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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.

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.

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

(The draft International Standard was circulated under the number ISO/DIS 8259.)

Annexes A and B of this International Standard are for information only.

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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 bearing:

— metallic thin-walled half-bearings, as specified in ISO 3548;

— metallic thin-walled flanged bearings, as specified in ISO 6864;

— metallic thick-walled half-bearings (with and without flange) which are manufactured as halves but which are not necessarily interchangeable and have the ratio $s_{tot} : D_o \geqslant 0{,}11$;

— 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, as specified in ISO 4379;

— thermoplastic bushes (with and without flange) with inside diameters up to and including 200 mm;

— ring-type thrust washers and pressed bimetallic half-thrust washers, as specified in ISO 6525 and ISO 6526, respectively;

— plain bearings made from sintered material, as specified in ISO 2795.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 286-1 : 1988, *ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits.*

ISO 468 : 1982, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 1880 : 1979, *Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of progressive profile transformation — Profile recording instruments.*

ISO 2178 : 1982, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method.*

ISO 2795 : 1991, *Plain bearings — Sintered bushes — Dimensions and tolerances.*

ISO 3543 : 1981, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method.*

ISO 3547 : 1976, *Plain bearings — Wrapped bushes — Dimensions, tolerances and methods of checking.*

ISO 3548 : 1978, *Plain bearings — Thin-walled half bearings — Dimensions, tolerances and methods of checking.*

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

ISO 4379 : — [2], *Plain bearings — Copper alloy bushes.*

ISO 4384-1 : 1982, *Plain bearings — Hardness testing of bearing metals — Part 1: Compound materials.*

1) To be published. (Revision of ISO 4378-1 : 1983)
2) To be published. (Revision of ISO 4379 : 1978)

ISO 4384-2 : 1982, *Plain bearings — Hardness testing of bearing metals — Part 2: Solid materials.*

ISO 4386-1 : 1992, *Plain bearings — Metallic multilayer plain bearings — Part 1: Non-destructive ultrasonic testing of bond.*

ISO 4386-2 : 1982, *Plain bearings — Metallic multilayer plain bearings — Part 2: Destructive testing of bond for bearing metal layer thicknesses* ⩾ 2 mm.

ISO 4386-3 : 1992, *Plain bearings — Metallic multilayer plain bearings — Part 3: Non-destructive penetrant testing.*

ISO 6524 : 1983, *Plain bearings — Methods of dimensional control — Peripheral length checking of thin-walled half bearings.*

ISO 6525 : 1983, *Plain bearings — Ring type thrust washers made from strip — Dimensions and tolerances.*

ISO 6526 : 1983, *Plain bearings — Pressed bimetallic half thrust washers — Features and tolerances.*

ISO 6691 : 1989, *Thermoplastics for plain bearings — Classification and designation.*

ISO 6864 : 1984, Plain bearings — Thin-walled flanged half bearings — Dimensions, tolerances and methods of checking.

ISO 12306 : —[1], *Plain bearings — Measurement of wall thickness of thin-walled half-bearings and thin-walled unsplit or wrapped bushes.*

ISO 12307 : —[1], *Plain bearings — Checking the outside diameter of wrapped bushes.*

3 Definitions

For the purposes of this International Standard, the definitions of technical terms relating to plain bearings given in ISO 4378-1 and the following definitions of terms relating to quality and measurement apply.

3.1 quality of plain bearing: Condition which renders a plain bearing fit to fulfil given requirements. The given requirements are generally dependent upon the intended use.

3.2 quality control techniques: The 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: The uncertainty of measurement, u, can be calculated using the following formula:

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

where

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

σ is the standard deviation.

NOTE 1 The uncertainty of measurement is normally included in the tolerance given.

3.6 measuring points [lines]: Agreed points [lines] established to facilitate agreement on testing.

NOTE 2 The establishment of measuring points [lines] does not preclude the need to comply with dimensional specifications in other areas.

3.7 tolerance: Range of acceptable measurements between the upper specified limit and the lower specified limit.

4 Symbols and units

For the purposes of this International Standard, the symbols and units are as given in table 1.

Table 1

Symbol	Parameter	SI Unit
a	Crush height (nip)	mm
Δa	Measured change in a	mm
a_c	Distance between measuring lines	mm
a_E	Distance between gauge faces	mm
a_{fl}	Distance between flanges	mm
A_{eff}	Effective cross-section	mm^2
B	Width	mm
B_Δ	Joint displacement	mm
d_c	Diameter of the checking block bore	mm
d_H	Housing diameter	mm
D_{fl}	Flange diameter	mm
D_{fs}	Diameter measured across the joint in the free state; free spread diameter	mm
D_i	Inside diameter	mm
D_o	Outside diameter	mm
E_{red}	Elastic reduction	mm
F_c	Checking load	N
F_{pin}	Checking load (measuring pin)	N
F_{tan}	Tangential load of bearing as fitted	N
h_Δ	Joint face taper	mm
H	Height	mm
r	Repeatability	µm
s_1	Steel thickness	mm
s_2	Bearing lining thickness	mm
$s_{2,\,red}$	Bearing lining thickness, reduced	mm
s_{fl}	Flange thickness	mm

1) To be published.

Table 1 (*concluded*)

Symbol	Parameter	SI Unit
s_{tot}	Wall thickness (total)	mm
T	Tolerance	mm
u	Uncertainty of measurement	mm
$x_1, x_2, \ldots, x_i$	Individual measured values	mm
ε_{max}	Maximum deformation in compression	mm
ε_{min}	Minimum deformation in compression	mm
σ_{tan}	Tangential strength	N/mm^2
Φ	Stress	N/mm^2

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 a guide 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 which, from their points of view, are required to assure reliability and lifetime of the product.

NOTE 3 A key explaining the meaning of signs used in table 2 is provided at the bottom of the table.

Table 2

Relevant clause/ sub-clause No.	Quality characteristic	Type of plain bearing						
		Thin-walled half-bearing	Thick-walled half-bearing	Wrapped bush	Unsplit metallic bush	Thermo-plastic bush	Sintered bush	Thrust washer (ring and half)
6	**Geometrical quality characteristics**							
6.1	Wall thickness, s_{tot}							
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 distibution 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 (*concluded*)

Relevant clause/ sub-clause No.	Quality characteristic	Type of plain bearing						
		Thin-walled half-bearing	Thick-walled half-bearing	Wrapped bush	Unsplit metallic bush	Thermo-plastic bush	Sintered bush	Thrust washer (ring and half)
7	**Material quality characteristics**							
7.1	Metallic solid material							
7.1.1	Hardness	–	+	–	+	–	–	–
7.1.2	Material composition	–	+	–	+	–	–	–
7.1.3	Material structure	–	+	–	+	–	–	–
7.2	Multilayer metallic 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	Plastic 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	Thermoplastic material (solid)							
7.4.1	Material composition	–	–	–	–	+	–	–
7.4.2	Material structure	–	–	–	–	+	–	–
7.5	Sintered material							
7.5.1	Material composition	–	–	–	–	–	+	–
7.5.2	Material structure	–	–	–	–	–	+	–

Key

Plus sign indicates that the characteristic is generally applicable to all types of bearings.

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

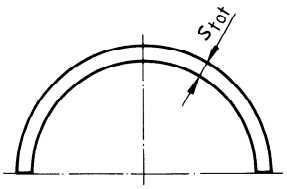
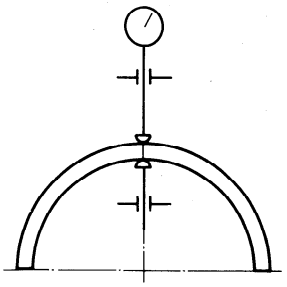
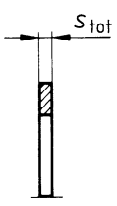
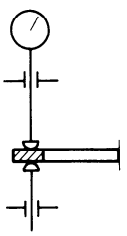
In order to assess plain bearing quality, important dimensional quality characteristics are specified in this clause.

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

6.1 Wall thickness, s_{tot}

See table 3.

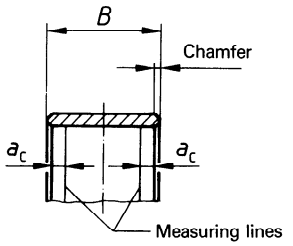
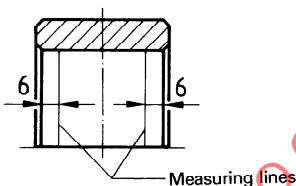
Table 3

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thin-walled half-bearing	See figure 1 and ISO 12306.  **Figure 1**	In accordance with ISO 12306. (See figure 2.) NOTE — This test method is also applicable when measuring joint face bore relief.  **Figure 2**	Device for measuring wall thickness (see also ISO 12306).
Metallic thick-walled half-bearing	See figure 1 and ISO 12306.	Measured normal to the back surface in the radial direction using the spherical faces of the measuring pins, in accordance with ISO 12306. (See figure 2.)	Device for measuring wall thickness.
Wrapped bush	See figure 1 and ISO 12306.	In accordance with ISO 12306. (See figure 2.) NOTE — Depending on the manufacturing process, the back of the wrapped bush may show slight hollows. The wall thickness shall, therefore, be measured outside these hollows, i.e. on the "bearing areas" (see ISO 3547). 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 also ISO 12306).
Unsplit metallic bush	See figure 1 and ISO 12306.	In accordance with ISO 12306. (See figure 2.) NOTE — The wall thickness may also be determined by obtaining the difference between the outside and inside diameters ($D_o - D_i$) (see 6.2 and 6.3).	Device for measuring wall thickness (see also ISO 12306).
Thermoplastic bush	See figure 1 and ISO 12306.	In accordance with ISO 12306. (See figure 2.)	Device for measuring wall thickness.
Sintered bush	See figure 1 and ISO 12306.	In accordance with ISO 12306. (See figure 2.)	Device for measuring wall thickness (see also ISO 12306).
Thrust washer	Axial distance between the two faces of the washer (see figure 3).  **Figure 3**	Measured parallel to the axial direction using the spherical faces of the measuring pins (see figure 4).  **Figure 4**	Device for measuring wall thickness.

6.1.1 Line measurement (wall thickness)

See table 4.

Table 4

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thin-walled half-bearing; wrapped bush; unsplit metallic bush	See figure 5 and ISO 12306. NOTE — The distance a_c between the measuring lines is measured from the edge of the sliding surface.  **Figure 5**	The thickness of the half-bearing or bush is measured continuously on one, two or three predetermined or agreed measuring lines, in accordance with ISO 12306. (See figure 5.) NOTE — The defined position of the measuring lines may have to be modified to avoid design features such as grooves, etc.	Device for measuring wall thickness (see also ISO 12306).
Metallic thick-walled half-bearing	See figure 6 and ISO 12306. NOTE — The distance a_c between the measuring lines (a_c = 6) is measured from the edge of the sliding surface.  **Figure 6**	The thickness of the half-bearing is measured continuously on two predetermined or agreed measuring lines, in accordance with ISO 12306. (See figure 6.) NOTES 1 In the case where s_{tot} > 25, the test method shall be subject to agreement between the manufacturer and user. 2 The defined position of the measuring lines may have to be modified to avoid design features such as grooves, etc.	Device for measuring wall thickness; for details see the following table.

Wall thickness s_{tot}	Checking load (measuring pin) F_{pin} N	Uncertainty of measurement	Radius of measuring anvil
$s_{tot} \leqslant 10$	$0{,}8 < F_{pin} < 1{,}5$	±0,001 5	3 ± 0,2
$10 < s_{tot} \leqslant 25$	$1{,}5 < F_{pin} \leqslant 2{,}5$	±0,002	

Table 4 (*concluded*)

<table>
<tr><th>Applicability</th><th>Definition of geometrical characteristic to be measured</th><th>Test method/measuring principle</th><th>Test equipment</th></tr>
<tr><td>Thermoplastic bush</td><td>See figure 7 and ISO 12306.

NOTE — The distance a_c between the measuring lines (a_c = 1,5) is measured from the edge of the sliding surface.

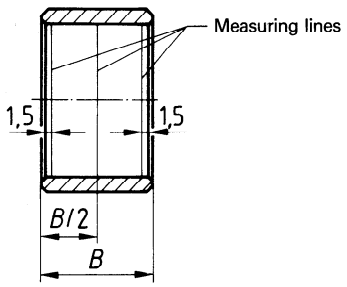
 

Figure 7</td><td>The thickness of the bush is measured continuously on one, two or three predetermined or agreed measuring lines, in accordance with ISO 12306. (See figure 7.)

NOTE — The defined position of the measuring lines may have to be modified to avoid design features such as grooves, etc.</td><td>Device for measuring wall thickness; for details see the following table.

<table>
<tr><th>Outside diameter D_o</th><th>Checking load (measuring pin) F_{pin} N</th><th>Radius of measuring anvil</th><th>Uncertainty of measurement</th></tr>
<tr><td>$D_o \leqslant 150$</td><td>$0,8 \leqslant F_{pin} \leqslant 1,5$</td><td>$3 \pm 0,2$</td><td rowspan="2">$\pm 0,005$</td></tr>
<tr><td>$150 < D_o \leqslant 300$</td><td>$1,5 < F_{pin} \leqslant 2,5$</td><td>$5 \pm 0,2$</td></tr>
</table>
</td></tr>
</table>

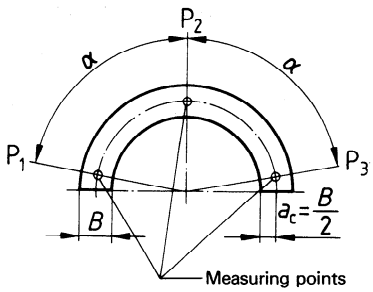
6.1.2 **Point measurement** (wall thickness)

See table 5.

Table 5

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thin-walled half-bearing; wrapped bush; unsplit metallic bush	Wall thickness measured at determined measuring points (see ISO 12306).	In accordance with ISO 12306. NOTE — The defined position of the measuring points may have to be modified to avoid design features such as grooves, etc.	Device for measuring wall thickness (see also ISO 12306).
Metallic thick-walled half-bearing	Wall thickness measured at determined measuring points which are subject to agreement between the manufacturer and user.	In accordance with ISO 12306. NOTE — The defined position of the measuring points may have to be modified to avoid design features such as grooves, etc.	External micrometer with dial indicator.
Thermoplastic bush; sintered bush	Wall thickness measured at determined measuring points (see ISO 12306).	In accordance with ISO 12306. NOTE — The defined position of the measuring points may have to be modified to avoid design features such as grooves, etc.	External micrometer with dial indicator. Device for measuring wall thickness (see also ISO 12306).

Table 5 (*concluded*)

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thrust washer	Wall thickness measured at determined measuring points (P) on measuring lines at a distance a_c from the inside diameter of the washers, as shown in figure 8.  Thrust half-washers: $\alpha = 80°$ Thrust washers: $\alpha = 120°$ **Figure 8**	The thrust washer is measured at measuring points positioned as shown in figure 8. NOTE — The defined position of the measuring points may have to be modified to avoid design features such as grooves, etc.	External micrometer with dial indicator. Device for measuring wall thickness; for details see the following table. **Checking load (measuring pin) F_{pin} N** / **Radius of measuring anvil** / **Uncertainty of measurement** $0,8 \leqslant F_{pin} \leqslant 1,5$ / 3 ±0,2 / ±10 % of tolerance

6.2 Outside diameter, D_o

See table 6.

Table 6

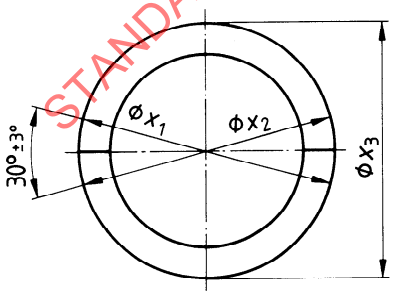
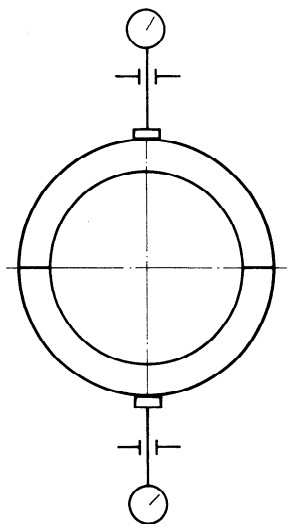
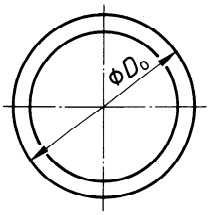
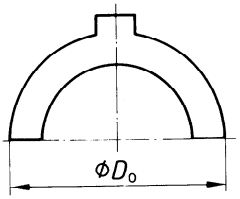
Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thick-walled half-bearing	Outside diameter of a metallic thick-walled half-bearing measured as a pair in the free condition, determined using the following formula: $D_o = \frac{x_3 + 0,5(x_1 + x_2)}{2}$  **Figure 9**	Measured in the radial direction between two flat parallel faces of the measuring device (see figure 10).  **Figure 10**	Measuring device. Holding device. Uncertainty of measurement: ±10 % of the tolerance on outside diameter.
Wrapped bush	See ISO 12307.	In accordance with ISO 12307.	In accordance with ISO 12307.

Table 6 (*concluded*)

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Unsplit metallic bush; thermoplastic bush; sintered bush	Outside diameter of a bush measured in the free condition, determined as the arithmetic mean of at least two measurements (see figure 11).  **Figure 11**	Measured in the radial direction between two flat parallel faces of the measuring device (see figure 10). NOTE — In cases where the wall thickness outside diameter ratio is such that the bush may be considered to be flexible, D_0 may be measured in accordance with method A specified in ISO 12307 for wrapped bushes.	Measuring device. External micrometer with dial indicator. Holding device. Uncertainty of measurement: ± 10 % of tolerance on outside diameter.
Thrust washer	Outside diameter of a thrust washer measured in the free condition over the outside end faces (see figure 12).  **Figure 12**	Measured in the radial direction between two flat parallel faces of the measuring device. NOTE — Measuring method should take account of design features such as chamfers.	Standard test equipment. Uncertainty of measurement: ± 10 % of tolerance on outside diameter.

6.3 Inside diameter, D_i

See table 7.

Table 7

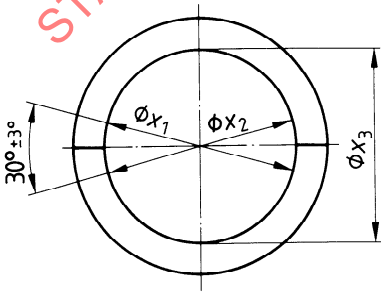
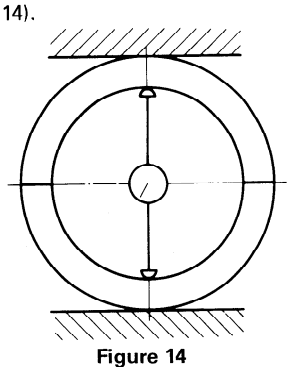
Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thick-walled half-bearing	Inside diameter of a metallic thick-walled half-bearing with cylindrical bore measured as a pair in the free condition, determined using the following formula: $D_i = \frac{x_3 + 0{,}5(x_1 + x_2)}{2}$  **Figure 13**	Measured in the radial direction using the spherical faces of the measuring pins (see figure 14).  **Figure 14** NOTES 1 The inside diameter may also be determined by calculating the difference between the outside diameter and the wall thickness ($D_o - s_{tot}$) (see 6.1 and 6.2). 2 The defined position of the measuring areas may have to be modified to avoid design features such as oil pockets, etc.	Measuring device, such as an internal two-point contact measuring instrument with a contact radius of 3 ± 0,2. Holding device. Uncertainty of measurement: ± 10 % of the tolerance on inside diameter.

Table 7 (*continued*)

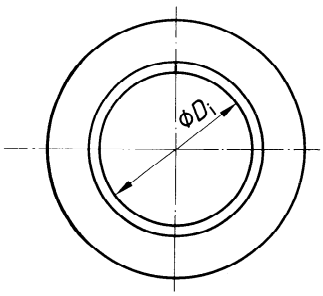
<table>
<tr><th>Applicability</th><th>Definition of geometrical characteristic to be measured</th><th>Test method/measuring principle</th><th>Test equipment</th></tr>
<tr><td>Wrapped bush</td><td>Inside diameter of a wrapped bush measured in pressed-in position (see figure 15).
 

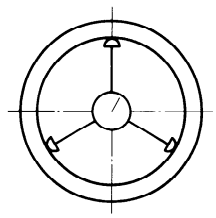
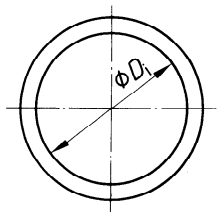
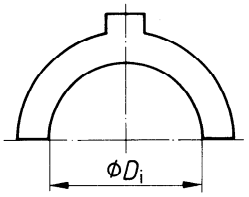
Figure 15</td><td>Measured in the radial direction using the spherical faces of the measuring pins (see figure 16).
NOTE — The inside diameter may also be determined by calculating the difference between the outside diameter and the wall thickness ($D_o - s_{tot}$) (see 6.1 and 6.2).
 
Figure 16</td><td>Bore gauge (two- or three-point contact) with setting gauge.
Air gauge with setting gauge.
Measuring device in accordance with ISO 12306 and ISO 12307.
For details of the measuring device, see the following table.
<table><tr><th>Inside diameter D_i</th><th>Radius for contact method</th><th>Uncertainty of measurement</th></tr><tr><td>$D_i \leqslant 15$</td><td>To be agreed</td><td rowspan="2">± 10 % of tolerance on inside diameter</td></tr><tr><td>$15 < D_i \leqslant 200$</td><td>3 ± 0,2</td></tr></table></td></tr>
<tr><td>Unsplit metallic bush; sintered bush</td><td>Inside diameter of a bush measured in the free condition, determined as the arithmetic mean of at least two measurements (see figure 17).
 

Figure 17</td><td>Measured in the radial direction using the spherical faces of the measuring pins (see figure 16).</td><td>Bore gauge (two- or three-point contact) with setting gauge.
Air gauge with setting gauge.
Plug gauge.
For details of the measuring device, see table for wrapped bush.</td></tr>
<tr><td>Thermoplastic bush</td><td>Inside diameter of a bush measured in the pressed-in condition, determined as the arithmetic mean of at least two measurements (see figure 15).</td><td>Measured in the radial direction using the spherical faces of the measuring pins (see figure 16).
NOTES
1 The bush is pressed into two ring gauges in succession, one of which corresponds to the maximum dimension and the other to the minimum dimension of the agreed tolerance zone of the location hole. When pressed into the ring gauge with the minimum dimension, the inner diameter of the bush shall not be less than the lower limit. When pressed into the ring gauge with the maximum dimension, the inner diameter of the bush shall not exceed the upper limit.
2 In the case of bushes with two flanges, the measurement is carried out, for example, by using split-ring gauges.</td><td>Bore gauge (two- or three-point contact) with setting gauge.
Air gauge with setting gauge.
Ring gauge.
For details of the measuring device, see table for wrapped bush.
NOTE — The use of measuring instruments which are also capable of measuring shapes of bush bores which 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 ±1/2 IT3, in accordance with ISO 286-1.</td></tr>
</table>

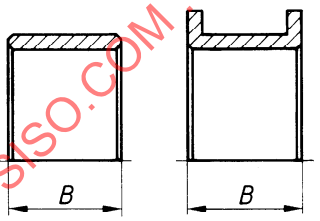
Table 7 (*concluded*)

Applicability	Definition of geometrical characteristic to be measured	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 18).  **Figure 18**	Measured in the radial direction. NOTE — Measuring method should take account of design features such as chamfers.	Standard test equipment. Uncertainty of measurement: ± 10 % of tolerance on inside diameter.

6.4 Width, B

See table 8.

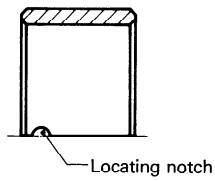
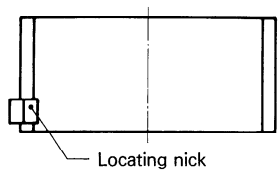
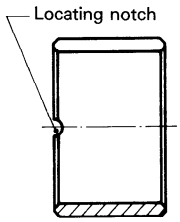
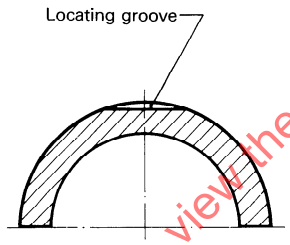
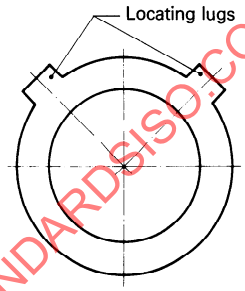
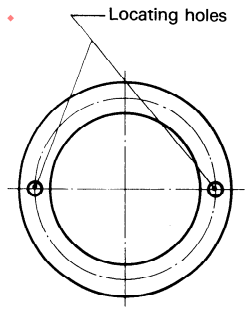
Table 8

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; thermoplastic bush; sintered bush	Width between the end faces measured at any point in the axial direction (see figure 19).  **Figure 19**	Measured between two flat parallel faces of a measuring device. NOTE — 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. Uncertainty of measurement: ± 10 % of tolerance on length.

6.5 Locating features

See table 9.

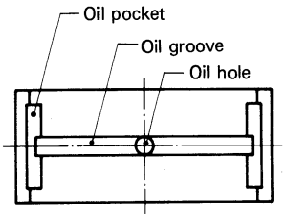
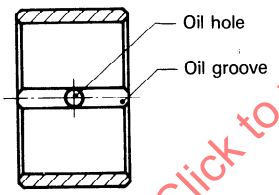
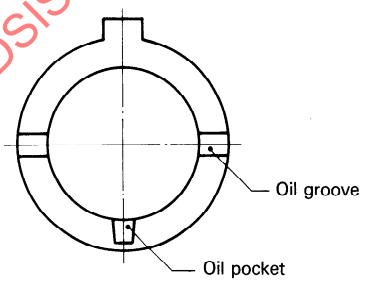
Table 9

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; thermoplastic bush; thrust washer	Element which locates the half-bearing, bush and thrust washer (see examples in figures 20 to 25).  **Figure 20**  **Figure 21**  **Figure 22**  **Figure 23**  **Figure 24**  **Figure 25**	Standard measuring methods.	Measuring device. Standard test equipment. Uncertainty of measurement: ± 10 % of the tolerance. Gauge.

6.6 Lubricant feed and distribution features

See table 10.

Table 10

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; thermoplastic bush; thrust washer	Element of lubricant feed and distribution features of half-bearing, bush and thrust washer (see examples in figures 26 to 28; for more details see ISO 3547, ISO 3548, ISO 6525 and ISO 6526).  **Figure 26**  **Figure 27**  **Figure 28**	Standard measuring methods.	Measuring device. Standard test equipment. Uncertainty of measurement: ± 10 % of the tolerance. Gauge.

6.7 Surface conditions

See table 11.

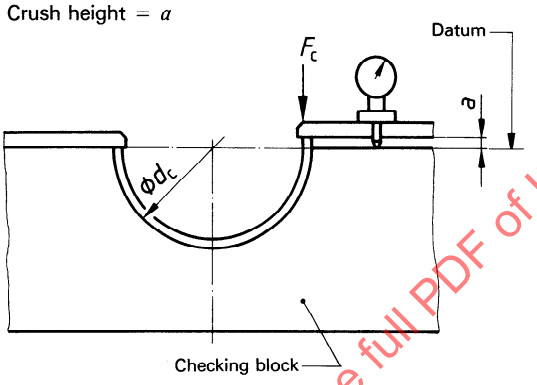
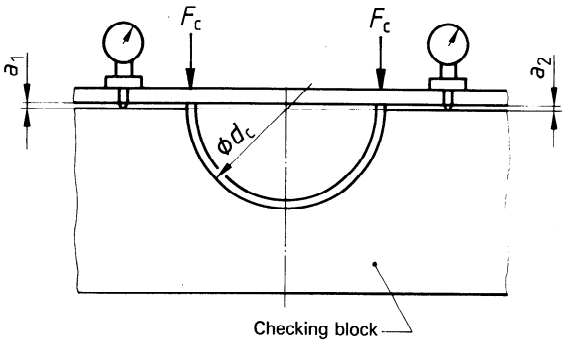
Table 11

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; thermoplastic bush; thrust washer	Surface roughness as defined in ISO 468.	Test method in accordance with ISO 468.	Standard test equipment. Radius of measuring area, as specified in ISO 1880: 0,005 ± 0,001 cut-off: 0,8. NOTE — In critical cases, reference area testing system should be used.
	Surface defects caused during manufacture and subsequent handling. NOTE — 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. Binocular viewers. Microscope. Roughness tester. Profilometer.

6.8 Crush height, a (peripheral length)

See table 12.

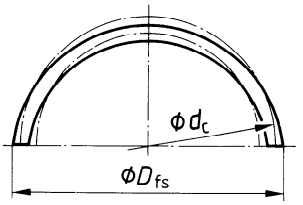
Table 12

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled half-bearing	a) Peripheral length: The circumferential length which runs from one joint face to the other. b) Crush height: The size a by which a half-bearing fitted in a checking block of bore diameter d_c under a predetermined checking load F_c exceeds the defined peripheral length of the checking block bore (see figure 29). NOTE — In practice, the datum serves as a basis for measuring a (see figure 29).	Test method shall be in accordance with ISO 6524. **Method A** For $D_o \leqslant 200$ Crush height = a  **Figure 29** **Method B** For $D_o > 200$ In cases where $D_o > 500$, the test method shall be subject to agreement between the manufacturer and user. The checking load F_c shall be applied to each joint face. Crush height = $a_1 + a_2$  **Figure 30**	For details relating to device for measuring crush height, see ISO 6524.

6.9 Free spread

See table 13.

Table 13

<table>
<tr><th>Applicability</th><th>Definition of geometrical characteristic to be measured</th><th>Test method/measuring principle</th><th>Test equipment</th></tr>
<tr>
<td>Thin-walled and thick-walled half-bearing</td>
<td>Length by which the free dimension D_{fs} of a half-bearing measured over the middle of the joint faces exceeds the diameter d_c (see figure 31).
 

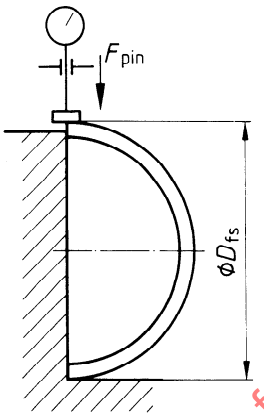
Free spread = $D_{fs} - d_c$
Figure 31</td>
<td>Measured parallel to the radial direction (see figure 32).
 

Figure 32</td>
<td>External micrometer.

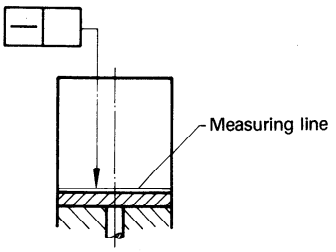
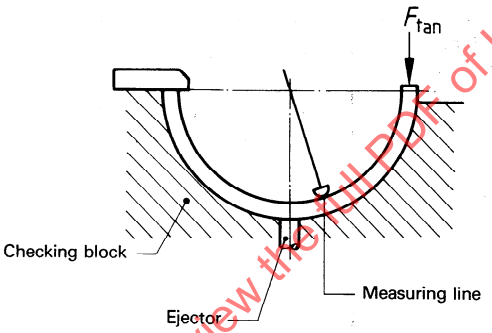
Device for measuring free spread. Details relating to device for measuring free spread are as follows:

a) for metallic thin-walled half-bearing, see the following table.
<table>
<tr><th>Outside diameter D_o</th><th>Checking load (measuring pin) F_{pin} N</th><th>Uncertainty of measurement</th></tr>
<tr><td>$D_o \leqslant 150$</td><td>$0,8 \leqslant F_{pin} \leqslant 1,5$</td><td>±0,007</td></tr>
<tr><td>$150 < D_o \leqslant 500$</td><td>$1,5 < F_{pin} \leqslant 2,5$</td><td>±0,013</td></tr>
</table>
b) for metallic thick-walled half-bearing, see the following table.
<table>
<tr><th>Outside diameter D_o</th><th>Checking load (measuring pin) F_{pin} N</th><th>Uncertainty of measurement</th></tr>
<tr><td>$D_o \leqslant 325$*)</td><td>2,5 max.</td><td>±0,012</td></tr>
<tr><td colspan="3">*) In the case where $D_o > 325$, the test equipment shall be subject to agreement between the manufacturer and user.</td></tr>
</table>
</td>
</tr>
</table>

6.10 Straightness of sliding surface

See table 14.

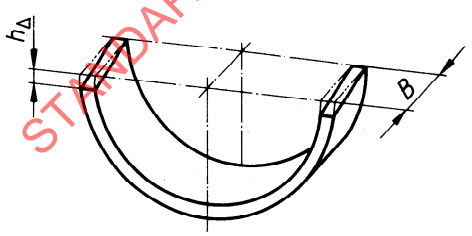
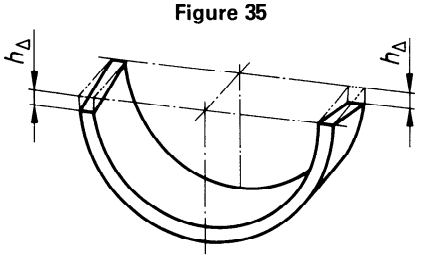
Table 14

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled half-bearing	Straightness of sliding surface measured in the axial direction (see figure 33).  Figure 33	Principal standard dimensional measuring methods (see figure 34). NOTES 1 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. 2 If an ejector pin is used, the measuring line should be 3 to 5 away from the edge of the pin. The measurement is made under a tangential load simulating general conditions of use. 3 See annex A for the calculation of tangential load, F_{tan}.  Figure 34	Device for measuring crush height. Checking block. Device for measuring straightness.

6.11 Joint face taper, h_Δ

See table 15.

Table 15

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled half-bearing	Deviation of the joint faces in the axial direction (see figures 35 and 36).  Figure 35  Figure 36	Test method shall be subject to agreement between the manufacturer and user.	Test equipment shall be subject to agreement between the manufacturer and user.

6.12 Back contact

See table 16.

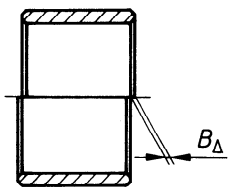
Table 16

Applicability	Definition of geometrical characteristic to be measured	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_c.	Visual assessment.	Device for measuring crush height. Checking block. Blueing (transfer dye).

6.13 Joint displacement, B_Δ

See table 17.

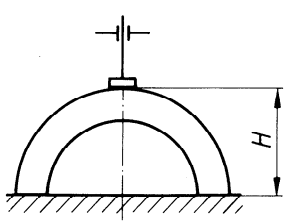
Table 17

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Wrapped bush	Displacement between the ends of the joint faces in the axial direction (see figure 37).  **Figure 37**	Test method shall be subject to agreement between the manufacturer and user.	Standard test equipment. Uncertainty of measurement: ±10 % of tolerance on length.

6.14 Height of thrust half-washer, H

See table 18.

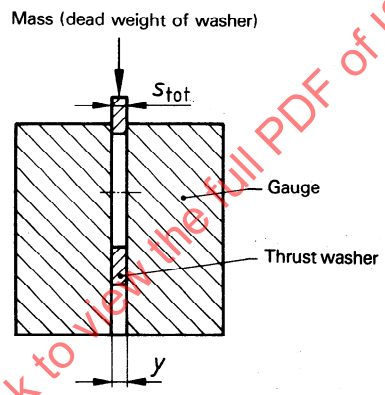
Table 18

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thrust washer	Height of the thrust half-washer above the parting line in the free condition (see figure 38).  **Figure 38**	Measured normal to the parting line between two flat parallel faces of the measuring device.	Measuring device. Uncertainty of measurement: ±10 % tolerance of height.

6.15 Flatness

See table 19.

Table 19

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thrust washer	Flatness of two faces with respect to each other.	Measured between two flat parallel faces of a gauge, having a defined distance y between the gauge faces (see figure 39). The washers shall fall through the gauge under their dead weight, i.e. without any further load being applied. NOTE — This test method is restricted by the mass, outside diameter and wall thickness of the washer.  **Figure 39**	Gauge.

6.16 Flange diameter, D_{fl}

See table 20.

Table 20

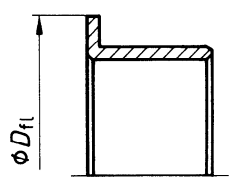
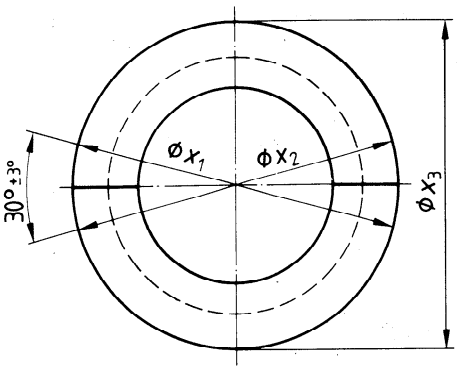
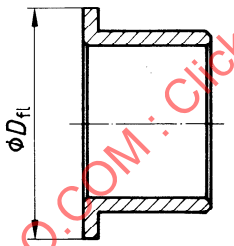
Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thin-walled half-bearing	Flange diameter of the half-bearing across the flange, without free spread (see figures 40 and 41).  **Figure 40**	Measured normal to the parting line between two flat parallel faces of the measuring instrument.	Standard test equipment. Uncertainty of measurement: ± 10 % of tolerance on flange diameter.

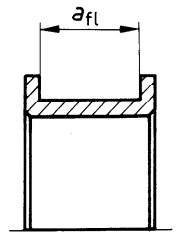
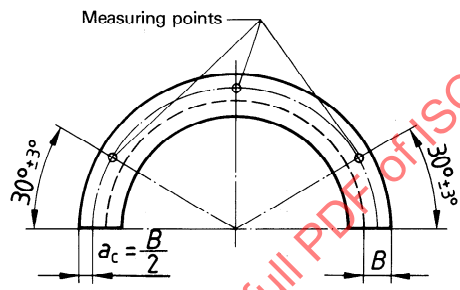
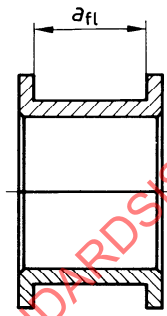
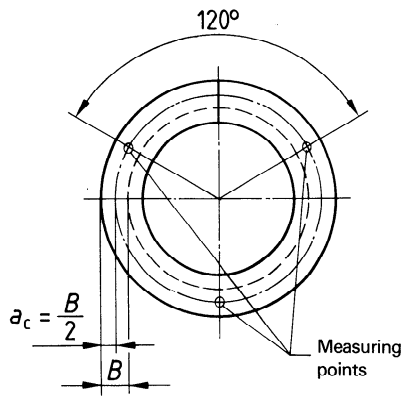
Table 20 (*concluded*)

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	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 the following formula: $D_{fl} = \frac{x_3 + 0{,}5(x_1 + x_2)}{2}$  **Figure 41**	Measured in the radial direction between two flat parallel faces of the measuring instrument.	Standard test equipment. Uncertainty of measurement: ± 10 % of tolerance on flange diameter.
Wrapped bush; unsplit metallic bush; thermoplastic bush; sintered bush	Diameter of the bush measured at the flange (see figure 42).  **Figure 42**	Measured in the radial direction between two flat parallel faces of the measuring instrument.	Standard test equipment. Uncertainty of measurement: ± 10 % of tolerance on flange diameter.

6.17 Distance between flanges, a_{fl}

See table 21.

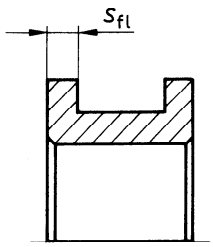
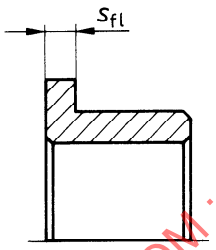
Table 21

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Metallic thin-walled and thick-walled half-bearings	Distance between the flanges in the axial direction (see figure 43).  **Figure 43**	Measured in the axial direction between two flat parallel faces. Other methods may be agreed between the manufacturer and user. However, measurement shall be made at the measuring points indicated in figure 44.  **Figure 44**	Gap gauge. Two-point internal micrometer. Standard test equipment. Uncertainty of measurement: ± 10 % tolerance on distance between flanges.
Wrapped bush; unsplit metallic bush; thermoplastic bush	Distance between the flanges in the axial direction (see figure 45).  **Figure 45**	Measured in the axial direction between two flat parallel faces. Other methods may be agreed between the manufacturer and user. However, measurements shall be made at the measuring points indicated in figure 46.  **Figure 46**	Gap gauge. Two-point internal micrometer. Standard test equipment. Uncertainty of measurement: ± 10 % tolerance on distance between flanges.

6.18 Flange thickness, s_{fl}

See table 22.

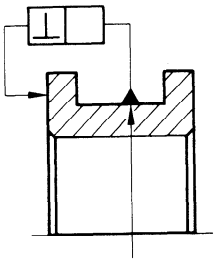
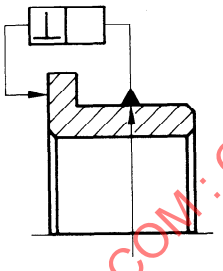
Table 22

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; thermo-plastic bush; sintered bush	Thickness in the axial direction between end face and inside face of the flange (see figures 47 and 48).  **Figure 47**  **Figure 48**	Standard measuring methods. Measuring points as shown in figure 44 (half-bearing) and figure 46 (bush). NOTE — If oil grooves or oil pockets are positioned in the area of the three determined measuring points, alternative measuring points should be agreed.	Measuring device. External micrometer with a sherical contact radius of 3 ± 0,2. Uncertainty of measurement: ± 10 % of tolerance on flange thickness.

6.19 Perpendicularity (squareness) of flange

See table 23.

Table 23

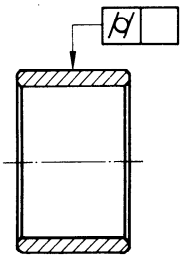
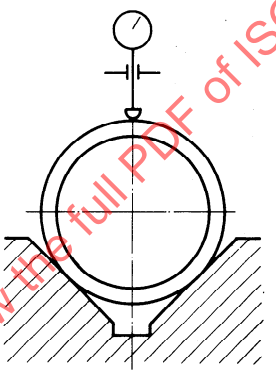
Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thin-walled and thick-walled half-bearing; wrapped bush; unsplit metallic bush; thermoplastic bush; sintered bush	Perpendicularity of flange with reference to the axis (datum axis) of the outside diameter of the half-bearing or bush (see figures 49 and 50). NOTE — The datum for a sintered bush is usually the sliding surface.  **Figure 49**  **Figure 50**	Test method shall be subject to agreement between the manufacturer and user.	Test equipment shall be subject to agreement between the manufacturer and user.

6.20 Geometric deviations

6.20.1 Cylindricity

See table 24.

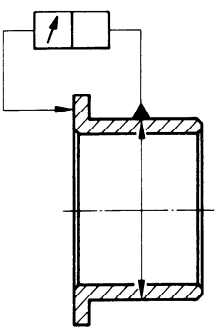
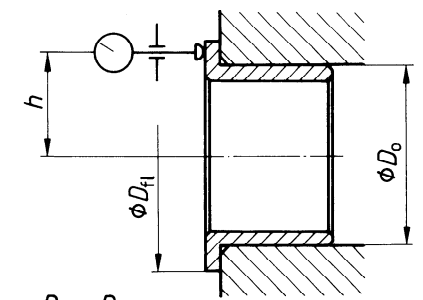
Table 24

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Unsplit metallic bush	Cylindricity of the backing in the axial direction (see figure 51).  **Figure 51**	Cylindricity measured by rotating the bush (see figure 52). NOTES 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. 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).  **Figure 52**	Measuring device. Indicator and V-block. For the radius of the measuring anvil, see the table concerning the thermoplastic bush in table 4. Uncertainty of measurement: ± 10 % of tolerance on cylindricity.

6.20.2 Run-out of thrust face

See table 25.

Table 25

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Unsplit metallic bush; thermoplastic bush; sintered bush	Circular run-out of thrust face with reference to the axis of the outside diameter (datum axis) of the bush (see figure 53). NOTE — The datum for a sintered bush is usually the sliding surface.  **Figure 53**	Circular run-out of thrust face measured at distance h from the axis (see figure 54).  $h = \frac{D_{fl} + D_o}{4}$ **Figure 54**	Measuring device. Standard test equipment. Uncertainty of measurement ± 10 % of the tolerance on thrust accuracy.

6.20.3 Coaxiality and concentricity

See table 26.

Table 26

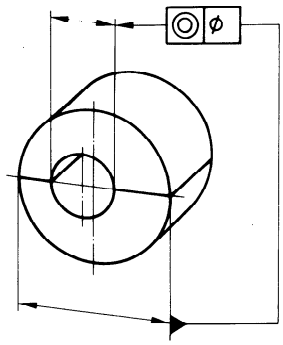
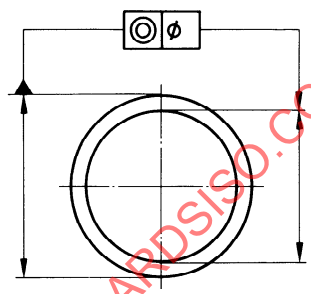
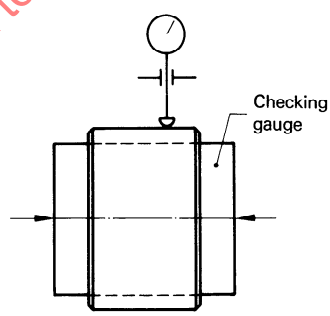
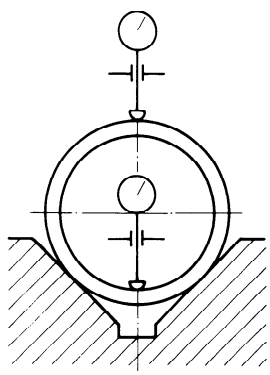
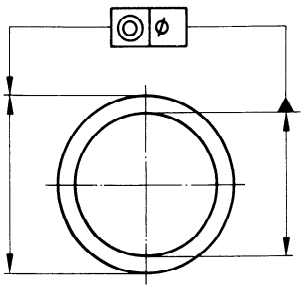
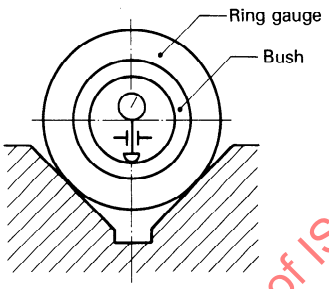
Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thick-walled half-bearing	Coincidence of the axes of the inside and outside diameters of the bearing (see figure 55).  **Figure 55**	Test method shall be subject to agreement between the manufacturer and user. NOTE — When the wall thickness is checked, deviations of coaxiality and concentricity should remain within the tolerance on the wall thickness.	Test equipment shall be subject to agreement between the manufacturer and user.
Unsplit metallic bush; sintered bush	Coincidence of the axes of the inside and outside diameters of the bush (see figure 56). NOTE — Both the inside and outside diameters may be considered as alternative datum axes.  **Figure 56**	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 figures 57 and 58).  **Figure 57**  **Figure 58**	Test equipment. Uncertainty of measurement: ± 10 % of tolerance on position. The concentricity of the checking gauge shall be less than 10 % of the tolerance on the concentricity of the bush.

Table 26 (*concluded*)

Applicability	Definition of geometrical characteristic to be measured	Test method/measuring principle	Test equipment
Thermoplastic bush	Coincidence of the axes of the inside and outside diameters of the bush (see figure 59).  **Figure 59**	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 thermoplastic bush (see figure 60).  **Figure 60**	Measuring device with ring gauge (the bush is inserted in the ring gauge). Radius of measuring anvil: 3 ± 0,2. Uncertainty of measurement: ± 10 % of tolerance on position. The concentricity of the ring gauge shall be less than 10 % of the tolerance on the concentricity of the bush.

7 Material quality characteristics

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

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 61 for the purposes of illustrating the various layers and their properties to be considered in this clause.

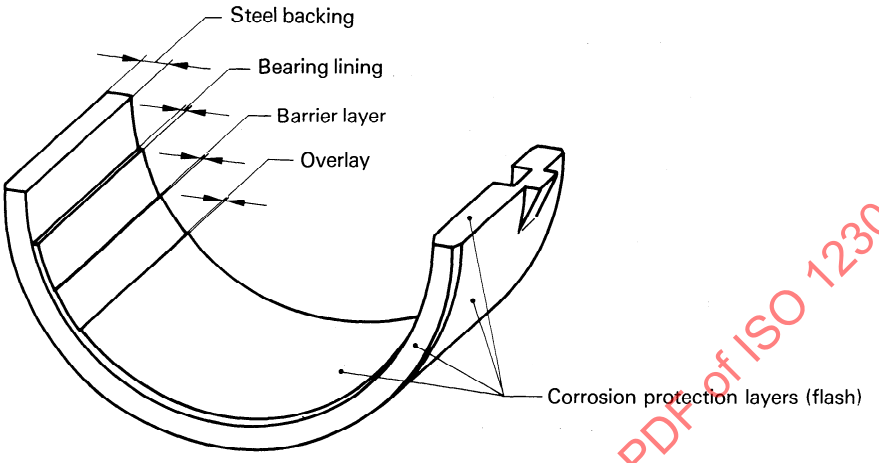


Figure 61

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 shall 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	Hardness testing shall be in accordance with ISO 4384-1.	Micro-hardness test apparatus.
7.2.2	**Lining properties**		
7.2.2.1	Lining thickness	Magnetic method shall 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 to standards shall be subject to agreement between the manufacturer and user.	Microscope.

Table 28 (*concluded*)

Material quality characteristic		Test method/measuring principle	Test equipment
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.
7.2.4	**Adhesion (bond) of adjacent layers**		
7.2.4.1	Adhesion (bond) of lining to backing	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. 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. Tests which may be used include the following. a) For lining thickness < 2 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. b) For lining thickness $\geqslant 2$ 1) tests 1) to 5) above may be used; 2) non-destructive qualitative ultrasonic test in accordance with ISO 4386-1 for lead/tin alloy linings; NOTE — Lack of bond at the edge of lined areas may be detected visually or with the aid of dye penetrants. 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.	As appropriate.
7.2.4.2	Adhesion of overlay to lining	There is no single established test for overlay adhesion. Qualitative tests used by manufacturers and users are generally destructive and include the "adhesive tape" test.	As appropriate.

7.3 Plastic 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	Micro-section.	—
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 to standard 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.

Table 29 (*concluded*)

Material quality characteristic		Test method/measuring principle	Test equipment
7.3.4	**Adhesion (bond) of adjacent layers**		
7.3.4.1	Adhesion (bond) of lining to backing	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. 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. Tests which may be used include the following: a) chisel test, b) bend test, c) pip shear test.	As appropriate.

7.4 Solid plastic 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 $^{+0,019}_{0}$ mm

Wall thickness, s_{tot}: 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_c: 4 500 N (method A)

A.1.2 Theoretical reduced bearing lining thickness equivalent to steel

Steel/lead alloys;
steel/tin alloys: $s_{2,red} = s_2 =$ [1] mm (no reduction)

Steel/copper alloys: $s_{2,red} = \frac{s_2}{2} = \frac{0,5}{2} = 0,25$ mm

Steel/aluminium alloys: $s_{2,red} = \frac{s_2}{3} =$ [1] mm

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

The effective cross-section, A_{eff}, is calculated using the following formula:

$$A_{eff} = s_{tot,eff} \times B$$

where $s_{tot,eff}$ is the reduced wall thickness (i.e. $s_1 + s_{2,red}$).

$$s_{tot,eff} = 1,5 + 0,25 = 1,75 \text{ mm}$$

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

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

1) Not required for this example.