BS EN 2311:2017

BSI Standards Publication

Aerospace series — Bushes with self-lubricating liner — Technical specification

bsi.

National foreword

This British Standard is the UK implementation of EN 2311:2017. It supersedes BS EN 2311:2012 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/12, Aerospace fasteners and fastening systems.

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Aerospace series - Bushes with self-lubricating liner - Technical specification

Série aérospatiale - Bagues avec garniture autolubrifiante - Spécification technique

Luft- und Raumfahrt - Buchsen mit selbstschmierender Beschichtung - Technische Lieferbedingungen

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 2311:2017) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2017, and conflicting national standards shall be withdrawn at the latest by September 2017.

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

This document supersedes EN 2311:2012.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies the required characteristics, inspections and tests, quality assurance and qualification, acceptance and delivery conditions for bushes, designed to be subjected under load, to slow sliding movements, rotations and small oscillations only for aerospace applications.

This standard applies to all bushes when referred to in the respective product standards or in a design documentation.

The liner is designed to be used in the temperature range of −50 °C to 163 °C. Aluminium bushes are limited to −55 °C to 121 °C.

2 Normative references

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

EN 2285, *Aerospace series — Bushes, plain, aluminium alloy, with self-lubricating liner — Dimensions and loads*

EN 2286, *Aerospace series — Bushes, flanged aluminium alloy, with self-lubricating liner — Dimensions and loads*

EN 2287, *Aerospace series — Bushes, plain corrosion resisting steel, with self-lubricating liner — Dimensions and loads*

EN 2288, *Aerospace series — Bushes, flanged, corrosion resisting steel, with self-lubricating liner — Dimensions and loads*

EN 2755, *Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner — Elevated loads at ambient temperature — Technical specification*

EN 4534-2, *Aerospace series — Bushes, plain in aluminium alloy with self-lubricating liner, elevated load — Part 2: Dimensions and loads — Inch series*

EN 4535-2, *Aerospace series — Bushes, flanged in aluminium alloy with self-lubricating liner, elevated load — Part 2: Dimensions and loads — Inch series*

EN 4536-2, *Aerospace series — Bushes, plain in corrosion resisting steel with self-lubricating liner, elevated load — Part 2: Dimensions and loads — Inch series*

EN 4537-2, *Aerospace series — Bushes, flanged in corrosion-resisting steel with self-lubricating liner, elevated load — Part 2: Dimensions and loads — Inch series*

EN 9100, *Quality Management Systems — Requirements for Aviation, Space and Defense Organizations*

EN 9133, *Aerospace series — Quality management systems — Qualification procedure for aerospace standard parts*

EN 10204, *Metallic products — Types of inspection documents*

EN ISO 8785, *Geometrical Product Specification (GPS) — Surface imperfections — Terms, definitions and parameters*

ISO 11078, *Aircraft — De-icing/anti-icing fluids — ISO type II, III and IV*

TR 4475, *Aerospace series — Bearings and mechanical transmissions for airframe applications — Vocabulary*[1)]

3 Terms and definitions

For the purpose of this standard the terms and definitions given in TR 4475 and the following definitions apply.

3.1
bush with self-lubricating liner
ring in corrosion resisting steel or aluminium alloy with a self-lubricating liner bonded to the bore

Note 1 to entry: With regards to flanged bushes the self-lubricating material is bonded to the outer face of the flange as well as the bore.

3.2
loads

3.2.1
permissible static load C_S or permissible static axial load C_a (flanged bushes only)
maximum permissible load (without safety factor), which can be applied statically

Note 1 to entry: It is defined as a unit pressure multiplied by the effective projected area (radial or axial) for deformations that are compatible with correct operational behaviour.

3.2.2
ultimate static load (radial or axial)
1,5 times the value of the permissible static load

Note 1 to entry: It is defined as being the highest load the bush will support without failure occurring.

3.2.3
permissible dynamic radial load C_{25}
load that a bush can withstand, when subjected to an oscillating motion for 25 000 cycles at the rate of (12 ± 2) cycles/min

3.2.4
cycle
angular displacement of the shaft in relation to the lined bush of 0° to −25°, then of −25° to +25° and finally +25° to 0°, see Figure 1

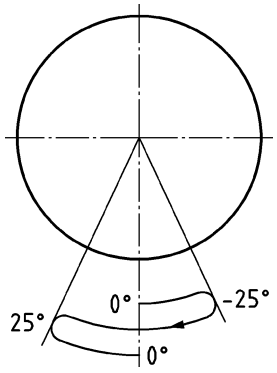


Figure 1 — Cycle

1) Published as ASD-STAN Technical Report at the date of publication of this standard. http://www.asd-stan.org/

3.3
friction torque under load at ambient temperature
coefficient of friction calculated as follows:

$$\mu = \frac{T}{C_{25} \cdot R}$$

where

μ is the coefficient of friction;

T is the dynamic rotational torque under load, expressed in Newton meters (Nm);

R is the radius of shaft, expressed in metres (m);

C_{25} is the dynamic radial load, expressed in Newton (N).

3.4
surface discontinuities

3.4.1
crack
linear recession with a sharp bottom resulting from a disturbance of the integrity of the surface and of the parent material of the workpiece

[SOURCE: EN ISO 8785, modified: figure not included]

3.4.2
scratch
score
surface imperfection which is a recession of irregular shape and unspecified direction

[SOURCE: EN ISO 8785, modified: synonym “score” added, figure not included]

3.4.3
lap
tongue-like raising of small thickness, often in the form of a seam, caused by folding over of material and forcing it into the surface when rolling, forging etc.

[SOURCE: EN ISO 8785, figure not included]

3.4.4
seam
non-welded fold which appears as an open defect in the material

3.5
void
area where the adhesive bond is broken or non-existent leaving a smooth and clean area on the metallic surface

Note 1 to entry: Used in context of adhesion of the liner.

3.6
delivery batch
consists of bushes bearing the same identity block although they may originate from different manufacturing batches

4 Required characteristics, inspection and test methods

According to Table 1.

Table 1 — Required characteristics, inspection and test methods *(1 of 4)*

Clause	Characteristics	Requirements	Inspection and test method	Q[a]	A[a]
4.1	Materials	In accordance with the product standards or design documentation	Chemical analysis and physical properties or a certificate of compliance according to EN 10204, 3.1B issued by the semi-finished product manufacturer.	X	X
4.2	Dimensions and tolerances	In accordance with the product standards or design documentation	Suitable measuring instruments **Measurement of the bore[b] and of the outer diameter** — Rings having a width of < 10 mm: — in the median plane. — Rings having a width of > 10 mm: — in two planes parallel to the outer faces and placed at a distance from these faces twice the maximum chamfer value of these rings. **Measurement of widths of rings:** — A minimum four point check on the width of each ring (distance between the two faces).	X	X
4.3	Masses	In accordance with the product standards or design documentation	Suitable methods	X	
4.4	Marking	In accordance with the product standards or design documentation	Visual examination	X	X
4.5	Surface appearance	— The bushes shall be free of surface discontinuities liable to have a detrimental effect on the characteristics and durability. — The liner shall not contain contaminant products and shall not show broken or voided areas. — No lubrication allowed.	Visual monitoring using appropriate procedures.	X	X

Table 1 — Required characteristics, inspection and test methods *(2 of 4)*

Clause	Characteristics	Requirements	Inspection and test method	Q[a]	A[a]
4.6	Surface roughness	Shall conform to product standards	Suitable measuring instruments or visual tactile samples.	X	X
4.7	Static loads:	Shall conform to product standards	According to Annex A.	X	
	— radial: C_s	With permissible static loads no maximum total deformations greater than those indicated in Table A.1.			
	— axial: C_a	After removal of the loads, no permanent deformations greater than those indicated in Table A.1.			
4.8	Ultimate loads — radial — axial	After removal of the loads, no rupture, or crack.	According to Annex A.	X	
4.9	Dynamic load and friction coefficient			X	
4.9.1	Dynamic radial load C_{25}	Shall conform to product standards. **After removal of the loads:** These shall be:	According to Annex B.		
	— at ambient temperature	— no metal to metal contact between the shaft and bush.			
	— at low temperature	— wear of the liner shall not exceed the values indicated in Table B.1.			
	— at high temperature	— liners resistance to peeling and adhesion shall meet the requirements of 4.11 and 4.12.			
4.9.2	Friction coefficient[c]	After dynamic test and before removal of load, torque to rotate shaft shown in Figure B.1 shall be measured and the value of μ calculated. The value shall not exceed 0,05 at ambient temperature	According to Annex E.		

Table 1 — Required characteristics, inspection and test methods *(3 of 4)*

Clause	Characteristics	Requirements	Inspection and test method	Q[a]	A[a]
4.10	Compatibility between the liner and fluids	The bushes shall meet the requirements of 4.9 at ambient temperature after immersion in the specified fluids. Wear of the liner shall not exceed the values indicated in Table B.1.	Check one bush per fluid: — the bush shall be immersed for 24 h in the fluids stated in Annex C at the following temperatures: — (45 ± 3) °C for those defined in C.1 and C.2, — (70 ± 3) °C for those defined in C.3, — ambient temperature for those defined in C.4. Within ½ h after this test, proceed to the test defined in B.2.4.	X	
4.11	Resistance of the liner to peeling	The requirements of this test shall only be applied when there is an indication from the manufacturer that the liner is susceptible to peeling. Bushes smaller than 15 mm diameter shall be exempt from this requirement. It shall present a mean peeling resistance of > 0,35 N/mm of width of the outer ring reduced by 2 mm to eliminate the effects of edges and chamfers. Mean resistance shall be such that at least 75 % of the recording curve lies above 0,35 N/mm.	According to Annex D. For acceptance, this test shall be carried out immediately after assembly and curing.	X	X

Table 1 — Required characteristics, inspection and test methods *(4 of 4)*

Clause	Characteristics	Requirements	Inspection and test method	Q[a] [a]	A[a]
4.12	Bond integrity	For peelable liners, the liner: — Shall not contain any contamination substances. — Shall adhere tightly to the outer ring over at least 90 % of the contact area. No void shall be allowed which cannot be described within a circle of diameter equal to: — 25 % of outer ring width; — 6 mm. whichever is smaller.	According to Annex D. After the peel strength test, evaluate the location and size of any voids.	X	X
		For non-peelable liners, a sectioned bush shall be examined for bond integrity. The liner: — Shall adhere tightly to the outer ring over at least 90 % of the contact area. No void shall be allowed which cannot be circumscribed within a circle of diameter equal to: — 25 % of outer ring width; — 6 mm. whichever is smaller.	Destructively examine the liner by chipping, scraping, abrasion, or other appropriate means to determine the bond integrity.	X	X
4.13	Surface treatment	In accordance with the product standard or design documentation	Visual examination	X	X

[a] Q: Qualification test; A: Acceptance test.

[b] Measurement of the bore could be carried out by “Go” and “NoGo” plug gauges.

[c] Not applicable for the standards: EN 2285, EN 2286, EN 2287 and EN 2288.

5 Quality assurance

5.1 Manufacturer's approval

According to EN 9100.

5.2 Product qualification

According to EN 9133 and Table 3.

The manufacturer shall obtain qualification for each set of bushes for each material and for dimensions indicated in the standards referred to in Clause 2 and Table 3. The below references dynamic testing only, see Table 2.

Table 2 — Dynamic testing only

Qualification groups	**I**						**II**						**III**					
Diameter code size.	06	08	10	12	15	16	18	20	22	25	28	30	32	35	40		45	50
EN 2285, EN 2286, EN 2287, EN 2288																		
Diameter code size	−04	−05	−06	−07, −08	−09	−10	−11	−12	−14	−16	−18		−20	−22	−24	−26	−28	−32
EN 4534-2, EN 4535-2, EN 4536-2, EN 4537-2																		
Test				X						X					X			

Size ranges for qualification:

Size 12 or −07 or −08 will qualify sizes 06 through to 16 and −04 through to −10. Providing the elevated loads can be met.

Size 25 or −16 will qualify sizes 18 through to 30 and −11 through to −18. Providing the elevated loads can be met.

Size 40 or −24 will qualify sizes 32 through to 50 and −20 through to −32. Providing the elevated loads can be met.

Qualification of the elevated load series permits automatic qualification for the reduced load series. See Annex F for permissible pressures.

Dynamic testing is only required for one material type, either steel or aluminium. The qualifying parts can also be either flanged or unflanged, see Table 3.

For full qualification where all 3 sizes will be tested, fluid tests and high temperature dynamic testing is only required for size 25 or −16 in accordance with Table 3.

Partial qualification for a size range is permitted at the discretion of the qualifying authority.

Alternative sizes to the above can be qualified with agreement of the qualifying authority.

Length of the qualifying bush is at the discretion of the qualifying authority. However, only one length per diameter size is required for qualification of a size range.

6 Acceptance conditions

6.1 Manufacturer's responsibility

According to EN 9100.

6.2 Inspections and tests to be carried out by the manufacturer

Acceptance of a delivery batch shall be carried out in accordance with Table 4, with the exception of the sampling plan which may be altered with the agreement of the customer or of the authority responsible for acceptance.

6.3 Customer quality control

The customer may, on acceptance of a delivery batch, proceed to its inspection by using all or some of the tests specified in Table 4, to ensure that the items conform to the required quality level and to determine whether the delivery batch is acceptable.

This inspection may be carried out in the customer's factory, or, by special agreement with the manufacturer, in the manufacturer's plant.

7 Packaging

The bushes shall be packed, either individually, or in rolls to avoid damage during transportation. They shall be protected against humidity, corrosion, dirt and other harmful substances.

The packing material in contact with the bush shall provide this protection.

The following indications shall appear on each individual packing:

— manufacturer's name and address;

— identity block as defined in the product standards;

— packing date.

In the case of group packing the minimum indications shall be as follows:

— manufacturer's name and address;

— contract or order number;

— quantity, i. e. number of items;

— identity block as defined in the product standards.

8 Certificate of compliance

All bushes supplied in accordance with this standard shall be accompanied by a certificate of compliance according to EN 10204, 2.1 issued by the manufacturer.

Table 3 — Inspections and tests to be carried out for qualification

Types of inspection and tests			Defined in subclause	Serial number of samples											
				1	2	3	4	5	6	7	8	9	10	11	12
Non-destructive inspections and tests															
Materials and physical properties			4.1	X	X	X	X	X							
Dimensions and tolerances			4.2	X	X	X	X	X							
Masses			4.3	X	X	X	X	X							
Marking			4.4	X	X	X	X	X							
Surface appearance			4.5	X	X	X	X	X							
Surface roughness			4.6	X	X	X	X								
Surface treatment			4.13	X	X	X	X	X							
Destructive inspections and tests															
Test under static load	radial	permissible	4.7			X	X								
		ultimate	4.8			X	X								
	axial[a]	permissible	4.7					X							
		ultimate	4.8					X							
Dynamic radial loads C_{25}	ambient temperature		4.9.1						X		X	X	X	X	X
	low temperature[b]			X											
	high temperature[b]				X										
Friction coefficient			4.9.2						X						
Liner compatibility with the fluids [b]	at 45 °C ± 3 °C[c]		4.10								X	X			
	at 70 °C ± 3 °C[c]												X	X	
	at ambient temperature [c]														X
Resistance of the liner to peeling			4.11	X	X				X	X	X	X	X	X	X
Bond integrity			4.12	X	X				X	X	X	X	X	X	X

NOTE Qualification may be granted for both plain and flanged bushes, when all the listed tests have been carried out for each required diameter and backing material e. g. when plain bush has been approved only tests 4.7 and 4.8 need to be carried out for the approval of the flanged bush.

a Flanged bushes only.

b Consideration will be given by the approving authority for the omission of the test if manufacturers have already been qualified to EN 2755 for bearings in corrosion resisting steel which incorporate the same liner materials.

c For these tests an established qualification for such a diameter in a given range of bushes applies automatically for all the other diameters and series.

Table 4 — Inspections and tests to be carried out for the acceptance of the bush

Type of inspection or test	Defined in subclause	Sampling plan[a,b]
Material	4.1	Certificate of compliance issued by semi-finished product manufacturer
Dimensions and tolerances	4.2	10 %[c]
Marking	4.4	100 %
Surface appearance	4.5	100 %[d]
Surface roughness	4.6	5 %[c]
Resistance of the liner to peeling	4.11	1 %[c]
Bond integrity	4.12	1 %[c]
Surface treatment	4.13	100 %

[a] When sampling is not 100 % any defect found during an inspection requires that this inspection is increased to 100 %.

[b] May vary with the approval of the user or authority responsible for acceptance.

[c] Minimum two pieces.

[d] This test shall be carried out within the production line.

Annex A
(normative)

Testing of permissible and ultimate static loads

A.1 Permissible radial static loads (C_s)

A.1.1 Principle

See Figure A.1 as an example.

A.1.2 Method

— Mount the bush as shown in Figure A.1.

— Apply a radial pre-load equivalent to 5 % of C_s for 3 min.

— Set the dial gauge to zero;

— Increase this pre-load continuously by 1 % per s until the value C_s is obtained.

— Maintain the load C_s for 3 min.

— Record the total deformation.

— Bring load C_s continuously down again by 1 % per s until the value of the pre-load is obtained.

— Note the value of the permanent deformation indicated on dial gauge.

— Remove the pre-load.

A.2 Ultimate radial static loads

This test follows on from the test described in Clause A.1.

A.2.1 Principle

See Figure A.1 as an example.

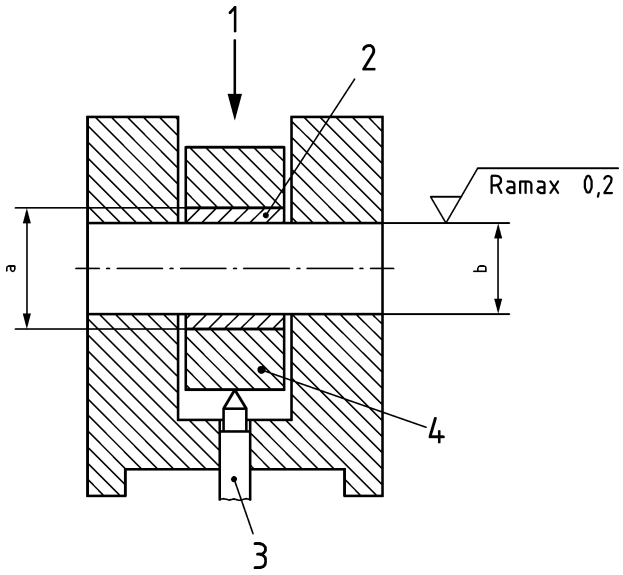
A.2.2 Method

— Mount the bush as shown in Figure A.1.

— Apply a radial load of 1,5 C_s by increasing the load at the rate of 1 % per s.

— Remove load continuously at the rate of 1 % per s.

— Check bush.



Key

1 permissible static radial load
2 bush
3 dial gauge
4 housing
a housing diameter, limit H7 for metric size; H6 for inch size
b shaft diameter, limit f6, hardness (50 + 5) HRC

Figure A.1 — Testing device for radial static loads

A.3 Permissible axial static loads (C_a)

A.3.1 Principle

See Figure A.2 as an example.

A.3.2 Method

— Mount bush as shown in Figure A.2.

— Apply an axial pre-load equal to 5 % of C_a for 3 min.

— Set the dial gauge to zero.

— Increase this pre-load continuously by 1 % per s until the value C_a is obtained.

— Maintain the load C_a for 3 min.

— Record the total deformation.

— Remove the load continuously by 1 % per s to pre-load.

— Note the value of the permanent deformation indicated on dial gauge.

— Remove the pre-load.

A.4 Ultimate axial static loads

This test follows on from that described in Clause A.3.

A.4.1 Principle

See Figure A.2 as an example.

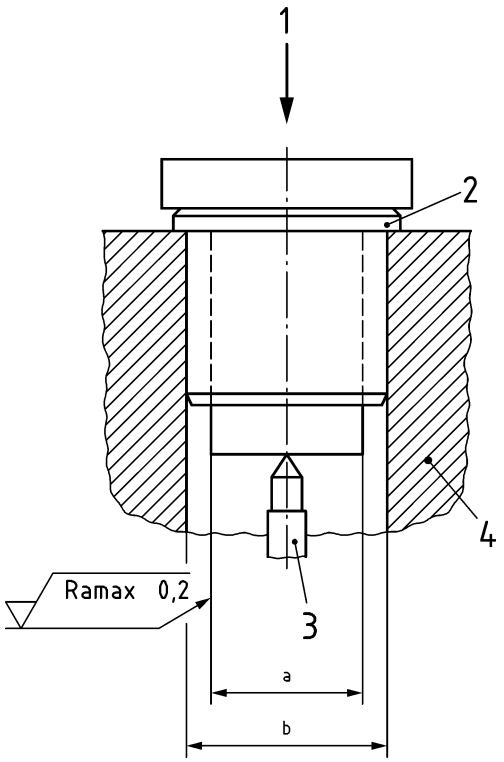
A.4.2 Method

— Mount bush as shown in Figure A.2.

— Apply an axial load of 1,5 C_a by increasing the load at the rate of 1 % per s.

— Remove load continuously at the rate of 1 % per s.

— Check bush.



Key

1 permissible static axial load
2 bush
3 dial gauge
4 housing
a shaft diameter, limit f6, hardness (50 ± 5) HRC
b housing diameter, limit H7 for metric size; H6 for inch size

Figure A.2 — Testing device for axial static loads

Table A.1 — Maximum and permanent deformation

Dimensions in millimetres

Bushes			**Deformation at**			
EN 2285 EN 2286 EN 2287 EN 2288	EN 4534-2 EN 4535-2 EN 4536-2 EN 4537-2		C_s		C_a	
$Ø\ d$	Diameter code	Nominal diameter	maximal	permanent	maximal	permanent
6	−04	6,350	0,18	0,08	0,15	0,08
8	−05	7,938	0,18	0,08	0,15	0,08
10	−06	9,525	0,25	0,08	0,25	0,08
12	−07	11,113	0,25	0,08	0,25	0,08
—	−08	12,700	0,25	0,08	0,25	0,08
15	−09	14,288	0,37	0,08	0,25	0,08
16	−10	15,875	0,37	0,08	0,34	0,08
18	−11	17,463	0,37	0,08	0,34	0,08
20	−12	19,050	0,43	0,08	0,34	0,08
22	−14	22,225	0,43	0,08	0,34	0,08
25	−16	25,400	0,43	0,08	0,34	0,08
28	−18	28,575	0,43	0,08	0,34	0,08
30	—	—	0,50	0,09	0,34	0,08
32	−20	31,750	0,50	0,10	0,34	0,08
35	−22	34,925	0,50	0,11	0,34	0,08
40	−24	38,100	0,50	0,12	0,34	0,08
—	−26	41,275	0,50	0,12	0,34	0,08
45	−28	44,450	0,75	0,14	0,34	0,08
50	−32	50,800	0,75	0,15	0,34	0,08

Annex B
(normative)

Testing of permissible radial dynamic loads (C_{25})

B.1 Principle

See Figure B.1 as an example.

B.2 Method

— Mount the bush as shown in Figure B.1, without affecting its characteristics. The testing device shall be designed with the aim that the rotation during the test shall be effective at the liner level.

— Apply the loads C_{25} corresponding to the test type as a pre-load onto the outer ring for a period of 15 min.

— Set the dial gauge to zero.

— Subject the shaft to angular oscillation with the bush static. The speed, load and temperature shall be as specified below.

— Check the wear of the liner, see Table B.1.

— For test B.2.1:

  — After the test measure the rotational breakaway torque under radial load C_{25}.

  — Calculate the friction coefficient μ according to 3.3.

— Follow this check with the peeling resistance test and the adhesion test defined in 4.11 and 4.12.

B.2.1 Test to be carried out at ambient temperature

Number of cycles:	25 000
Max. rate:	(12 ± 2) cycles/min
Load to be applied:	100 % of load C_{25}

B.2.2 Test to be carried out at low temperature

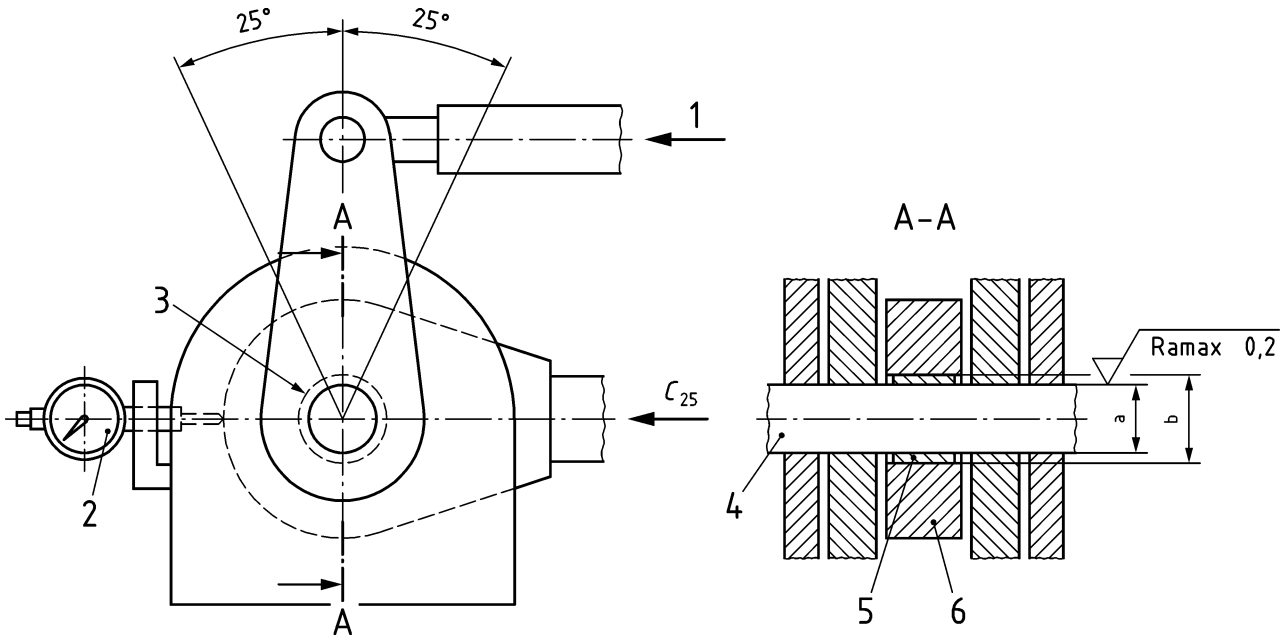
Number of cycles:	25 000
Max. rate:	(12 ± 2) cycles/min
Load to be applied:	75 % of load C_{25}
Temperature to be maintained:	-55 °C
throughout test:	The temperature may increase to -35 °C, in this case, stop test to bring it down to -55 °C again, then continue the test.

B.2.3 Test to be carried out at high temperature

Number of cycles:	25 000
Max. rate:	(12 ± 2) cycles/min
Load to be applied:	100 % of load C_{25}
Temperature to be maintained:	(163 ± 5) °C for steel, (121 ± 5) °C for aluminium
throughout test:	The heat caused by friction may be compensated by adjusting the supply of heat.

B.2.4 Test to be carried out at ambient temperature following immersion

Number of cycles:	25 000
Max. rate:	(12 ± 2) cycles/min
Load to be applied:	75 % of load C_{25}



Key

1 power unit
2 dial gauge
3 location of temperature gauge
4 pin in steel (50 + 5) HRC
5 bush with self-lubricating liner
6 bush support
a shaft diameter f6
b housing diameter H7 for metric size; H6 for inch size

Figure B.1 — Testing device for radial dynamic loads

Table B.1 — Testing radial dynamic loads

Test with allowable radial dynamic load C_{25}	**Maximum allowable wear** mm
At ambient temperature	0,13
At low temperature	0,20
At high temperature	0,15
At ambient temperature after immersion in the fluids	0,15

Annex C
(normative)

Fluids — Essential characteristics

C.1 Fuel for turbine aero engine

Flash point, min.:	38 °C
Freezing point, max.:	−50 °C
Viscosity at 34,4 °C, max.:	15 mm^2/s
Net calorific value, min.:	42,5 MJ/kg
Total acidity, max.:	0,016 mg KOH/g
Aromatics content, max.:	20 %
Olefins content, max.:	5 %
Total sulphur, max.:	0,2 %

C.2 Fluids for de-icing circuit

Nature:	96 % denatured isopropylalcohol
Density at 15 °C, max.:	0,806 g/cm^3
Distillation:	90 % distilled between 80 °C and 90 °C
Final distillation point, max.:	123 °C

C.3 Hydraulic fluids

C.3.1 Mineral fluid for hydraulic transmission

Pour point, max.:	−60 °C
Flash point, min.:	82 °C
Acid value, max.:	0,1 mg KOH/g
Colour:	Red
Kinematic viscosity, min.	
at 98 °C:	5 mm^2/s
at 38 °C:	14 mm^2/s
at −40 °C:	500 mm^2/s
at −54 °C:	3 000 mm^2/s

C.3.2 Phosphate of ester hydraulic fluid

Flash point:	182 °C
Fire point:	215 °C
Acid value, max.:	0,04 mg KOH/g
Kinematic viscosity, min.	
at 98 °C:	3,85 mm^2/s
at 37 °C:	11,75 mm^2/s
at −4 °C:	600 mm^2/s
at −53 °C:	3 500 mm^2/s

C.4 De-icing and anti-icing fluids

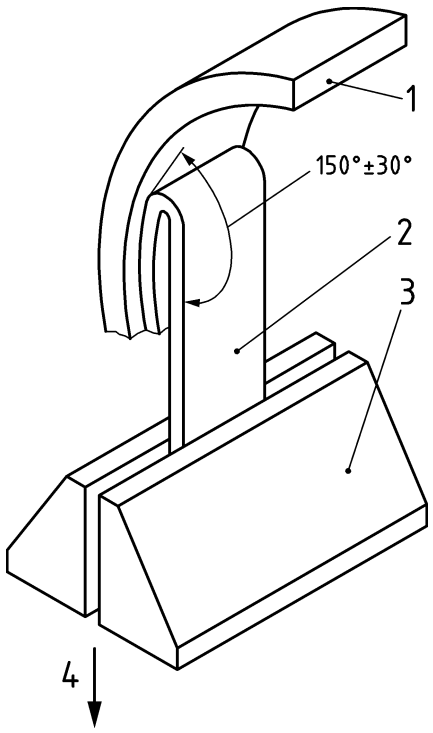
ISO type II (glycol base) according to ISO 11078.

Annex D
(normative)

Resistance of the liner to peeling

D.1 Principle

See Figure D.1 as an example.



Key

1 bush
2 self-lubricating liner
3 device for clamping self-lubricating liner
4 pull

Figure D.1 — Measurement of resistance of the liner to peeling

D.2 Method

— Divide the bush into sections.

— Immobilize, in an appropriate device, the section which was not subjected to the loads.

— Commence unsticking of the liner using a blade, for example.

— Grasp the end of the liner in the jaw of the clamping device, fitted with a reading and recording mechanism.

— Exert a tractive force on this device, at an angle of 150° ± 30° to the sticking surface, and at a speed of (13 to 25) mm/min..

— Check the values recorded.

Annex E
(normative)

Measurement of friction coefficient for EN 4534-2, EN 4535-2, EN 4536-2 and EN 4537-2 (for inch size only)

E.1 Principle

See Figure E.1 as an example.

E.2 Starting torque under load C_{25} at room temperature

E.2.1 General

After measuring the rotational torque under load the coefficient of friction is calculated as follows:

$$\mu = \frac{T}{C_{25} \cdot R}$$

where

μ is the coefficient of friction;

T is the dynamic rotational torque under load, expressed Newton meters (Nm);

R is the radius of shaft, expressed in metres (m);

C_{25} is the dynamic radial load, expressed in Newton (N).

E.2.2 Method

— Mount the bush as shown in Figure E.1.

— Hold the bush stationary.

— Apply the test at ambient temperature.

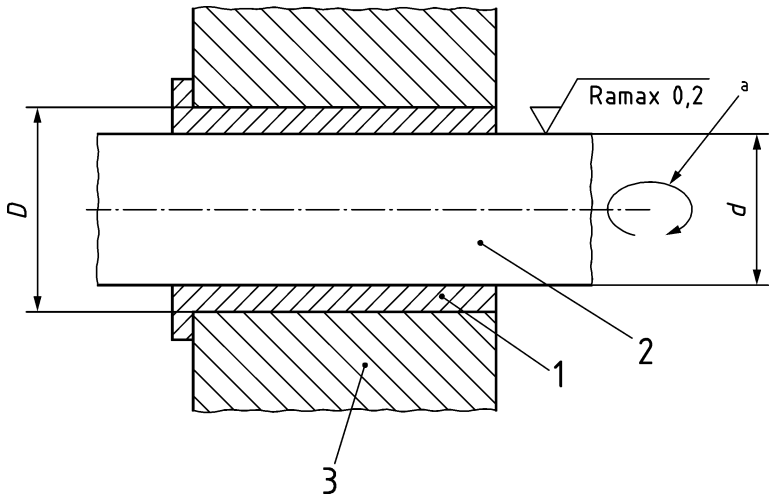
— Apply a radial load C_{25}.

— Measure the rotational torque with a suitable measuring instruments (e. g. torque wrench); apply it continuously to the shaft.

— Measure the torque in both directions.

— Record the maximum value required to start up the shaft.

— Calculate the value μ.



Key

d shaft diameter, limit f6
D housing diameter, limit H7 for metric size; H6 for inch size
1 bush
2 shaft (pin), hardness (50+5) HRC
3 housing
a torque

Figure E.1 — Measurement of friction coefficient

Annex F
(informative)

Permissible unit pressure

See Table F.1.

Table F.1 — Permissible unit pressure

Standard	Temperature range °C	Static radial permissible MPa	Static axial permissible MPa	Dynamic radial permissible MPa	Material
EN 2285	−55 121	206	—	172	Aluminium
EN 2286		206	206	172	Aluminium
EN 2287	−55 163	430	—	172	Steel
EN 2288		430	430	172	Steel
EN 4534-2	−55 121	290	—	259	Aluminium
EN 4535-2		290	206	259	Aluminium
EN 4536-2	−55 163	541	—	259	Steel
EN 4537-2		541	430	259	Steel

Annex G
(informative)

Standard evolution form

The main changes with respect to the previous edition are listed in Table G.1.

Table G.1 — Main changes to previous edition

prEN/EN Number	Edition	Publication Date	Modification	Reason and validation
prEN 2311	P1	10/2010	Changes to the qualification requirements. Quantity of parts and size.	EN 2311 P1 endurance testing requirements were extensive and not practical. The requirements stated that only a bush next to in diameter and length size of the tested part could be qualified by analogy. The modifications to the specification include a reduction in testing where a qualification for a certain size qualifies a size range. The changes also include qualification by analogy in certain cases. No effect of interchangeability of parts from pervious revisions.
			Editorial changes.	

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