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ISO 3548-3

Second edition
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Plain bearings — Thin-walled half bearings with or without flange —

Part 3:
Determination of the peripheral length

Paliers lisses — Demi-coussinets minces à collerette ou sans collerette —

Partie 3: Détermination de la longueur développée

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document 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 3548-3:2012), which has been technically revised.

The main changes are as follows:

— the errors in the calculation form in Annex A, Figure A.1 and Figure A.4 have been corrected;

— the errors in the calculation form in Annex B, Figure B.1 and Figure B.3 have been corrected;

— the errors in the formulae and in the calculated example in Clause E.3 have been corrected.

A list of all parts in the ISO 3548 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Plain bearings — Thin-walled half bearings with or without flange —

Part 3:
Determination of the peripheral length

1 Scope

This document specifies, according to ISO 12301, the checking of the peripheral length of thin-walled half bearings with or without flange, and describes the necessary checking methods and measuring equipment.

Thin-walled half bearings are flexible and, in the free condition, do not conform to a cylindrical profile. This is one reason the peripheral length of the half bearings can only be measured under a constraining load by use of specialized measuring equipment.

In addition, measuring equipment different from that illustrated in this document can be used, provided the measuring accuracy of the equipment is consistent with the specifications given in Clause 17.

This document does not include the measurement of the parting line taper.

This document applies to thin-walled half bearings, the specifications of which are given in ISO 3548-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 3548-1, *Plain bearings — Thin-walled half bearings with or without flange — Part 1: Tolerances, design features and methods of test*

ISO 12301, *Plain bearings — Quality control techniques and inspection of geometrical and material quality characteristics*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
peripheral length
circumferential length which runs from one parting line face to the other

3.2
crush height
a
value by which a half bearing, fitted in a checking block of bore diameter, d_{cb}, under a pre-determined checking load, *F*, exceeds the defined *peripheral length* (3.1) of the checking block bore

Note 1 to entry: In practice, the datum serves as a basis for measuring *a* (see Figure 1).

Note 2 to entry: The symbol for crush height "(*nip*)" is no longer used and has been replaced with "*a*".
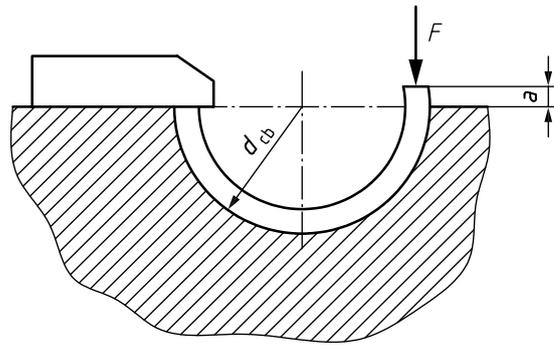
Figure 1 — Crush height, *a*

3.3
repeatability
closeness of agreement between successive results obtained with the same method on the same test piece, under the same conditions

Note 1 to entry: Repeatability is assessed from the standard deviation of repeatability σ_Δ (see Annex E).

3.4
reproducibility
closeness of agreement between individual results obtained with the same method on the same test piece but under different conditions (same or different operator, same, identical or different measurement equipment, same or different checking place and different times)

Note 1 to entry: For the purposes of this document, reproducibility is the difference between the two averages obtained from two sets of measuring equipment (see Annex E).

3.5
comparability
accuracy in the case of operators working in different checking places at different periods and each of them achieving individual results, one using method A and the other using method B, on the same plain bearing test piece in different checking blocks

Note 1 to entry: Comparability is assessed from the difference between the two averages obtained from the two methods (see Annex E).

4 Symbols

For the purposes of this document, the following symbols of Table 1 apply.

Table 1 — Symbols and units

Symbol	Parameter	Unit
a	Crush height	μm
B	Width of the half bearing without flange	mm

Table 1 (continued)

Symbol	Parameter	Unit
B_1	Checking block width of the construction for flanged half bearings	mm
B_2	Checking block width (bottom width of checking lock)	mm
B_3	Checking block width of the construction for half bearings without flange	mm
d	Diameter	mm
D	Outside diameter	mm
E	Elasticity modulus	MPa
f	Friction coefficient in calculation of deflection under load	—
F	Checking load (Method A)	N
F_1	Checking load, side 1 (Method B)	N
F_2	Checking load, side 2 (Method B)	N
F_{cor}	Correction factor	mm
h	Fillet radius between back and flange on flanged half bearing	mm
H_{cb}	Distance from the bottom of the checking block bore to the datum face	mm
ΔH_{cb}	Elastic deformation of the height of the checking block under load	mm
K_1	Checking block chamfer of the construction for half bearings without flange	mm
K_2	Checking block chamfer of the construction for flanged half bearings	mm
l	Peripheral length	mm
Δl	Deviation of the actual peripheral length of the checking block	mm
p_E	Elastic depression of the metering bar	mm
Ra	Surface roughness	µm
s	Wall thickness	mm
t_i	Tolerance value of several features (F, i = 1 to 9)	mm
t_{bms}	Tolerance of B_{ms}	mm
t_{dcbm}	Tolerance of d_{cbm}	mm
t_{dcbs}	Tolerance of d_{cbs}	mm
t_{Hcbm}	Tolerance of H_{cbm}	mm
t_{Hcbs}	Tolerance of H_{cbs}	mm
t_{sms}	Tolerance of s_{ms}	mm
U	Uncertainty of measurement	µm
W	Width of the metering bar contact area	mm
x_{1i}	Measured value of bearing no. i out of bearing set number 1	µm
x_{2i}	Measured value of bearing no. i out of bearing set number 2	µm
$\bar{x}_1$	Arithmetic mean value of measured bearings out of bearing set number 1	µm
$\bar{x}_2$	Arithmetic mean value of measured bearings out of bearing set number 2	µm
$\bar{x}_A$	Arithmetic mean value of set of bearings measured according to method A	µm
$\bar{x}_B$	Arithmetic mean value of set of bearings measured according to method B	µm
$\bar{x}_A^*$	Arithmetic mean value $\bar{x}_A$ corrected with empirical correction factor δ	µm
$\bar{x}_B^*$	Arithmetic mean value $\bar{x}_B$ corrected with empirical correction factor δ	µm
z	Distance between flanges of the flanged half bearing	mm
δ	Empirical correction to compensate for the difference in elastic deflections under load between method A and method B	mm
δ_x	Correction, approximated by calculation	mm
σ	Standard deviation	—

The characteristic subscripts are given in Table 2.

Table 2 — Subscripts

Subscript	Description
A	measurement method A
B	measurement method B
B1	position 1 of measurement method B
B2	position 2 of measurement method B
bs	bearing to be checked
cb	checking block
cbm	master checking block
cbs	series checking block
cs	comparison shell
M	measured
max	maximum
mean	arithmetic mean
min	minimum
ms	master shell
new	origin, beginning of use
th	theoretical
tot	total
worn	wear limit, end of use
1,2	consecutive number

NOTE   The following notation for multi-subscripts is used: literal subscripts are separated by a blank, however, additionally needed numbers are directly connected to the subscript.

5 Purpose of checking

In order to ensure the required mounting compression (interference fit) for the half bearings in the housing bore, the crush height tolerances shall be kept as specified in ISO 3548-1 and ISO 12301.

6 Measurement methods

6.1 Method A

The checking load, F, is directly applied via the measuring head with a pivoting metering bar to one parting line face of the half bearing while the other parting line face is in contact with a fixed stop (see Figure 2).

The measured crush height according to method A is indicated a_A.
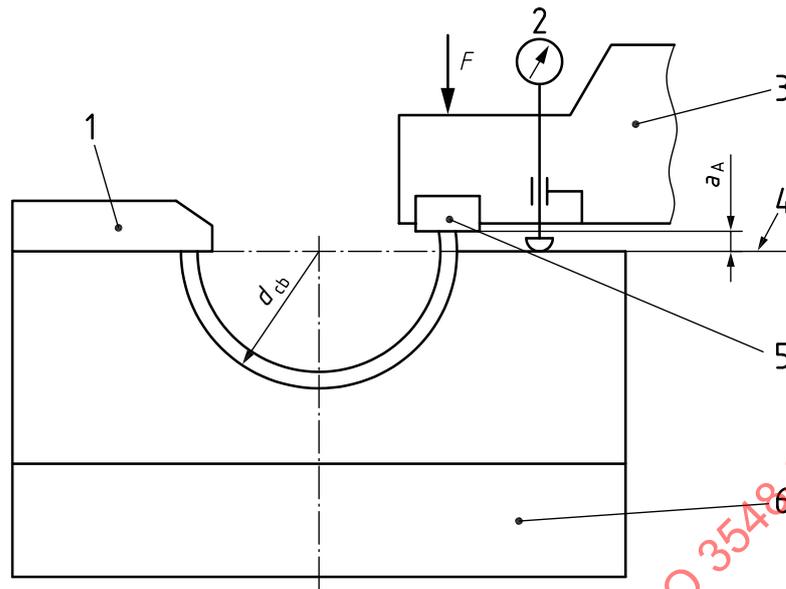
Key

1   fixed stop
2   dial gauge
3   movable measuring head
4   datum
5   metering bar
6   checking block

Figure 2 — Measuring principle of method A

6.2   Method B

The checking loads, F_1 and F_2, are applied via the measuring head and two metering bars to both parting line faces of the half bearing (see Figure 3).
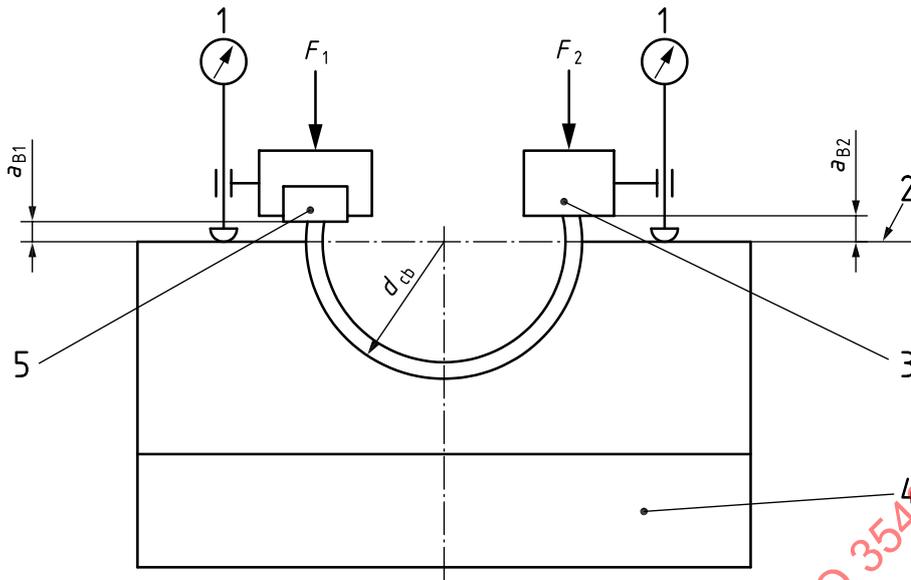
The crush height of method B is the sum of the measurements on the two sides [as shown in Formula (2)]:

$$a_B = a_{B1} + a_{B2} \qquad\qquad (2)$$

Key
1   dial gauge
2   datum
3   rigid metering bar
4   checking block
5   pivoting toe piece
NOTE   Bearings can also be checked using two pivoting metering bars.

Figure 3 — Measuring principle of method B

NOTE   In the case of method A, the fixed stop exerts the required counterforce, which, in the case of method B, is applied directly by the measuring equipment via two metering bars.

EXAMPLE

Method A F = 6 000 N

Method B F_1 = 6 000 N

                  F_2 = 6 000 N

7   Choice and designation of checking method

7.1   Choice of checking method

Recommendations for choosing either method A or method B, based on dimensions of the half bearings to be checked, are given in Table 3.

However, any size of bearing can be tested by either method by agreement between the manufacturer and user. In that case, a correction, δ, should be applied to compensate for the difference in deflections at parting line face(s) under load between method A and method B, and should be implemented as shown in Formula (3):

$$a_A = a_{B1} + a_{B2} + \delta = a_B + \delta \tag{3}$$

The value of δ shall be determined empirically by actual measurements obtained on the two different types of equipment used. Since the detailed design of the checking feature shall be varied between

different manufacturers, the value of δ established by one manufacturer cannot be transferred to another, who shall determine it separately. See example in Annex E.

For general guidance, the value of δ can be derived from the formula (Euler-Eytelwein) used in the mathematical analysis of belt friction, which gives Formula (4):

$$\delta = \frac{d_{\text{cb M}} \cdot F}{s_{\text{ms}} \cdot B_{\text{ms}}} \cdot \frac{1}{2Ef}\left(1 + e^{-f\pi} - 2e^{-f\pi/2}\right) \tag{4}$$

With a value of the friction coefficient f = 0,15, Formula (4) becomes Formula (5):

$$\delta_{f=0,15} = 7 \cdot 10^{-7} \cdot \frac{d_{\text{cb M}} \cdot F}{s_{\text{ms}} \cdot B_{\text{ms}}} \tag{5}$$

Table 3 — Selection of checking method

D_{bs} mm	Recommended checking method
$D_{\text{bs}} \leq 200$	A, B
$200 < D_{\text{bs}} \leq 500$	B

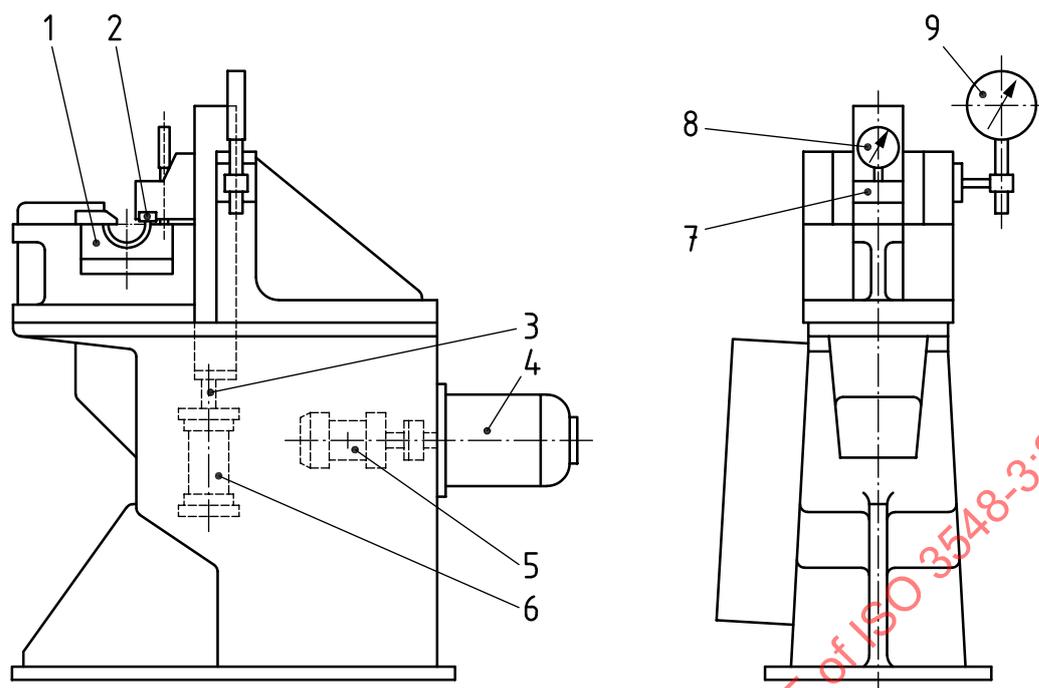## 7.2 Designation of checking method

An example of the designation of method B for checking thin-walled half bearings with an outside diameter, D_{bs} of 340 mm is as follows:

Method ISO 3548-3-B-340

8 Measuring equipment

Figures 4 and 5 show typical measuring equipment for the measurement of the crush height by method A and by method B, respectively.

Key

1	checking block	6	pressure cylinder
2	pivoting metering bar	7	movable measuring head
3	pressure adjustment valve	8	dial gauge
4	drive motor	9	pressure gauge
5	oil pump		

Figure 4 — Typical measuring equipment with one column for method A

NOTE   Figures 4 and 5 show hydraulically operated equipment. Pneumatically or mechanically operated equipment can also be used.
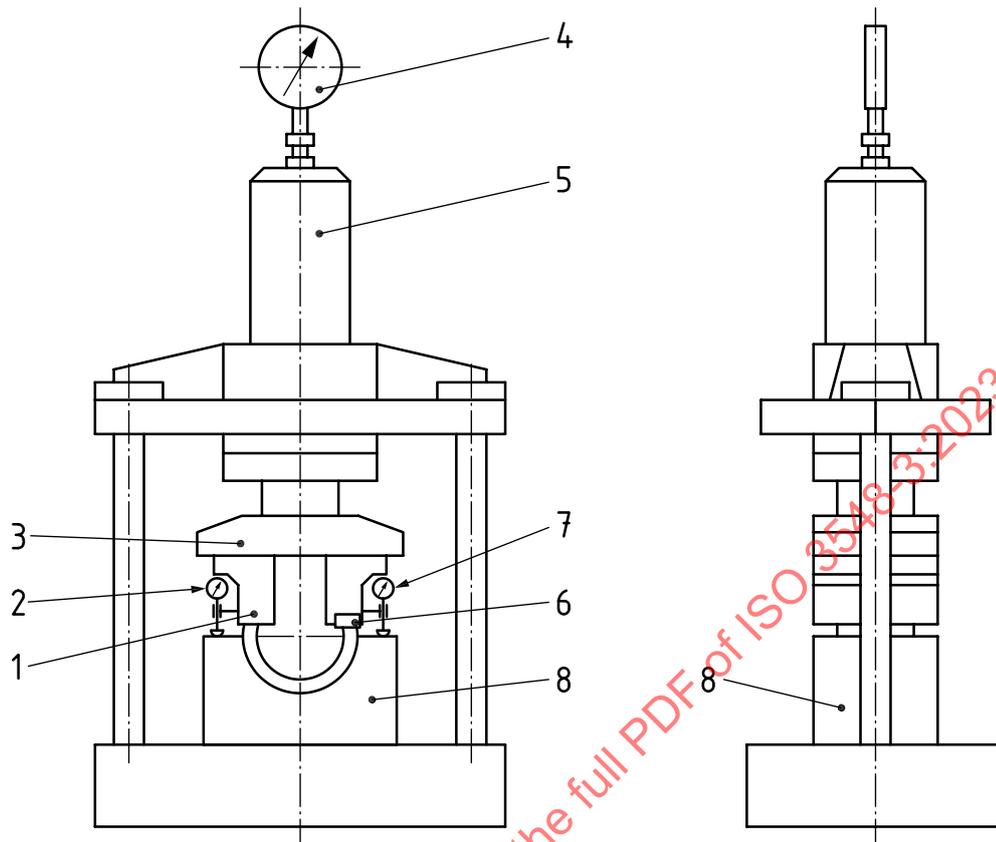
Key

1   rigid metering bar
2   dial gauge
3   movable measuring gauge
4   pressure gauge

5   hydraulic ram
6   pivoting toe piece
7   dial gauge
8   checking block

NOTE   The bearings can also be checked using two pivoting metering bars for the rigid metering bar.

Figure 5 — Typical measuring equipment with two columns, for method B

9   Measuring equipment requirements

9.1   General

The most important factors affecting the accuracy of the measuring equipment (and hence the measured crush height) are given in the following subclauses.

9.2   Tolerance on checking load setting

The permissible tolerances are given in Table 4.

Table 4 — Tolerance ranges for checking loads

F N	Tolerance on F t_F %
$F \leq 2\ 000$	±1,25
$2\ 000 < F \leq 5\ 000$	±1,00
$5\ 000 < F \leq 10\ 000$	±0,75
$10\ 000 < F \leq 50\ 000$	±0,50
$50\ 000 < F$	±0,25

9.3 Speed of approach of measuring head

The checking load, F, shall be applied to the parting line face(s) of the half bearing so that shock load shall not occur. The speed of approach shall be consistent.

NOTE   A guideline for speed of approach is (10 ± 2) mm/s.

For devices in which the speed of approach cannot be altered, the load shall be applied, released and applied a second time before the measurement is made.

9.4 Construction of measuring head

The measuring head shall be so designed and manufactured that it is accurately guided and moves normal to the datum of the checking block. The deviation from parallelism between the metering bar(s) in the measuring head and the supporting plane of the checking block shall not exceed 0,04 mm per 100 mm in in direction of parting line.

9.5 Accuracy of the measuring plane for metering bars

Specifications on the accuracy of the measuring plane of the metering bars are given in Table 5.

Table 5 — Tolerances of the measuring plane for metering bars

D_{bs} mm	Surface roughness Ra µm	Tolerance on flatness t_3 mm
$D_{bs} \leq 160$	0,2	0,001 5
$160 < D_{bs} \leq 340$	0,4	0,003 0
$340 < D_{bs} \leq 500$		0,004 0

9.6 Accuracy of the dial gauge

The uncertainty of measurement is $u \leq |1,2|$ µm ($\pm 2\sigma$) with $\sigma = 0,3$ µm.

10 Gauging tools for establishing the datum

10.1 General

The following equipment can be used for carrying out measurements:

— a master checking block for reference measurements (see Clause 11), or

— a series checking block for series control in production (see Clause 11), or

— a master shell for series control in production (see Clause 12).

It shall be used in three ways (as indicated in 10.2, 10.3 and 10.4) to establish the appropriate datum for setting the gauge.

10.2 Master checking block (used alone)

The master checking block is the comparison basis for the other checking blocks used for series control.

10.3 Series checking block used alone

The peripheral length of the bore of this type of checking block is determined by comparison with the master checking block.

lt is applied in series control without using a master shell or a comparison shell.

10.4 Series checking block with master shell

The peripheral length of the checking block bore is determined by the master shell or comparison shell, the peripheral length of which was determined in the master checking block.

This combination of gauging tools is applied in series control.

NOTE   For series control, a checking block can also be used with a checking master, but this combination of gauging tools is not within the scope of this document.

11 Checking block requirements

11.1 General

A typical block is shown in Figure 6. The gauging part has a bore diameter, d_{cb}, and height, H_{cb}, and holds the half bearings to be checked. Value of d_{cb} should be equal to the maximum size of the housing bore.

The checking block should preferably be of hardened steel and of rigid design and manufacturing so that the requirements of Clause 16 are met when the half bearing is tested under load.

The bore of the checking block shall not be chromium plated.

Recesses shall be cut into the checking block to accommodate the locating lip in the half bearings. They shall be 1 mm wider and deeper and 1,5 mm longer than the locating lips in the half bearings.

11.2 Reference tooling: Master checking block — General

11.2.1 Reference tooling — Master checking block
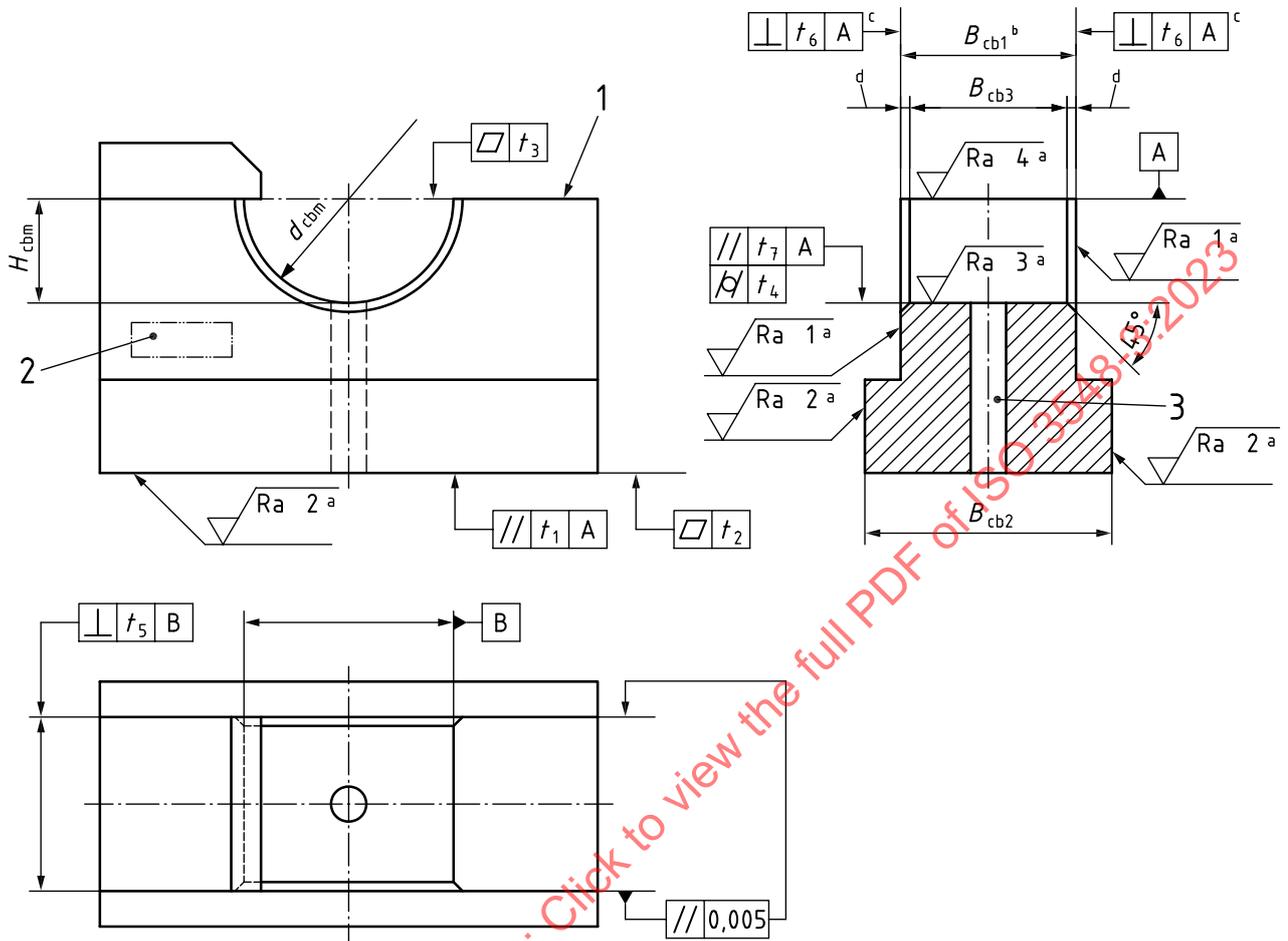
Key

1 datum for $F_{\text{cor cb}}$ and $F_{\text{cor cbs}}$ (see 13.1 and 13.2.1)

2 field for marking of d_{cbm}, $H_{\text{cb M}}$ and $F_{\text{cor cb}}$ (or $F_{\text{cor cbs}}$)

3 ejector hole (optional)

[a] It is recommended to use the values given in Tables 5 and 6.

[b] The construction for half bearing without flange:

— B_1 can correspond to B_2 or it can be adjusted to the width of the half bearing,

— i.e. to $B_{\max}$ + 1,2 mm with $K_{1\max}$ = 0,4 mm.

[c] The construction for flanged half bearing:

— B_1; see Table 7;

— $K_2 = h_{\max}$ + 0,5 mm.

[d] K_1 or K_2.

Figure 6 — Checking block

11.2.2 Manufacturing limits — General

11.2.2.1 Manufacturing limits

Manufacturing limits and specifications for the master checking block are given in Table 6.

Table 6 — Manufacturing limits and specifications for the master checking block

Outside diameter D_{bs} mm	Tolerance on d_{cbm} t_{dcbm} mm	Surface roughness of checking block bore Ra µm	Tolerance on H_{cbm} t_{Hcbm} mm	Surface roughness of the datum face Ra µm
$D_{bs} \leq 75$	+0,003 00	0,2	+0,003 00	0,3
$75 < D_{bs} \leq 110$	+0,004 00	0,2	+0,003 50	0,3
$110 < D_{bs} \leq 160$	+0,005 00		+0,004 00	
$160 < D_{bs} \leq 250$	+0,006 00	0,4	+0,004 50	0,6
$250 < D_{bs} \leq 340$	+0,007 50	0,6	+0,005 00	1,0
$340 < D_{bs} \leq 500$	+0,010 00	0,6	+0,006 00	1,0

11.2.2.2 Tolerances of form and orientation, surface roughness and specifications

It is the responsibility of the manufacturer of the master checking block to achieve high quality regarding tolerances of form and orientation, the values of which are given in Tables 7 and 8.

The surface roughnesses, Ra_1 and Ra_2, and the specifications for B_1, B_2 and B_3 are also given in Tables 7 and 8.

Table 7 — Tolerances of form and orientation

Outside diameter D_{bs} mm	Bearing without flange B_{3min} mm	Flanged bearing B_{1min}	B_{1max} mm	Surface roughness Ra_1 µm	t_1	t_2	t_3	t_4	t_5	t_6 mm
$D_{bs} \leq 75$					0,002	0,002	0,002	0,002	0,002	0,005
$75 < D_{bs} \leq 110$										
$110 < D_{bs} \leq 160$	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2						
$160 < D_{bs} \leq 250$					0,005	0,005	0,005	0,004	0,003	0,006
$250 < D_{bs} \leq 340$										
$340 < D_{bs} \leq 500$					0,007		0,007			

Table 8 — Tolerances of form and orientation

B mm	B_2 mm	Surface roughness Ra_2 µm	Tolerance on parallelism t_7 mm
$B \leq 55$	$60^{+2}_{\ \ 0}$		0,002
$55 < B \leq 80$	$85^{+2}_{\ \ 0}$	1,2	0,003
$80 < B$	$B + 5^{+2}_{\ \ 0}$		0,004

11.2.3 Measuring accuracy of equipment used for establishing $d_{cbm,M}$ and $H_{cbm,M}$

Determination of $d_{cbm\ M}$ and $H_{cbm\ M}$ shall be carried out using measuring equipment with a tolerance of:

— ±0,001 mm for $d_{cbm} \leq 160$ mm;

— ±0,002 mm for $d_{cbm} > 160$ mm.

These values are necessary for calculating the correction factor, $F_{cor\ cbm}$ (see 13.1), which is based on the peripheral length, determined from Formula (6):

$$l_{cbm\ M} = d_{cbm\ M} \cdot \frac{\pi}{2} + 2 \cdot \left(H_{cbm\ M} - \frac{d_{cbm\ M}}{2} \right) \tag{6}$$

11.2.4 Permissible wear limit

The tolerance specified in 11.2.2 for the master checking block shall not be exceeded through wear. If wear occurs within the specified tolerance range, it can be necessary to change the correction factor.

11.3 Series gauging tools

11.3.1 Series checking block used alone

Since the peripheral length of this checking block bore is determined by comparison with the master checking block (see 11.2), larger tolerances for d_{cbs} and H_{cbs} are acceptable.

11.3.2 Manufacturing limits, correction factor and permissible wear limit

11.3.2.1 Manufacturing limits

Manufacturing limits and specifications for the series checking block are given in Table 9.

Table 9 — Manufacturing limits and specifications for the series checking block

Outside diameter D_{bs} (mm)	Tolerance on d_{cbs} t_{dcbs} (mm)	Surface roughness of checking block bore Ra (μm)	Tolerance on H_{cbs} t_{Hcbs} (mm)	Surface roughness of the datum Ra (μm)	Bearing without flange B_{3min} (mm)	Flanged bearing B_{1min} (mm)	Flanged bearing B_{1max} (mm)	Surface roughness Ra_1 (mm)	t_1 (mm)	t_2 (mm)	t_3 (mm)	t_4 (mm)	t_5 (mm)	t_6 (mm)	B (mm)	B_2 (mm)	Surface roughness Ra_2 (μm)	Tolerance on parallelism t_7 (mm)
$D_{bs} \le 75$	+0,008 0	0,2	+0,008 0	0,3	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2	0,004	0,004	0,004	0,004	0,004	0,010	$B \le 55$	$60\ ^{+2}_{\ 0}$	1,2	0,004
$75 < D_{bs} \le 110$	+0,010 0	0,2	+0,009 0	0,3	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2	0,004	0,004	0,004	0,004	0,004	0,010	$B \le 55$	$60\ ^{+2}_{\ 0}$	1,2	0,004
$110 < D_{bs} \le 160$	+0,012 0	0,4	+0,010 0	0,6	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2	0,010	0,010	0,010	0,008	0,006	0,012	$55 < B \le 80$	$85\ ^{+2}_{\ 0}$	1,2	0,006
$160 < D_{bs} \le 250$	+0,014 0	0,4	+0,010 0	0,6	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2	0,010	0,010	0,010	0,008	0,006	0,012	$55 < B \le 80$	$85\ ^{+2}_{\ 0}$	1,2	0,006
$250 < D_{bs} \le 340$	+0,017 0	0,6	+0,011 0	1,0	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2	0,014	0,010	0,014	0,008	0,006	0,012	$80 < B$	$B + 5\ ^{+2}_{\ 0}$	1,2	0,008
$340 < D_{bs} \le 500$	+0,022 0	0,6	+0,012 0	1,0	$B_{max} + 0,4$	$z_{min} - 0,1$	$z_{min} - 0,05$	1,2	0,014	0,010	0,014	0,008	0,006	0,012	$80 < B$	$B + 5\ ^{+2}_{\ 0}$	1,2	0,008

11.3.2.2 Correction factor, $F_{\text{cor cbs}}$

See 13.2.1.

11.3.2.3 Permissible wear limit

The limit of permissible wear of the series checking block is reached when the difference between the correction factor in original and worn conditions is equal to the values stated in Table 10.

Table 10 — Limit of permissible wear of the series checking block

Checking block diameter d_{cbs} mm	Permissible difference $\lvert F_{\text{cor cbs new}} - F_{\text{cor cbs worn}} \rvert$ mm
$d_{\text{cbs}} \leq 75$	0,012
$75 < d_{\text{cbs}} \leq 110$	0,016
$110 < d_{\text{cbs}} \leq 160$	0,020
$160 < d_{\text{cbs}} \leq 250$	0,024
$250 < d_{\text{cbs}} \leq 340$	0,030
$340 < d_{\text{cbs}} \leq 500$	0,040

11.3.3 Series checking block with master shell or with comparison shell

11.3.3.1 Manufacturing limits

Manufacturing limits and specifications for the series checking block are given in Table 9.

11.3.3.2 Correction factor

See 13.2.2.

11.3.3.3 Permissible wear limit

The limit of permissible wear of the series checking block is reached when the difference between the correction factor in original and worn conditions is equal to the values stated in Table 12.

12 Master shell and comparison shell requirements

12.1 Master shell requirements

The basic dimensions of the master shell shall be corresponded to those of the half bearings to be checked (see Figure 7). The master shell shall have similar behaviour to the half bearing when it is fitted into the checking block.

NOTE   This cylindrical master shell can also be used for checking flanged half bearings.

Master shells shall be made from hardened steel (58 HRC min.). Normally, master shells are only used up to 200 mm in diameter.

In order that a single master shell can be used for a group of parts down to 1 mm undersize, s_{ms} shall be equal to the total wall thickness, s_{tot}, of the standard half bearing to be checked plus 0,125 mm.
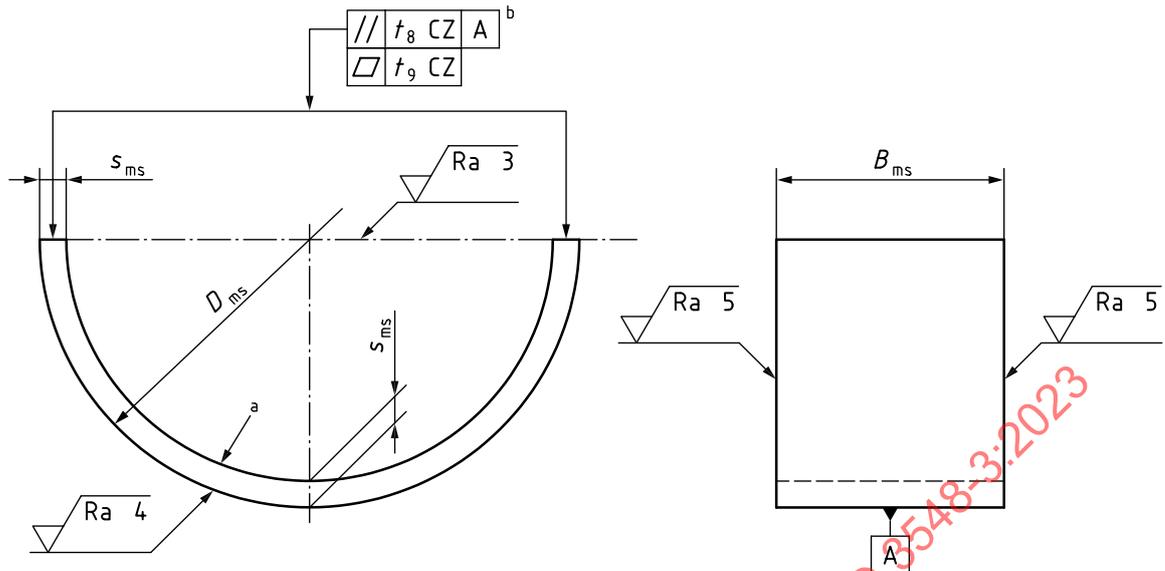
Key

$s_{ms} = s_{tot} + 0{,}125$ mm

a Field for marking of $D_{ms\,M}$, F and $F_{cor\,ms}$ (see 13.2.3).

b Tolerances on parallelism t_8 and flatness t_9 apply when the master shell is fitted in the checking block (zero free spread) under the checking load.

Figure 7 — Master shell

The master shell shall be of similar geometry to that of the bearing being checked. Masters of a different geometry from that of the shell shall not be used since friction and elastic deformation can differ significantly from those of the bearing (see Figure 8).
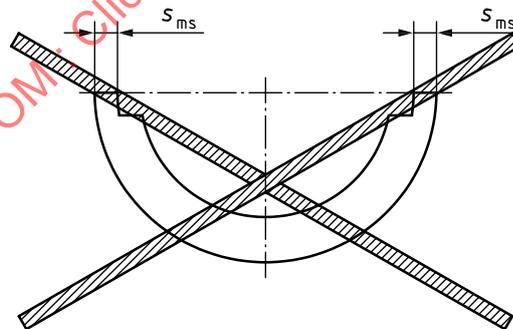
NOTE The stepped master shell is not suitable for checking bearings or uniform wall thickness.

Figure 8 — Stepped master shell

12.1.1 Manufacturing limits

Manufacturing limits and specifications for the master shell are given in Tables 11 and 12.

Table 11 — Manufacturing limits and specifications for the master shell — No. 1

Outside diameter D_{ms} Mm	Tolerance on B_{ms} t_{Bms} mm	Tolerance on s_{ms} t_{Sms} mm	Surface roughness	
			Ra_3 µm	Ra_5 µm
$D_{ms} \leq 160$	±0,10	±0,015	0,2	2
$160 < D_{ms} \leq 200$	±0,15	±0,020		

Table 12 — Manufacturing limits and specifications for the master shell — No. 2

Outside diameter D_{ms} mm	Surface roughness Ra_4 µm	Tolerance on parallelism t_8 mm	Spread	Tolerance on flatness t_9 µm
$D_{ms} \leq 160$	0,3	0,004	Within the limits of the half bearing to be checked	0,003
$160 < D_{ms} \leq 200$	0,5	0,006		

12.1.2 Correction factor, $F_{cor\,ms}$

See 13.2.3.

12.1.3 Permissible wear limit

The limit of the permissible wear of the master shell is reached when the difference between the correlation factor in original and worn conditions is equal to the values stated in Table 13.

Table 13 — Limit of the permissible wear of the master shell

Outside diameter D_{ms} mm	Permissible difference $|F_{cor\,ms\,new} - F_{cor\,ms\,worn}|$ mm
$D_{ms} \leq 160$	0,030
$160 < D_{ms} \leq 200$	0,035

12.2 Comparison shell requirements

For economic reasons, the crush height of the half bearings can be determined using comparison shells rather than master shells.

Comparison shells shall be made from stainless steel or cold or hot worked tool steel. In special cases, a normal production bearing can also be used.

The relative manufacturing limits shall be agreed upon between the manufacturer and customer.

13 Correction factors

13.1 Reference tooling: Master checking block correction factor, $F_{\text{cor cbm}}$

The measured peripheral length of the master checking block bore, $l_{\text{cbm M}}$, is given by Formula (7) (see 11.2.3):

$$l_{\text{cbm M}} = d_{\text{cbm M}} \cdot \frac{\pi}{2} + 2 \cdot \left(H_{\text{cbm M}} - \frac{d_{\text{cbm M}}}{2} \right) \tag{7}$$

The theoretical peripheral length of the master checking block bore, $l_{\text{cbm th}}$, is given by Formula (8) (see 11.2.3):

$$l_{\text{cbm th}} = d_{\text{cbm th}} \cdot \frac{\pi}{2} \tag{8}$$

The correction factor of the master checking block is therefore as given in Formula (9):

$$F_{\text{cor cbm}} = l_{\text{cbm M}} - l_{\text{cbm th}} \tag{9}$$

Method A according to Annex A (for the calculation form, see Table A.1 and Figures A.1, A.2, A.3 and A.4, and for the numerical example, see Table A.2) and method B according to Annex B (for the calculation form, see Table B.1 and Figures B.1, B.2 and B.3, and for the numerical example, see Table B.2) shall be used to determine and calculate the other factors that are to be taken into account.

The basis for the correction factor, $F_{\text{cor cbm}}$, is the datum of the master checking block (see Figures 2 and 3).

13.2 Series control tooling

13.2.1 Correction factor for series checking block used alone, $F_{\text{cor cbs}}$

The correction factor, $F_{\text{cor cbs}}$, is the difference between the crush height of a half bearing measured in a master checking block, a_{cbm}, and in a series checking block, a_{cbs}, under equal checking conditions [see Formula (10)]:

$$F_{\text{cor cbs}} = a_{\text{cbmM}} - a_{\text{cbsM}} \tag{10}$$

Annex C shall be used for determining the correction factor $F_{\text{cor cbs}}$.

When setting the dial gauge, the correction factor, $F_{\text{cor cbs}}$, of the series checking block only shall be taken into consideration.

The basis for the correction factor, $F_{\text{cor cbs}}$, is the datum of the series checking block.

13.2.2 Correction factor for series checking block with master shell

The correction factor, $F_{\text{cor cbs}}$, of the series checking block should not be taken into consideration when carrying out measurements; it is only to check the wear limit of the series checking block.

When setting the dial gauge, the correction factor, $F_{\text{cor ms}}$, of the master shell only (see 13.2.3) shall be taken into consideration.

13.2.3 Master shell correction factor, $F_{\text{cor ms}}$

The correction factor, $F_{\text{cor ms}}$, is the amount by which a master shell fitted in a master checking block bore, under a predetermined checking load, deviates from the theoretical peripheral length of the master checking block bore.

Annex D shall be used for determining the correction factor $F_{\text{cor ms}}$.

When setting the dial gauge, the correction factor of the master shell, $F_{\text{cor ms}}$, shall be taken into consideration.

The basis for the correction factor, $F_{\text{cor ms}}$, is the parting line of the master shell, the peripheral length of which shall be measured in a master checking block, in accordance with 13.1.

NOTE   The correction factor, $F_{\text{cor ms}}$, is equal to zero when the master shell is exactly adjusted to the peripheral length of the master checking block bore, the bore diameter, d_{cbm}, of which corresponds to the outside diameter, D_{bs}, of the half bearing to be checked.

13.2.4 Comparison shell correction factor, $F_{\text{cor cs}}$

The correction factor, $F_{\text{cor cs}}$, is the amount by which a comparison shell fitted in a master checking block bore, under a predetermined checking load, deviates from the theoretical peripheral length of the master checking block bore.

Annex D shall be used for determining the correction factor $F_{\text{cor cs}}$.

When setting the dial gauge, the correction factor of the comparison shell, $F_{\text{cor cs}}$, shall be taken into consideration.

The basis for the correction factor, $F_{\text{cor cs}}$, is the parting line of the comparison shell, the peripheral length of which shall be measured in a master checking block, in accordance with 13.1.

NOTE   The correction factor, $F_{\text{cor cs}}$, is equal to zero when the comparison shell is exactly adjusted to the peripheral length of the master checking block bore, the bore diameter, d_{cbm}, of which corresponds to the outside diameter, D_{bs}, of the half bearing to be checked.

13.3 Marking

The correction factor calculated shall be permanently marked (e.g. engraved) on each of the gauging tools.

13.4 Reference setting

In cases of dispute, the setting shall be made in accordance with the determined correction factor in a master checking block (see 13.1). The method shall be agreed between the manufacturer and customer.

14 Typical checking procedure

14.1 Place the checking block in the measuring equipment, line it up and secure it against lateral movement.

14.2 Set the checking load in accordance with the specifications.

14.3 Under the specified checking load, lower the pivoting metering bar (for method A) or the metering bars (for method B) vertically on to the parting line of the master shell, or of the comparison shell.

In the case of method A, adjust the dial gauge to the full value of the correction factor permanently marked on either the checking block ($F_{\text{cor cb}}$ or $F_{\text{cor cbs}}$), the master shell ($F_{\text{cor ms}}$) or the comparison shell ($F_{\text{cor cs}}$).

In the case of method B, adjust both dial gauges to one-half of the correction factor (see Figure 3).

14.4 Place the half bearing to be checked (see also Clause 15) in the checking block and apply the checking load via the measuring head.

14.5 Determine the crush height variation of the half bearing, in the case of method A, by reading off the dial gauge directly or, in the case of method B, by adding the partial crush height variations recorded on the two dial gauges.

14.6 The measuring temperature shall be between 20 °C and 25 °C when using the master block, but series checking can take place at room temperature if both the measurement equipment and the half bearings being checked are at the same temperature.

14.7 When carrying out reference measurements, the value of the crush height is the average of three measurements taken at a temperature of 20 °C.

15 Conditions of the half bearings to be checked

The joint and back faces of the half bearing shall be free of foreign matter, grease and any damage, and shall be at the same temperature as the checking block being used.

16 Measuring errors

16.1 Errors due to measuring equipment

These errors are due to

— an incorrect position of the checking block (longitudinal or transversal direction),

— the checking block being incorrectly fixed in the measuring equipment,

— an incorrect setting of the checking load,

— an excessive speed of approach of the load,

— the pivoting metering bar being too tight or having too much clearance, or

— damage or wear of the metering bar(s).

16.2 Errors due to the checking block

These errors are due to

— the difference in temperature between the half bearing and checking block,

— damage or wear of the checking block,

— the recess for locating lips being too large,

— the locating lip fouling the notch in the checking block,

— the bore of the checking block being chromium plated,

— the fixed stop for method A not covering the total parting line face of the bearing,

— the fixed stop for method A deflecting too much and/or being poorly attached,

— damage or wear of the fixed stop,

— the checking block width, B_3, being smaller than the bearing width in the case of bearings without flange, or

— the checking block width, B_1 or B_3, for flanged bearings being too large, so that bearings are in contact with the checking block at the fillet radius between back and flange (K_1 or K_2 incorrect).

16.3 Errors due to the correction factor

These errors are due to

— an incorrect reading when measuring $d_{cb\ M}$ and $H_{cb\ M}$, or

— an error in calculating the correction factor.

16.4 Errors due to the half bearing

These errors are due to

— grease, dirt or damage on the outside diameter or parting line, or

— the parting line taper being excessive.

16.5 Error due to the choice of checking method

An error can arise if the correction, δ, is not considered when the half bearing is tested by a method other than the method specified on the bearing drawing (see 7.1 and Clause E.3).

17 Accuracy of methods used

17.1 General

Clause 17 gives a statistical approach to evaluate the accuracy of the methods used by determining the repeatability and reproducibility of the measurement results and by comparing results obtained with methods A and B.

17.2 Checking conditions

See Table 14.

17.3 Limits

The values given in Table 15 are a basis for interpreting the test results.

17.4 Calculation

Follow the methods of calculation and the interpretation of the test results of repeatability, reproducibility and comparability in Annex E.

18 Specifications on bearing drawings

The following should be specified in the drawing, represented graphically or otherwise, for the measurement of the peripheral length:

a) the recommended checking method (A or B) (see Clause 7);

b) the checking load;

c) the crush height;

d) diameter $d_{cb\ th}$ and the distance from the bottom of the checking block to the datum plane, $H_{cb\ th}$.

19 Specifications for the control of the checking means

19.1 The gauging tools shall be checked regularly; significant damage shall be refurbished and any dimensional changes to the gauging tools shall be engraved on them.

19.2 The measuring equipment shall be checked as to its accuracy, at specified time intervals (with regard to statistical methods).

Table 14 — Specifications for the control of the checking means

Date	Repeatability	Reproducibility		Comparability
		Case 1[a]	Case 2[b]	
Half bearings	S	S	S	S
Measuring equipment	S	S or I	I or D	D
Checking block	S	S	I or D	D
Operator	S	S or D	D	D
Checking place	S	S or D	D	D
Checking time	Short period	D	D	D

Key

S: Same, i.e. physically the same

I: Identical, i.e. in accordance with this document, made to the same design, drawings and specifications

D: Different, i.e. in accordance with this document, but made to different design, drawings and specifications

[a] The same half bearings are checked in the same checking block with the same checking equipment, or with an identical one (in which the checking block can be mounted), by a single operator or different operators working in the same or in different places at different times.

[b] The same half bearings shall be checked in identical or in different checking blocks with identical or different checking equipment by operators working in different places at different times.

Table 15 — Specifications for the control of the checking means

D_{bs}	Repeatability $\sigma_{\Delta B}$	Reproducibility $\lvert \bar{x}_1 - \bar{x}_2 \rvert$ max.		Comparability[a] $\lvert \bar{x}_A - \bar{x}_B - \delta \rvert$ max.
		Case 1[b]	Case 2[c]	
mm	μm	μm	μm	μm
$D_{bs} \leq 75$	1,1	3	8	10
$75 < D_{bs} \leq 160$	1,4	4	9	14
$160 < D_{bs} \leq 340$	2,2	6	16	24
$340 < D_{bs} \leq 500$	2,8	8	18	30

[a] In order to achieve these values, especially for thicker bearings, a good contact between the metering bar (fixed stop) and the bearing joint faces is of prime importance.

[b] The same half bearings are checked in the same checking block with the same checking equipment, or with an identical one (in which the checking block can be mounted), by a single operator or different operators working in the same or in different places at different times.

[c] The same half bearings are checked in identical or in different checking blocks, with identical or different checking equipment by operators working in different places at different times.
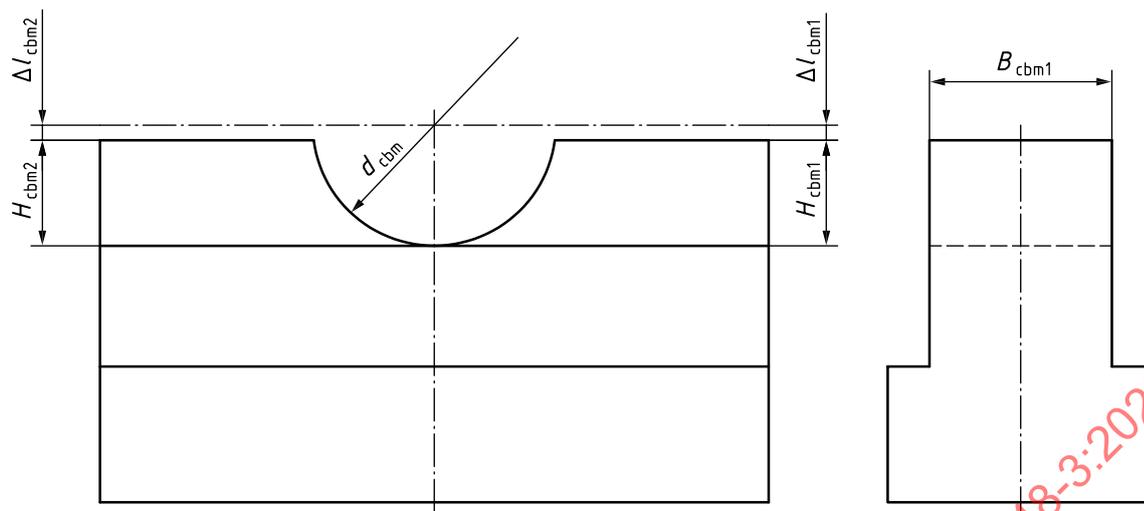
Annex A
(normative)

Determination of the correction factor of the master checking block — Method A

A.1 Calculation form

Table A.1 — Calculation form

Firm	Number of drawing	Type of bearing

$d_{cbm, th} =$ ☐☐☐☐/☐☐ mm $s_{tot} =$ ☐☐☐☐/☐☐ mm $B_{max} =$ ☐☐☐☐/☐☐ mm

$F =$ ☐☐☐☐☐☐ N B_{cbm1} or $B_{cbm3, min} =$ ☐☐☐/☐☐ mm

1 Actual peripheral length before correction (see figure A.1)

$d_{cbm, M} \times \dfrac{\pi}{2} =$ ☐☐☐☐☐/☐ × 1,570 8 = ⟶ ☐☐☐☐☐☐/☐ mm

2 Deviations Δl_{cbm1} and Δl_{cbm2} (take signs into account, see note under figure A.1)

$\Delta l_{cbm1} =$ [−] ☐☐☐/☐☐ mm
$\Delta l_{cbm2} =$ [+] ☐☐/☐☐ mm

$\Sigma \Delta l_{cbm} =$ [−] ☐☐☐/☐ mm ⟶ [−] ☐☐/☐ mm

3 Elastic variation of $H_{cbm, th}$ (see figure A.2)

$\Delta H_{cbm} = \dfrac{H_{cbm, th} \, F}{5 \times 10^5 \times wB_{cbm1}} = \dfrac{☐☐☐☐/☐ \times ☐☐☐☐/☐}{500\,000 \times ☐☐☐/☐} = [+] \; ☐☐☐☐☐/☐$ mm

4 Elastic depressions at the fixed stop and toe piece (see figure A.3)

$p_{E1} + p_{E2} = \dfrac{0,000\,03\,F}{s_{tot}\,B} = \dfrac{0,000\,03 \times ☐☐☐☐/}{☐☐☐☐☐/☐ \times ☐☐☐☐/} = [+] \; ☐☐☐☐☐/☐$ mm

5 Flexibility of the fixed stop under checking load Δl_{cbm} (see figure A.4)

[+] ☐☐☐/☐ mm

6 Measured peripheral length (after correction)

$l_{cbm, M} = \Sigma \,(1 \text{ to } 5) =$ [+] ☐☐☐☐☐/☐ mm

7 Theoretical peripheral length

$l_{cbm, th} = d_{cbm, th} \times \dfrac{\pi}{2} =$ ☐☐☐☐☐/☐ × 1,570 8 = ⟶ [−] ☐☐☐☐☐☐/☐ mm

8 Correction factor for master checking block

$F_{cor, cbm} =$ [+] ☐☐☐/☐ mm ⟵ [+] ☐☐☐☐/☐ mm

Determine steps 1, 2 and 5 by measurement.

NOTE $\quad \Delta l_{\text{cbm1}} = H_{\text{cbm1 M}} - \dfrac{d_{\text{cbm M}}}{2}$ and $\Delta l_{\text{cbm2}} = H_{\text{cbm2 M}} - \dfrac{d_{\text{cbm M}}}{2}$

Figure A.1 — Checking block

Key
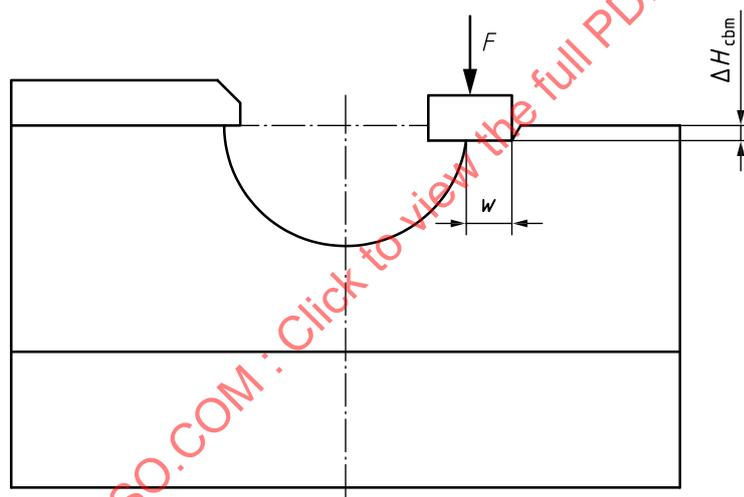
w width of the toe piece contact area, in mm

Figure A.2 — Checking block with fixed stop and metering bar
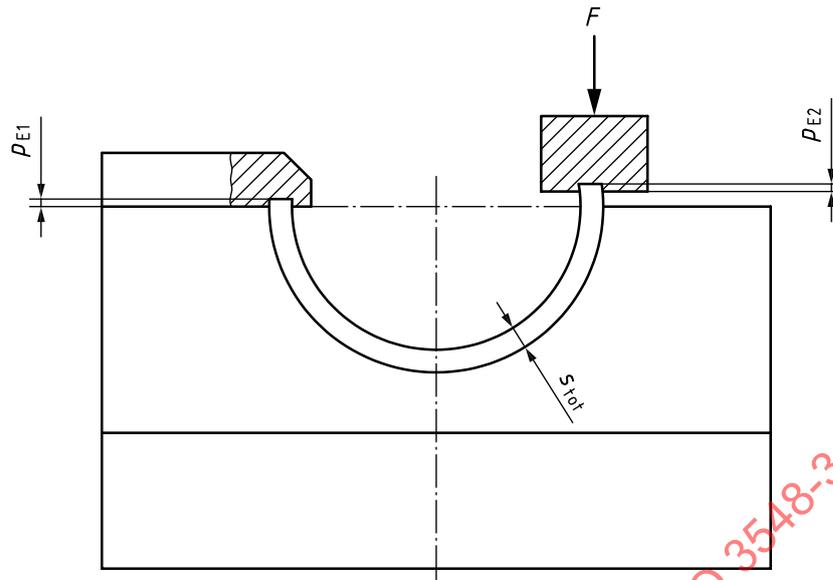
NOTE p_{E1} und p_{E2} are negligible if the measuring planes of the toe piece and the fixed stop are coated with hard carbide.

Figure A.3 — Checking block with inserted bearing shell
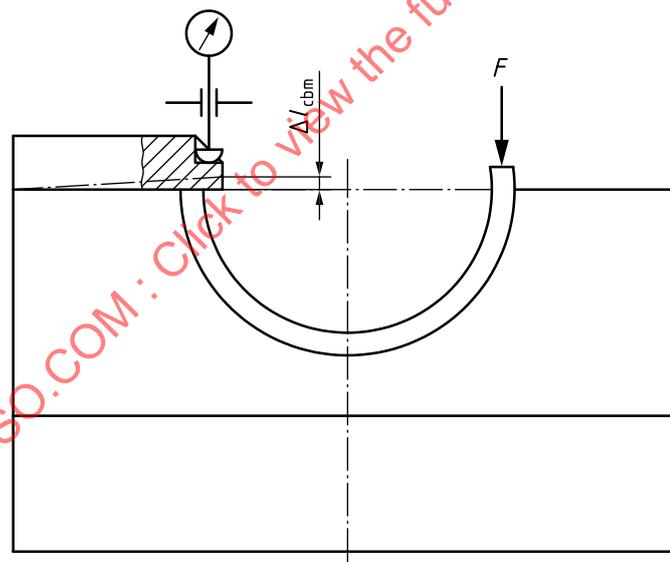
Figure A.4 — Checking block with inserted bearing shell

A.2 Numerical example

Table A.2 — Numerical example

Firm	Number of drawing	Type of bearing

$d_{cbm, th}$ = | 5 4 5 2 1 | mm s_{tot} = | 1 9 5 0 | mm B_{max} = | 3 5 0 0 | mm

F = | 5 8 0 0 | N B_{cbm1} or $B_{cbm3, min}$ = | 3 5 0 0 | mm

1 Actual peripheral length before correction (see figure A.1)

$d_{cbm, M} \times \dfrac{\pi}{2}$ = | 5 4 5 2 2 | × 1,570 8 = ⟶ | 8 5 6 4 2 9 | mm

2 Deviations Δl_{cbm1} and Δl_{cbm2} (take signs into account, see note under figure A.1)

Δl_{cbm1} = | − | 0 0 0 1 | mm

Δl_{cbm2} = | + | 0 0 0 0 | mm

$\Sigma \Delta l_{cbm}$ = | − | 0 0 0 1 | mm ⟶ | − | 0 0 0 1 0 | mm

3 Elastic variation of $H_{cbm, th}$ (see figure A.2)

$\Delta H_{cbm} = \dfrac{H_{cbm, th}\, F}{5 \times 10^5 \times w B_{cbm1}}$ = $\dfrac{\boxed{2\,7\,2\,6\,0} \times \boxed{5\,8\,0\,0}}{500\,000 \times \boxed{1\,0} \times \boxed{3\,5\,0\,0}}$ = | − | 0 0 0 0 9 | mm

4 Elastic depressions at the fixed stop and toe piece (see figure A.3)

$p_{E1} + p_{E2} = \dfrac{0,000\,03\, F}{s_{tot}\, B}$ = $\dfrac{0,000\,03 \times \boxed{5\,8\,0\,0}}{\boxed{1\,9\,5\,0} \times \boxed{3\,5\,0\,0}}$ = | + | 0 0 0 2 5 | mm

5 Flexibility of the fixed stop under checking load Δl_{cbm} (see figure A.4) | + | 0 0 0 2 | mm

6 Measured peripheral length (after correction)

$l_{cbm, M} = \Sigma$ (1 to 5) = | + | 8 5 6 4 5 5 | mm

7 Theoretical peripheral length

$l_{cbm, th} = d_{cbm, th} \times \dfrac{\pi}{2}$ = | 5 4 5 2 1 | × 1,570 8 = ⟶ | − | 8 5 6 4 1 3 | mm

8 Correction factor for master checking block

$F_{cor, cbm}$ = | + | 0 0 0 4 | mm ⟵ | + | 0 0 0 4 2 | mm

Determine steps 1, 2 and 5 by measurement.

Annex B
(normative)

Determination of the correction factor of the master checking block — Method B

B.1 Calculation form

Table B.1 — Calculation form

Firm	Number of drawing	Type of bearing
$d_{cbm, th}$ = ⬚⬚⬚⬚⬚ mm	s_{tot} = ⬚⬚⬚⬚⬚ mm	B_{max} = ⬚⬚⬚⬚ mm
F = ⬚⬚⬚⬚⬚ N		B_{cbm1} or $B_{cbm3, min}$ = ⬚⬚⬚⬚ mm

1 Actual peripheral length before correction (see figure B.1)

$d_{cbm, M} \times \dfrac{\pi}{2}$ = ⬚⬚⬚⬚⬚ × 1,570 8 = ⟶ ⬚⬚⬚⬚⬚⬚ mm

2 Deviations Δl_{cbm1} and Δl_{cbm2} (take signs into account, see note under figure B.1)

Δl_{cbm1} = [−] ⬚⬚⬚ mm
Δl_{cbm2} = [+] ⬚⬚⬚ mm

$\Sigma \Delta l_{cbm}$ = [−] ⬚⬚⬚ mm ⟶ [−] ⬚⬚⬚⬚ mm

3 Elastic variation: $\Delta H_{cbm} = \Delta H_{cbm1} + \Delta H_{cbm2}$ (see figure B.2)

$\Delta H_{cbm} = \dfrac{H_{cbm, th}\, F}{2,5 \times 10^5 \times w B_{cbm1}} = \dfrac{⬚⬚⬚⬚⬚ \times ⬚⬚⬚⬚⬚⬚}{250\,000 \times ⬚⬚ \times ⬚⬚⬚⬚}$ = [−] ⬚⬚⬚⬚⬚⬚⬚ mm

4 Elastic depressions at both toe pieces (see figure B.3)

$p_{E1} + p_{E2} = \dfrac{0,000\,03\, F}{s_{tot}\, B} = \dfrac{0,000\,03 \times ⬚⬚⬚⬚⬚}{⬚⬚⬚⬚⬚ \times ⬚⬚⬚⬚}$ = [+] ⬚⬚⬚⬚⬚⬚⬚ mm

5 Measured peripheral length (after correction)

$l_{cbm, M} = \Sigma$ (1 to 4) = [+] ⬚⬚⬚⬚⬚⬚⬚⬚ mm

6 Theoretical peripheral length

$l_{cbm, th} = d_{cbm, th} \times \dfrac{\pi}{2}$ = ⬚⬚⬚⬚⬚ × 1,570 8 = ⟶ [−] ⬚⬚⬚⬚⬚⬚ mm

7 Correction factor for master checking block

$F_{cor, cbm}$ = [+] ⬚⬚⬚⬚ mm ⟵ [+] ⬚⬚⬚⬚⬚⬚ mm

Determine steps 1 and 2 by measurement.

NOTE $\Delta l_{cbm1} = H_{cbm1\,M} - \dfrac{d_{cbm\,M}}{2}$ and $\Delta l_{cbm2} = H_{cbm2\,M} - \dfrac{d_{cbm\,M}}{2}$

Figure B.1 — Checking block

Key
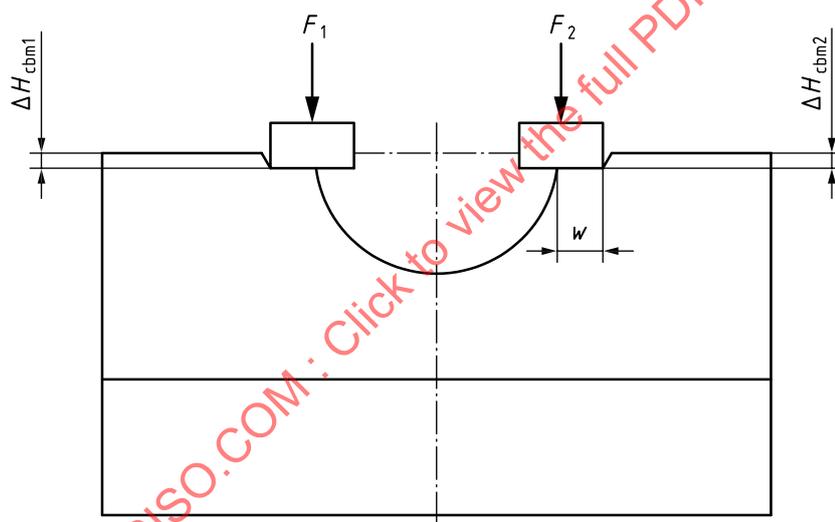
w width of the toe piece contact area, in mm

Figure B.2 — Checking block with two metering bars
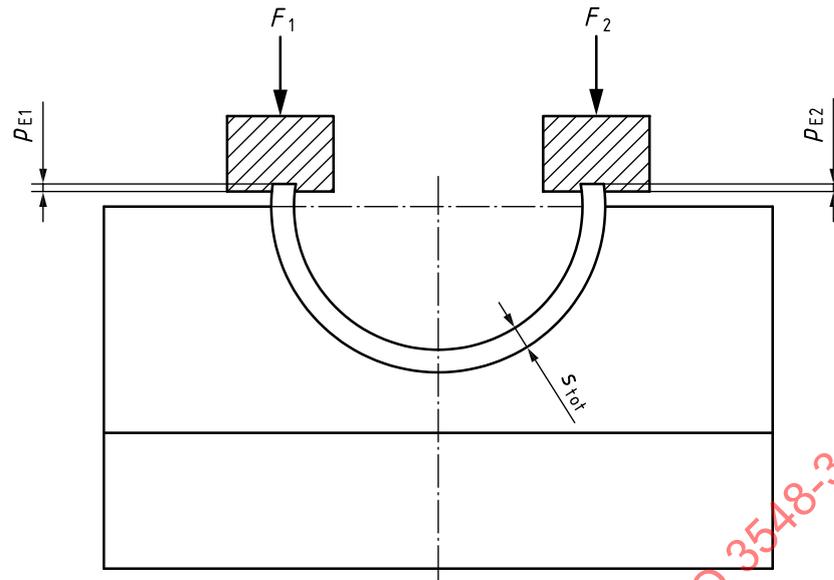
NOTE p_{E1} und p_{E2} are negligible if the measuring planes of the toe piece and the fixed stop are coated with hard carbide.

Figure B.3 — Checking block with inserted shell and two metering bars

B.2 Numerical example

Table B.2 — Numerical example

Firm	Number of drawing	Type of bearing

$d_{cbm, th} =$ `5 4 5 2 1` mm $s_{tot} =$ `1 9 5 0` mm $B_{max} =$ `3 5 0 0` mm

$F =$ `5 8 0 0` N B_{cbm1} or $B_{cbm3, min} =$ `3 5 0 0` mm

1 Actual peripheral length before correction (see figure B.1)

$d_{cbm, M} \times \dfrac{\pi}{2} =$ `5 4 5 2 2` $\times$ 1,570 8 = ⟶ `8 5 6 4 2 9` mm

2 Deviations Δl_{cbm1} and Δl_{cbm2} (take signs into account, see note under figure B.1)

$\Delta l_{cbm1} =$ `-` `0 0 0 1` mm

$\Delta l_{cbm2} =$ `+` `0 0 0 0` mm

$\Sigma\, \Delta l_{cbm} =$ `-` `0 0 0 1` mm ⟶ `-` `0 0 0 1 0` mm

3 Elastic variation: $\Delta H_{cbm} = \Delta H_{cbm1} + \Delta H_{cbm2}$ (see figure B.2)

$\Delta H_{cbm} = \dfrac{H_{cbm, th}\, F}{2,5 \times 10^5 \times w B_{cbm1}} = \dfrac{\boxed{2\ 7\ 2\ 6\ 0} \times \boxed{5\ 8\ 0\ 0}}{250\ 000 \times \boxed{1\ 0} \times \boxed{3\ 5\ 0\ 0}} =$ `-` `0 0 0 1 8` mm

4 Elastic depressions at both toe pieces (see figure B.3)

$p_{E1} + p_{E2} = \dfrac{0,000\ 03\, F}{s_{tot}\, B} = \dfrac{0,000\ 03 \times \boxed{5\ 8\ 0\ 0}}{\boxed{1\ 9\ 5\ 0} \times \boxed{3\ 5\ 0\ 0}} =$ `+` `0 0 0 2 5` mm

5 Measured peripheral length (after correction)

$l_{cbm, M} = \Sigma$ (1 to 4) = `+` `8 5 6 4 2 6` mm

6 Theoretical peripheral length

$l_{cbm, th} = d_{cbm, th} \times \dfrac{\pi}{2} =$ `5 4 5 2 1` $\times$ 1,570 8 = ⟶ `-` `8 5 6 4 1 3` mm

7 Correction factor for master checking block

$F_{cor, cbm} =$ `+` `0 0 0 1 3` mm ⟵ `+` `0 0 0 1 3` mm

Determine steps 1 and 2 by measurement.