
**Plain bearings — Quality control
techniques and inspection of geometrical
and material quality characteristics**

*Paliers lisses — Techniques de contrôle de la qualité et vérifications
des caractéristiques de qualité géométriques et des matériaux*



Reference number
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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 12301 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 5, *Quality analysis and assurance*.

This second edition cancels and replaces the first edition (ISO 12301:1992), which has been technically revised. (It also incorporates the Technical corrigendum ISO 12301:1992/Cor. 1:1995.)

Plain bearings — Quality control techniques and inspection of geometrical and material quality characteristics

1 Scope

This International Standard specifies quality control techniques and inspection of the geometrical and material quality characteristics of the following types of plain bearings:

- thin-walled half-bearings with or without flange, as specified in ISO 3548;
- metallic thick-walled half-bearings (with and without flange) that are manufactured as halves but that are necessarily interchangeable and have the ratio $s_3 : D_o > 0,11$;
- wrapped bushes, as specified in ISO 3547;
- unsplit metallic bushes (with and without flange) made from solid and multilayer materials and with outside diameters up to 230 mm;
- solid polymer bushes (with and without flange) with inside diameters up to 200 mm;
- ring-type thrust washers and pressed bimetallic half-thrust washers, as specified in ISO 6525 and ISO 6526, respectively;
- bushes made from sintered material, as specified in ISO 2795.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2795, *Plain bearings — Sintered bushes — Dimensions and tolerances*

ISO 3274 *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*

ISO 3547-1, *Plain bearings — Wrapped bushes — Part 1: Dimensions*

ISO 3547-2, *Plain bearings — Wrapped bushes — Part 2: Test data for outside and inside diameters*

ISO 3547-3, *Plain bearings — Wrapped bushes — Part 3: Lubrication holes, grooves and indentations*

ISO 3547-4, *Plain bearings — Wrapped bushes — Part 4: Materials*

ISO 3547-5, *Plain bearings — Wrapped bushes — Part 5: Checking the outside diameter*

ISO 3547-6, *Plain bearings — Wrapped bushes — Part 6: Checking the inside diameter*

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ISO 3547-7, *Plain Bearings — Wrapped bushes — Part 7: Measurement of wall thickness of thin-walled bushes*

ISO 3548, *Plain bearings — Thin-walled half bearings with or without flange — Tolerances, design features and methods of test*

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 4378-1, *Plain bearings — Terms, definitions and classification — Part 1: Design, bearing materials and their properties*

ISO 4384-1, *Plain bearings — Hardness testing of bearing metals — Part 1: Compound materials*

ISO 4384-2, *Plain bearings — Hardness testing of bearing metals — Part 2: Solid materials*

ISO 4386-1, *Plain bearings — Metallic multilayer plain bearings — Part 1: Non-destructive ultrasonic testing of bond*

ISO 4386-2 *Plain bearings — Metallic multilayer plain bearings — Part 2: Destructive testing of bond for bearing metal layer thicknesses ≥ 2 mm*

ISO 4386-3, *Plain bearings — Metallic multilayer plain bearings — Part 3: Non-destructive penetrant testing*

ISO 6524:1992, *Plain bearings — Thin-walled half bearings — Checking of peripheral length*

ISO 6525, *Plain bearings — Ring type thrust washers made from strip — Dimensions and tolerances*

ISO 6526, *Plain bearings — Pressed bimetallic half thrust washers — Features and tolerances*

ISO 6691, *Thermoplastic polymers for plain bearings — Classification and designation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4378-1 and the following apply.

3.1

quality of plain bearing

condition which renders a plain bearing fit to fulfil given requirements

NOTE The given requirements are generally dependent upon the intended use.

3.2

quality control techniques

method, equipment and procedure by means of which the quality of a plain bearing is assessed

3.3

quality characteristic

characteristic by means of which the quality of a plain bearing is judged

3.4

inspection

checking of one or more quality characteristics of a plain bearing with applicable requirements

3.5**uncertainty of measurement**

parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[Guide 99]

NOTE The uncertainty, u , should be evaluated using statistical methods, e.g. repeatability and reproducibility studies, or as shown below:

$$u = \pm t \cdot \sigma$$

where

t is the stochastic variable according to Student's t distribution; $t = 2$ and corresponds to a statistical probability in measurement $P = 95\%$, for which the probability of exceeding the value $(1 - P) = 0,05$ or 5% ;

σ is the standard deviation of the whole lot.

NOTE 1 The uncertainty of measurement is normally $\pm 10\%$ of the tolerance.

3.6**measuring points**

agreed points established to facilitate agreement on checking

NOTE The establishment of measuring points does not preclude the need to comply with dimensional specifications in other areas.

3.7**measuring lines**

agreed lines established to facilitate agreement on checking

NOTE The establishment of measuring lines does not preclude the need to comply with dimensional specifications in other areas.

3.8**tolerance**

range between the upper specified limit and the lower specified limit

4 Symbols and units

For the purposes of this document, the symbols and units given in Table 1 apply.

Table 1

Symbol	Parameter	SI unit
a	Crush height	millimetres
Δa	Measured change in a	millimetres
a_{ch}	Distance to measuring position	millimetres
a_E	Distance between gauge faces	millimetres
a_{fl}	Distance between flanges	millimetres
A_{eff}	Effective cross-section	square millimetres
B	Width	millimetres
B_{Δ}	Joint displacement	millimetres
d_{ch}	Diameter of the checking block bore	millimetres
D_H	Housing diameter	millimetres
D_{fl}	Flange diameter	millimetres
D_{fs}	Diameter measured across the joint in the free state; free spread diameter	millimetres
D_i	Inside diameter	millimetres
D_o	Outside diameter	millimetres
v	Elastic reduction	millimetres
F_{ch}	Checking load	newtons
F_{pin}	Measuring pin load	newtons
F_{tan}	Tangential load of bearing as fitted	newtons
h_{ch}	Radius for flange thickness measurement	millimetres
h_{Δ}	Joint face taper	millimetres
H	Height	millimetres
M	Number of measuring lines	—
s_1	Thickness of the backing layer	millimetres
s_2	Thickness of the bearing material layer	millimetres
$s_{2, red}$	Thickness of the bearing material layer, reduced	millimetres
s_{fl}	Flange thickness	millimetres
s_3	Wall thickness	millimetres
T	Tolerance	millimetres
t	Stochastic variable	—
u	Uncertainty of measurement	millimetres
x_1, x_2, \dots, x_i	Individual measured values	millimetres
y	Flatness gauge gap	millimetres
ϵ_{max}	Maximum diametral deformation in compression	millimetres
ϵ_{min}	Minimum diametral deformation in compression	millimetres
σ	Standard deviation	—
σ_{tan}	Tangential strength	newtons per square millimetre
Φ	Stress	newtons per square millimetre

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5 Summary of defined quality characteristics

A summary of defined quality characteristics is given in Table 2 for the convenience of users of this International Standard, as guidance indicating which defined quality characteristics are relevant to each type of bearing.

The sequence of the characteristics listed in Table 2 does not determine their importance. The manufacturer and user shall agree on priorities for the quality characteristics that, from their points of view, are required to assure reliability and lifetime of the product.

Table 2

Relevant clause/ subclause number	Quality characteristics	Type of plain bearing						
		Thin-walled half-bearing	Thick-walled half-bearing	Wrapped bush	Unsplit metallic bush	Solid polymer bush	Sintered bush	Thrust washer (ring and half)
6 Geometrical quality characteristics^a								
6.1	Wall thickness, s_3							
6.1.1	Line measurement	+	+	+	+	+	-	-
6.1.2	Point measurement	+	+	+	+	+	+	+
6.2	Outside diameter, D_o	-	+	+	+	+	+	+
6.3	Inside diameter, D_i	-	+	+	+	+	+	+
6.4	Width, B	+	+	+	+	+	+	-
6.5	Locating features	+	+	+	+	+	-	+
6.6	Lubricant feed and distribution features	+	+	+	+	+	-	+
6.7	Surface conditions	+	+	+	+	+	-	+
6.8	Crush height, a	+	-	-	-	-	-	-
6.9	Free spread	+	+	-	-	-	-	-
6.10	Straightness of sliding surface	+	-	-	-	-	-	-
6.11	Joint face taper, h_{Δ}	+	-	-	-	-	-	-
6.12	Back contact	+	-	-	-	-	-	-
6.13	Joint displacement, B_{Δ}	-	-	+	-	-	-	-
6.14	Height of thrust half-washer, H	-	-	-	-	-	(+)	+
6.15	Flatness	-	-	-	-	-	(+)	+
6.16	Flange diameter, D_{fl}	+	+	+	+	+	+	-
6.17	Distance between flanges, a_{fl}	+	+	+	+	+	-	-
6.18	Flange thickness, s_{fl}	+	+	+	+	+	+	-
6.19	Perpendicularity (squareness) of flange	+	+	+	+	+	(+)	-
6.20	Geometric deviations							
6.20.1	Cylindricity	-	(+)	-	+	-	(+)	-
6.20.2	Run-out of thrust face	-	(+)	-	+	+	(+)	-
6.20.3	Coaxiality and concentricity	-	+	-	+	+	+	-

Table 2 (continued)

Relevant clause/ subclause number	Quality characteristics	Type of plain bearing						
		Thin-walled half-bearing	Thick-walled half-bearing	Wrapped bush	Unsplit metallic bush	Solid polymer bush	Sintered bush	Thrust washer (ring and half)
7 Material quality characteristics ^a								
7.1	Metallic solid material							
7.1.1	Hardness	-	+	+	+	-	-	+
7.1.2	Material composition	-	+	+	+	-	-	+
7.1.3	Material structure	-	+	+	+	-	-	+
7.2	Metallic multilayer material							
7.2.1	Overlay properties	+	+	+	-	-	-	+
7.2.2	Lining properties	+	+	+	-	-	-	+
7.2.3	Backing properties	+	+	+	-	-	-	+
7.2.4	Adhesion (bond) of adjacent layers	+	+	+	-	-	-	+
7.3	Polymer layer material							
7.3.1	Overlay properties	-	-	+	-	-	-	(+)
7.3.2	Lining properties	-	-	+	-	-	-	(+)
7.3.3	Backing properties	-	-	+	-	-	-	(+)
7.3.4	Adhesion (bond) of adjacent layers	-	-	+	-	-	-	(+)
7.4	Solid polymer material							
7.4.1	Material composition	-	-	-	-	+	-	-
7.4.2	Material structure	-	-	-	-	+	-	-
7.5	Sintered material							
7.5.1	Material composition	-	-	-	-	-	+	-
7.5.2	Material structure	-	-	-	-	-	+	-
^a Significance of symbols: Plus sign indicates that the characteristic is generally applicable to the corresponding type of bearing. Plus sign in parentheses indicates that this characteristic is not always applicable. Minus sign indicates that the characteristic is not relevant for the corresponding type of bearing.								

6 Geometrical quality characteristics

In order to assess plain bearing quality, important dimensional quality characteristics are specified in Clause 6.

Unless otherwise stated, the dimensions in the tables and figures are given in millimetres.

6.1 Wall thickness, s_3

See Table 3.

Table 3

Dimensions in millimetres, unless otherwise stated

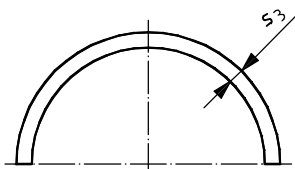
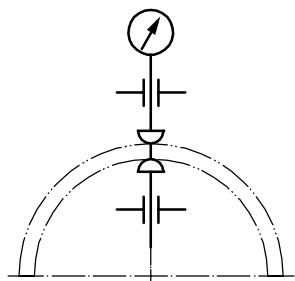
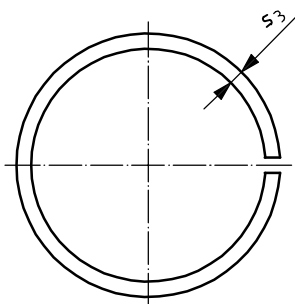
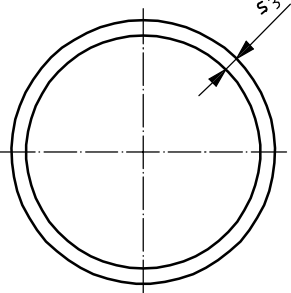
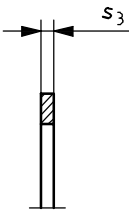
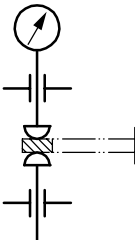
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Metallic thin-walled half-bearing	See Figure 1.  Figure 1	NOTE This test method is also applicable when measuring joint face bore relief.  Figure 2	
Metallic thick-walled half-bearing	See Figure 1.	Measured normal to the back surface in the radial direction using the spherical faces of the measuring pins	Device for measuring wall thickness
Wrapped bush	See Figure 3 and ISO 3547-7.  Figure 3	Measure in accordance with ISO 3547-7. Depending on the manufacturing process, the back of the wrapped bush can show slight hollows. The wall thickness shall, therefore, be measured outside these hollows, i.e. on the "bearing areas" (see ISO 3547-7). In the cases $D_i < 8$ or $D_i > 150$, the test method shall be subject to agreement between the manufacturer and user.	Device for measuring wall thickness (see ISO 3547-7)

Table 3 (continued)

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Unsplit metallic bush	See Figure 4.  <p>Figure 4</p>	Similar to Figure 2	Device for measuring wall thickness
Solid polymer bush	See Figure 4	Similar to Figure 2 Measure normal to the back surface in the radial direction using the spherical faces of the measuring pins.	Device for measuring wall thickness
Sintered bush	See Figure 4.	Similar to Figure 2	Device for measuring wall thickness
Thrust washer	Axial distance between the two faces of the washer (see Figure 5)  <p>Figure 5</p>	Measure parallel to the axial direction using the spherical faces of the measuring pins (see Figure 6).  <p>Figure 6</p>	Device for measuring wall thickness

6.1.1 Line measurement (wall thickness)

See Table 4.

Table 4

Dimensions in millimetres, unless otherwise stated

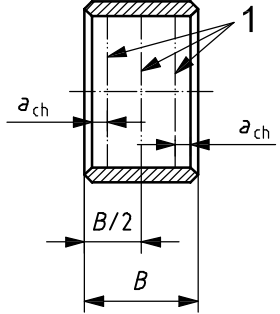
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment															
Metallic thin-walled half-bearing																		
Wrapped bush; unsplit metallic bush	See Figure 7 and ISO 3547-7. Each measuring line distance, a_{ch} , is specified from the beginning of the sliding surface or from the end face by adding the nominal value of the chamfer. This measurement may also be used for an unsplit bush.  Key 1 measuring lines $a_{ch} = 1,5$	The thickness of the half-bearing or bush is measured continuously on one, two or three predetermined or agreed measuring lines (see Figure 7). It can be necessary to modify the defined position of the measuring lines to avoid design features, such as grooves, etc.	Device for measuring wall thickness															
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Width</th> <th style="width: 25%;">Distance to measuring position</th> <th style="width: 25%;">Number of measuring lines</th> </tr> </thead> <tbody> <tr> <td>B</td> <td>a_{ch}</td> <td>M</td> </tr> <tr> <td>≤ 15</td> <td>$B/2$</td> <td>1</td> </tr> <tr> <td>$> 15 \leq 50$</td> <td>4</td> <td>2</td> </tr> <tr> <td>> 50</td> <td>6</td> <td>2</td> </tr> </tbody> </table>		Width	Distance to measuring position	Number of measuring lines	B	a_{ch}	M	≤ 15	$B/2$	1	$> 15 \leq 50$	4	2	> 50	6	2	Figure 7	
Width	Distance to measuring position	Number of measuring lines																
B	a_{ch}	M																
≤ 15	$B/2$	1																
$> 15 \leq 50$	4	2																
> 50	6	2																

Table 4 (continued)

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment			
Metallic thick-walled half-bearing	See Figure 7. Each measuring line distance, a_{ch} , is specified from the beginning of the sliding surface or from the end face by adding the nominal value of the chamfer.	The thickness of the half-bearing is measured continuously on two predetermined or agreed measuring lines (see Figure 7). In the case where $s_3 > 25$, the test method shall be subject to agreement between the manufacturer and user. It can be necessary to modify the defined position of the measuring lines to avoid design features, such as grooves, etc.	Device for measuring wall thickness; for details see the following table.			
			Wall thickness	Measuring pin load N	Uncertainty of measurement	Radius of measuring anvil
			$s_3 \leq 10$	$0,8 \leq F_{pin} \leq 1,5$	$\pm 0,001\ 5$	3 ± 0,2
			$10 < s_3 \leq 25$	$1,5 < F_{pin} \leq 2,5$	$\pm 0,002$	
Solid polymer bush	See Figure 7. Each measuring line distance, a_{ch} , is specified from the beginning of the sliding surface or from the end face by adding the nominal value of the chamfer.	The thickness of the bush is measured continuously on one, two or three predetermined or agreed measuring lines (see Figure 7). It can be necessary to modify the defined position of the measuring lines to avoid design features such as grooves, etc.	Device for measuring wall thickness; for details see the following table.			
			Outside diameter	Measuring pin load N	Radius of measuring anvil	Uncertainty of measurement
			$D_o \leq 150$	$0,8 \leq F_{pin} \leq 1,5$	3 ± 0,2	± 0,005
$150 < D_o \leq 300$	$1,5 < F_{pin} \leq 2,5$	5 ± 0,2				

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6.1.2 Point measurement (wall thickness)

See Table 5.

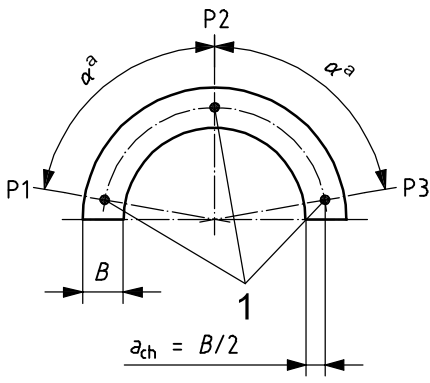
Table 5

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment															
Metallic thin-walled half-bearing		See Figure 2.																
Wrapped bush; unsplit metallic bush	Wall thickness measured at determined measuring points; see ISO 3547-7	According to ISO 3547-7 It can be necessary to modify the defined position of the measuring points to avoid design features such as grooves, etc. This measurement can also be used for an unsplit bush.	Device for measuring wall thickness															
Metallic thick-walled half-bearing	Wall thickness measured at determined measuring points which are subject to agreement between the manufacturer and user.	It can be necessary to modify the defined position of the measuring points to avoid design features such as grooves, etc.	External micrometer with dial indicator															
Solid polymer bush; sintered bush	<p>Wall thickness measured at determined measuring points (see Figure 8)</p> <table border="1"> <thead> <tr> <th>Width</th> <th>Distance to measuring position</th> <th>Number of measuring lines</th> </tr> </thead> <tbody> <tr> <td>B</td> <td>a_{ch}</td> <td>M</td> </tr> <tr> <td>≤ 15</td> <td>$B/2$</td> <td>1</td> </tr> <tr> <td>$> 15 \leq 50$</td> <td>4</td> <td>2</td> </tr> <tr> <td>> 50</td> <td>6</td> <td>2</td> </tr> </tbody> </table> <p>Figure 8</p>	Width	Distance to measuring position	Number of measuring lines	B	a_{ch}	M	≤ 15	$B/2$	1	$> 15 \leq 50$	4	2	> 50	6	2	It can be necessary to modify the defined position of the measuring points to avoid design features such as grooves, etc.	Device for measuring wall thickness External micrometer with dial indicator
Width	Distance to measuring position	Number of measuring lines																
B	a_{ch}	M																
≤ 15	$B/2$	1																
$> 15 \leq 50$	4	2																
> 50	6	2																

Table 5 (continued)

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment					
Thrust washer	<p>Wall thickness measured at determined measuring points (P) on measuring lines at a distance, a_{ch}, from the inside diameter of the washers, as shown in Figure 9</p>  <p>Key 1 measuring points a For thrust half-washers, $\alpha = 80^\circ$; for thrust washers, $\alpha = 120^\circ$.</p> <p>Figure 9</p>	<p>The thrust washer is measured at measuring points positioned as shown in Figure 9.</p> <p>It can be necessary to modify the defined position of the measuring points to avoid design features such as grooves, etc.</p>	<p>External micrometer with dial indicator</p> <p>Device for measuring wall thickness; for details see the following table</p> <table border="1" data-bbox="992 577 1394 739"> <thead> <tr> <th data-bbox="992 577 1198 685">Measuring pin load N</th> <th data-bbox="1198 577 1394 685">Radius of measuring anvil</th> </tr> </thead> <tbody> <tr> <td data-bbox="992 685 1198 739">$0,8 \leq F_{pin} \leq 1,5$</td> <td data-bbox="1198 685 1394 739">$3 \pm 0,2$</td> </tr> </tbody> </table>		Measuring pin load N	Radius of measuring anvil	$0,8 \leq F_{pin} \leq 1,5$	$3 \pm 0,2$
Measuring pin load N	Radius of measuring anvil							
$0,8 \leq F_{pin} \leq 1,5$	$3 \pm 0,2$							

6.2 Outside diameter, D_o

See Table 6.

Table 6

Dimensions in millimetres, unless otherwise stated

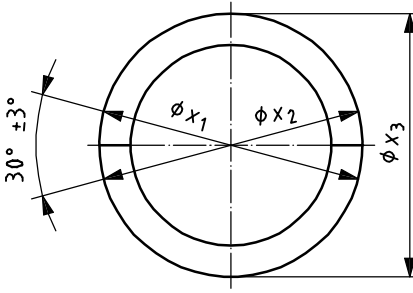
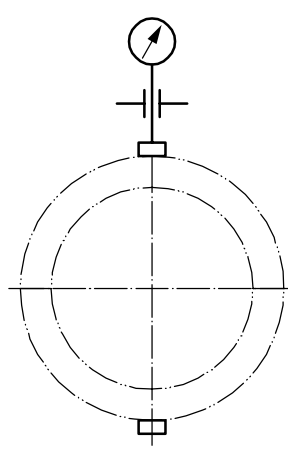
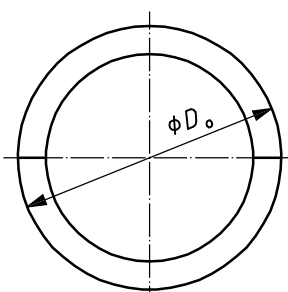
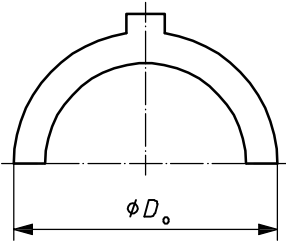
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Metallic thick-walled half-bearing</p>	<p>Outside diameter of a metallic thick-walled half-bearing is measured as a pair in the free condition, determined using Equation (1) (see Figure 10)</p> $D_o = \frac{x_3 + 0,5(x_1 + x_2)}{2} \quad (1)$  <p>Figure 10</p>	<p>Measured in the radial direction between two flat parallel faces of the measuring device (see Figure 11)</p>  <p>Figure 11</p>	<p>Measuring device Holding device</p>
<p>Wrapped bush</p>	<p>See ISO 3547-2 and 3547-5.</p>	<p>In accordance with ISO 3547-5</p>	<p>In accordance with ISO 3547-5</p>
<p>Unsplit metallic bush; solid polymer bush; sintered bush</p>	<p>Outside diameter of a bush measured in the free condition, determined as the arithmetic mean of at least two measurements (see Figure 12)</p>  <p>Figure 12</p>	<p>Measured in the radial direction between two flat parallel faces of the measuring device (see Figure 11).</p> <p>In cases where the wall thickness outside diameter ratio is such that the bush may be considered to be flexible, D_o may be measured according to method A specified in ISO 3547-5 for wrapped bushes.</p>	<p>Measuring device External micrometer with dial indicator Holding device</p>

Table 6 (continued)

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Thrust washer	<p>Outside diameter of a thrust washer measured in the free condition over the outside end faces (see Figure 13)</p>  <p style="text-align: center;">Figure 13</p>	<p>Measured in the radial direction between two flat parallel faces of the measuring device</p> <p>Measuring method should take account of design features, such as chamfers</p>	Standard test equipment

6.3 Inside diameter, D_i

See Table 7.

Table 7

Dimensions in millimetres, unless otherwise stated

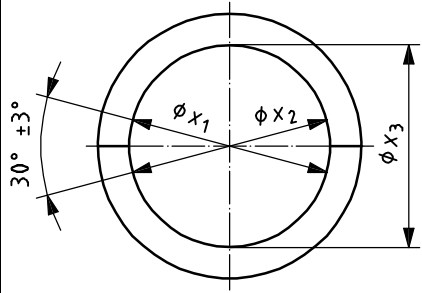
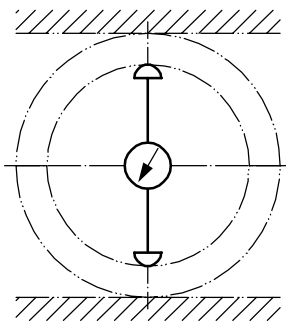
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Metallic thick-walled half-bearing	<p>Inside diameter of a metallic thick-walled half-bearing with cylindrical bore measured as a pair in the free condition, determined using Equation (2); see Figure 14.</p> $D_i = \frac{x_3 + 0,5(x_1 + x_2)}{2} \quad (2)$  <p style="text-align: center;">Figure 14</p>	<p>Measured in the radial direction using the spherical faces of the measuring pins (see Figure 15)</p>  <p style="text-align: center;">Figure 15</p> <p>The inside diameter may also be determined by calculating the difference between the outside diameter and the wall thickness ($D_o - 2s_3$) (see 6.1 and 6.2).</p> <p>It can be necessary to modify the defined position of the measuring areas to avoid design features such as oil pockets, etc.</p>	<p>Measuring device, such as an internal two-point contact measuring instrument with a contact radius of $3 \pm 0,2$</p> <p>Holding device</p>

Table 7 (continued)

Dimensions in millimetres, unless otherwise stated

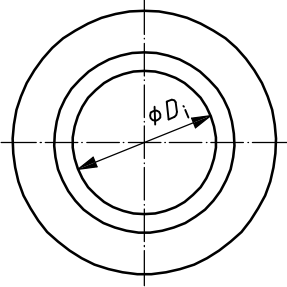
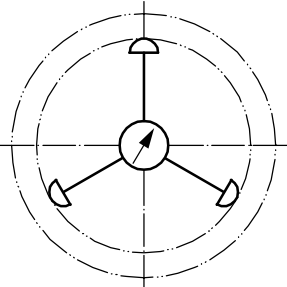
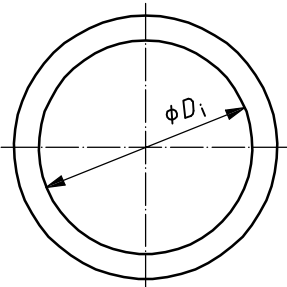
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Wrapped bush</p>	<p>Inside diameter of a wrapped bush measured in pressed-in position (see Figure 16 and ISO 3547-2)</p>  <p style="text-align: center;">Figure 16</p>	<p>Measured in the radial direction using the spherical faces of the measuring pins (see Figure 17) or a gauge</p> <p>Test method In accordance with ISO 3547-6.</p> <p>The inside diameter may also be determined by calculating the difference between the outside diameter and the wall thickness ($D_o - 2s_3$) (see 6.1 and 6.2).</p>  <p style="text-align: center;">Figure 17</p>	<p>Bore gauge (two- or three-point contact) with setting gauge</p> <p>Air gauge with setting gauge</p> <p>Measuring device according to ISO 3547-6</p>
<p>Unsplit metallic bush; sintered bush</p>	<p>Inside diameter of a bush measured in the free condition, determined as the arithmetic mean of at least two measurements (see Figure 18)</p>  <p style="text-align: center;">Figure 18</p>	<p>Measured in the radial direction using the spherical faces of the measuring pins (see Figure 17)</p>	<p>Bore gauge (two- or three-point contact) with setting gauge</p> <p>Air gauge with setting gauge</p> <p>Plug gauge</p>

Table 7 (continued)

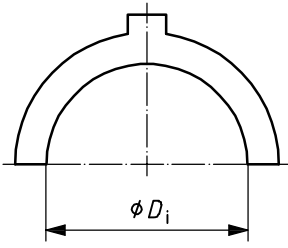
Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Solid polymer bush	Inside diameter of a bush measured in the pressed-in condition, determined as the arithmetic mean of at least two measurements (see Figure 16)	<p>a) Measured in the radial direction using the spherical faces of the measuring pins (see Figure 17)</p> <p>b) Checking the inside diameter of a bush with one ring gauge The bush is successively inserted into two gauging rings, one corresponding to the maximum size limit and the other to the minimum size limit of the housing tolerance class H7.</p> <p>c) Checking the inside diameter of a bush with one ring gauge In accordance with ISO 3547-2:2006, Test C, for wrapped bushes, the bush is pressed into a ring gauge, the size of which is made up of the nominal bush diameter, D_o, and the rounded average value of the tolerance class H7 or, alternatively, as agreed between supplier and customer.</p> <ul style="list-style-type: none"> — The inside diameter in the pressed-in condition, $D_{i, ch}$, shall be measured with a three-point measuring instrument or checked with a GO and NO-GO plug gauge. — The inside diameter may also be determined by calculating the difference between the outside diameter, D_o, and the wall thickness, s_3, ($D_o - 2s_3$); see also 6.1 and 6.2. — In order to enable the manufacturer and the customer to compare results of different test methods, it should be agreed how to obtain the results. <p>NOTE In the case of bushes with two flanges, the measurement is carried out, for example, by using split-ring gauges.</p>	<p>Bore gauge (two- or three-point contact) with setting gauge.</p> <p>Air gauge with setting gauge.</p> <p>Ring gauge.</p> <p>Test equipment according to ISO 3547-6.</p> <p>The use of measuring instruments that are also capable of measuring shapes of bush bores that deviate from the cylindrical shape is recommended. The width of the ring gauges shall be greater than the width of the bush. The permissible deviations for the ring gauges amount to $\pm \frac{1}{2} IT3$, as specified in ISO 286-1.</p>

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Table 7 (continued)

Dimensions in millimetres, unless otherwise stated

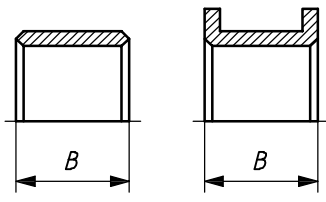
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Thrust washer	Inside diameter of a thrust washer measured in the free condition between the inside end faces (see Figure 19)  Figure 19	Measured in the radial direction Measuring method should take account of design features such as chamfers.	Standard test equipment

6.4 Width, *B*

See Table 8.

Table 8

Dimensions in millimetres, unless otherwise stated

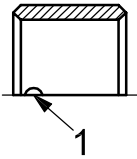
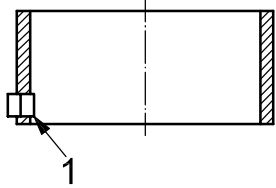
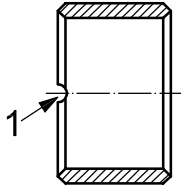
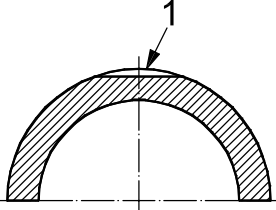
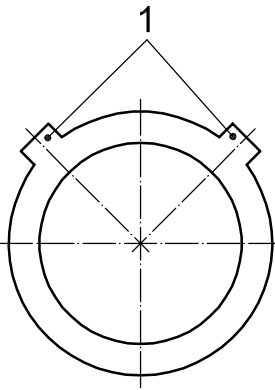
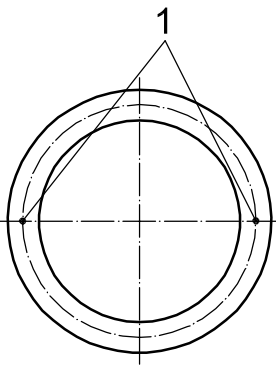
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped-bush; unsplit-metallic bush; solid-polymer bush; sintered-bush	Width between the end faces measured at any point in the axial direction (see Figure 20)  Figure 20	Measured between two flat parallel faces of a measuring device Flanged bearings may also be manufactured from plain journal bearings and thrust washers, in which case an appropriate checking method should be agreed between the manufacturer and user.	Measuring device Standard test equipment

6.5 Locating features

See Table 9.

Table 9

Dimensions in millimetres, unless otherwise stated

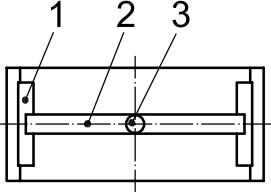
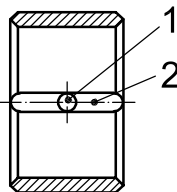
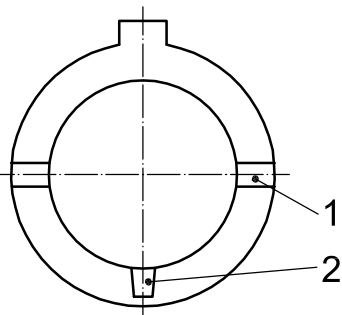
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment	
Thin-walled and thick-walled half-bearing; wrapped-bush; unsplit metallic bush; solid polymer bush; thrust washer	Element which locates the half-bearing, bush and thrust washer (see examples in Figures 21 to 26)  Key 1 locating notch Figure 21	 Key 1 locating nick Figure 22	Standard measuring methods	Measuring device Standard test equipment Gauge
	 Key 1 locating notch Figure 23	 Key 1 locating groove Figure 24		
	 Key 1 locating lugs Figure 25	 Key 1 locating holes Figure 26		

6.6 Lubricant feed and distribution features

See Table 10.

Table 10

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
<p>Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; solid polymer bush; thrust washer</p>	<p>Element of lubricant feed and distribution features of half-bearing, bush and thrust washer (see examples in Figures 27 to 29; for more details see ISO 3547-3, ISO 3548, ISO 6525 and ISO 6526)</p> <div style="text-align: center;">  <p>Key</p> <p>1 oil pocket 2 oil groove 3 oil hole</p> <p>Figure 27 — Key</p>  <p>Key</p> <p>1 oil hole 2 oil groove</p> <p>Figure 28</p>  <p>Key</p> <p>1 oil groove 2 oil pocket</p> <p>Figure 29</p> </div>	<p>Standard measuring methods.</p>	<p>Measuring device Standard test equipment Gauge</p>

6.7 Surface conditions

See Table 11.

Table 11

Dimensions in millimetres, unless otherwise stated

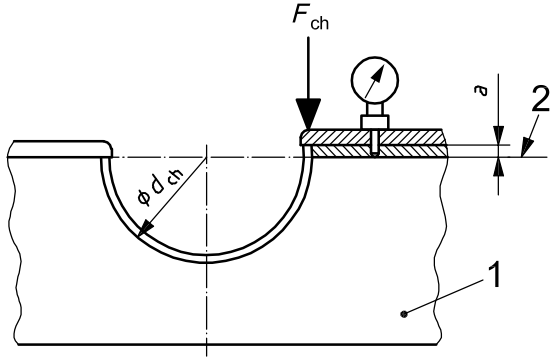
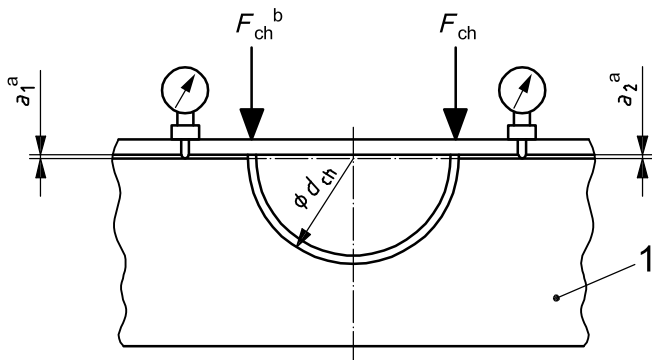
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; solid polymer bush; thrust washer	Surface roughness as defined in ISO 4287	Test method according to ISO 4288	Roughness test equipment Radius of measuring tip, as specified in ISO 3274 preferred: 5 µm cut-off: 0,8. In critical cases, reference area testing system should be used.
	Surface defects caused during manufacture and subsequent handling. According to degree, the defects may be considered either detrimental or non-detrimental to performance. Defects detrimental to performance may be — cracks, — burrs, — material accumulation, — mounds, etc. Defects non-detrimental to performance may be — stains, — gauging marks, — scratches, etc.	Visual inspection	Naked eye Magnifying glasses Stereoscopic microscope Microscope Roughness tester Profilometer

6.8 Crush height, a (peripheral length)

See Table 12.

Table 12

Dimensions in millimetres, unless otherwise stated

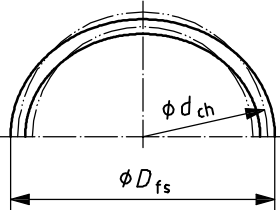
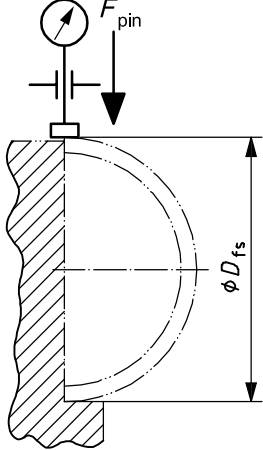
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Thin-walled half-bearing	<p>a) Peripheral length: The circumferential length which runs from one joint face to the other</p> <p>b) Crush height: The size, a, by which a half-bearing fitted in a checking block of bore diameter, d_{ch}, under a predetermined checking load, F_{ch}, exceeds the defined peripheral length of the checking block bore (see Figure 30).</p> <p>NOTE In practice, the datum serves as a basis for measuring a (see Figure 30).</p>	<p>Test method shall be in accordance with, ISO 6524:1992.</p> <p>a) Method A for $D_o \leq 200$</p>  <p>Key</p> <p>1 checking block 2 date a crush height</p> <p>Figure 30</p> <p>b) Method B for $D_o > 200$</p> <p>In cases where $D_o > 500$, the test method shall be subject to agreement between the manufacturer and user.</p>  <p>Key</p> <p>1 checking block a The crush height equals $a_1 + a_2$. b The checking load, F_{ch}, shall be applied to each joint face.</p> <p>Figure 31</p>	For details relating to device for measuring crush height, see ISO 6524.

6.9 Free spread

See Table 13.

Table 13

Dimensions in millimetres, unless otherwise stated

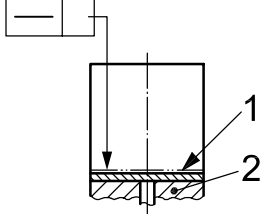
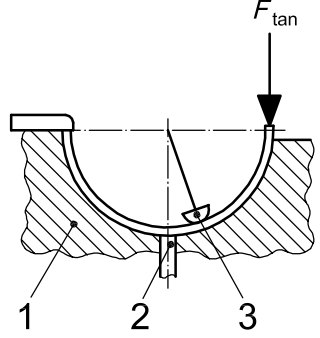
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment	
Thin-walled and thick-walled half-bearing	Length by which the free dimension, D_{fs} , of a half-bearing measured over the middle of the joint faces exceeds the diameter, d_{ch} (see Figure 32)  Figure 32	Measured parallel to the radial direction (see Figure 33)  Figure 33	External micrometer Device for measuring free spread a) Details relating to device for measuring free spread for metallic thin-walled half-bearing are as follows:	
			Outside diameter	Measuring pin load N
			$D_o \leq 150$	$0,8 \leq F_{pin} \leq 1,5$
			$150 < D_o \leq 300$	$1,5 < F_{pin} \leq 2,5$
			b) Details relating to device for measuring free spread for metallic thick-walled half-bearing are as follows:	
			Outside diameter	Measuring pin load N
			$D_o \leq 325^a$	$F_{pin} \leq 2,5$
^a In the case where $D_o > 325$, the test equipment shall be subject to agreement between the manufacturer and user.				

6.10 Straightness of sliding surface

See Table 14.

Table 14

Dimensions in millimetres, unless otherwise stated

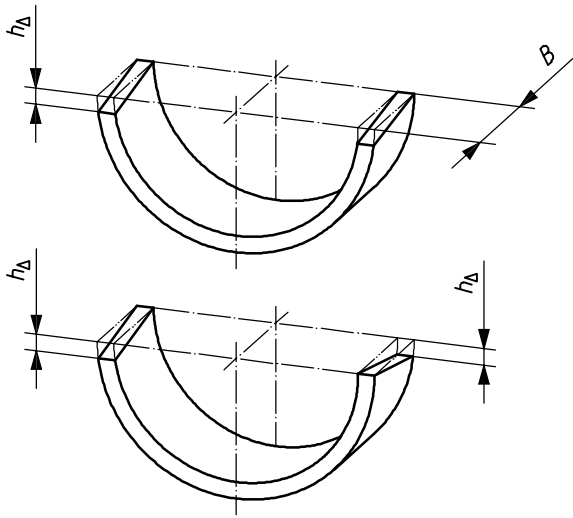
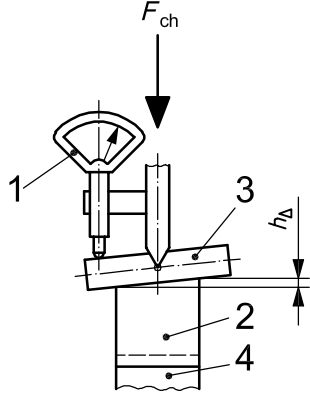
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
Thin-walled half-bearing	<p>Straightness of sliding surface measured in the axial direction (see Figure 34).</p>  <p>Key</p> <ul style="list-style-type: none"> 1 measuring line 2 checking block with ejector <p>Figure 34</p>	<p>Principal standard dimensional measuring methods (see Figure 35)</p> <p>This method applies to $D_o \leq 150$; in the case where $D_o > 150$, the method shall be subject to agreement between the manufacturer and the user.</p> <p>If an ejector pin is used, the measuring line should be 3 mm to 5 mm away from the edge of the pin.</p> <p>The measurement is made under a tangential load simulating general conditions of use.</p> <p>NOTE See Annex A for the calculation of tangential load, F_{tan}.</p>  <p>Key</p> <ul style="list-style-type: none"> 1 checking block 2 ejector 3 measuring line <p>Figure 35</p>	<p>Device for measuring crush height</p> <p>Checking block</p> <p>Device for measuring straightness</p>

6.11 Joint face taper, h_{Δ}

See Table 15.

Table 15

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
Thin-walled half-bearing	Deviation of the joint faces parallelism in the axial direction (see Figures 36 and 37)  <p style="text-align: center;">Figure 36</p>	Test should be done under test load, F_{ch} (see Figure 37).  <p>Key</p> <ul style="list-style-type: none"> 1 dial gage 2 bearing 3 metering bar 4 checking block <p style="text-align: center;">Figure 37</p>	Device for measuring crush height with a turnable meter bar (see Figure 37)

6.12 Back contact

See Table 16.

Table 16

Dimensions in millimetres, unless otherwise stated

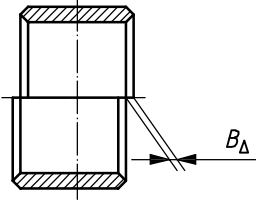
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
Thin-walled half-bearing	Pattern of contact to be established between bearing back and checking block bore under a checking load, F_{ch} .	Visual assessment. e.g. using blue ink between block and bearing during the check	Device for measuring crush height Checking block Blueing (transfer dye)

6.13 Joint displacement, B_{Δ}

See Table 17.

Table 17

Dimensions in millimetres, unless otherwise stated

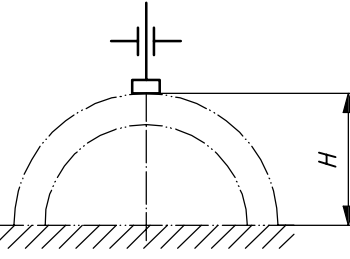
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
Wrapped bush	Displacement between the ends of the joint faces in the axial direction (see Figure 38) <div style="text-align: center;">  <p>Figure 38</p> </div>	Test method shall be subject to agreement between the manufacturer and user.	Standard test equipment

6.14 Height of thrust half-washer, H

See Table 18.

Table 18

Dimensions in millimetres, unless otherwise stated

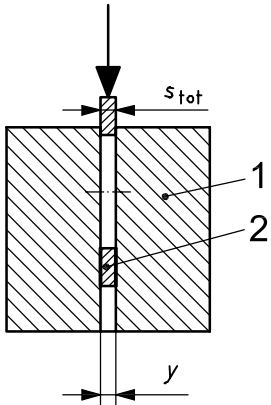
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
Thrust washer	Height of the thrust half-washer above the parting line in the free condition (see Figure 39) <div style="text-align: center;">  <p>Figure 39</p> </div>	Measured normal to the parting line between two flat parallel faces of the measuring device	Measuring device

6.15 Flatness

See Table 19.

Table 19

Dimensions in millimetres, unless otherwise stated

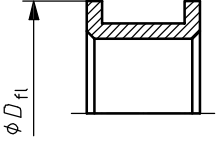
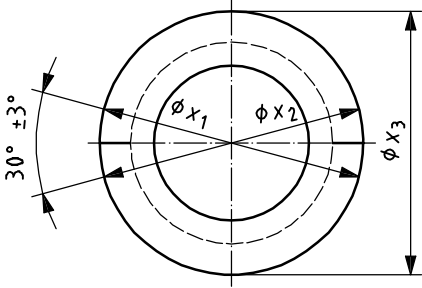
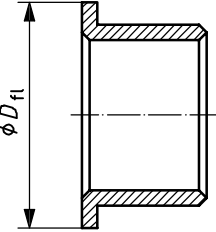
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Thrust washer</p>	<p>Flatness of two faces with respect to each other</p>	<p>Measured between two flat parallel faces of a gauge, having a defined distance, y, between the gauge faces (see Figure 40)</p> <p>The washers shall fall through the gauge under their dead weight, i.e. without any further load being applied.</p> <p>NOTE This test method is restricted by the mass, outside diameter and wall thickness of the washer.</p>  <p>Key</p> <p>1 gauge 2 thrust washer</p> <p>Figure 40</p>	<p>Gauge according to Figure 40</p> <p>Guideline: $y = s_{3max} + 0,1$</p>

6.16 Flange diameter, D_{fl}

See Table 20.

Table 20

Dimensions in millimetres, unless otherwise stated

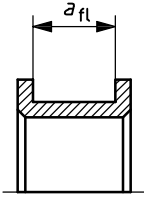
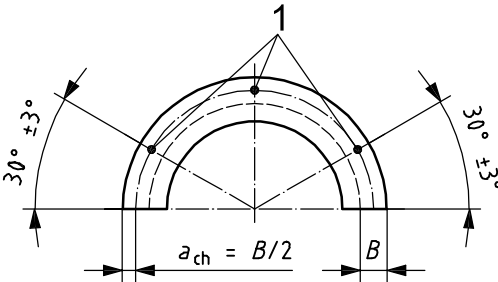
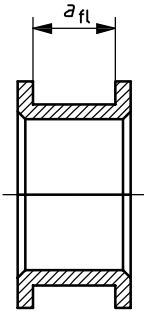
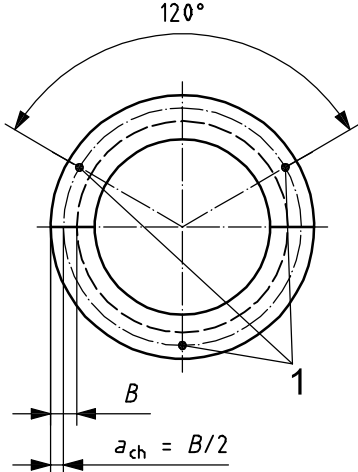
Applicability	Definition of measured geometrical characteristic	Test method/ measuring principle	Test equipment
Metallic thin-walled half-bearing	Flange diameter of the half-bearing across the flange, without free spread (see Figures 41 and 42)  Figure 41	Measured normal to the parting line between two flat parallel faces of the measuring instrument	Standard test equipment
Metallic thick-walled half-bearing	Flange diameter of the half-bearing measured as a pair across the flange, in the free condition, determined using Equation (3): $D_{fl} = \frac{x_3 + 0,5(x_1 + x_2)}{2} \quad (3)$  Figure 42	Measured in the radial direction between two flat parallel faces of the measuring instrument	Standard test equipment
Wrapped bush; unsplit metallic bush; solid polymer bush; sintered bush	Diameter of the bush measured at the flange (see Figure 43)  Figure 43	Measured in the radial direction between two flat parallel faces of the measuring instrument	Standard test equipment

6.17 Distance between flanges, a_{fl}

See Table 21.

Table 21

Dimensions in millimetres, unless otherwise stated

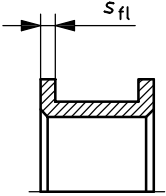
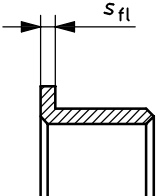
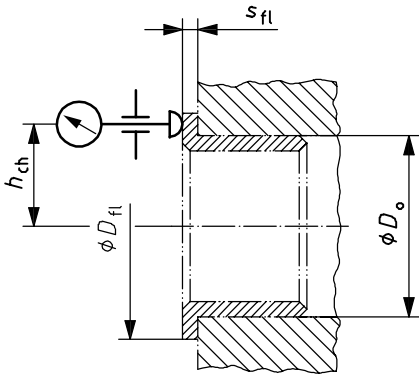
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Metallic thin-walled and thick-walled half-bearings</p>	<p>Distance between the flanges in the axial direction (see Figure 44)</p>  <p>Figure 44</p>	<p>Measured in the axial direction between two flat parallel faces</p> <p>Other methods may be agreed between the manufacturer and user. However, measurements shall be made at the measuring points indicated in Figure 45.</p>  <p>Figure 45</p>	<p>Gap gauge</p> <p>Two-point internal micrometer</p> <p>Standard test equipment</p>
<p>Unsplit metallic bush; solid polymer bush</p>	<p>Distance between the flanges in the axial direction (see Figure 46)</p>  <p>Figure 46</p>	<p>Measured in the axial direction between two flat parallel faces</p> <p>Other methods may be agreed between the manufacturer and user. However, measurements shall be made at the measuring points indicated in Figure 47.</p>  <p>Figure 47</p>	<p>Gap gauge</p> <p>Two-point internal micrometer</p> <p>Standard test equipment</p>

6.18 Flange thickness, s_{fl}

See Table 22.

Table 22

Dimensions in millimetres, unless otherwise stated

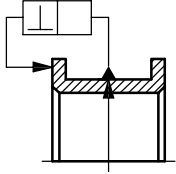
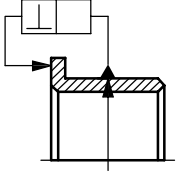
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Thin-walled and thick-walled half-bearing; unsplit metallic bush; solid polymer bush; sintered bush</p>	<p>Thickness in the axial direction between end face and inside face of the flange (see Figures 48, 49 and 50)</p>  <p>Figure 48</p>  <p>Figure 49</p>	<p>Standard measuring methods</p> <p>Measuring points as shown in Figure 45 (half-bearing) and Figure 47 (bush).</p> <p>If oil grooves or oil pockets are positioned in the area of the three determined measuring points, alternative measuring points should be agreed.</p>	<p>Measuring device</p> <p>External micrometer with a spherical contact radius of $3 \pm 0,2$</p>
<p>Wrapped bush</p>	<p>Distance between the flange face and the supporting surface of a ring gauge</p>  <p>$h_{ch} = (D_{fl} + D_o)/4$</p> <p>Figure 50</p>	<p>Measured in axial direction from flange face to ring gauge supporting surface on three measuring points as shown in Figures 47 and 50.</p> <p>The bush shall be pressed into the ring gauge up to the supporting surface.</p>	<p>Measuring instrument with a spherical contact radius of $1,5 \pm 0,2$</p> <p>Ring gauge middle H7 according to ISO 3547-2:2006, Table 6, or, alternatively, as agreed between supplier and customer</p>

6.19 Perpendicularity (squareness) of flange

See Table 23.

Table 23

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Thin-walled and thick-walled half-bearing; unsplit metallic bush; solid polymer bush; sintered bush</p>	<p>Perpendicularity of flange with reference to the axis (datum axis) of the outside diameter of the half-bearing or bush (see Figures 51 and 52)</p> <p>NOTE The datum for a sintered bush is usually the sliding surface.</p> <div style="text-align: center;">  <p>Figure 51</p>  <p>Figure 52</p> </div>	<p>Test method shall be subject to agreement between the manufacturer and user.</p>	<p>Test equipment shall be subject to agreement between the manufacturer and user.</p>

6.20 Geometric deviations

6.20.1 Cylindricity

See Table 24.

Table 24

Dimensions in millimetres, unless otherwise stated

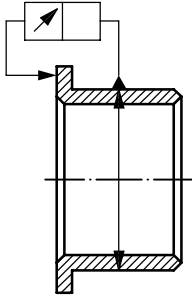
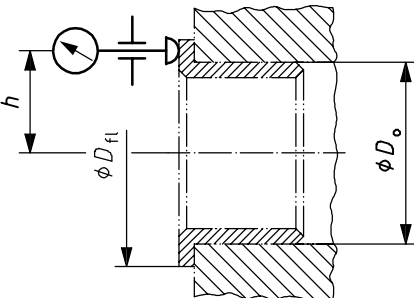
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Unsplit metallic bush</p>	<p>Cylindricity of the backing in the axial direction (see Figure 53)</p> <div data-bbox="459 1205 651 1460" data-label="Image"> </div> <p data-bbox="497 1487 609 1518">Figure 53</p>	<p>Cylindricity measured by rotating the bush (see Figure 54)</p> <p>NOTE 1 In assessing cylindricity, the conical form, convexity, etc., are all included when making the measurements; the total indicator reading is equal to twice the cylindricity error.</p> <p>NOTE 2 Unless otherwise agreed, the position of the measuring points is the same as in the line measurement for unsplit metallic bushes (see 6.1.1).</p> <div data-bbox="778 1025 1082 1473" data-label="Image"> </div> <p data-bbox="874 1496 986 1527">Figure 54</p>	<p>Measuring device</p> <p>Indicator and V-block, angle 90° to 110°</p> <p>For the radius of the measuring anvil, see the table concerning the solid polymer bush in Table 4.</p>

6.20.2 Run-out of thrust face

See Table 25.

Table 25

Dimensions in millimetres, unless otherwise stated

Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Unsplit metallic bush; solid polymer bush; sintered bush</p>	<p>Circular run-out of thrust face with reference to the axis of the outside diameter (datum axis) of the bush (see Figure 55)</p> <p>NOTE The datum for a sintered bush is usually the sliding surface.</p>  <p style="text-align: center;">Figure 55</p>	<p>Circular run-out of thrust face measured at distance, h, from the axis (see Figure 56)</p>  <p style="text-align: center;">Figure 56</p>	<p>Measuring device Standard test equipment</p>

6.20.3 Coaxiality and concentricity

See Table 26.

Table 26

Dimensions in millimetres, unless otherwise stated

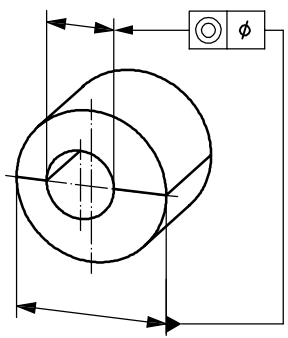
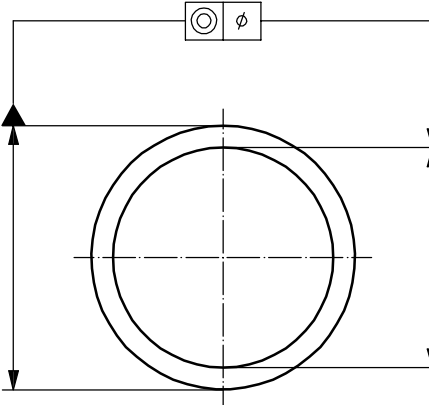
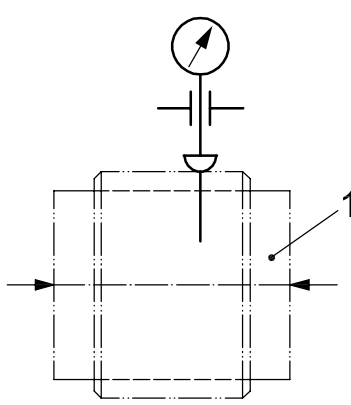
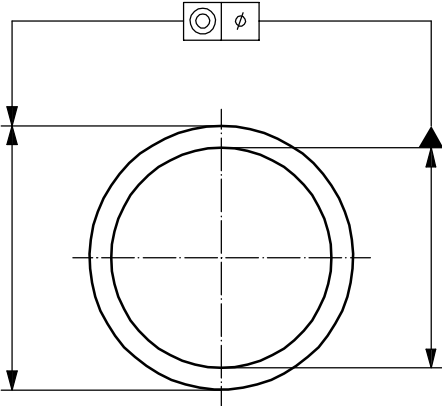
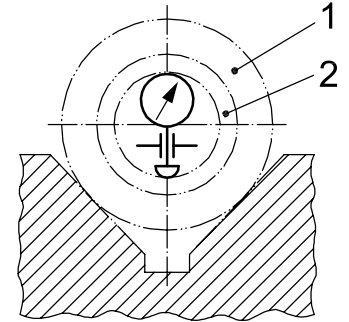
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Thick-walled half-bearing</p>	<p>Coincidence of the axes of the inside and outside diameters of the bearing (see Figure 57)</p>  <p style="text-align: center;">Figure 57</p>	<p>Test method shall be subject to agreement between the manufacturer and user.</p> <p>When the wall thickness is checked, deviations of coaxiality and concentricity should remain within the tolerance on the wall thickness.</p>	<p>Test equipment shall be subject to agreement between the manufacturer and user.</p>
<p>Unsplit metallic bush; sintered bush</p>	<p>Coincidence of the axes of the inside and outside diameters of the bush (see Figure 58)</p> <p>Both the inside and outside diameters may be considered as alternative datum axes.</p>  <p style="text-align: center;">Figure 58</p>	<p>Unless otherwise agreed between the manufacturer and user, continuous measurement of the position of the surface on circumferential lines at predetermined measuring points as described in 6.1.1 for the line measurement for an unsplit metallic bush (see Figure 59)</p>  <p>Key 1 checking gauge</p> <p style="text-align: center;">Figure 59</p>	<p>Test equipment</p> <p>The concentricity of the checking gauge shall be less than 10 % of the tolerance on the concentricity of the bush.</p>

Table 26 (continued)

Dimensions in millimetres, unless otherwise stated

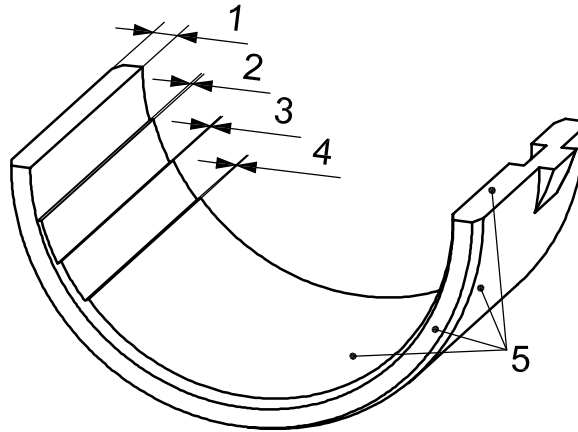
Applicability	Definition of measured geometrical characteristic	Test method/measuring principle	Test equipment
<p>Solid polymer bush</p>	<p>Coincidence of the axes of the inside and outside diameters of the bush (see Figure 60)</p>  <p style="text-align: center;">Figure 60</p>	<p>Unless otherwise agreed between the manufacturer and user, continuous measurement of the sliding surface of the fitted bush on circumferential lines at predetermined measuring points as described in 6.1.1 for the line measurement of a solid polymer bush (see Figure 61)</p>  <p style="text-align: center;">Figure 61</p>	<p>Measuring device with ring gauge (the bush is inserted in the ring gauge)</p> <p>Radius of measuring anvil: $3 \pm 0,2$</p> <p>The concentricity of the ring gauge shall be less than 10 % of the tolerance on the concentricity of the bush.</p>

7 Material quality characteristics

In order to assess the quality of the plain bearing, important material quality characteristics are specified in Clause 7.

NOTE The applicability of the quality characteristics to specific types of bearing is given in Table 2.

An example of the construction of a typical multilayer thin-walled half-bearing with optional layers is shown in Figure 62 for the purposes of illustrating the various layers and their properties considered in Clause 7.



Key

- 1 steel backing
- 2 bearing lining
- 3 barrier layer
- 4 overlay
- 5 corrosion protection layers (flash)

Figure 62

7.1 Metallic solid materials

See Table 27.

Table 27

Material quality characteristic		Test method/measuring principle	Test equipment
7.1.1	Hardness	Hardness testing shall be in accordance with ISO 4384-2	Hardness tester
7.1.2	Material composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.1.3	Material structure	Standard micro-section techniques	Microscope, etc.

7.2 Metallic multilayer material

See Table 28.

Table 28

Material quality characteristic		Test method/measuring principle	Test equipment
7.2.1	Overlay properties		
7.2.1.1	Overlay thickness	Non-destructive measurement can be in accordance with ISO 3543. Beta backscatter method	Beta backscatter gauge
7.2.1.2	Overlay composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.2.1.3	Overlay hardness	Test method shall be subject to agreement between the manufacturer and user.	Micro-hardness test apparatus
7.2.2	Lining properties		
7.2.2.1	Lining thickness	Magnetic method should be in accordance with ISO 2178.	Magnetic gauge
7.2.2.2	Lining composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.2.2.3	Lining structure	Micro-structural analysis shall be subject to agreement between the manufacturer and user. Hardness shall be according to ISO 4384-1.	Microscope
7.2.2.4	Lining hardness		Hardness tester
7.2.3	Backing properties		
7.2.3.1	Backing composition	Chemical and/or physical analysis.	Subject to agreement between the manufacturer and user
7.2.3.2	Backing hardness	Hardness testing shall be in accordance with ISO 4384-1.	Hardness tester

Table 28 (continued)

Material quality characteristic	Test method/measuring principle	Test equipment
<p>7.2.4</p> <p>7.2.4.1</p>	<p>Adhesion (bond) of adjacent layers</p> <p>Bonding of lining to backing</p> <p>The method selected for bond strength assessment shall be appropriate to the types of lining and backing material and the lining thickness for a given part.</p> <p>There is no single established test appropriate to all situations and many of the tests used during manufacture are empirical in nature and relate solely to specific material combinations and bonding processes.</p> <p>Tests that may be used include the following lists (all thickness measurements are also possible on a micro-section with a microscope).</p> <p>a) For lining thickness < 2:</p> <ol style="list-style-type: none"> 1) chisel and peel back tests for aluminium alloy linings; 2) bend test for copper alloy linings; 3) pip shear test for all lining materials; 4) fatigue test for all lining materials; 5) non-destructive qualitative ultrasonic tests for lead/tin alloy linings. <p>b) For lining thickness \geq 2:</p> <ol style="list-style-type: none"> 1) tests 1) to 5) above may be used; 2) non-destructive qualitative ultrasonic test according to ISO 4386-1 for lead/tin alloy linings; <p>lack of bond at the edge of lined areas may be detected visually or with the aid of dye penetrants;</p> <ol style="list-style-type: none"> 3) destructive test (Chalmers) in accordance with ISO 4386-2 for all lining materials; 4) non-destructive testing by dye penetration method in accordance with ISO 4386-3. 	<p>As appropriate</p>
<p>7.2.4.2</p>	<p>Bonding of overlay to lining</p> <p>There is no single established test for overlay adhesion. Qualitative tests used by manufacturers and users are generally destructive:</p> <ol style="list-style-type: none"> a) cross-cut test; b) heat treatment test; c) pull-off test; d) bonding test by solder; e) knife test. <p>NOTE Test principles similar to a) and c) are described in ISO 2409 and ISO 4624.</p>	<p>Subject to agreement between the manufacturer and user</p>

7.3 Polymer layer material

See Table 29.

Table 29

Material quality characteristic		Test method/measuring principle	Test equipment
7.3.1	Overlay properties		
7.3.1.1	Overlay thickness	Test method shall be subject to agreement between the manufacturer and user.	—
7.3.1.2	Overlay composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.3.2	Lining properties		
7.3.2.1	Lining thickness	Test method shall be subject to agreement between the manufacturer and user.	—
7.3.2.2	Lining composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.3.2.3	Lining structure	Micro-structural analysis shall be subject to agreement between the manufacturer and user	Microscope
7.3.3	Backing properties		
7.3.3.1	Backing composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.3.3.2	Backing hardness	Hardness testing in accordance with ISO 4384-1	Hardness tester
7.3.4	Adhesion (bond) of adjacent layers		
7.3.4.1	Bonding of lining to backing	<p>The method selected for bond strength assessment shall be appropriate to the types of lining and backing material and the lining thickness for a given part.</p> <p>There is no single established test appropriate to all situations and many of the tests used during manufacture are empirical in nature and relate solely to specific material combinations and bonding processes.</p> <p>Tests that may be used include the following:</p> <ul style="list-style-type: none"> a) chisel test; b) bend test; c) pip shear test. 	As appropriate
7.3.4.2	Bonding of overlay	<p>Test method shall be subject to agreement between the manufacture and user.</p> <p>Tests that may be used include following:</p> <ul style="list-style-type: none"> a) cross-cut test; b) bend test; c) pull-off test. <p>NOTE test principles similar to a) and c) are described in ISO 2409 and ISO 4624.</p>	Subject to agreement between the manufacturer and user

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7.4 Solid polymer material

Test methods shall be in accordance with ISO 6691.

See Table 30.

Table 30

Material quality characteristic		Test method/measuring principle	Test equipment
7.4.1	Material composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.4.2	Material structure	Standard micro-section techniques	Microscope, etc.

7.5 Sintered material

See Table 31.

Table 31

Material quality characteristic		Test method/measuring principle	Test equipment
7.5.1	Material composition	Chemical and/or physical analysis	Subject to agreement between the manufacturer and user
7.5.2	Material structure	Standard micro-section techniques	Microscope, etc.

Annex A
(informative)

Calculation of tangential load

A.1 Example of calculation of tangential load, F_{tan} , of bearing as fitted for bearings without flange

A.1.1 Technical data

Customer:

Part No.:

Engine type:

Bearing type: connecting rod bearing (without flange)

Bearing lining: **G-CuPb24Sn**
(see ISO 4383)

Housing material: steel

Housing diameter, D_H : 64 mm $+ \begin{smallmatrix} 0,019 \\ 0 \end{smallmatrix}$ mm

Wall thickness, s_3 : 1,990 mm to 2,000 mm

Steel thickness, s_1 : 1,5 mm

Bearing lining thickness, s_2 : $\approx 0,5$ mm

Bearing width, B : 25 mm

Checking load, F_{ch} : 4 500 N (method A)

A.1.2 Theoretical reduced bearing lining thickness equivalent to steel

Thicknesses, expressed in millimetres, for various alloys are calculated as given in Equations (A.1) to (A.3).

Steel/tin alloys:

$$s_{2,red} = s_2^1 \text{ (no reduction)} \tag{A.1}$$

Steel/copper alloys:

$$s_{2,red} = \frac{s_2}{2} \tag{A.2}$$

EXAMPLE $\frac{0,5}{2} = 0,25$

1) Not required for this example.

Steel/aluminium alloys:

$$s_{2,\text{red}} = \frac{s_2}{3} \quad (\text{A.3})$$

A.1.3 Effective cross-section, A_{eff}

The effective cross-section, A_{eff} , expressed in millimetres, is calculated using Equation (A.4):

$$A_{\text{eff}} = s_{3,\text{eff}} B \quad (\text{A.4})$$

where $s_{3,\text{eff}}$, expressed in millimetres, is the reduced wall thickness (i.e. $s_1 + s_{2,\text{red}}$), as given in Equation (A.5):

$$s_{3,\text{eff}} = 1,5 + 0,25 = 1,75 \text{ mm} \quad (\text{A.5})$$

Therefore, for an effective wall thickness of 1,75 mm,

$$A_{\text{eff}} = 1,75 \times 25 = 43,75 \text{ mm}^2$$

A.1.4 Elastic reduction, ν

The elastic reduction, ν , expressed in millimetres, is calculated using Equation (A.6):

$$\nu = \frac{D_H \times F_{\text{ch}}}{A_{\text{eff}}} \times 6 \times 10^{-6} = \frac{64 \times 4500}{43,75} \times 6 \times 10^{-6} = 0,039 \quad (\text{A.6})$$

A.1.5 Crush height, a

According to the drawing specification, $a = 0,040 \text{ mm}$ to $0,070 \text{ mm}$ ($a_{\text{min}} = 0,040 \text{ mm}$; $a_{\text{max}} = 0,070 \text{ mm}$).

Tolerance on crush height, T_a , is $0,030 \text{ mm}$.

A.1.6 Diametral deformation in compression, ε

NOTE If the diameter of the checking block bore is larger than the upper limit of the housing diameter, ε is increased by that difference.

The minimum diametral deformation in compression, ε_{min} , expressed in millimetres, is calculated using Equation (A.7):

$$\varepsilon_{\text{min}} = \frac{2}{\pi} (\nu + a_{\text{min}}) = \frac{2}{\pi} (0,039 + 0,040) = 0,05 \quad (\text{A.7})$$

The maximum diametral deformation in compression, ε_{max} , expressed in millimetres, is calculated using Equation (A.8):

$$\varepsilon_{\text{max}} = \frac{2}{\pi} \times T_a + (T_{\text{DH}} + \varepsilon_{\text{min}}) = \frac{2}{\pi} \times 0,030 + (0,019 + 0,050) = 0,088 \quad (\text{A.8})$$

where T_{DH} is the tolerance on the housing diameter D_H .

A.1.7 Tangential load, F_{tan}

$$\frac{s_{3, eff}}{D_H} = \frac{1,75}{64} = 0,027$$

(See Figure A.1.)

The stress, Φ , is derived from Figure A.1.

$$\Phi = 1,93 \times 10^5 \text{ N/mm}^2$$

Using this value derived for Φ , the minimum and maximum tangential strengths, expressed in newtons per square millimetre, can be calculated as given in Equations (A.9) and (A.10):

$$\sigma_{tan, min} = \frac{\Phi}{D_H} \times \varepsilon_{min} = \frac{1,93 \times 10^5}{64} \times 0,050 = 151 \tag{A.9}$$

$$\sigma_{tan, max} = \frac{\Phi}{D_H} \times \varepsilon_{max} = \frac{1,93 \times 10^5}{64} \times 0,088 = 265 \tag{A.10}$$

Thus, the median tangential load, \bar{F}_{tan} , expressed in newtons, for application in this example can be calculated as given in Equation (A.11):

$$\bar{F}_{tan} = \frac{\sigma_{tan, min} + \sigma_{tan, max}}{2} \times A_{eff} = \frac{151 + 265}{2} \times 43,75 = 9\ 100 \tag{A.11}$$

A.2 Example of calculation of tangential load, F_{tan} , of bearing as fitted for bearings with flange

A.2.1 Technical data

Customer:

Part No.:

Engine type:

Bearing type: main bearing (with flange)

Bearing lining: **G-CuPb24Sn**
(see ISO 4383)

Housing material: grey cast iron

Housing diameter, D_H : 110 mm $^{+0,022}_0$ mm

Wall thickness, s_3 : 3,455 mm $^{+0,015}_0$ mm

Steel thickness, s_1 : 3 mm

Bearing lining thickness, s_2 : $\approx 0,5$ mm

Steel thickness of flange, s_{fl} : 3 mm

Flange diameter, D_{fl} : 128 mm

Bearing width, B : 39,82 mm $- \begin{smallmatrix} 0 \\ 0,07 \end{smallmatrix}$ mm

Distance between flanges, a_{fl} : 33 mm $+ \begin{smallmatrix} 0,05 \\ 0 \end{smallmatrix}$ mm

Checking load, F_{ch} : 18 000 N (method A)

A.2.2 Theoretical reduced bearing lining thickness equivalent to steel

Thicknesses, expressed in millimetres, for various alloys are calculated as given in Equations (A.12) to (A.14).

Steel/lead alloys; steel/tin alloys

$$s_{2,red} = s_2 \quad (1) \text{ (no reduction)} \quad (\text{A.12})$$

Steel/copper alloys

$$s_{2,red} = \frac{s_2}{2} \quad (\text{A.13})$$

EXAMPLE $\frac{0,5}{2} = 0,25$

Steel/aluminium alloys

$$s_{2,red} = \frac{s_2}{3} \quad (1) \quad (\text{A.14})$$

A.2.3 Effective cross-section, A_{eff}

The effective cross-section, A_{eff} , expressed in square millimetres, is calculated using Equation (A.15):

$$A_{eff} = (s_{3,eff} \times B) + [s_{fl} (D_{fl} - D_H)] \quad (\text{A.15})$$

where $s_{3,eff}$, expressed in millimetres, is the reduced wall thickness (i.e. $s_1 + s_{2,red}$), as given in Equation (A.16):

$$s_{3,eff} = 3 + 0,25 = 3,25 \quad (\text{A.16})$$

Therefore, for an effective wall thickness of 3,25 mm,

$$A_{eff} = (3,25 \times 39,82) + [3 (128 - 110)] = 183,4 \text{ mm}^2$$

For the purposes of obtaining the stress, Φ , from Figure A.1, the effective wall thickness (bearing and flange), $s_{3,eff}$, expressed in millimetres, is calculated from Equation (A.17):

$$s_{3,eff} = \frac{A_{eff}}{a_{fl}} = \frac{183,4}{33} = 5,56 \quad (\text{A.17})$$

A.2.4 Elastic reduction, ν

The elastic reduction, ν , is calculated using Equation (A.18):

$$\nu = \frac{D_H \times F_{ch}}{A_{eff}} \times 6 \times 10^{-6} = \frac{110 \times 18000}{183,4} \times 6 \times 10^{-6} = 0,0648 \tag{A.18}$$

A.2.5 Crush height, a

According to the drawing specification, $a = 0,050$ mm to $0,080$ mm ($a_{min} = 0,050$ mm; $a_{max} = 0,080$ mm).

Tolerance on crush height, T_a , is $0,030$ mm.

A.2.6 Diametral deformation in compression, ε

NOTE If the diameter of the checking block bore is larger than the upper limit of the housing diameter, ε is increased by that difference.

The minimum diametral deformation in compression, ε_{min} , expressed in millimetres, is calculated using Equation (A.19):

$$\varepsilon_{min} = \frac{2}{\pi} (\nu + a_{min}) = \frac{2}{\pi} (0,065 + 0,050) = 0,073 \tag{A.19}$$

The maximum diametral deformation in compression, ε_{max} , expressed in millimetres, is calculated using Equation (A.20):

$$\varepsilon_{max} = \frac{2}{\pi} \times T_a + (T_{DH} + \varepsilon_{min}) = \frac{2}{\pi} \times 0,030 + (0,022 + 0,073) = 0,114 \tag{A.20}$$

where T_{DH} is the tolerance on the housing diameter, D_H .

A.2.7 Tangential load, F_{tan}

$$\frac{s_{3, \text{eff}}}{D_{\text{H}}} = \frac{5,56}{110} = 0,05$$

(See Figure A.1.)

The stress, ϕ , is derived from Figure A.1.

$$\phi = 1,75 \times 10^5 \text{ N/mm}^2$$

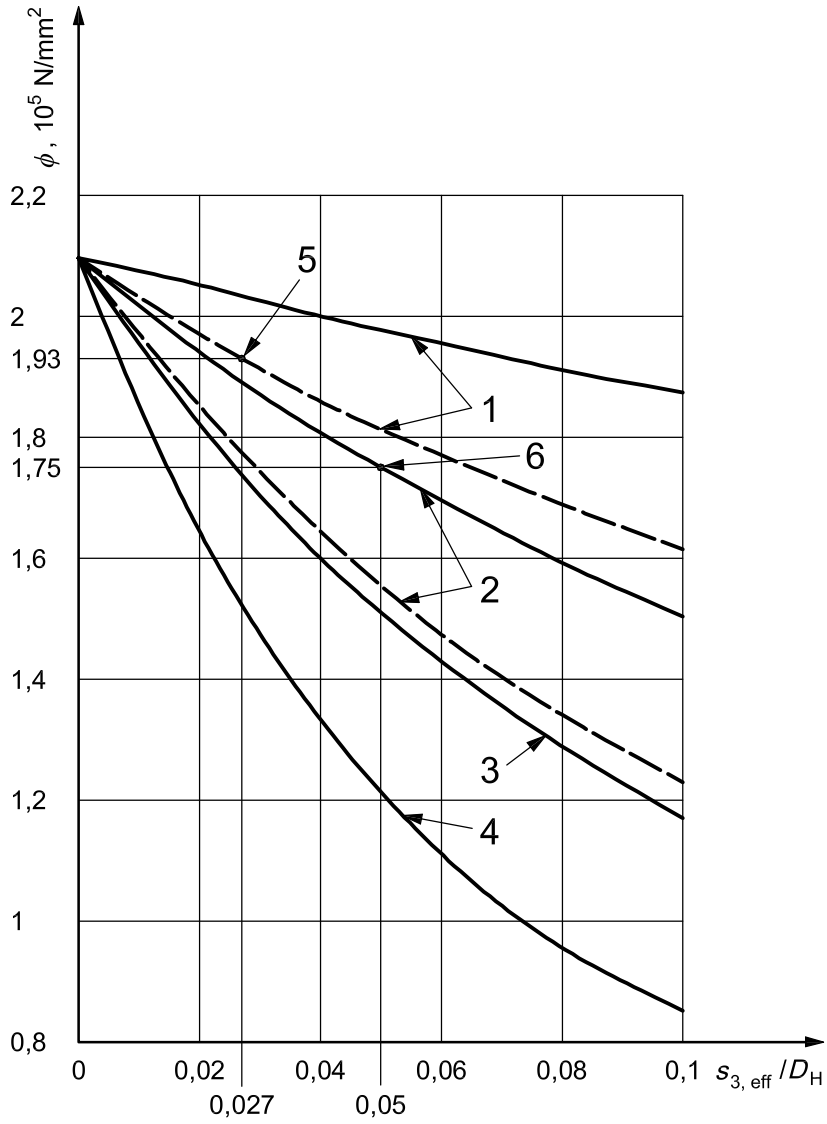
Using this derived value for ϕ , the minimum and maximum tangential strengths, expressed in newtons per square millimetre, can be calculated from Equations (A.21) and (A.22):

$$\sigma_{\text{tan,min}} = \frac{\phi}{D_{\text{H}}} \times \varepsilon_{\text{min}} = \left[\frac{1,75 \times 10^5}{110} \times 0,073 \right] = 116 \quad (\text{A.21})$$

$$\sigma_{\text{tan,max}} = \frac{\phi}{D_{\text{H}}} \times \varepsilon_{\text{max}} = \left[\frac{1,75 \times 10^5}{110} \times 0,114 \right] = 181 \quad (\text{A.22})$$

Thus, the median tangential load, \bar{F}_{tan} , expressed in newtons, for application in this example can be calculated as given in Equation (A.23):

$$\bar{F}_{\text{tan}} = \frac{\sigma_{\text{tan,min}} + \sigma_{\text{tan,max}}}{2} \times A_{\text{eff}} = \left[\frac{116 + 181}{2} \times 183,4 \right] = 27\,235 \quad (\text{A.23})$$



Key

rod bearing: - - - - -

main bearing: _____

- 1 steel
- 2 grey cast iron
- 3 aluminium
- 4 magnesium
- 5 example described in Clause A.1
- 6 example described in Clause A.2

Figure A.1

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