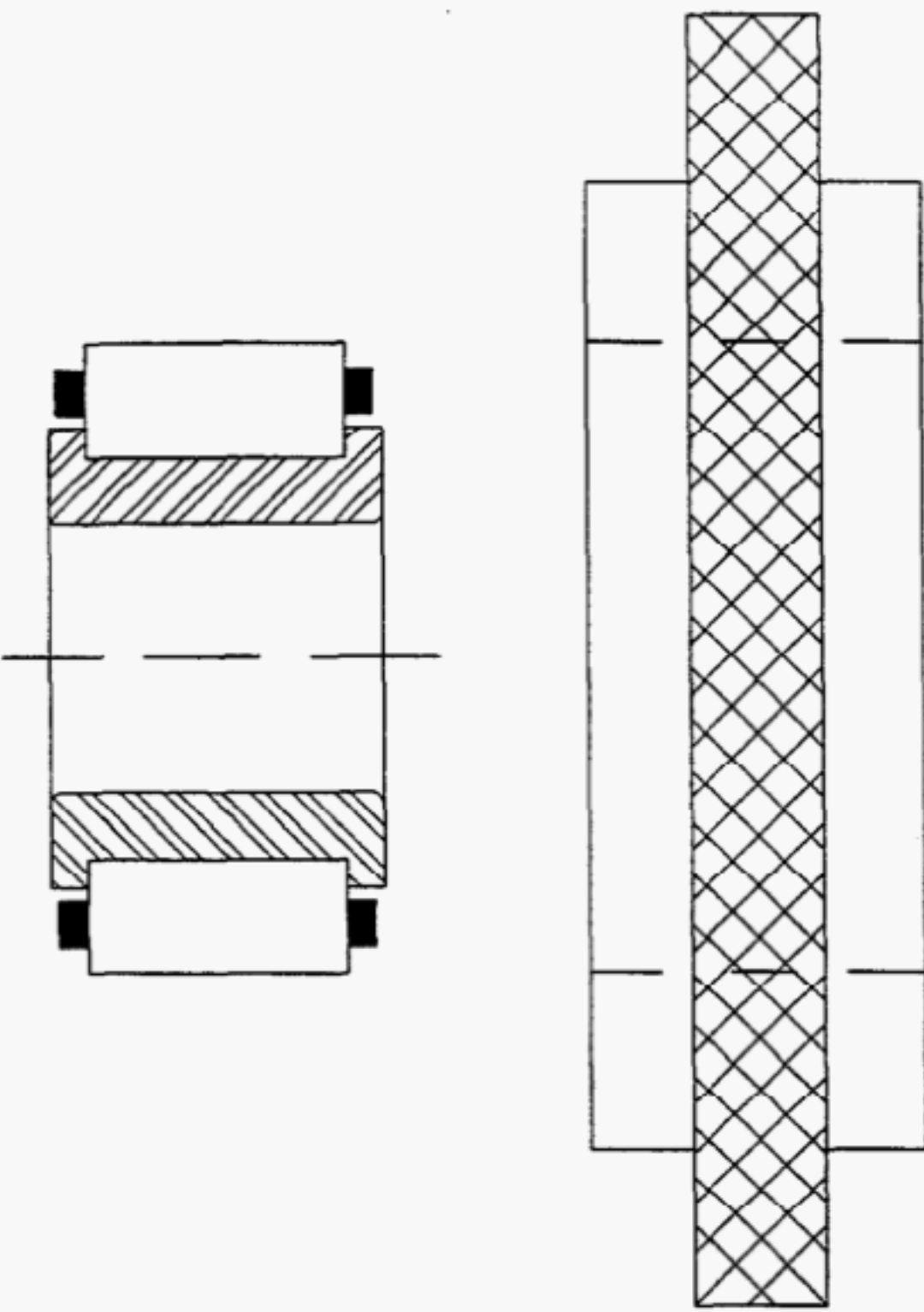
Method	Comments
 <p>The diagram consists of two parts. On the left, a cross-sectional view of a housing with a central bore. A 'ring gauge' is shown as a shaded rectangular block with a central hole, positioned within the bore. A label 'housing' points to the outer part of the housing, and 'ring gauge' points to the shaded block. On the right, a side view of a 'plug gauge' is shown. It is a cylindrical component with a central hole, labeled 'plug gauge'.</p> <p>Place the radial roller and cage assembly in a housing ring gauge with a bore equal to the roller complement minimum outside diameter specified by ANSI/ABMA Standard 18.1 or 18.2.</p> <p>Insert a plug gauge equal to the complement nominal bore diameter specified by ANSI/ABMA Standard 18.1 or 18.2.</p>	<p>This method is used for gauging of the needle roller complement bore and outside diameter of radial needle roller and cage assemblies.</p> <p>The roller and cage radial assembly must rotate freely when either the plug or ring gauge is rotated. The roller complement bore and outside diameters, <math>F_w</math> and <math>E_w</math>, are not directly measured.</p>



### 3.4 Methods of measuring incomplete cylindrical or needle roller bearings

#### 3.4.3 Roller complement outside diameter

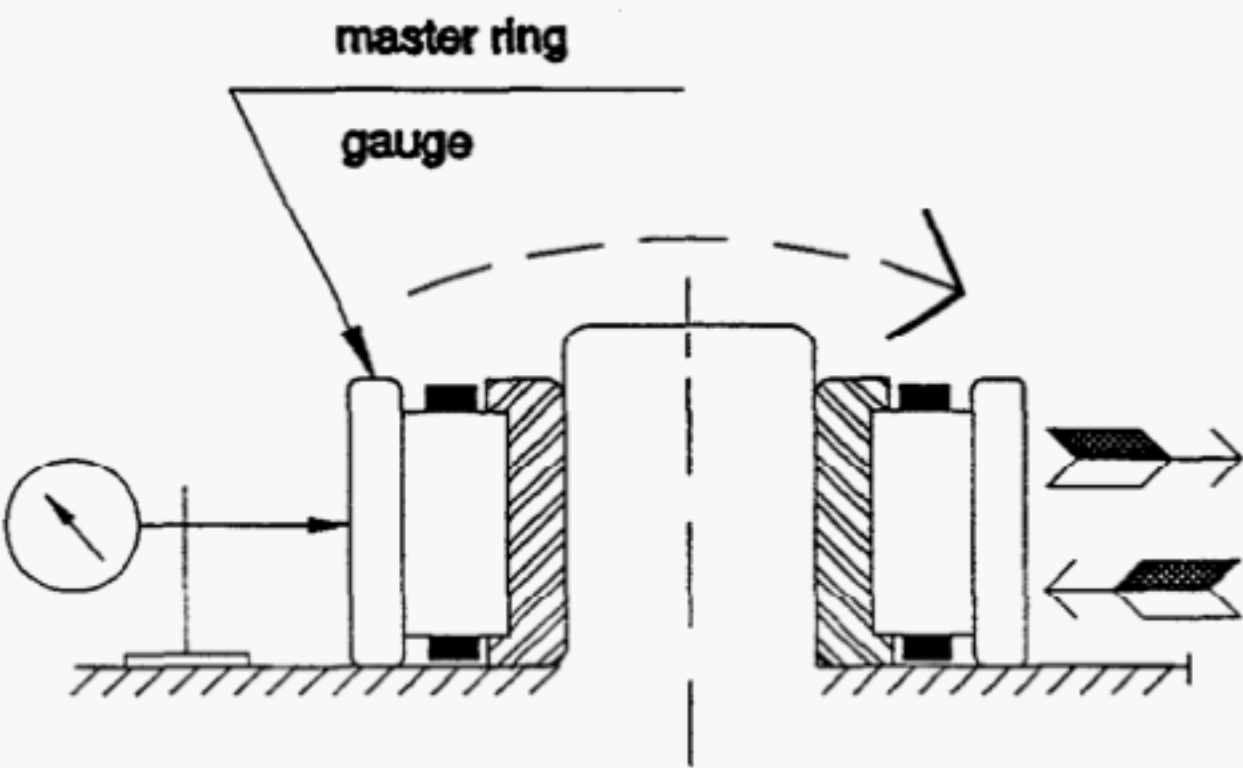
##### 3.4.3.1 Method 1. Functional gauging with inner ring free

Method	Comments
 <p>The roller complement outside diameter, <math>E_w</math>, is gauged with GO and NO GO housing ring gauges.</p> <p>The GO ring gauge size is larger than the roller complement maximum outside diameter by 0.0025 mm (0.0001 inch).</p> <p>The NO GO ring gauge size is smaller the roller complement minimum outside diameter by 0.0025 mm (0.0001 inch).</p>	<p>This method is used for gauging of the roller complement outside diameter of a bearing with machined inner ring and without outer ring.</p> <p>The GO gauge must pass over the outside diameter of the roller complement and the NO GO gauge must not pass over the roller complement. The roller complement outside diameter, <math>E_w</math>, is not directly measured.</p>

### 3.4 Methods of measuring incomplete cylindrical roller bearings

#### 3.4.3 Roller complement outside diameter

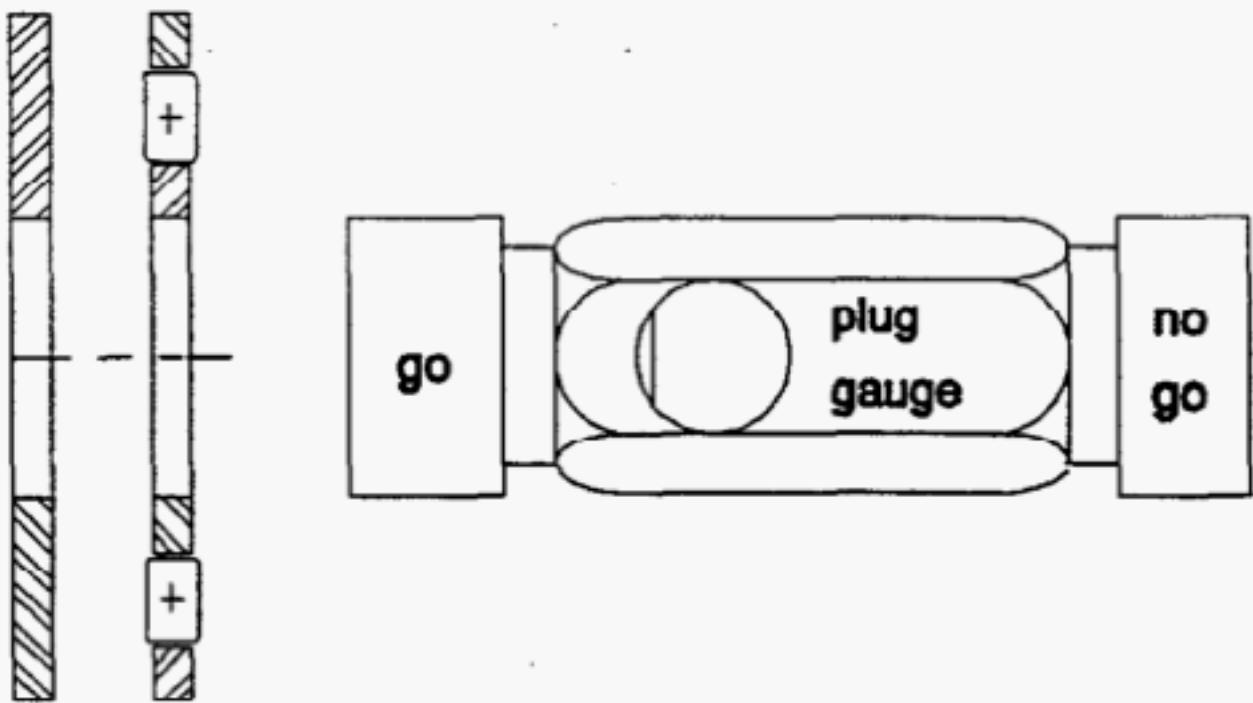
##### 3.4.3.2 Method 2. Measurement of radial displacement inside a master ring gauge

Method	Comments
 <p>Position the bearing without outer ring in a master ring gauge and with the inner ring on a close fitting rigid arbor. Apply the indicator to the master ring gauge outside diameter surface opposite the middle of the inner ring width.</p> <p>Apply sufficient radial loading alternately on the ring gauge in the same radial direction as that of the indicator.</p> <p>Take indicator readings at the extreme radial positions of the master ring gauge. Repeat the measurement on the bearing in several different angular positions.</p>	<p>This method is used for gauging of a roller complement outside diameter of a bearing with machined inner ring and without outer ring.</p> <p>The roller complement outside diameter, <math>E_w</math>, will equal the master ring gauge bore diameter minus the average of the measurements taken.</p>

### 3.4 Methods of measuring incomplete cylindrical or needle roller bearings

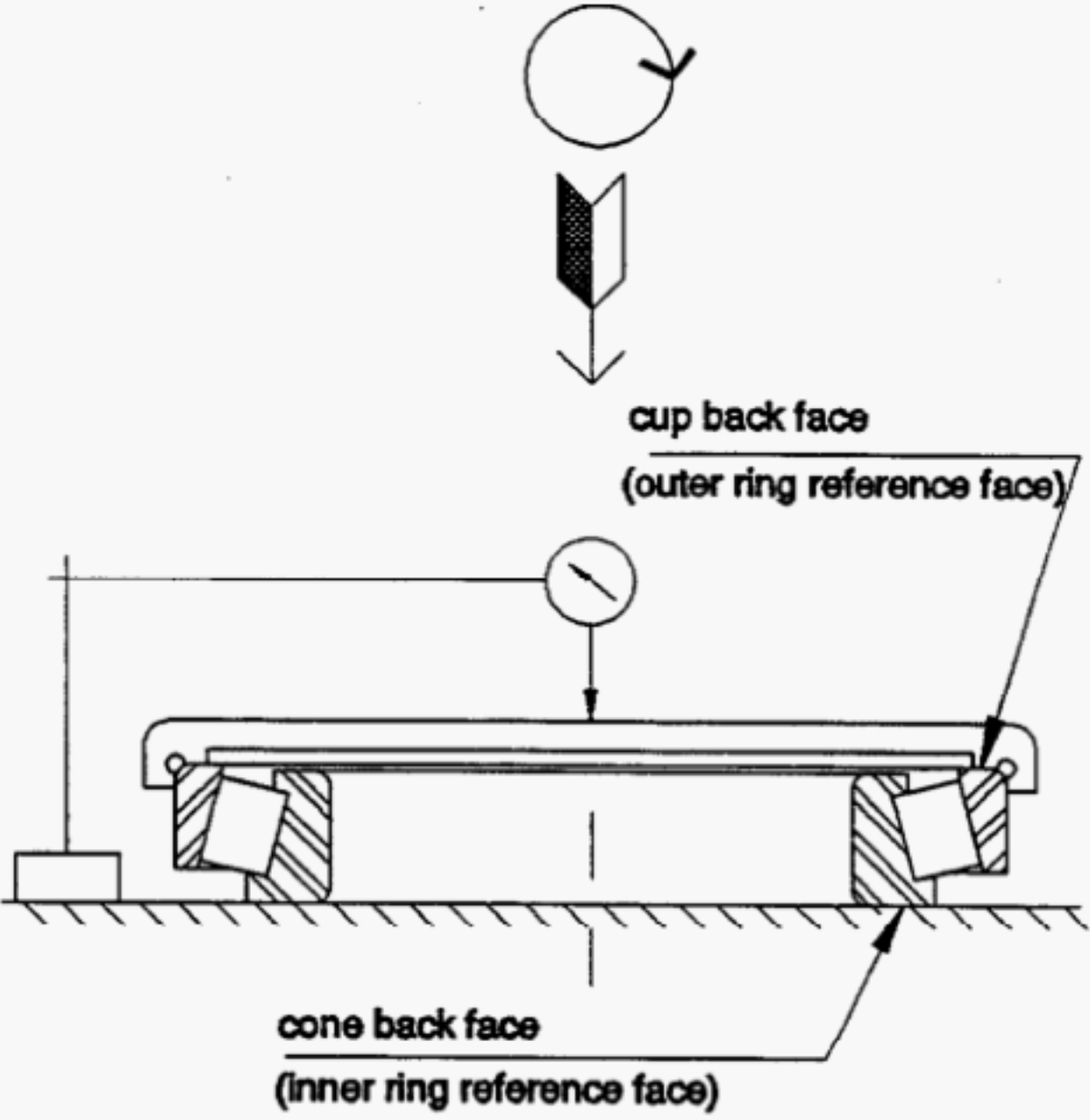
#### 3.4.4 Bore diameter

##### 3.4.4.1 Functional gauging with thrust assembly or washer free

Method	Comments
 <p>The bore diameter of a free thrust needle roller and cage assembly or free thrust washer is gauged with GO and NO GO plug gauges.</p> <p>The GO plug gauge size is the thrust needle roller and cage assembly or washer minimum bore diameter specified by ANSI/ABMA Standard 21.1 or 21.2.</p> <p>The NO GO plug gauge size is the thrust needle roller and cage assembly or washer minimum bore diameter specified by ANSI/ABMA Standard 21.1 or 21.2.</p>	<p>This method is used for gauging the bore diameter of a needle roller and cage thrust assembly, <math>D_{c1}</math>, and their thrust washers, <math>d</math>.</p> <p>This method may also be used to measure thrust cylindrical washer bore diameter, <math>D_1</math>, specified in ANSI/ABMA Standard 24.1 or 24.2.</p> <p>The assembly or washer, under its own weight, must fall freely from the GO plug gauge.</p> <p>The NO GO plug gauge should not enter the bore of the assembly or washer. Where the NO GO plug gauge can be forced through the bore, the assembly or washer must not fall from the gauge under its own weight.</p> <p>The bore diameter is not directly measured.</p> <p>Note: The thrust assembly and corresponding washer require different plug gauges due to their respective tolerances.</p>



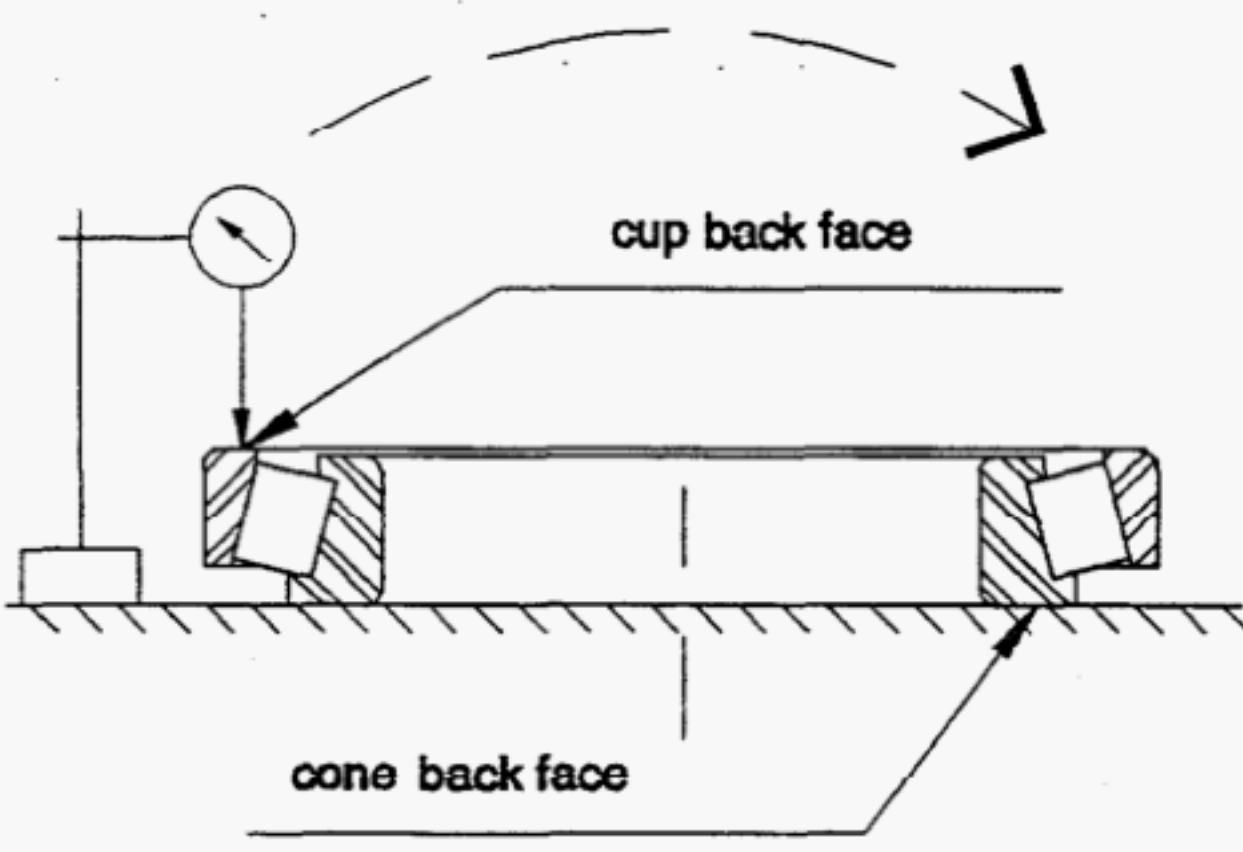
**3.5 Methods of measuring assembled bearing**  
**3.5.1 Assembled roller bearing width (or height)**  
**3.5.1.1 Method 1. Measurement with surface plate**

Method	Comments
 <p>Support the bearing on the cone back face (or inner ring reference face) and ensure the rollers are in contact with the cone back face (or inner ring reference face) rib and raceways.</p> <p>Place a plate of known dimensions on the cup back face (or outer ring reference) face, apply a dynamically stable coaxial load (see 3.1.6) and position an indicator over the center of the plate.</p> <p>Rotate the cup (outer ring) several times to be sure to reach the minimum width (or height) and take indicator reading.</p>	<p>This method is applicable to tapered roller bearings, angular contact single row spherical roller bearings and single row spherical roller thrust bearings.</p> $\Delta_{Ts} = T_s - T$ <p><math>\Delta_{Ts}</math> = deviation of the actual bearing width (or height)</p> <p><math>T_s</math> = actual bearing width (or height)</p> <p><math>T</math> = nominal bearing width (or height)</p> <p>This measurement method excludes the effects of ring face surface flatness.</p> <p>The actual bearing width (or height), <math>T_s</math>, will equal the indicator reading minus the known plate dimension.</p>

### 3.5 Methods of measuring assembled bearing

#### 3.5.1 Assembled roller bearing width

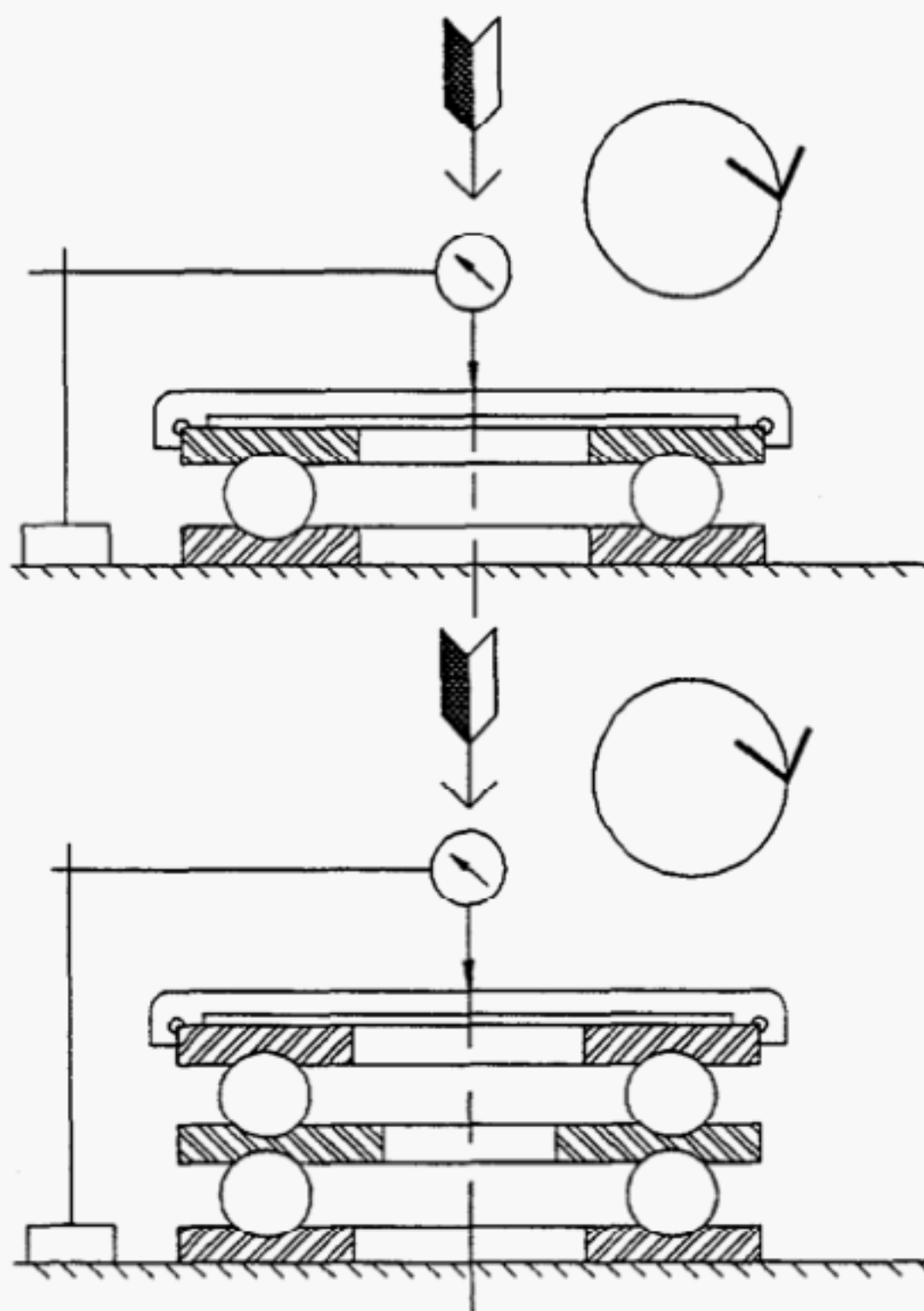
##### 3.5.1.2 Method 2. Measurement without surface plate

Method	Comments
 <p>Support the bearing on the cone back face and ensure the rollers are in contact with the cone back face rib and raceways.</p> <p>Position an indicator on the cup back face and take indicator reading.</p> <p>Cup should be rotated several times before taking measurements to be sure to reach the minimum width.</p> <p>Repeat readings at several positions around the circumference of the bearing.</p>	<p>This method is applicable to tapered roller bearings.</p> $\Delta_{Ts} = T_s - T$ <p> <math>\Delta_{Ts}</math> = deviation of the actual bearing width  <math>T_s</math> = actual bearing width  <math>T</math> = nominal bearing width         </p> <p>The assembled roller bearing width is the average of the measurements taken.</p> <p>This measurement method includes the effects of ring face surface flatness.</p> <p>This method is also applicable to measure the distance between the cone back face and the flange back face of tapered roller bearings with cup outer diameter flange.</p>

### 3.5 Methods of measuring assembled bearing height

#### 3.5.2 Assembled thrust bearing height

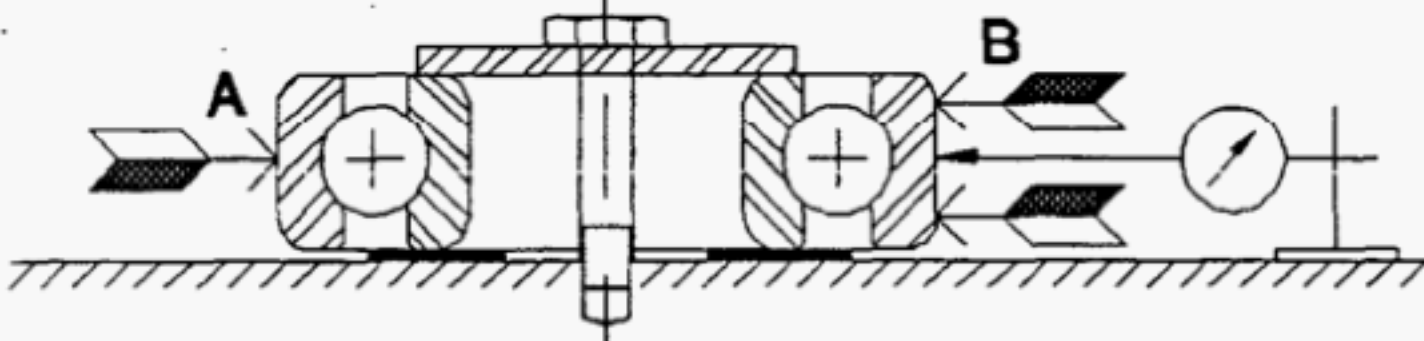
##### 3.5.2.1 Measurement with surface plate

Method	Comments
 <p>Support the bearing on a surface plate. Place a plate of known dimensions on the bearing assembly, apply a dynamically stable coaxial load (see 3.1.6) and position an indicator over the center of the plate.</p> <p>Rotate parts several times to be sure to reach the minimum height, and take indicator readings.</p>	<p>This method is applicable to ball, cylindrical, and tapered roller thrust bearings.</p> $\Delta_{Ts} = T_s - T$ <p> <math>\Delta_{Ts}</math> = deviation of the actual bearing height  <math>T_s</math> = actual bearing height  <math>T</math> = nominal bearing height         </p> <p>The actual bearing height, <math>T_s</math>, will equal the indicator reading minus the known plate dimension.</p>



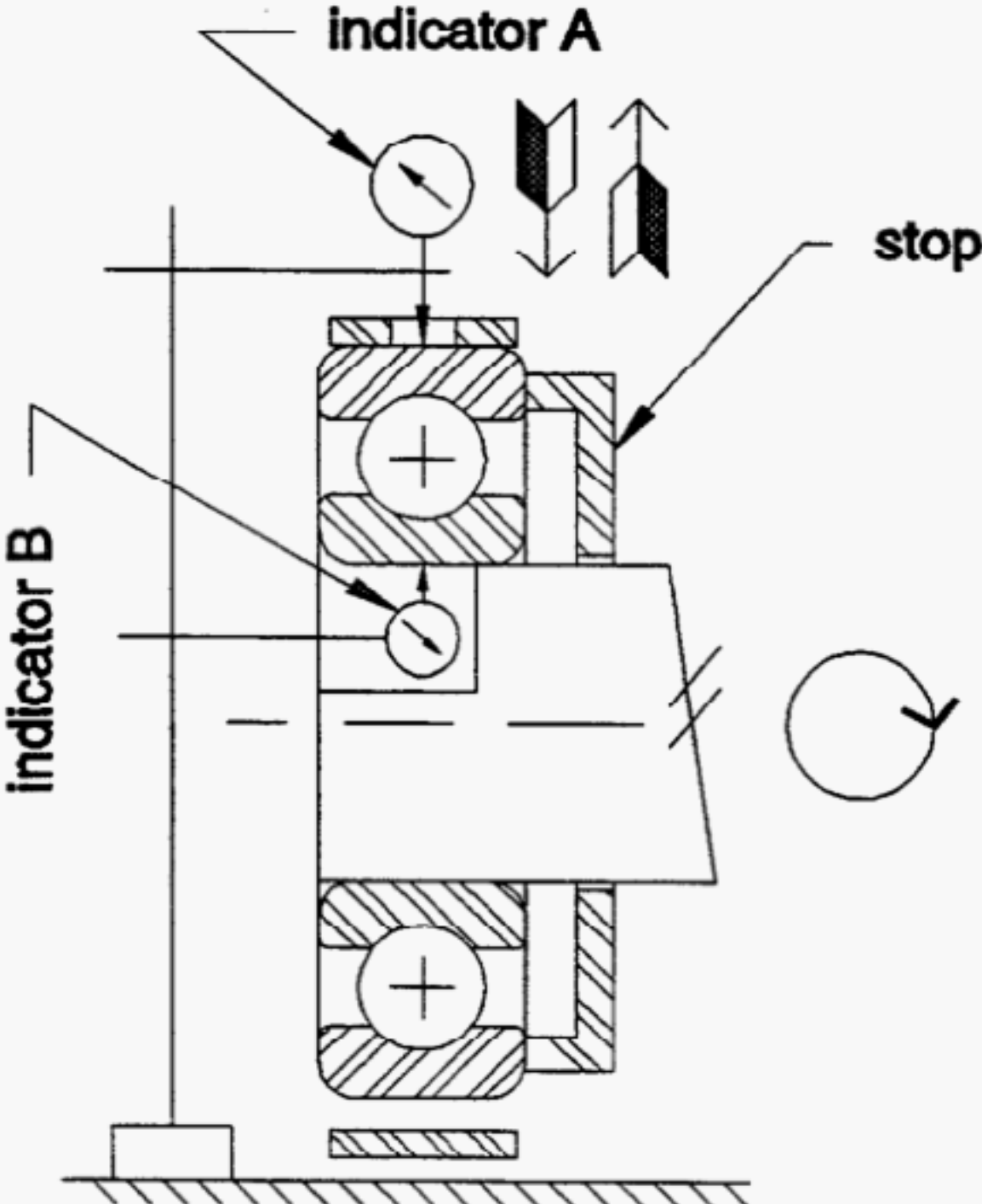
### 3.6 Methods of measuring radial internal clearance

#### 3.6.1 Method 1. Measurement of radial displacement of outer ring in relation to the fixed inner ring

Method	Comments
 <p>Fasten the inner ring of the assembled bearing on a plate with shim inserted between inner ring and surface plate.</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 direction A with care not to lift the opposite side. Move the outer ring repeatedly at this point up and down axially and oscillate circumferentially (for purpose of moving the balls to the bottom of the raceway) until the indicator can be seen to give 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, move the outer ring at this point first up and then down without circumferential motion. When the balls 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, with care not to lift the opposite side. Move the outer ring repeatedly at this point up and down axially and oscillate circumferentially (for purpose of moving the balls to the bottom of the raceway) until the indicator can be seen to give 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 move the outer ring at this point first up and then down without circumferential motion. When the balls 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 inner ring by repeating the same procedure several times at different angular positions.</p>	<p>This method is applicable to radial contact grooved ball bearings.</p> <p>This method is used for measuring the radial internal clearance directly employing simple means and without the use of a master bearing.</p> <p>The difference between minimum and maximum measured reading is the measured radial internal clearance. The average of the several sets of measurements is the radial internal clearance, <math>G_r</math>, of the bearing.</p> <p>Prelubricated bearings and some designs of bearings with closures may adversely affect accuracy of gauging.</p> <p>Note: If the indicator needle does not pass through a clear maximum or minimum reading, respectively, the shim is probably too thin.</p>

### 3.6 Methods of measuring radial internal clearance

#### 3.6.2 Method 2. Measurement of radial internal displacement of outer ring during rotation inner ring around a fixed axis

Method	Comments
 <p>Mount the assembled bearing onto 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 measuring load of approximately 1% of the basic dynamic load rating (<math>C_r</math>), calculated in accordance with ANSI/ABMA Standard 9 (for ball bearings) or Standard 11 (for roller bearings).</p> <p>Record mean readings of indicators A and B. Reverse the radial load and record the mean readings of indicators A and B. Record the differences (<math>\Delta A</math> and <math>\Delta B</math>) between the two sets of readings.</p> <p>Repeat the measurement twice more after turning the outer ring <math>120^\circ</math> each time (three measuring operations in all).</p> <p>Compensate for the effect of the deformation caused by load.</p>	<p>This method is applicable to deep groove type ball bearings, radial cylindrical roller bearings, and radial spherical roller bearings.</p> <p>The tolerance of the measuring load shall be <math>\pm 10\%</math>.</p> $G_r = \Delta A - \Delta B$ <p> <math>G_r</math> = Measured radial internal clearance  <math>\Delta A</math> = Difference in indicator A readings  <math>\Delta B</math> = Difference in indicator B readings </p> <p>The bearing radial internal clearance, <math>G_r</math>, is the average of the three measurement values.</p> <p>Prelubricated bearings and some designs of bearings with closures may adversely affect accuracy of gauging.</p>