INTERNATIONAL STANDARD

ISO 12307-1

First edition
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Plain bearings — Wrapped bushes —

Part 1:
Checking the outside diameter

Paliers lisses — Bagues roulées —
Partie 1: Contrôle du diamètre extérieur

Reference number
ISO 12307-1:1994(E)

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 12307-1 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 5, *Quality analysis and assurance*.

ISO 12307 consists of the following parts, under the general title *Plain bearings — Wrapped bushes*:

— *Part 1: Checking the outside diameter*

— *Part 2: Checking the inside diameter*

Annexes A, B and C of this part of ISO 12307 are for information only.

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Plain bearings — Wrapped bushes —

Part 1:
Checking the outside diameter

1 Scope

This part of ISO 12307 specifies in accordance with ISO 12301 the checking of the outside diameter of wrapped bushes (methods A and B specified in ISO 3547) and describes the necessary checking methods and measuring equipment.

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.

NOTES

1 All dimensions in this part of ISO 12307 are given in millimetres.

2 The dimensions and tolerances of wrapped bushes are given in ISO 3547. Checking the wall thickness is the subject of ISO 12306.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 12307. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 12307 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 286-2:1988, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts.*

ISO/R 1938:1971, *ISO system of limits and fits — Part II: Inspection of plain workpieces.*

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

3 Symbols and units

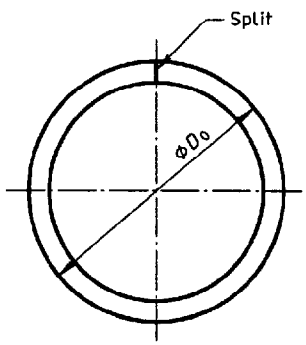
For the purposes of this part of ISO 12307, the symbols and units are as given in table 1.

Table 1 — Symbols and units

Symbol	Parameter	SI unit
a_c	Distance between checking block halves	mm
B	Width of the bush	mm
$b_{c,1}$	Width of the checking block	mm
$b_{c,2}$	Width of the setting plug ($b_{c,2} = b_{c,1} + 5$)	mm
D_o	Outside diameter of the bush	mm
$d_{c,1}$	Diameter of the checking block bore (see ISO 3547)	mm
$d_{c,2}$	Diameter of the setting plug	mm
$d_{c,a,1}$	Actual diameter of the checking block	mm
$d_{c,a,2}$	Actual diameter of the setting plug	mm
E_{red}	Elastic reduction of the outside diameter under the checking load F_c	mm
F_c	Checking load	N
C	Correction factor	mm
n	Number of test pieces	
P_{zw}	Confidence level, on both sides	%
R_a	Surface roughness (in accordance with ISO 468)	µm
T	Tolerance on D_o	mm
$t_1 \ldots t_6$	Tolerances of form and position	mm
u	Uncertainty of measurement ($P_{zw} = 95$ %)	mm
u_E	Uncertainty of measurement of the measuring equipment	mm
Δx	Difference in measured values between first and second readings	mm
$\overline{\Delta x}$	Arithmetic mean of Δx	mm
σ	Standard deviation	mm
$\sigma_{\Delta x}$	Standard deviation of Δx	mm

4 Outside diameter, D_o

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



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

5 Purpose of checking

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

6 Methods of checking

6.1 Checking method A: Measurement of outside diameter, D_o (see ISO 3547)

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 of F_c.

Measure the outside diameter indirectly as the difference in the value of a_c (Δa_c).

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

6.2 Checking method B: Gauging of outside diameter, D_o (see ISO 3547)

Check the outside diameter of a wrapped bush in "GO" and "NOT-GO" ring gauges.

The checking result is of an attributive nature, i.e. "GO" or "NOT-GO".

7 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. Both 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.

8 Test ISO 3547 — A: Outside diameter, D_o

8.1 Measuring equipment

See tables 2 to 4.

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;

— aggregate to generate the checking load;

— upper plate;

— system transferring the distance a_c of both checking block halves to the measuring pin (see figure 2);

— measuring pin with indicating instrument;

— checking block (see figures 3 and 4) with setting plug (see figures 5 and 6);

— correlation compression (load table).

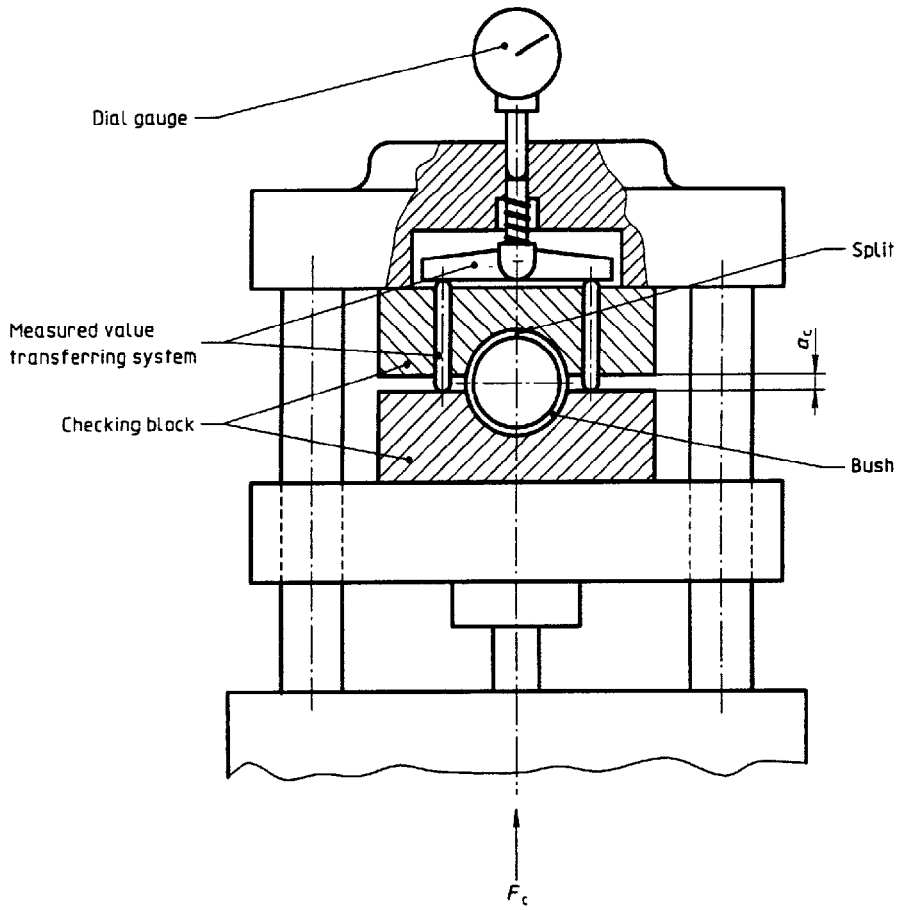


Figure 2 — Typical outside diameter measuring system

Figure 2 shows hydraulically operated equipment. Pneumatically or mechanically operated equipment may also be used.

The force F_c may be 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, limiting deviations, speeds of approach and temperatures

Checking load F_c N	**Permissible limiting deviations** %	**Maximum speed of approach to apply the checking load** F_c mm/s	**Test temperature**[1] °C
$F_c \leqslant 2\,000$	± 1,25	10 ± 2 without impact	20 to 25
$2\,000 < F_c \leqslant 5\,000$	± 1		
$5\,000 < F_c \leqslant 10\,000$	± 0,75		
$10\,000 < F_c \leqslant 50\,000$	± 0,5		

1) 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

Outside diameter D_o mm	Scale graduation value mm		Total deviation[1] mm	
	dial gauge	electronic gauge	dial gauge	electronic gauge
$D_o \leqslant 80$	0,001	0,001	0,001 2	0,5 % of measuring range
$D_o > 80$	0,005	0,001	0,006	

1) Maximum measuring value indication (full-scale ± 500 µm).

Table 4 — Manufacturing tolerances for the upper and lower clamping surfaces of the measuring equipment

Tolerance of parallelism between both clamping surfaces mm	Tolerance of flatness mm	Surface roughness, R_a µm
0,01/100	0,005	0,2

8.2 Requirements for measuring equipment

The requirements for the measuring equipment for measurement of the bush outside diameter, D_o, shall be as shown in figures 3 to 6 and given in table 5:

$$d_{c,1} = D_{o,max} - E_{red}$$

E_{red} = 0,006 mm for $D_o < 12$ mm

E_{red} = 0,0012 mm for $D_o \geqslant 12$ mm

$$b_{c,1} \geqslant B + 2$$

$$b_{c,2} = b_{c,1} + 5$$

where E_{red} is the elastic reduction in accordance with ISO 3547.

Dimensions in millimetres,
surface roughness values in micrometres

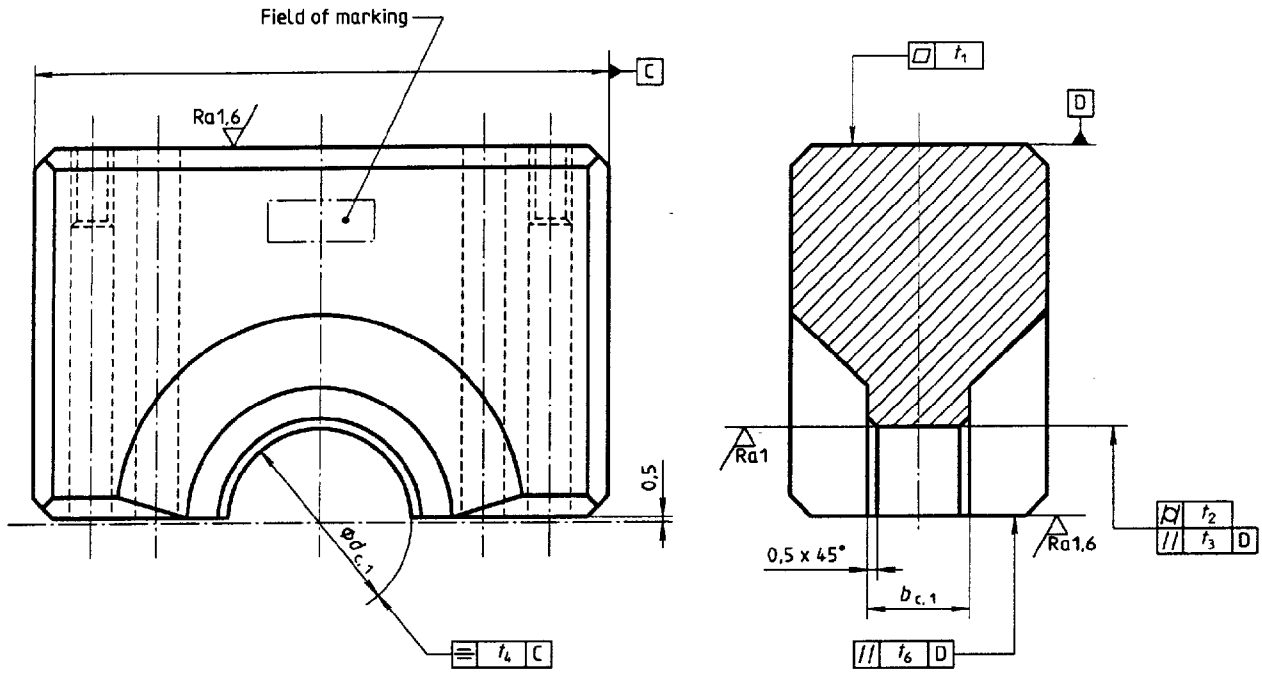


Figure 3 — Upper half of checking block

Dimensions in millimetres,
surface roughness values in micrometres

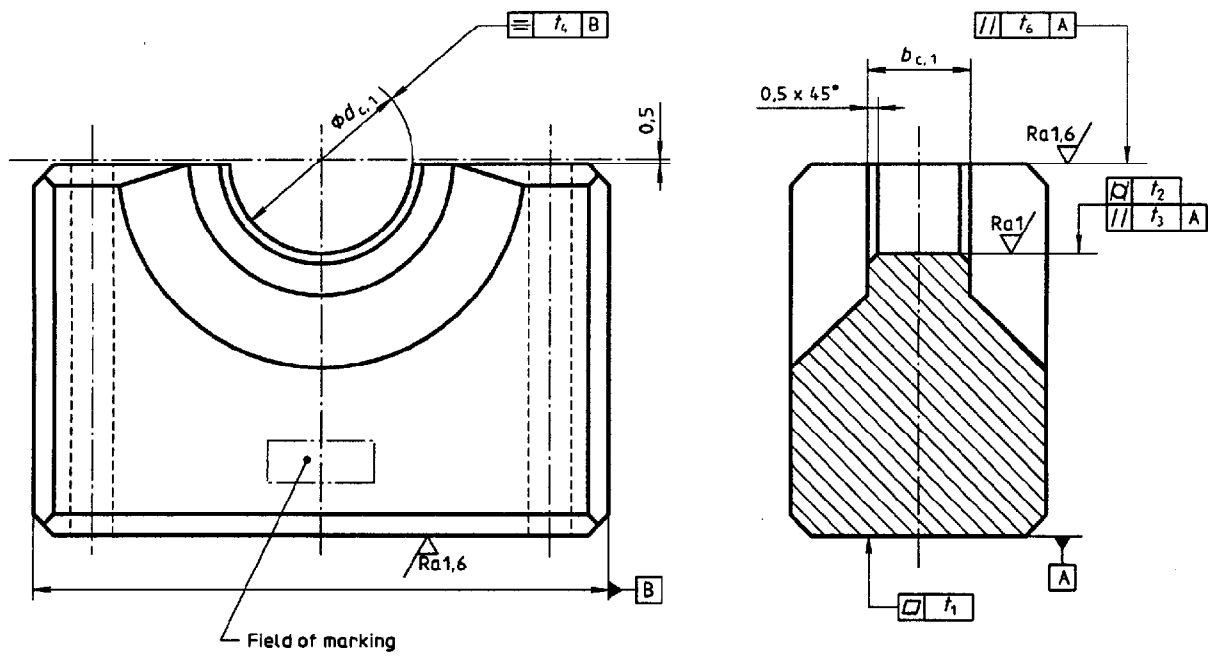


Figure 4 — Lower half of checking block

Dimensions in millimetres,
surface roughness values in micrometres

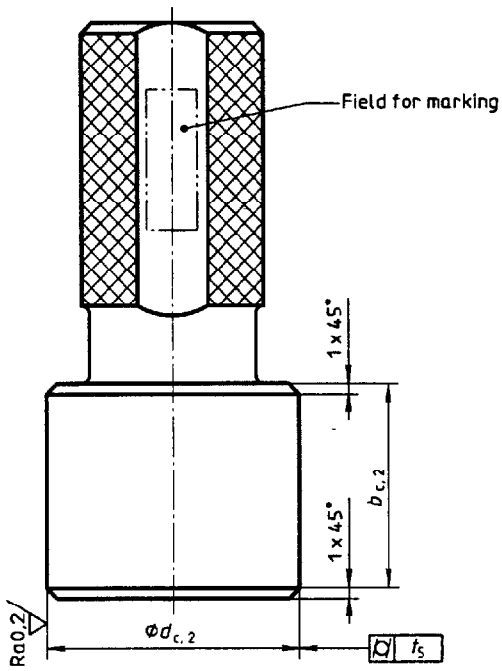


Figure 5 — Setting plug, solid, for $d_{c,2} \leqslant 80$ mm

Dimensions in millimetres,
surface roughness values in micrometres

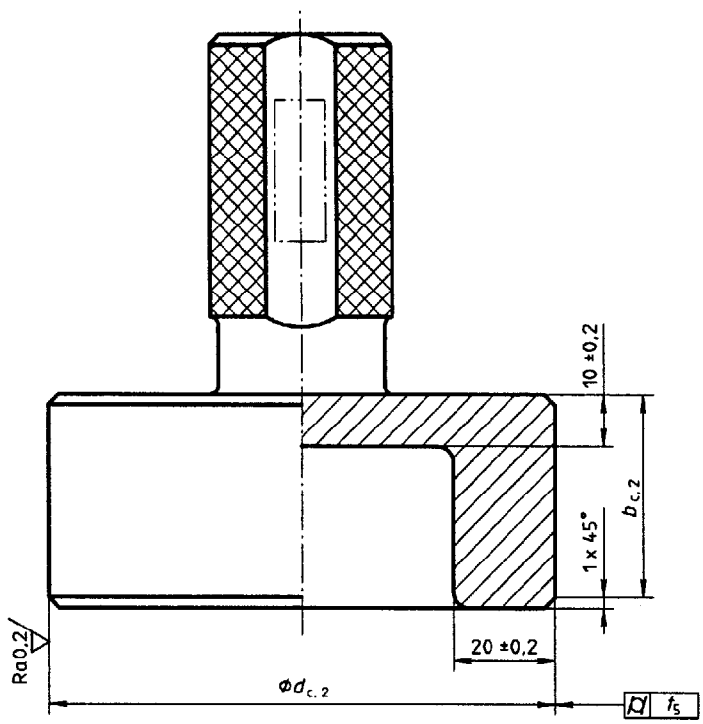


Figure 6 — Setting plug, for example with blind hole, for $d_{c,2} > 80$ mm

Table 5 — Manufacturing tolerances and wearing limits for checking block and setting plug

Outside diameter D_o	Limits of manufacturing tolerances or wearing limits	$d_{c,2}$	$d_{c,1}$	t_1	t_2	t_3	t_4	t_5	t_6
$D_o \leqslant 80$	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
$80 < D_o \leqslant 150$ [1]	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

1) For $D_o > 150$ mm, agreement shall be reached between the manufacturer and customer.

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 and the setting plug may be marked with their nominal diameter, $d_{c,1}$.

The setting plugs shall be additionally marked with their correction factor C.

8.3 Determination of correction factor C

The correction factor, C, is calculated from the following formula:

$$C = \frac{\pi}{2}(d_{c,a,1} - d_{c,1}) - (d_{c,a,1} - d_{c,a,2})$$

EXAMPLE

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

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

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

Therefore

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

$C = -0{,}001$ mm

If the actual diameter $d_{c,a,1}$ of the checking block deviates from the $d_{c,1}$ diameter of the bushes to be checked, these checking blocks may still be used provided that the deviation $|d_{c,a,1} - d_{c,1}| \leqslant 0{,}03$ mm. The tolerances of the setting plug according to table 4 are not affected.

EXAMPLE

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

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

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

$$|d_{c,a,1} - d_{c,1}| = 0{,}010 \text{ mm} = < 0{,}030 \text{ mm}$$

Therefore

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

$$C = -0{,}020 \text{ mm}$$

8.4 Procedure

Perfect positioning of both checking block halves to each other is given when the lower half is inserted first and fixed centrally to the bush measuring equipment. Then press the loosely mounted upper checking block half under a given checking load against the lower checking block half with the setting plug inserted. Fix it in this state and adjust the correction factor C in accordance with 8.3, and take the reading Δa_c. Then insert the bushes centrally.

8.5 Measuring errors

The most frequent errors are given in 8.5.1 to 8.5.3.

8.5.1 Errors due to measuring equipment

a) The upper and lower checking block halves are not lined up to each other.

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

c) Tightness [too much clearance, damage of the transmission system (see figure 2), dial gauge, measuring pin, etc.].

d) Damage to or wear of the checking block or setting plug.

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

f) The checking load, F_c, does not correspond to the calculated load.

8.5.2 Errors due to the bush

Presence of grease, dirt, burrs, etc. on the outside diameter (back surface) and/or in the split, and damage or deformation of the outside diameter and/or the split.

8.5.3 Errors due to human factors

a) Wrong setting of the checking load.

b) The bush is measured eccentrically to the width of the checking block bore, $b_{c,1}$.

c) The split in the bush inserted in the checking block does not point vertically towards the upper checking block.

d) Incorrect reading taken at measurement of the actual diameters $d_{c,a,1}$ and $d_{c,a,2}$.

e) Wrong calculation and/or setting of the correction value.

f) Wrong conversion of the outside diameter, D_c.

8.6 Summary of the principle bases of calculation for measuring the outside diameter, D_o, of the bush

8.6.1 Checking load, F_c

The checking load F_c shall be calculated in accordance with ISO 3547.

8.6.2 Diameter of the checking block, $d_{c,1}$, and of the setting plug according to the drawing

The diameter is calculated from the equation

$$d_{c,1} = D_{o,max} - E_{red}$$

where E_{red} is the elastic reduction in accordance with ISO 3547.

8.6.3 Upper limiting value and lower limiting value for Δa_c

Upper limiting value = 0

Lower limiting value = $-T\left(\frac{\pi}{2}\right)$ (rounded up to 0,005 mm)

where $T = D_{o,max} - D_{o,min}$

8.6.4 Correction factor, C

This shall be calculated according to 8.3.

8.6.5 Conversion of the indicated measured value Δa_c for outside diameter

This is calculated from the equation

$$D_o = d_{c,1} + E_{red} + \Delta a_c\left(\frac{2}{\pi}\right)$$

9 Test ISO 3547 — B: Outside diameter, D_o

9.1 Gauging equipment

The test is carried out by means of two ring gauges, one corresponding to the maximum limiting value (GO ring gauge), the other corresponding to the minimum limiting value (NOT-GO ring gauge) of the outside diameter, D_o, of the bush according to the drawing. Both ring gauges shall have a lead-in chamfer of narrow angle (see figure 7) or radius in order to avoid damage and failure during the test.

9.2 Requirements for measuring equipment

Ring gauges shall be of hardened (60 HRC to 64 HRC) and non-ageing steel. The width of the ring gauge (without chamfer) shall at least correspond to the maximum width of the bush.

The limiting values of the ring gauge inside diameter for a GO ring gauge and a NOT-GO ring gauge are JS3 in accordance with ISO 286-1 and ISO 286-2.

Wear of the ring gauges shall not exceed the y_1 value (reference value for the wearing limit) for work pieces IT 8 in accordance with ISO/R 1938.

9.3 Procedure

Introduce the bush into the GO ring gauge from the side having the slipping chamfer. It must be possible to introduce it and push it through the GO ring gauge by hand (maximum force 250 N) but not (with the same force) into the NOT-GO ring gauge.

In critical cases, the accuracy of the test may be reduced if the bush is not circular or the split not closed. Therefore the test according to method A shall be preferred.

Dimensions in millimetres,
surface roughness values in micrometres

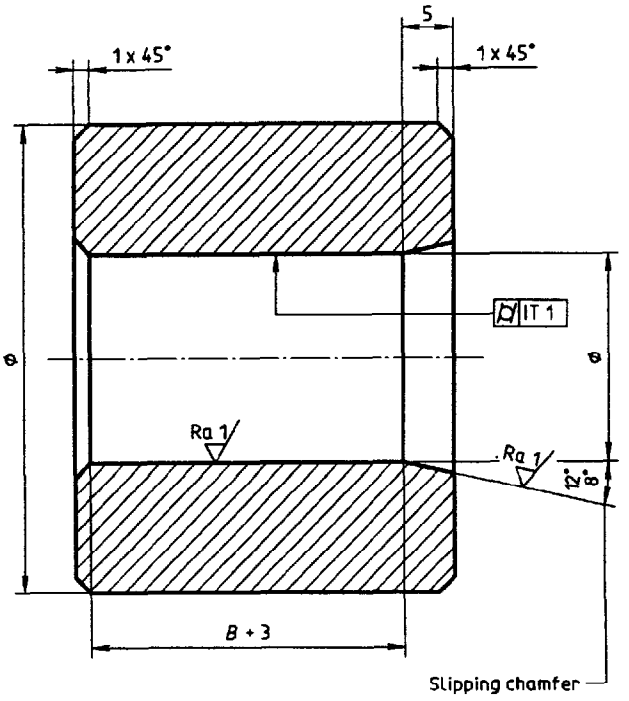


Figure 7 — Ring gauge

9.4 Measuring errors

The most frequent measuring errors are as follows.

a) Damaged or worn ring gauges.

b) Ring gauges have no lead-in chamfer.

c) Bushes are introduced into the ring gauge in an inclined position.

d) Bushes are pressed into the ring gauge by applying too much force.

e) The width of the ring gauge is less than the width of the bush.

f) Deviation from circularity and open split of the bush in the free condition.

g) Presence of grease, dirt, burrs, etc. on the outside diameter (back surface) and/or in the split, and damage or deformation of the outside diameter and/or the split.

10 Checking of measuring equipment with regard to the requirements for accuracy

10.1 Requirements

The quality of the measuring equipment shall be such that the random component of the uncertainty measurement, u, of a single test result, determined by means of the measuring instrument on a typical object to be measured (bush), is lower than the limiting value u_E given in table 6. For the determination of u, see 10.2.

Furthermore, the quality of the measuring equipment shall be such that the sum $|\overline{\Delta x}|$ of the difference between two measurement series, determined according to 10.2 for two different times or for the application of the measuring equipment in two similar or different sets of measuring equipment, does not exceed the limiting value $|\overline{\Delta x}|_E$ given in table 6.

Table 6 — Limiting values for the measuring equipment

Outside diameter D_o	u_E	$\lvert\overline{\Delta x}\rvert_E$
$D_o \leqslant 80$	0,008	0,003
$80 < D_o \leqslant 150$ 1)	0,010	0,005
1) For $D_o > 150$ mm, agreement shall be reached between the manufacturer and customer.		

10.2 Determination of the uncertainty of measurement, u (see annex A)

Twenty-four bushes shall be measured twice each (after each reinsertion of the bush) within a short period of time, by means of the same measuring equipment including the measuring instrument to be checked, and by the same person at the same checking place.

The difference, Δx, between the two measurements determined with correct signs gives the standard deviation, σ (calculated by computer) from the equation:

$$\sigma_{\Delta x} = \sqrt{\left(\frac{1}{24-1}\right)\sum_{i=1}^{24}(\Delta x_i - \overline{\Delta x})^2}$$

Provided that the values derive from a normal distribution and that σ is considered to be a sufficiently exact assessed value for the standard deviation of the lot, a random component of the measurement uncertainty u for a single result measured by means of this measuring instrument is (for a confidence level of $1 - \alpha = 95$ %):

$$u \approx \frac{4\sigma_{\Delta x}}{\sqrt{2}}$$

The value u is compared to the limiting value u_E.

10.3 Determination of comparability $|\overline{\Delta x}|$ (see annex B)

The 24 bushes shall be measured on two similar or different sets of measuring equipment by different persons at different checking places and at different checking times.

The measured values under the two conditions 1 and 2 are $x_{1,i}$ and $x_{2,i}$.

The mean values are

$$\bar{x}_1 = \left(\frac{1}{24}\right)\sum_{i=1}^{24} x_{1,i}$$

$$\bar{x}_2 = \left(\frac{1}{24}\right)\sum_{i=1}^{24} x_{2,i}$$

The sum of the difference between the mean values of the two measurement series is

$$|\overline{\Delta x}| = |\bar{x}_1 - \bar{x}_2|$$

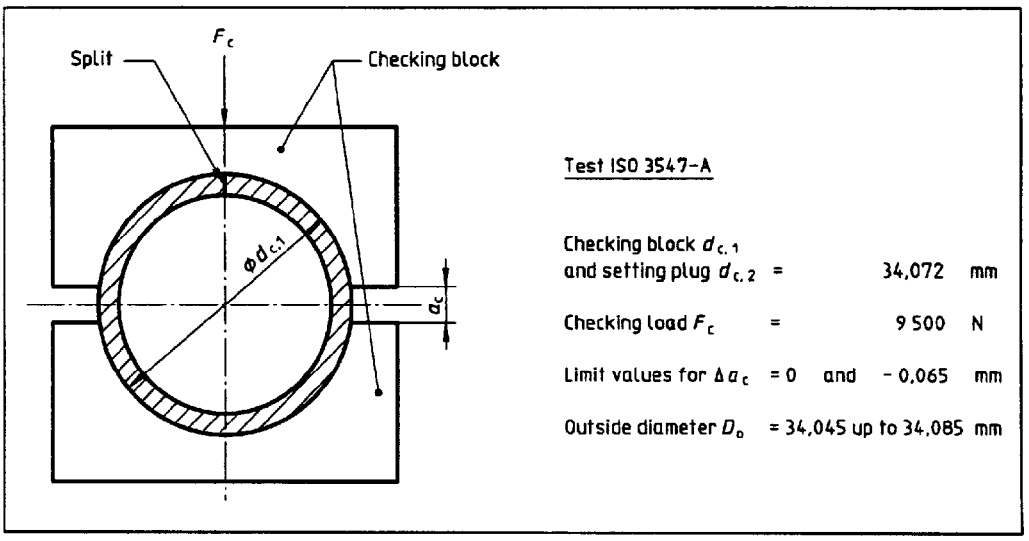
This is compared to the limiting value $|\overline{\Delta x}|_E$.

11 Specifications on drawings of bushes

The preferred option for the checking method shall be specified on the drawing as shown in 11.1 and 11.2.

11.1 Checking method A

EXAMPLE



11.2 Checking method B

EXAMPLE

Test ISO 3547-B

GO ring gauge diameter = 34,095 mm

NOT-GO ring gauge diameter = 34,045 mm

12 Specifications for control of the checking equipment

12.1 Gauging tools

The gauging tools shall be checked regulary, significant damage shall be made good and any dimensional changes to the gauging tools shall be recorded on them.

12.2 Measuring equipment

The measuring equipment shall be checked for accuracy, at time intervals which should be specified (in accordance with statistical methods).

Annex A
(informative)

Determination of uncertainty of measurement

Tabulation of test results for checking the outside diameter of wrapped bushes in accordance with ISO 3547 to determine the uncertainty of measurement, u, according to 10.2 should be as shown in table A.1.

Table A.1 — Test results

Values in micrometres

Bush No.	1st reading	2nd reading	Difference Δx between 1st and 2nd readings
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
—	—	—	$\sigma_{\Delta x}$ =
$u = \frac{4\sigma_{\Delta x}}{\sqrt{2}}$ =			

Annex B
(informative)

Determination of comparability

Tabulation of test results for checking the outside diameter of wrapped bushes in accordance with ISO 3547 to determine the comparability, $|\overline{\Delta x}|$, according to 10.3 should be as shown in table B.1.

Table B.1 — Test results

Values in micrometres

Bush No.	Reading from 1st set of measuring equipment	Reading from 2nd set of measuring equipment
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
$\bar{x} = \frac{\Sigma x}{24}$	$\bar{x}_1 =$	$\bar{x}_2 =$
$\|\overline{\Delta x}\| = \|\bar{x}_1 - \bar{x}_2\| =$		

Annex C
(informative)

Bibliography

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

[2] ISO 12301:1992, *Plain bearings — Quality control techniques and inspection of geometrical and material quality characteristics.*

[3] ISO 12306:1994, *Plain bearings — Measurement of wall thickness of thin-walled half-bearings and thin-walled bushes.*

ICS 21.100.10

Descriptors: bearings, plain bearings, bearing bushes, wrapped bushes, dimensional measurements, diameter measurement, measuring instruments, gauges.

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