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Second edition
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# Plain bearings — Wrapped bushes —

## Part 5: Checking the outside diameter



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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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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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 3547-5:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Clause 2 has been updated;

— Clause 9 has been updated;

— Figure 8 has been updated.

A list of all parts in the ISO 3547 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.



# Introduction

Wrapped bushes in the free condition are flexible, but after insertion they adapt largely to the shape of the housing bore due to the oversize between the outside diameter of the bush and the housing bore. For this reason, checking of the outside diameter of wrapped bushes can only be carried out under a constraining load by use of specialized measuring equipment.

# Plain bearings — Wrapped bushes —

# Part 5: Checking the outside diameter

## 1 Scope

This document specifies, following ISO 12301, the checking of the outside diameter of wrapped bushes (ISO 3547-2:2017, methods A, B and D) and describes the necessary checking methods and measuring equipment.

NOTE The dimensions and tolerances of wrapped bushes are given in ISO 3547-1. Checking the wall thickness is the subject of ISO 3547-7.

## 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 286-2:2010, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 1938-1, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Part 1: Plain limit gauges of linear size*

ISO 3547-2:2017, *Plain bearings — Wrapped bushes — Part 2: Test data for outside and inside diameters*

## 3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

## 4 Symbols and units

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

**Table 1 — Symbols and units**

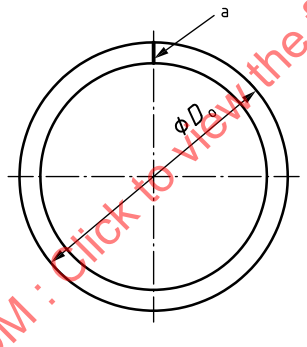
| Symbol | Parameter | SI unit |
|---|---|---|
| $B$ | Width of the bush | millimetres |
| $b_{ch,1}$ | Width of the checking block | millimetres |
| $b_{ch,2}$ | Width of the setting plug | millimetres |
| $d_o$ | Outside diameter of the ring gauge | millimetres |
| $D_o$ | Outside diameter of the bush | millimetres |
| $d_{ch,1}$ | Diameter of the checking block bore (see ISO 3547-2) | millimetres |

**Table 1** *(continued)*

| Symbol | Parameter | SI unit |
|---|---|---|
| $d_{ch,2}$ | Diameter of the setting plug (see ISO 3547-2) | millimetres |
| $d_{ch,a,1}$ | Actual diameter of the checking block | millimetres |
| $d_{ch,a,2}$ | Actual diameter of the setting plug | millimetres |
| $F_{ch}$ | Checking load | newtons |
| $C$ | Correction factor | millimetres |
| Ra | Surface roughness | micrometres |
| $t_1 \ldots t_6$ | Tolerances of form and position | millimetres |
| $x$ | Length of checking block | millimetres |
| $y$ | Width of checking block | millimetres |
| $z$ | Distance between checking block halves | millimetres |
| $\Delta D_o$ | Tolerance of $D_o$ | millimetres |
| $\Delta z$ | Indicator reading | millimetres |
| $\Delta z_D$ | Circumference indicator reading | millimetres |

## 5 Outside diameter, $D_o$

For the outside diameter of a wrapped bush, see Figure 1.




a Split line.

NOTE The free diameter of a wrapped bush is not measured directly because of the flexible nature of the component.

**Figure 1 — Outside diameter of a wrapped bush**



## 6 Purpose of checking

The outside diameter shall be checked to ensure the designated mounting compression (interference fit) for the wrapped bush in the housing bore.

## 7 Methods of checking

### 7.1 General

Checking method C is for measuring the inside diameter and is covered by ISO 3547-6.

For the methods described in 7.2 to 7.4, see also ISO 3547-2.

### 7.2 Checking method A — Measurement of outside diameter, $D_o$

Check the outside diameter of a wrapped bush using measuring equipment as shown in Figure 2, with a checking block consisting of upper and lower halves (see Figures 3 and 4) and setting plugs (see Figures 5 and 6), at a determined checking load, $F_{ch}$.

Measure the outside diameter indirectly as the difference in the value of $z$, $\Delta z$.

The checking load is calculated so that the bush outside diameter is reduced only elastically during checking and that there is no permanent deformation.

### 7.3 Checking method B — Gauging of outside diameter, $D_o$

Check the outside diameter of a wrapped bush in "GO" and "NO GO" ring gauges.

### 7.4 Checking method D — Measurement of outside diameter, $D_o$ > 120 mm

Check the outside diameter of a wrapped bush above 120 mm diameter using a precision measuring tape.

## 8 Selection of checking method for outside diameter

Method A is a precise method involving complex tooling. Method B is an attributive method using simpler tooling. Method D is used only for wrapped bushes with an outside diameter > 120 mm. All three methods are in general use. Method A is generally unsuitable for small bushes up to 10 mm outside diameter but is preferred for bushes over 10 mm outside diameter.

## 9 ISO 3547-2:2017, test A — Outside diameter, Do

### 9.1 Measuring equipment

Typical equipment for measuring the bush consists essentially of the following components:

— base plate used as fixture and guiding device for the split checking block;

— means to generate the checking load;

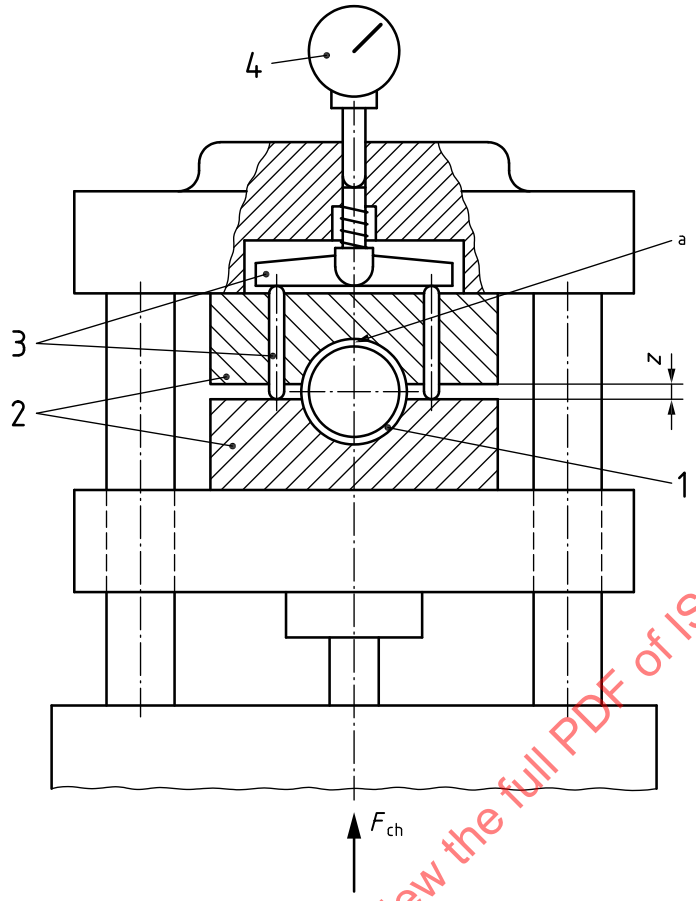
— means to calibrate the measuring load (see Table 2);

— upper plate;

— system for transmitting the distance, $z$, of both checking block halves to the measuring pin (see Figure 2);

— measuring pin with indicating instrument (see Table 3);

— checking block (see Figures 3 and 4) with setting plug (see Figures 5 and 6).




**Key**

1 bush
2 checking block
3 measuring pins
4 indicating instrument
a Split line.

**Figure 2 — Typical outside diameter measuring system**

Figure 2 shows a typical outside diameter measuring system. This may be operated hydraulically, pneumatically or mechanically.

The force, $F_{ch}$, may be smoothly applied from the top or from below.

The bush split shall be in the vertical direction and pointing towards the upper checking block.

**Table 2 — Checking loads and their limiting deviations, speed of approach and temperature**

| Checking load $F_{ch}$ N | | Permissible limiting deviations of the checking load % | Maximum speed of approach to apply the checking load, $F_{ch}$ mm/s | Test temperature[a] °C |
|---|---|---|---|---|
| — | ≤2 000 | ±1,25 | 12 | 20 to 25 |
| >2 000 | ≤5 000 | ±1 | | |
| >5 000 | ≤10 000 | ±0,75 | | |
| >10 000 | ≤50 000 | ±0,5 | | |
| [a] The difference in temperature between the checking block and the bush to be measured shall not exceed 1 °C. | | | | |

**Table 3 — Deviations for dial gauge and electronic gauge**

Dimensions in millimetres

| Outside diameter Tolerance $\Delta D_o$ | | Resolution | | Total deviation[a] | |
|---|---|---|---|---|---|
| | | dial gauge | electronic gauge | dial gauge | electronic gauge |
| — | ≤0,1 | 0,001 | 0,001 | 0,001 2 | 0,5 % of measuring range |
| >0,1 | | 0,005 | 0,005 | 0,006 | |

[a] Maximum measuring value indication (for a full-scale range of ±500 µm).

## 9.2 Requirements for checking the block and the setting plug

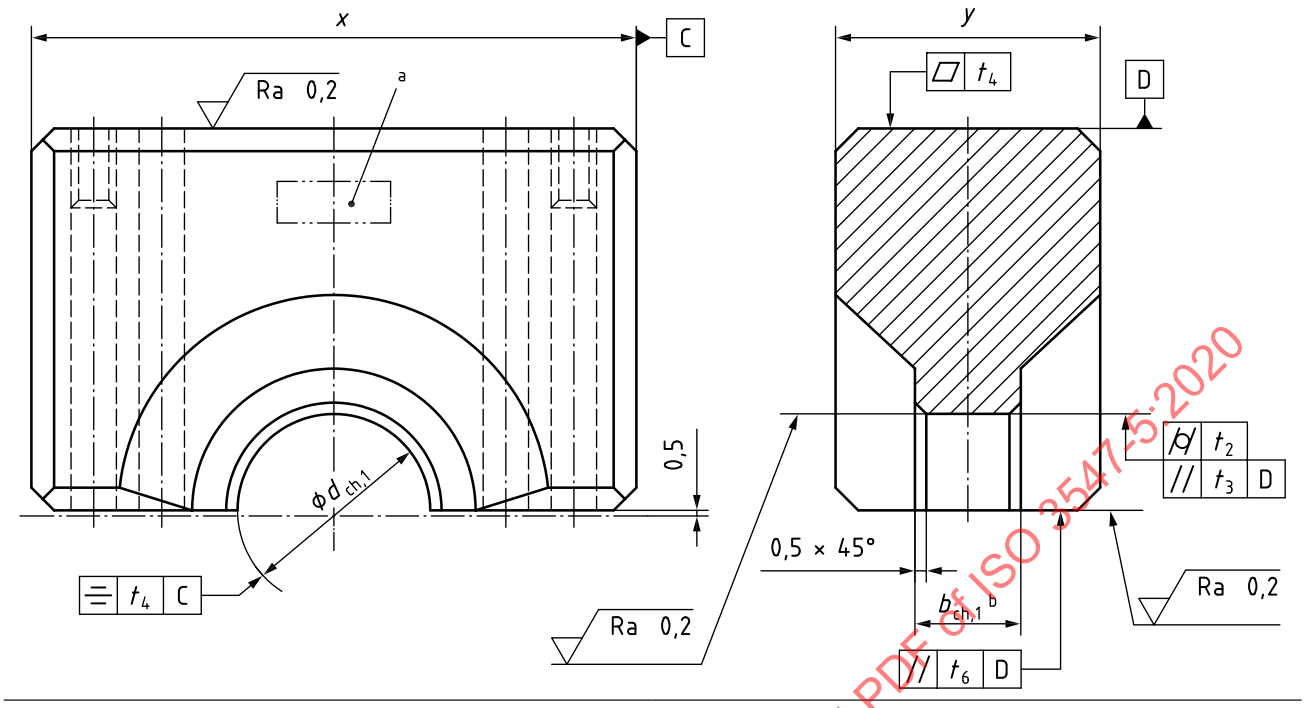
The requirements for the checking block and the setting plug for measuring the bush outside diameter, $D_o$, shall be as shown in Figures 3 to 6 and as given in Table 4. Manufacturing tolerances and wear limits are given in Table 5.

**Table 4 — Maximum difference between the diameters of the checking block, $d_{ch,1}$, and setting plug, $d_{ch,2}$, for a usable combination**

Dimensions in millimetres

| $D_o$ nominal | | $d_{ch,1} - d_{ch,2}$ max. |
|---|---|---|
| | ≤18 | 0,006 |
| >18 | ≤50 | 0,008 |
| >50 | ≤80 | 0,01 |
| >80 | ≤120 | 0,012 |
| >120 | ≤180 | 0,016 |

Dimensions in millimetres




$x \geq 160$ mm

$x \geq d_{ch,1} + 90$ mm

$y \geq 70$ mm

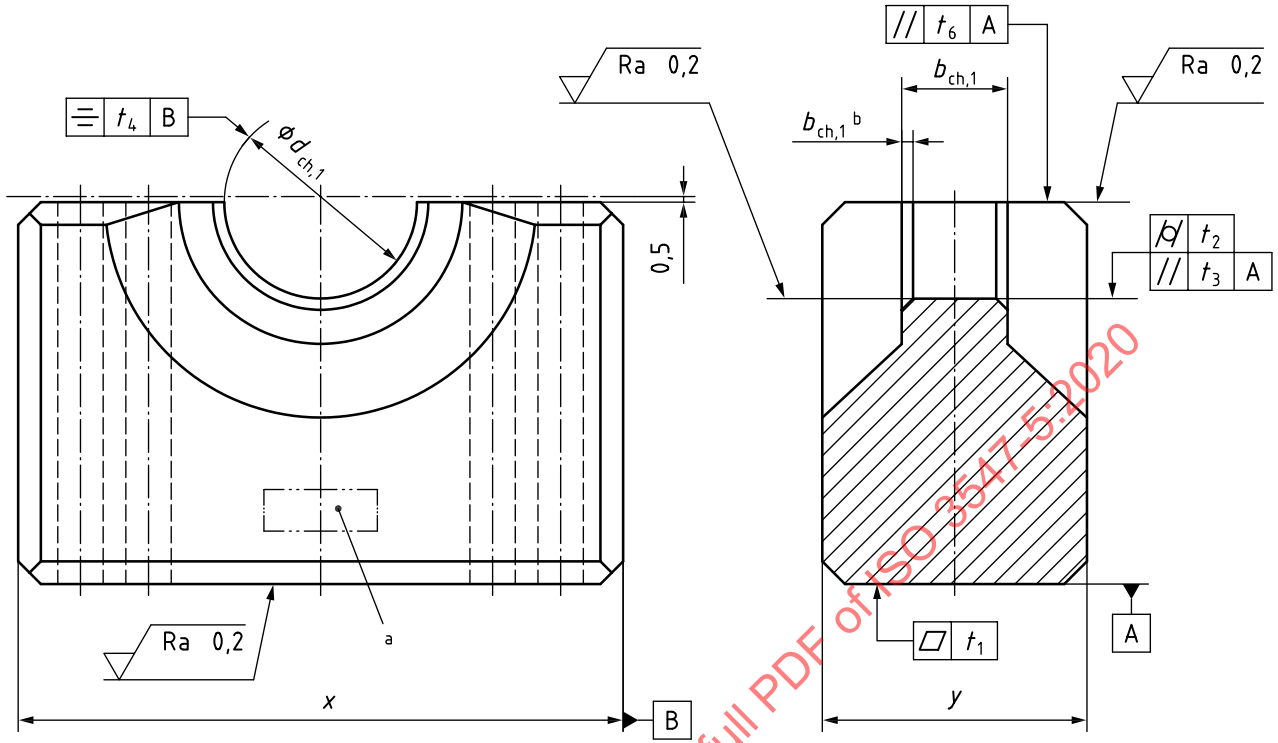
$y \geq b_{ch,1} + 5$ mm

a Field for marking.

b $b_{ch,1} \geq B + 2$.

**Figure 3 — Upper half of checking block**

Dimensions in millimetres, unless otherwise indicated




$x \geq 160$ mm

$x \geq d_{ch,1} + 90$ mm

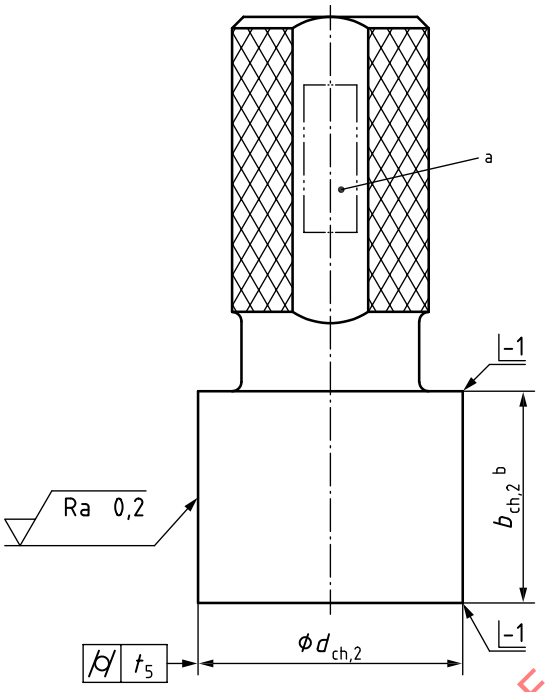
$y \geq 70$ mm

$y \geq b_{ch,1} + 5$ mm

a Field for marking.

b $b_{ch,1} \geq B + 2$.

**Figure 4 — Lower half of checking block**

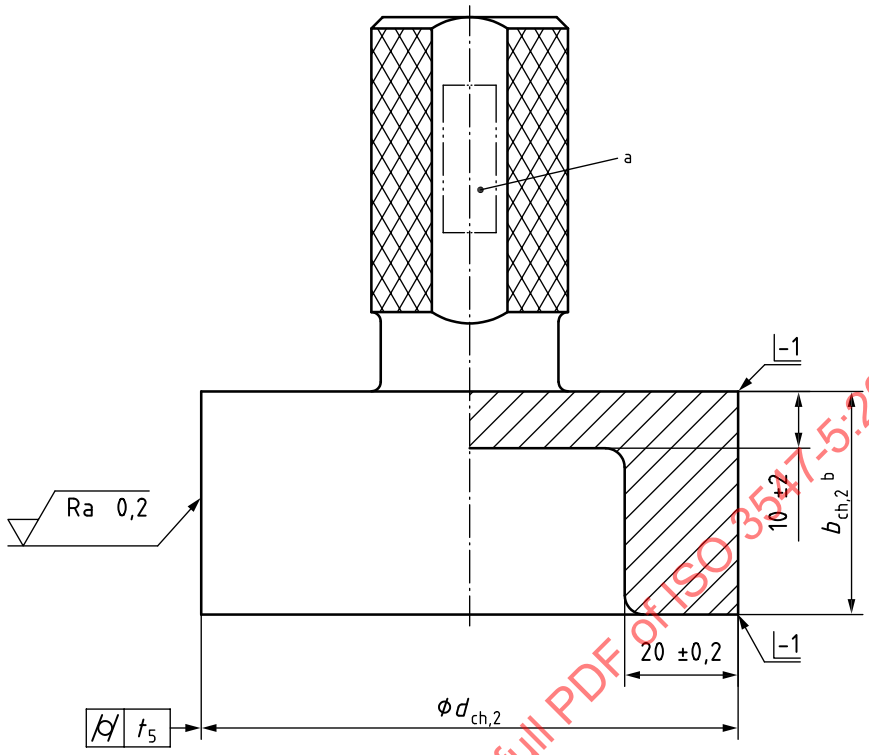



a Field for marking.

b $b_{ch,2} \geq b_{ch,1} + 5$.

**Figure 5 — Setting plug, solid, for $d_{ch,2} \leq 80$ mm**

Dimensions in millimetres




a Field for marking.

b $b_{ch,2} \geq b_{ch,1} + 5$.

**Figure 6 — Setting plug, for example with blind hole, for $d_{ch,2}$ > 80 mm**

**Table 5 — Manufacturing tolerances and wear limits for checking block, setting plug and ring gauge**

Dimensions in millimetres

| $D_o$ nominal | | Limits of manufacturing tolerances or wear limits | $d_{ch,2}$ | $d_{ch,1}$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | $t_6$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | ≤80 | manufacture | $^{0}_{-0,003}$ | $^{+0,003}_{0}$ | 0,002 | 0,002 | 0,003 | 0,05 | 0,002 | 0,03 |
| | | wear | −0,005 | +0,005 | 0,004 | 0,004 | 0,005 | 0,05 | 0,004 | 0,05 |
| >80 | ≤150[a] | manufacture | $^{0}_{-0,005}$ | $^{+0,005}_{0}$ | 0,003 | 0,003 | 0,004 | 0,05 | 0,003 | 0,03 |
| | | wear | −0,007 | +0,007 | 0,005 | 0,005 | 0,006 | 0,05 | 0,005 | 0,05 |

a For $D_o$ > 150 mm, agreement shall be reached between the supplier and user.

Checking block halves (see Figures 3 and 4) and setting plugs (see Figures 5 and 6) shall be made from hardened (60 HRC to 64 HRC) and non-ageing steel.

The checking block halves shall be of rigid construction so that only negligible deformations are caused by the forces arising during measurement of the bushes.

The bore of the checking block halves and the checking surface of the setting plug shall not be chromium plated.

The checking block diameter, $d_{ch,1}$, and the setting plug diameter, $d_{ch,2}$, may be marked with their nominal value.

## 9.3 Determination of correction factor, $C$

The correction factor, $C$, is used to correct the setup of the indicating instrument and is calculated from Formula (1):

$$C = \frac{\pi}{2}\left[\left(d_{ch,a,1} - d_{ch,1}\right) - \left(d_{ch,a,1} - d_{ch,a,2}\right)\right] \quad (1)$$

EXAMPLE

$d_{ch,1}$ = 20,050 mm

$d_{ch,a,1}$ = 20,052 mm

$d_{ch,a,2}$ = 20,048 mm

Therefore,

$$C = \frac{\pi}{2}[(20{,}052 - 20{,}050) - (20{,}052 - 20{,}048)]$$

$C$ = − 0,003 mm

If the actual diameter, $d_{ch,a,1}$, of the checking block deviates from the checking block diameter, $d_{ch,1}$, of the bushes to be checked, these checking blocks may still be used provided that the deviation $\left|d_{ch,a,1} - d_{ch,1}\right| \leq 0{,}03$ mm . The tolerances of the setting plug according to Table 5 are not affected.

EXAMPLE

$d_{ch,1}$ = 20,062 mm

$d_{ch,a,1}$ = 20,052 mm

$d_{ch,a,2}$ = 20,048 mm

$$\left|d_{ch,a,1} - d_{ch,1}\right| = 0{,}010 \text{ mm} \leq 0{,}030 \text{ mm}$$

Therefore,

$$C = \frac{\pi}{2}[(20{,}052 - 20{,}062) - (20{,}052 - 20{,}048)]$$

$C$ = − 0,022 mm

## 9.4 Procedure

Perfect positioning of both checking block halves is achieved when the following procedure is used. With the setting plug positioned and fixed centrally in the lower checking block, mount the upper checking block on the setting plug. Apply the checking load, $F_{ch}$ and clamp in position.

Adjust the correction factor, $C$, in accordance with 9.3, remove the setting plug and insert the bush centrally with the split vertically upwards. Reapply the check load and take the indicator reading, Δz.

## 9.5 Measuring errors

### 9.5.1 General

The most frequent errors are given in 9.5.2 to 9.5.4.

### 9.5.2 Errors due to measuring equipment

a) The upper and lower checking block halves are not aligned.

b) The checking block halves are not correctly fixed in the measuring equipment.

c) The tightness is not correct [e.g. too much clearance, damage of the transmitting system (see Figure 2), dial gauge].

d) The checking block or setting plug is damaged or worn.

e) The width of the checking block bore, $b_{ch,1}$, is less than the width of the bush, $B$.

f) The checking load, $F_{ch}$, does not correspond to the calculated load.

### 9.5.3 Errors due to the bush

Errors due to the bush are caused by, for example, the presence of grease, dirt and burrs on the outside diameter (back surface) and/or in the split, and damage or deformation of the outside diameter and/or the split.

### 9.5.4 Errors due to human factors

a) The checking load is incorrectly set.

b) The bush is not centralized in the checking block.

c) The split in the bush is not pointed vertically towards the upper checking block.

d) An incorrect reading is taken during measurement of the actual diameters, $d_{ch,a,1}$ and $d_{ch,a,2}$.

e) The correction factor is incorrectly calculated and/or set.

f) The outside diameter, $D_o$, is incorrectly calculated.

## 9.6 Summary of the factors relating to the measurement of the outside diameter, $D_o$, of the bush

### 9.6.1 Checking load, $F_{ch}$

The checking load, $F_{ch}$, shall be calculated in accordance with ISO 3547-2.

### 9.6.2 Diameter of the checking block, $d_{ch,1}$, and of the setting plug, $d_{ch,2}$

The diameter shall be calculated in accordance with ISO 3547-2.

### 9.6.3 Upper limiting value and lower limiting value for $\Delta z$

The upper limiting value is 0.

The lower limiting value is $-\Delta D_o \left(\frac{\pi}{2}\right)$, rounded up to 0,005 mm, where $\Delta D_o = D_{o,max} - D_{o,min.}$