BRITISH STANDARD

BS EN 1337-2:2001

Structural bearings —

Part 2: Sliding elements

The European Standard EN 1337-2:2000 has the status of a British Standard

ICS 91.010.30; 93.040

National foreword

This British Standard is the official English language version of EN 1337-2:2000.

The UK participation in its preparation was entrusted to Technical Committee B/522, Structural bearings, which has the responsibility to:

- — aid enquirers to understand the text;
- — present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- — monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 167 "Structural bearings", the secretariat of which is held by UNI.

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of an identical text or by endorsement, at the latest by June 2001, and conflicting national standards shall be withdrawn at the latest by June 2001.

This European Standard EN 1337 “Structural bearings”, consists of the following 11 Parts:

Part 1: General design rules

Part 2: Sliding elements

Part 3: Elastomeric bearings

Part 4: Roller bearings

Part 5: Pot bearings

Part 6: Rocker bearings

Part 7: Spherical and cCylindrical PTFE bearings

Part 8: Guide bearings and restrain bearings

Part 9: Protection

Part 10: Inspection and maintenance

Part 11: Transport, storage and installation

Further to CEN/TC 167’s decision Part 1and 2 form a package of standards and they come into force together, while the other parts come into force separately after the publication of parts 1 and 2.

Annexes A, B, C and L are informative. Annexes D, E, F, G, H, J and K are normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This standard considers a minimum operating temperature of –35°C.
An extension down to –40°C will be considered in a future amendment.
Applications beyond the range of temperature given in clause 1 need special consideration not covered by this standard. Characteristics and requirements given in this standard do not apply in such cases.

1 Scope

This European Standard specifies the characteristics for the design and manufacture of sliding elements and guides which are not structural bearings but only parts of them for combination with structural bearings as defined in other Parts of this European Standard.

Suitable combinations are shown in Table 1 of EN 1337-1:2000.

Sliding surfaces with a diameter of the circumscribing circle of single or multiple PTFE sheets less than 75 mm or greater than 1500 mm, or with effective bearing temperatures less than –35°C or greater than 48°C are outside the scope of this European Standard.

Sliding elements for use as temporary devices during construction, for example during launching of the superstructure, are also outside the scope of this European Standard.

In this standard the specification is also given for curved sliding surfaces which are not part of separate sliding elements but which are incorporated in cylindrical or spherical PTFE bearings as per EN 1337.

NOTE The general principles detailed in this European Standard may be applied for sliding elements outside this scope, but their suitability for the intended use should be proven.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1337-1:2000	Structural bearings - Part 1: General design rules
prEN 1337-3:1996	Structural bearings - Part 3: Elastomeric bearings
EN 1337-7	Structural bearings - Part 7: Spherical and cylindrical PTFE bearings
EN 1337-9	Structural bearings – Part 9: Protection
prEN 1337-10:1998	Structural bearings - Part 10: Inspection and maintenance
EN 1337-11:1997	Structural bearings - Part 11: Transport, storage and Installation
ENV 1992-1-1	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for building

ENV 1993-1-1	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for building
EN 10025:1990/A1:1993	Hot rolled products of non-alloy structural steels –Technical delivery conditions (includes amendment A1:1993)
EN 10088-2	Stainless steels – Part 2: Technical delivery conditions for sheet/plate and strip for general purposes
EN 10113-1	Hot-rolled products in weldable fine grain structural steels - Part 1: General delivery conditions
EN 10137-1	Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions – Part 1: General delivery conditions
EN 10204	Metallic products - Types of inspection documents
ISO 527-2:1993	Plastics - Determination of tensile properties - Part 2: Testing conditions for moulding and extrusion plastics
ISO 1083	Spheroidal graphite cast iron - Classification
ISO 1183	Plastics - Methods for determining the density and relative density of non-cellular plastics
ISO 2039-1	Plastics - Determination of hardness - Part 1: Ball indentation method
ISO 2137	Petroleum products - Lubricating grease and petrolatum - Determination of cone penetration
ISO 2176	Petroleum products - Lubricating grease - Determination of dropping point
ISO 2409	Paints and varnishes - Cross-cut-test
ISO 3016	Petroleum products - Determination of pour point
ISO 3522	Cast aluminium alloys - Chemical composition and mechanical properties
ISO 3755	Cast carbon steels for general engineering purposes
ISO 4287	Geometrical product Specifications (GPS) – Surface textute: Profile method – Terms, definitioons and surface texture parameters
ISO 6158	Metallic coatings - Electroplated coatings of chromium for engineering purposes
ISO 6506	Metallic materials – Brinell hardness test
ISO 6507-1	Metallic materials – Vickers hardness test - Part 1: Test method
ISO 6507-2	Metallic materials - Vickers hardness test - Part 2: Verification of testing machine

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

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

3.1.1
backing plate
metallic component which supports sliding materials

3.1.2
coefficient of friction
ratio of lateral force (resisting force) to the normal force.

3.1.3
composite material
sliding material used in guides.

3.1.4
guide
sliding element which restrains a sliding bearing from moving in one axis.

3.1.5
hard chromium surface
steel backing element plated with a hard chromium layer.

3.1.6
lubricant
special grease used to reduce the friction and wear in the sliding surfaces.

3.1.7
mating surface
hard smooth metallic surface against which the PTFE or composite materials slide.

3.1.8
polytetrafluoroethylene (PTFE)
a thermoplastic material used for its low coefficient of friction.

3.1.9
sliding surface
combination of a pair of flat or curved surfaces of different materials which allow relative displacements.

3.1.10
sliding materials
materials which form sliding surfaces.

3.2 Symbols

The most frequently occurring symbols are defined below. Those that are local, and unique to a particular clause, are defined at their first appearance.

3.2.1 Latin upper case letters

A	contact area of sliding surface	mm^2
E	modulus of elasticity	GPa
F	action; force	N; kN
G	permanent action	N; kN
L	diameter of the circumscribing circle of single or multiple PTFE sheets (see Figures 3, 4 and 5); length of PTFE or composite materials sheets of guides (see Figure 6)	mm
M	bending moment	N x mm; kN x m
N	axial force; force normal to principal bearing surface	N; kN
R_{y5i}	average surface roughness	µm
S	shape factor	
T	temperature	°C
V	transverse or shear force	N; kN

3.2.2 Latin lower case letters

a	smallest dimension of PTFE sheets; minor side of rectangular plates or sheets	mm
b	major side of rectangular plates or sheets	mm
c	cleareance between sliding components (difference in width between key and keyway)	mm
d	diameter, diagonal	mm
e	eccentricity	mm
f	nominal compressive strength	MPa
h	protrusion of PTFE sheet from its recess	mm
n	number of cycles	
s	sliding distance	mm
t	thickness, time	mm; s; h
u	perimeter of PTFE sheet	mm
v	sliding speed	mm/s
w	deformation	
x	longitudinal axis	
y	transverse axis	

z axis normal to the principle bearing surface

3.2.3 Greek letters

α angle .... rad

γ partial safety factor

δ elongation at break .... %

Δz maximum deviation of plane or curved sliding surfaces from theoretical surface .... mm

λ ratio, coefficient

μ coefficient of friction

μ_1 initial coefficient of friction; i.e. the maximum coefficient of friction occurring during the first movement at the start or restart of any test

μ_T maximum coefficient of friction during a given temperature phase

ρ mass density .... kg/m^3

σ normal pressure .... MPa

3.2.4 Subscripts

a	average
b	backing plate
c	concrete
CM	composite materials
d	design
dyn	dynamic
G	permanent action
g	geometrical
k	characteristic
M	material
max	maximum
min	minimum
n	cycle number
p	PTFE
pl	preload
Q	variable action
R	resistance
r	reduced
S	internal forces and moments from actions
s	static
t	tension
T	temperature
u	ultimate
x, y, z	coordinates

3.3 Abbreviations

CM Composite Material

PTFE Polytetrafluoroethylene

4 Functional requirements

NOTE Sliding elements and guides permit movements in plane or curved sliding surfaces with a minimum of friction. Specific verification of frictional resistance is required, as verification of mechanical and physical properties alone is not sufficient to ensure that these components will have the required characteristics. The performance of the sliding elements and guides is deemed to be satisfactory if standardized specimens shown in annex D of specified material combinations meet the requirements of this clause when tested as specified in specific friction tests described in annex D

4.1 Sliding elements and guides incorporating sliding surfaces with PTFE sheets

4.1.1 Requirements in short term friction tests

The coefficients of friction in each phase of friction testing shall not exceed the values given in Table 1.

Table 1 - Maximum coefficients of friction in short term tests of PTFE sheets in combination with hard chromium plating, austenitic steel or aluminium alloy used for curved or plane sliding surfaces.

Test See annex D	Temperature	Hard chromium or austenitic steel				Aluminium alloy			
		$\mu_{s,1}$	$\mu_{dyn,1}$	$\mu_{s,T}$	$\mu_{dyn,T}$	$\mu_{s,1}$	$\mu_{dyn,1}$	$\mu_{s,T}$	$\mu_{dyn,T}$
C	+ 21 °C	0,012	0,005	–	–	0,018	0,008	–	–
D	- 35 °C	0,035	0,025	–	–	0,053	0,038	–	–
E	0 °C	0,018	0,012	–	–	0,027	0,018	–	–
E	- 35 °C	–	–	0,018	0,012	–	–	0,027	0,018

NOTE $\mu_{s,1}$ is the static coefficient of friction at the first cycle.
$\mu_{dyn,1}$ is the dynamic coefficient of friction at the first cycle.
$\mu_{s,T}$ is the static coefficient of friction at subsequent cycles.
$\mu_{dyn,T}$ is the dynamic coefficient of friction at subsequent cycles.
(see also annex D, Figures D.4 and D.6)

4.1.2 Requirements in long term friction tests

The coefficients of friction of the sliding material combinations shall not exceed the values listed in Tables 2 and 3.

4.2 Guides incorporating composite materials CM1 and CM2

4.2.1 Requirements in short term friction test

The maximum static or dynamic coefficient of friction shall not exceed 0,15.

Table 2 - The coefficients of friction in long term tests of PTFE sheets in combination with austenitic steel used for plane sliding surfaces.

Temperature	Total slide path			
	5 132 m		10 242 m	
	$\mu_{s,T}$	$\mu_{dyn,T}$	$\mu_{s,T}$	$\mu_{dyn,T}$
-35°C	0,030	0,025	0,050	0,040
-20°C	0,025	0,020	0,040	0,030
0°C	0,020	0,015	0,025	0,020
+21°C	0,015	0,010	0,020	0,015
NOTE $\mu_{s,T}$ and $\mu_{dyn,T}$ are the static and dynamic coefficient of friction respectively at the relevant temperatures.				

Table 3 - Maximum coefficients of friction in long term tests of PTFE sheets in combination with hard chromium plating, austenitic steel or aluminium alloy used for curved sliding surfaces.

Temperature	Total slide path 2 066 m			
	Austenitic steel or hard chromium		Aluminium alloy	
	$\mu_{s,T}$	$\mu_{dyn,T}$	$\mu_{s,T}$	$\mu_{dyn,T}$
-35°C	0,030	0,025	0,045	0,038
-20°C	0,025	0,020	0,038	0,030
0°C	0,020	0,015	0,030	0,022
+21°C	0,015	0,010	0,022	0,015

4.2.2 Requirements in long term friction test

Maximum static or dynamic coefficients of friction shall not exceed the values listed in Table 4.

Table 4 - Maximum static or dynamic coefficients of friction μ_T in long term tests of composite material CM1 and CM2 in combination with austenitic steel used for plane sliding surfaces in guides

Temperature	Total slide path 2 066 m
	μ_T
-35°C	0,200
-20°C	0,150
0°C	0,100
+21°C	0,075

5 Material properties

In the absence of specific Standards, material testing shall be in accordance with the procedures given in annexes D to H.

5.1 PTFE sheets

5.1.1 Material specification

The raw material for PTFE sheets shall be pure polytetrafluoroethylene free sintered without regenerated or filler materials.

5.1.2 Mechanical and physical properties

The characteristics of PTFE shall be in accordance with Table 5.

Table 5 - Mechanical and physical properties of PTFE.

Property	Testing Standard	Requirement	
mass density	ISO 1183	ρ_p = 2140 to 2200	kg/m^3
tensile strength	ISO 527-2	f_{ptk} = 29 to 40	MPa
elongation at break	ISO 527-2	$\delta_p \geq 300$	%
ball hardness	ISO 2039-1	H132/60 = 23 to 33	MPa

The test specimens shall be prepared from fully finished sheet but without impressed dimples. They shall be tested at 23°C ± 2°C.
Mass density shall be determined on three specimens.

Tensile strength test and elongation at break shall be conducted on five specimens type 1 (in accordance with Figure 1 of ISO 527-2:1993). The thickness of the specimens shall be 2 mm ± 0,2 mm and the speed of testing shall be 50 mm/min (speed E as defined in ISO 527-2).

A total of 10 ball hardness tests shall be conducted using at least three specimens with a minimum of three tests per specimen ; the thickness of the specimens shall be at least 4,5 mm.

All specimens shall pass all the tests conducted on them.

5.1.3 Geometrical properties

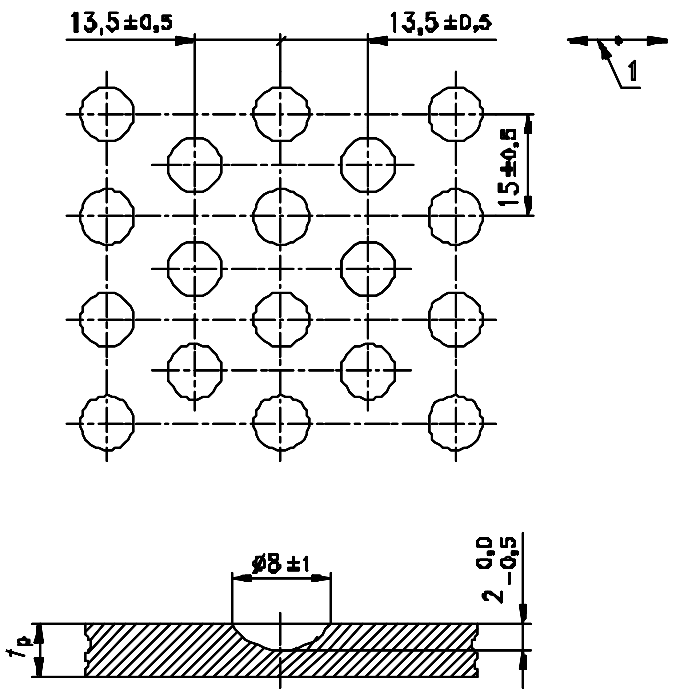
5.1.3.1 Tolerance on thickness

The admissible tolerance on thickness of single PTFE sheets or associated multiple sheets is $^{+0,3}_{0}$ mm or sheets with a diameter L less than 1200 mm and $^{+0,4}_{0}$ mm for larger sheets.

5.1.3.2 Dimple pattern

Dimples and dimple pattern shall be in accordance with Figure 1.
Where dimples are produced by hot pressing, the temperature during the pressing process shall not exceed 200°C.

Dimensions in millimetres



Key

1 main direction of sliding

Figure 1 - Pattern of dimples in recessed PTFE sheets

5.1.4 Suitability as sliding material

PTFE shall be tested in accordance with annex D and shall meet the requirements of 4.1.1 and 4.1.2.
Lubricant shall be in accordance with 5.7.
The mating surfaces for the short term friction test shall be austenitic steel or hard chromium and for the long term friction test austenitic steel in accordance with 5.3 and 5.4.

5.2 Composite materials

5.2.1 Composite material CM1

This is a composite material consisting of three layers: a bronze backing strip and a sintered interlocking porous matrix, impregnated and overlaid with a PTFE / lead mixture.
The material shall conform to the characteristics listed in Table 6.
In addition, the condition of the material and its surface finish shall be checked visually.

Table 6 - Characteristics of CM1.

Bronze backing	material: CuSn 6				
	composition by mass	Sn		5 to 7,50	%
		P	≤	0,35	%
		Pb	≤	0,10	%
		Fe	≤	0,10	%
		Zn + Ni	≤	0,30	%
		Remainder Cu			
	thickness			(2,1 ± 0,15)	mm
	hardness HB - ISO 6506			80 to 160	
Bronze interlayer	material: CuSn 10				
	composition by mass	Sn		10 to 12	%
		Pb	≤	1,00	%
		P		0,25 to 0,4	%
		Si	≤	0,17	%
		Fe	≤	0,15	%
		Ni	≤	0,15	%
	saturation with PTFE - Pb		≥	25	%
	thickness			$0{,}25^{+0{,}15}_{0{,}0}$	mm
Surface layer	material: PTFE/Pb				
	composition by volume	Pb 20 %, remainder PTFE			
	thickness			$0{,}01^{+0{,}02}_{0{,}0}$	mm
	total thickness			$2{,}4^{+0{,}1}_{0{,}0}$	mm
	overlay adhesion - ISO 2409			GT 2	

5.2.2 Composite material CM2

The material shall consist of a flexible metal mesh which is sintered into a PTFE compound with the bearing or sliding surface having the thicker PTFE coat.

The metal mesh shall be CuSn6 stabilised mesh from 0,25 mm diameter wires which are linked at intersections and which has a thickness after calendering of approximately 0,4 mm. The mesh count in warp and weft direction shall be 16 ± 1 per 10 mm.

The PTFE compound shall be PTFE with 30% ± 2% filler content, consisting of glass fibres and graphite.

The material is to conform to the characteristics listed in Table 7.

In addition, the condition of the material and its surface finish shall be checked visually.

Table 7 - Characteristic of CM2.

Density	4100 kg/m^3 to 4400 kg/m^3
Tensile strength	> 45 MPa
Elongation	> 10%
Thickness	(0,48 ± 0,2) mm
Overlay adhesion (in accordance with ISO 2409)	GT2

5.2.3 Suitability as sliding material

Composite materials CM1 and CM2 shall be tested in accordance with annex D and shall meet the requirements of 4.2.1 and 4.2.2.

The mating austenitic steel sheet and the lubricant to be used in the test shall both be in accordance with this European Standard.

5.3 Austenitic steel sheet

5.3.1 Material specification

Steel in accordance with EN 10088-2 1.4401 + 2B shall be used.

The contact surface shall be ground and if necessary machine polished.

5.3.2 Surface characteristics

After the surface treatment the roughness R_{y5i} shall not exceed 1 μm in accordance with ISO 4287 and the hardness shall be in the range 150 HV1 to 220 HV1, according to ISO 6507-2.

5.4 Hard chromium plated surfaces

The entire curved surface of the backing plate shall be hard chromium plated.

The hard chromium plating process shall comply with the requirements of ISO 6158.

5.4.1 Material specification

The substrate for hard chromium plated sliding surfaces shall be steel in accordance with EN 10025:1990/A1:1993 grade S 355 J2G3 or fine grain steel of the same or higher grade in accordance with EN 10113-1.
Hard chromium plating shall be free from cracks and pores.
The surface of the base material shall be free from surface porosity, shrinkage cracks and inclusions.
Small defects may be repaired e.g. by pinning prior to hard chromium plating.

5.4.2 Surface characteristics

5.4.2.1 Roughness

The final surface roughness R_{y5i} in accordance with ISO 4287 of the plated surface shall not exceed 3 μm.

> NOTE Both the base material and hard chromium plating may be polished to achieve the specified surface roughness.

5.4.2.2 Thickness

The thickness of the hard chromium plating shall be at least 100 μm.

5.4.2.3 Visual inspection

The hard chromium surface shall be visually inspected for cracks and pores.

5.4.2.4 Ferroxyl test

In addition to the visual inspection, the absence of defects shall be verified by a Ferroxyl test in accordance with Annex E.
If the visual inspection of the surfaces reveals any potential defects, the Ferroxyl test shall be applied over the entire affected area.
If any defects are detected by Ferroxyl test, the hard chrome plating shall be rejected.

5.5 Ferrous materials for backing plates

Steel plates in accordance with EN 10025:1990/A1:1993 or EN 10137-1, cast iron in accordance with ISO 1083, cast carbon steel in accordance with ISO 3755 or stainless steel in accordance with EN 10088 shall be used for the backing plates with flat or curved surfaces, as appropriate.

5.6 Aluminium alloy

5.6.1 Material specification for backing plates

Aluminium alloy may be used only for the convex element of spherical or cylindrical PTFE bearings
The alloy shall be Al-Mg6M or Al-Si7MgTF in accordance with the requirements of ISO 3522.

5.6.2 Surface treatment

The curved surface shall be anodized after machining.
The minimum average thickness of the coating shall be 15 μm.
The minimum local thickness of the coating shall be 14 μm.
Thickness measurements shall be carried out according to the method described in annex F.
The surface may be polished if necessary to achieve the finish required in 5.6.3.

5.6.3 Characteristics of sliding surfaces

The surface roughness R_{y5i} after anodizing shall not exceed 3 μm in accordance with ISO 4287.

The surface shall be free from injurious defects, such as cracks and significant porosity.

5.6.4 Suitability as sliding material

Aluminium alloy shall be tested in accordance with annex D and meet the requirements of 4.1.

5.7 Lubricant

NOTE The purpose of the lubricant is to reduce the frictional resistance and wear of the PTFE.

5.7.1 General Requirements

Lubricant shall retain its properties within the specified temperature range and shall not resinify nor attack other materials at the sliding interface.

5.7.2 Properties

The characteristics of lubricant shall be in accordance with Table 8.
An IR spectral analisis shall be carried out for the purpose of identification.

Table 8 - Physical and chemical properties of lubricant.

Properties	Testing standard	Requirements	
Worked penetration	ISO 2137	26,5 to 29,5	mm
Dropping point	ISO 2176	≥ 180	°C
Oil separation after 24 h at 100°C	Annex G	≤ 3 % (mass)	
Oxidation resistance pressure drop after 100 h at 160°C	Annex H	≤ 0,1	MPa
Pour-point of base oil	ISO 3016	below –60	°C

5.7.3 Suitability for use in sliding elements

When tested in accordance with annex D, the lubricant shall meet the friction requirements given in 4.1.1 and 4.1.2.
For the short term friction test the mating sliding surface shall be made of hard chromium in accordance with 5.4 or austenitic steel in accordance with 5.3 and for the long term friction test of austenitic steel in accordance with 5.3.

5.8 Adhesive for bonding austenitic steel sheets

NOTE The main function of the adhesive is to join austenitic steel sheets to the backing plate in such a way that shear is transmitted without relative movement.

The adhesive shall be solvent free.

5.8.1 Requirements in short term test

The short term test shall be carried out in accordance with annex J on five specimens.
When tested without ageing, the lap shear strength of the fastening of each specimen shall not be less than 25 MPa.

5.8.2 Requirements in long term test

The long term test shall be carried out in accordance with annex J on each of five specimens.
When tested after accelerated ageing in accordance with J 4.2.1 and J 4.2.2, the average lap shear strength of the fastening from both sets of five specimens shall not be less than 25 MPa.

6 Design requirements

This clause deals with all the design details, design data and dimensioning.

6.1 Combination of sliding materials

The sliding materials shall be combined as shown in Table 9. Only one combination shall be used in a sliding surface.

The sliding surface shall be lubricated in accordance with 7.4.

Table 9 - Permissible combination of materials for permanent applications as sliding surfaces.

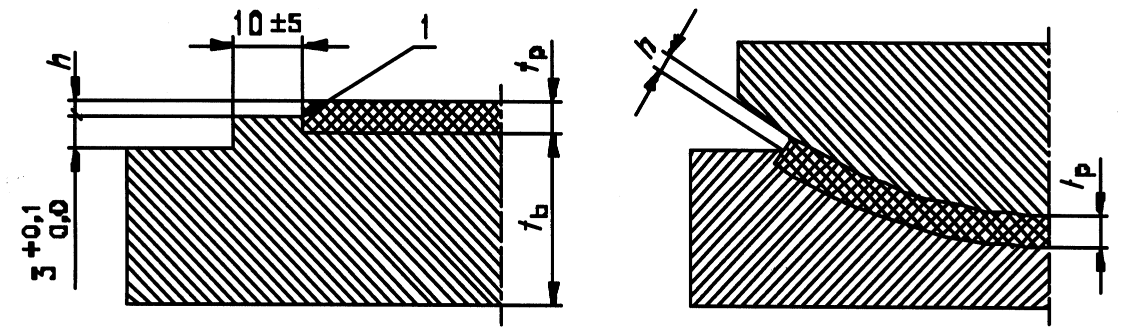
<table>
<tr><th colspan="2">Plane surface</th><th colspan="2">Curved surface</th><th colspan="2">Guides</th></tr>
<tr><td rowspan="3">Dimpled PTFE</td><td rowspan="3">Austenitic steel</td><td rowspan="3">Dimpled PTFE</td><td>austenitic steel</td><td>undimpled PTFE</td><td rowspan="3">Austenitic steel</td></tr>
<tr><td>hard chromium</td><td>CM1</td></tr>
<tr><td>aluminium</td><td>CM2</td></tr>
</table>

6.2 PTFE Sheets

6.2.1 Recessed PTFE sheets

The PTFE sheets shall be recessed into a backing plate as shown in Figure 2.

Dimensions in millimetres



NOTE A fixed value for the depth of the relief is given to facilitate the measurement of the PTFE protrusion "h" after installation. For section x –x, see Figure 3.

Key
1 Sharp edge

Figure 2 - Details of PTFE recess and relief

For pressures due to characteristic permanent actions G_k exceeding 5 MPa a uniform pattern of dimples shall be provided to retain the lubricant. The shape and arrangement of the dimples in the unloaded and unused condition is shown in Figure 1.
The dimple pattern shall be aligned with the main direction of sliding as shown in Figure 1.
The thickness "t_p" of the PTFE sheets and protrusion "h" in the unloaded condition with corrosion protection shall meet the following conditions:

$$h = 1{,}75 + \frac{L}{1200} \text{(mm) but not less than 2,2 mm} \qquad (1)$$

$$2{,}2h \le t_p \le 8{,}0 \text{ mm} \qquad (2)$$

The tolerance on the protrusion "h" is ± 0,2 mm for L less than or equal to 1200 mm and ± 0,3 mm for L greater than 1200 mm. The protrusion "h" shall be verified at marked measuring points, where the corrosion protection coating shall not exceed 300 µm. There shall be at least two measuring points, suitably located.

6.2.1.1 Flat PTFE sheets

Flat PTFE sheets shall be circular or rectangular and may be sub-divided into a maximum of four identical parts. Further sub-divisions are beyond the scope of this European Standard.
The smallest dimension "a" shall not be less than 50 mm.
The distance between individual PTFE sheets shall not be greater than twice the thickness of the backing plate, of the PTFE or the mating material, whichever is least.
Figure 3 shows some examples of sub-division of flat PTFE sheets.

Dimension in millimetres

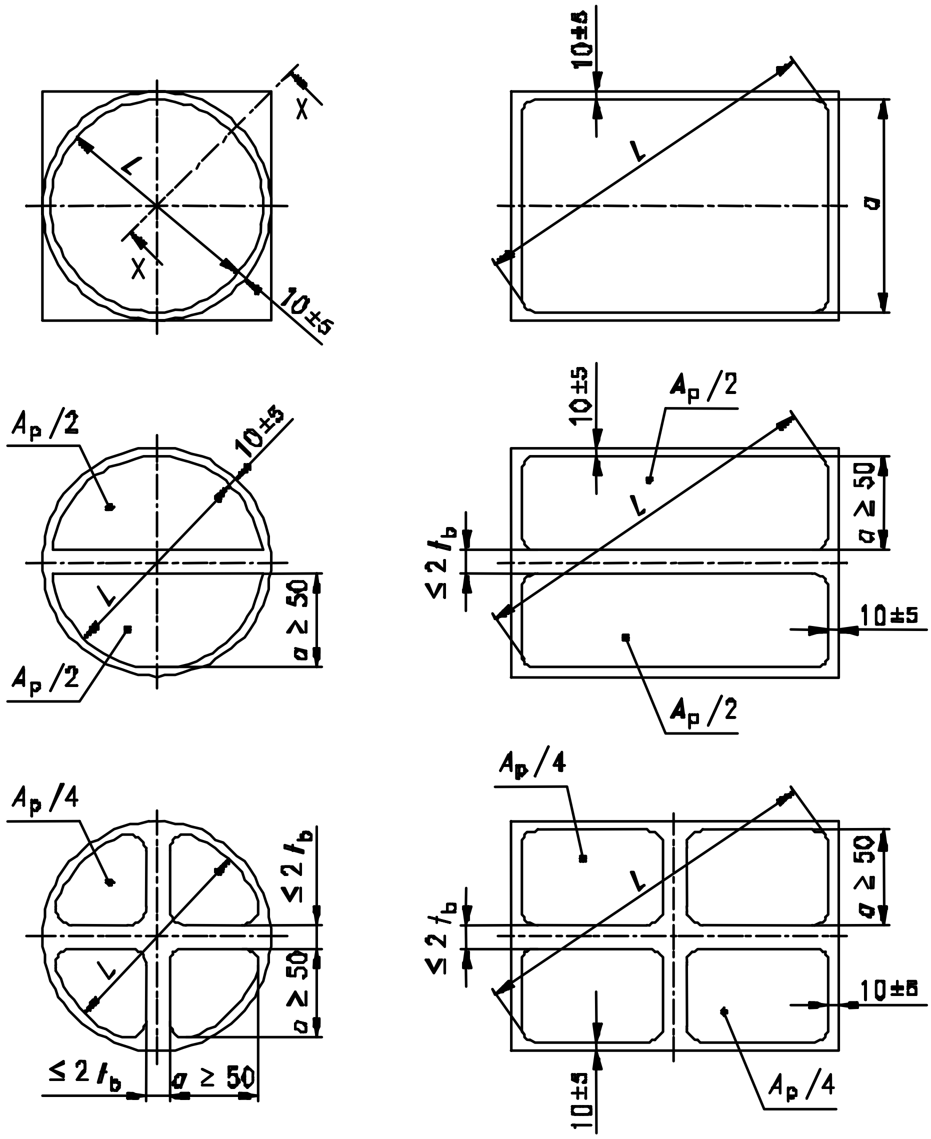


Figure 3 - Examples of recessed flat PTFE configurations

6.2.1.2 Curved PTFE sheets

Curved PTFE sheets for cylindrical sliding surfaces shall be rectangular and may be subdivided into a maximum of two identical parts. Figure 4 shows the configurations of curved PTFE sheets for cylindrical sliding surfaces.

Dimensions in millimetres

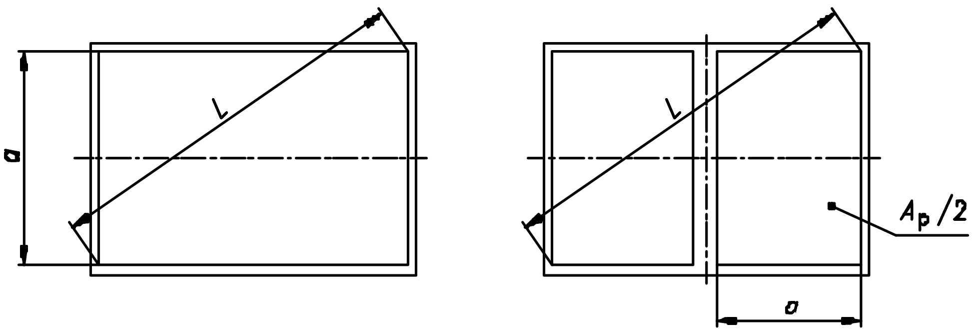


Figure 4 - Configuration of recessed PTFE sheets for cylindrical sliding surfaces

Curved PTFE sheets for spherical sliding surfaces shall be circular and may be subdivided into a disc and an annulus. The disc shall not be less than 1000 mm in diameter and the width of the annulus shall not be less than 50 mm. The annulus may be divided into equal segments.

Both the disc and the annulus may be retained in recesses. The separating ring of the backing plate shall not be more than 10 mm wide. Figure 5 shows the configurations of curved PTFE sheets for spherical sliding surfaces.

Dimensions in millimetres

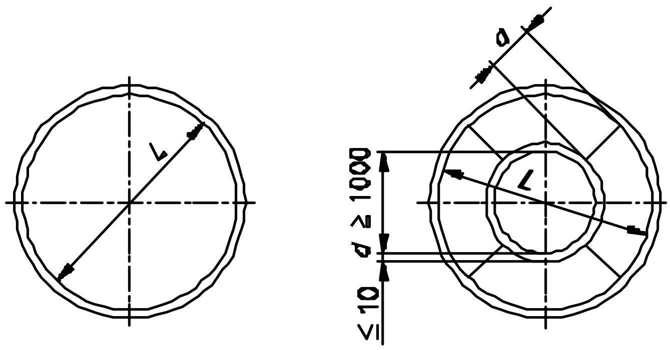


Figure 5 - Subdivision of recessed PTFE sheets for spherical sliding surfaces

6.2.1.3 PTFE sheets for guides

PTFE sheets for guides shall have a minimum thickness of 5,5 mm and a protrusion in the unloaded condition of 2,3 mm ± 0,2 mm.

Dimension “a” shall not be less than 15 mm and the modified shape factor

$$S = \frac{A_p}{u \times h} \times \frac{t_p - h}{h} \qquad (3)$$

shall be greater than 4. (See Figure 6).

Dimensions in millimetres

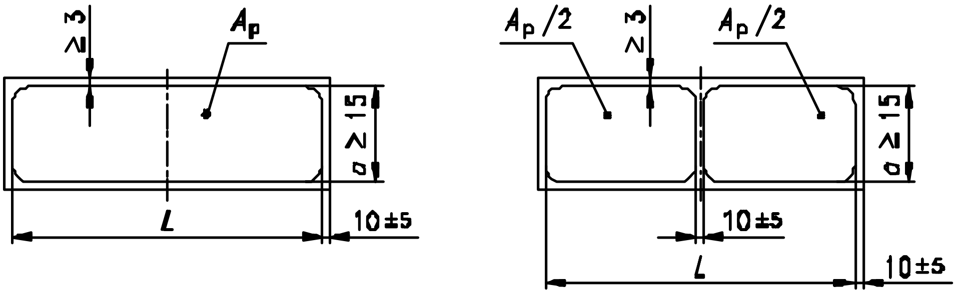


Figure 6 - Examples of recessed PTFE sheets for guides

6.2.2 PTFE sheets bonded to elastomeric bearings

NOTE Presetting of elastomeric bearings to compensate for creep and shrinkage in concrete structures is difficult. A possible solution is the introduction of a PTFE sliding element. PTFE sheets bonded to elastomer may be used to accommodate displacements deriving from creep and shrinkage deformations of concrete structures (type D in Table 2 of prEN 1337–3:1996).

PTFE sheets bonded to elastomeric bearings shall be attached by vulcanization.
Where undimpled PTFE is used, it shall be at least 1,5 mm thick and shall be initially lubricated.
The verification as per 6.8.1 and 6.8.2 does not apply.

6.3 Composite materials

Composite materials shall only be used where self-alignment between the mating parts of the bearing is possible.
Width “a” shall be equal to or greater than 10 mm.

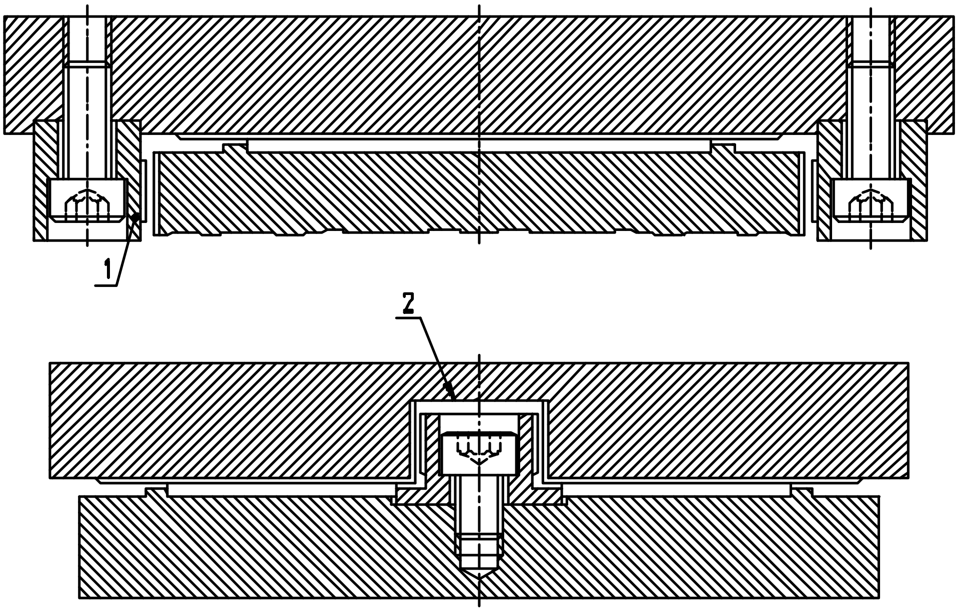
6.4 Guides

Guides may be used for resisting horizontal forces V_d due to variable and permanent actions.
Depending on the bearing construction, the guides may be arranged externally or centrally.
The sliding materials shall be fixed on keys and keyways in the backing plates.
Clearance c between sliding components in unused condition shall meet the following condition:

$$c \leq 1{,}0\,\text{mm} + \frac{L}{1000}\text{mm} \qquad (4)$$

Typical examples of the attachment of keys and guides are shown in Figures 7 and 8.
In the design of the connection at ultimate limit state in accordance with ENV 1993-1-1, the effects of horizontal force V_d, its induced moment and the friction forces shall be considered.

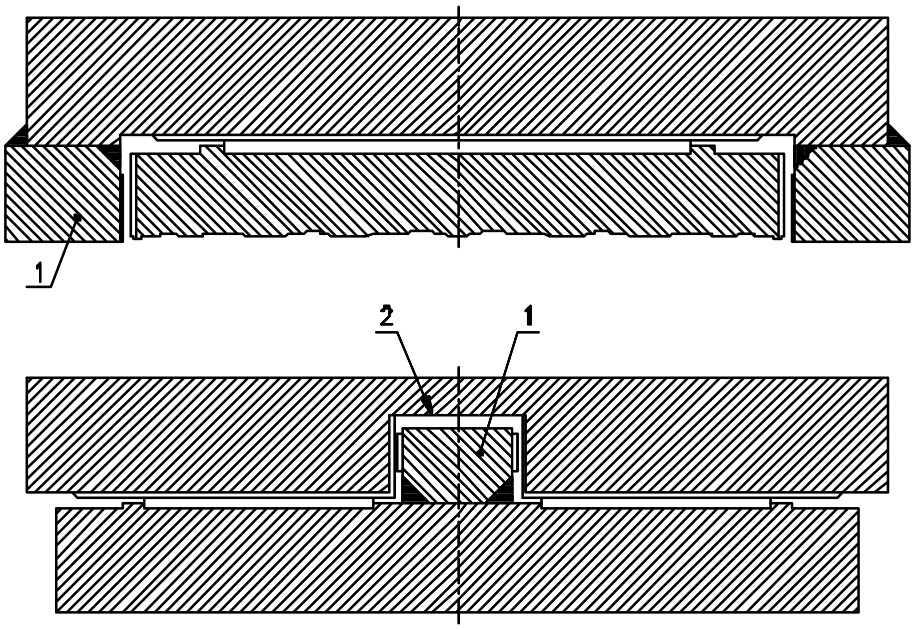
Where, under predicted rotation about a transverse axis the differential deformation of the PTFE sheet across its smallest dimension “a” would exceed 0,2 mm, a rotation element shall be included in the backing plate (see Figure 1, 3.3 of EN 1337-1:2000).
This condition shall be verified for the unfactored characteristic actions.



Key

1 key
2 keyway

Figure 7 - Typical examples of bolted keys arrangement.



Key

1 key
2 keyway

Figure 8 - Typical examples of welded keys arrangement

6.5 Austenitic Steel Sheet

6.5.1 Displacement capacity

The austenitic steel sheets shall be so proportioned that in all conditions they completely cover the PTFE and CM sheets.
The minimum dimensions of the austenitic steel sheets depend on the lateral displacements required of the bearing. These shall be determined in accordance with EN 1337-1:2000, 5.4.

6.5.2 Thickness

The minimum thickness of austenitic steel sheet shall be in accordance with Table 13.

6.6 Design compressive strength for sliding materials

The design value f_d given in Table 10 shall be used for verification at ultimate limit state in accordance with 6.8.3.
Values listed in Table 10 are valid for effective bearing temperatures up to 30°C.
For bearings exposed to a maximum effective bearing temperature in excess of 30°C and up to 48°C the afore-mentioned values shall be reduced by 2 % per degree above 30°C in order to reduce creep effects of PTFE.

Table 10 - Design values of compressive strength for sliding materials.

Material	Action	f_d (MPa)
PTFE for main bearing surfaces	permanent and variable loads	60
PTFE for guides	variable loads	60
	temperature, shrinkage and creep	20
	permanent loads	7
CM1	permanent and variable horizontal loads	130
CM2	permanent and variable horizontal loads	80

6.7 Coefficient of friction

The coefficients of friction μ_{max} given in Table 11 shall be used for verification of the bearing and the structure in which it is incorporated.
Intermediate values can be obtained by linear interpolation or by using formula given in annex B.
These values shall not be applied in the presence of high dynamic actions which may occur for instance in seismic zones.
The effects of friction shall not be used to relieve the effects of externally applied horizontal loads.
The values shown in Table 11 are valid only for dimpled lubricated PTFE.

Table 11 - Coefficients of friction μ_{max}.

Contact pressure σ_p (MPa)	≤ 5	10	20	≥ 30
PTFE dimpled / austenitic steel or hard chromium plating	0,08	0,06	0,04	0,03 (0,025) [a]
PTFE dimpled / aluminium alloy anodized	0,12	0,09	0,06	0,045 (0,038) [a]
[a] These values apply to the frictional resistance of curved sliding surfaces.				

In the zones where the minimum effective bearing temperature does not fall below –5°C, the coefficients of friction given in Table 11 may be multiplied by a factor of 2/3.
For guides with a combination of sliding materials given in the third column of Table 9, the coefficient of friction shall be considered to be independent of contact pressure and the following values shall be used:

PTFE: μ_{max}=0,08
Composite materials μ_{max}=0,20

6.8 Design verification for sliding surfaces

6.8.1 General

When dimensioning sliding surfaces, all the internal forces and moments due to actions and frictional resistance shall be considered. The design values of the action to be taken into account shall be determined in accordance with the basic design criteria given in EN 1337-1:2000.

Deformation of sliding materials shall not be used to accommodate rotations except as permitted in 6.4.

6.8.2 Separation of sliding surfaces

NOTE Separation of the sliding surfaces may lead to loss of lubricant, wear due to contamination and increased deformation due to lack of confinement of PTFE. As this could endanger long term fitness for use, the condition $\sigma_p = 0$ is considered as serviceability limit state.

With the exception of guides, it shall be verified that $\sigma_p \geq 0$ for all load combination at serviceability limit state.
In doing so the sliding material shall be assumed to be linear elastic and the backing plates shall be deemed to be rigid.

6.8.3 Compressive stress verification

NOTE Excessive pressure may cause loss of the sliding function and this may lead to structural failure or states close to structural failure. Therefore this condition is considered ultimate limit state.

For combinations of materials according to Table 9, the following condition shall be verified at ultimate limit state:

$$N_{Sd} \leq f_d \times A_r \qquad (5)$$

where:

N_{Sd} is the design value of the axial force due to the design values of action

f_d is the design compressive resistance given in Table 10.

A_r is the reduced contact area of the sliding surface whose centroid is the point through which N_{Sd} acts with the total eccentricity e ,which is caused by both mechanical and geometrical effects.
A_r shall be calculated on the basis of the theory of plasticity assuming a rectangular stress block (see annex A).
For guides eccentricity can be neglected.

For PTFE sheets with dimension “a” ≥ 100 mm, contact areas A and A_r shall be taken as the gross area without deduction for the area of the dimples. For sheets with “a” < 100 mm the area of the dimples shall be deducted from the gross area.

For curved surfaces see EN 1337-7.

6.9 Design verification of backing plates

6.9.1 General

The PTFE and the mating sliding materials shall be supported by metal plates (backing plates) with plane or curved surfaces.
The design of the backing plates shall take into account the following:

- verification at ultimate limit state when internal forces and moments from lateral actions are to be considered in addition to the effects from deformation as per 6.9.2
- any cross section reduction (for example due to keyway and the attachment bolts)
- deformations as per 6.9.2
- the required stiffness for transport and installation as per 6.9.3
- distribution of forces to the adjacent structural members as per 6.9.4

6.9.2 Deformation verification

NOTE If the deformations (see Figure 9) exceed the values given below, unacceptably small clearance between the adjacent backing plates and higher wear will occur. As this could endanger the long term fitness for use of the sliding element, this condition is considered serviceability limit state.

Total deformation $\Delta w_1 + \Delta w_2$ (see Figure 9) shall meet the following condition:

$$\Delta w_1 + \Delta w_2 \leq h\left(0{,}45 - 2\sqrt{h/L}\right) \qquad (6)$$

The stress induced by this deformation in the backing plate shall not exceed the elastic limit in order to avoid permanent deformations.
The theoretical model for verification of the above requirements (deformation Δw_1 and yield strength) shall include the effects of all the bearing components which have a significant influence on these deformations including the adjacent structural members and their short and long-term properties.

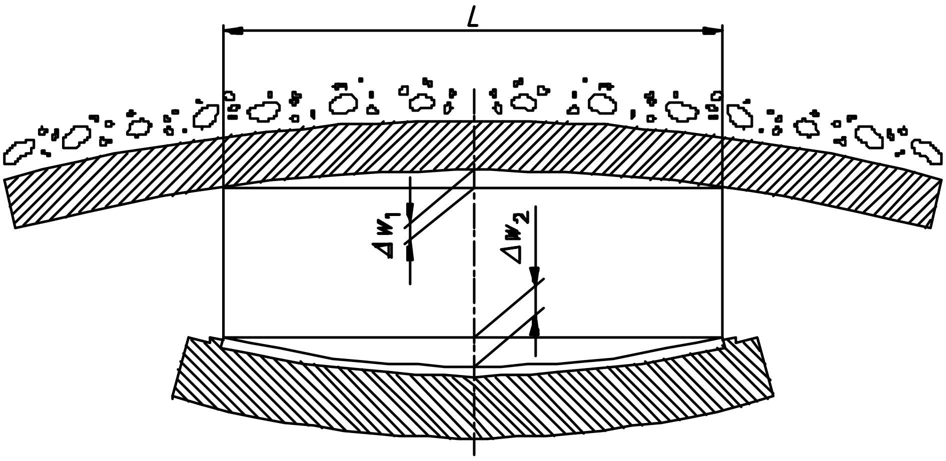


Figure 9 - Deformations of backing plates.

For steel and concrete, the design values of material properties in accordance with ENV 1993-1-1 and ENV 1992-1-1 respectively apply.

In this model the following assumptions shall be made:

a) central load

b) notional design modulus of elasticity of PTFE = 0,4 GPa

c) the total thickness t_p of PTFE sheet

d) notional design Poisson' s ratio of PTFE = 0,44

e) in the case of adjacent structural members of massive construction:
linear reduction of the elastic modulus of concrete or mortar from the edge to the centre of the backing plate from 100% to 80%

A suitable method for calculating deformation Δw_1 for common materials is given in annex C.

When using the method given in annex C elastic limit verification of the backing plate is not required if:

- condition (6) is met;

- the concrete strength class is at least C 25/30 in accordance with ENV 1992-1-1and;

- the steel grade is at least S355 in accordance with EN 10025:1990/A1:1993.

The above also applies when using lower concrete strength classes and/or steel grades, provided the deformation limit values calculated as above are reduced by a factor of:

0,90 when using concrete strength class C 20/25

0,67 when using steel S 235

0,60 when using both concrete C 20/25 and steel S235.

NOTE The above is not the only criterion to be considered in determining the relative deformation Δw_1. Particular attention shall be paid to loadings during construction (e.g. when large backing plates are not propped during concrete casting).

For circular backing plates in contact with reinforced elastomeric bearings or the elastomeric pads of pot bearings, the maximum deformation Δw_2 shall be calculated according to the theory of elastic circular plates in combination with the pressure distributions shown in Figures 10 and 11.

The more unfavourable of the pressure distributions shown in Figure 10 shall be used.

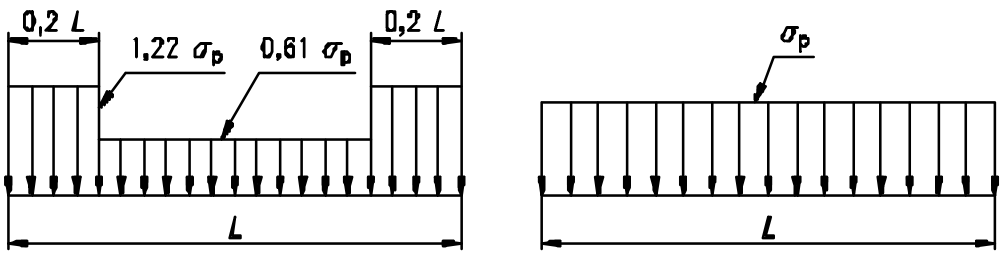
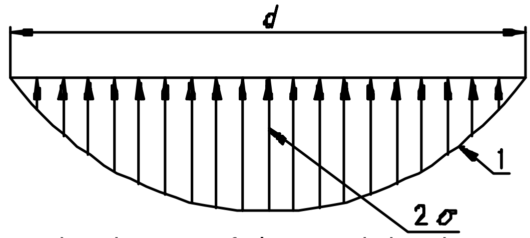
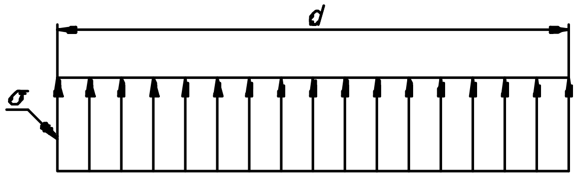


Figure 10 - Alternative PTFE pressure distributions



a) In the case of elastomeric bearings



b) In the case of pot bearings

Key

1 parabolic distribution

Figure 11 - Elastomeric pressure distributions.

For spherical and cylindrical PTFE bearings the calculation of the relative deformation of the backing plate with convex surface shall be omitted and Δw_2 taken as zero.

For all other types, if the calculations show that the two metal backing plates are deformed in the same direction, then Δw_2 shall also be taken as zero.

Square or rectangular plates shall be idealised to circular plates of diameter

$$d_b = 1{,}13\ a_b \qquad (7)$$

where a_b is the side of the square plate or the minor side of the rectangular plate.

6.9.3 Stiffness for transport and installation

The thickness of the backing plate shall be:

$$t_b \geq 0{,}04 \times \sqrt{a_b^2 + b_b^2} \quad \text{or } 10 \text{ mm, whichever is greater} \qquad (8)$$

where:

a_b is the minor side of backing plate

b_b is the major side of backing plate

6.9.4 Backing plates for elastomeric bearings with bonded PTFE sheets.

The mating austenitic steel sheet in accordance with 6.2.2 shall be supported by a metal backing plate with a thickness of:

$$t_b \geq 0{,}025 \times \sqrt{a_b^2 + b_b^2} \quad \text{or } 10 \text{ mm, whichever is greater} \qquad (9)$$

Further verifications are not required.

7 Manufacturing, assembly and tolerances

This clause deals with workmanship, assembly and fitting tolerances.

7.1 Backing plates

7.1.1 PTFE confinement

The shoulders of the recess shall be sharp and square to restrict the flow of PTFE (see Figure 2). The radius at the root of the recess shall not exceed 1 mm.

The depth of the confining recess shall be related to the dimensions of the PTFE sheet in accordance with 6.2.1

In principle the PTFE sheet shall fit the recess without clearance. Intermittent gaps between the edge of the PTFE sheet and the recess shall not exceed the values given in Table 12 at room temperature.

Table 12 - Fit of confined PTFE sheets.

Dimension L (mm)	Gap (mm)
75 ≤ L ≤ 600	0,6
600 < L ≤ 1200	0,9
1200 < L ≤ 1500	1,2

7.1.2 Flatness

Surfaces of backing plates in contact with sliding materials or anchor and shimming plates shall be treated in such a way that the maximum deviation Δz from theoretical plane surface shall not exceed 0,0003 × d or 0,2 mm, whichever is greater.

7.1.3 Fit of sliding surfaces

The maximum deviation Δz from theoretical plane or curved surface within the area of the mating PTFE sheet shall not exceed 0,0003 × L or 0,2 mm, whichever is greater.

7.2 Attachment of sliding materials

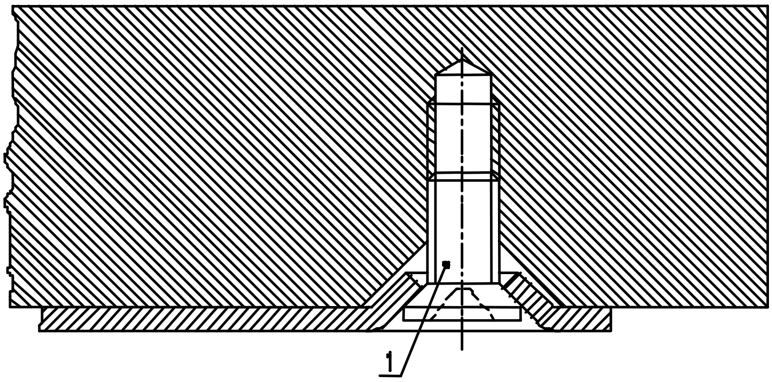
7.2.1 Austenitic steel sheet

Austenitic steel sheets shall be attached by one of the methods shown in Table 13.

Table 13 - Thickness and methods of attachment of austenitic steel sheets.

Type of surface	Method of attachment	Thickness (mm)
Flat	full surface bonding	1,5
	continuous fillet weld	≥ 1,5
	counterpunched screwing [a]	≥ 1,5
	screwing, rivetting	≥ 2,5
Spherical	full surface bonding	≥ 2,5
	continuous fillet weld	≥ 2,5
Cylindrical	full surface bonding	1,5
	continuous fillet weld on straight edges	≥ 1,5

[a] Figure 12 shows the method of attachment of austenitic steel sheets using screws and counterpunching



Key

1 Stainless steel countersunk screw fixing

Figure 12 - Counterpunched screwing.

Care shall be taken to ensure that the austenitic steel sheet is fully in contact with the backing plate over the area which will be in contact with the PTFE sheet.

When attaching the austenitic steel sheet by screwing, counterpunched screwing and rivetting, corrosion resistant fasteners compatible with the austenitic steel sheet shall be used for securing its edges. They shall be provided at all corners and along the edges outside the area of contact with the PTFE sheet, with the maximum spacings listed in Table 14.

Table 14 - Maximum fastner spacing for attachment of austenitic steel sheets by screwing, counterpunched screwing and rivetting.

Austenitic steel sheet thickness (mm)	Maximum fasteners spacing (mm)
1,5	150
2,0	300
2,5	450
3,0	600

When bonding the austenitic steel sheet, an adhesive of characteristics given in 5.8 shall be used.
Preparation of the adherends shall be in accordance with adhesive manufacturer's recommendations. There shall be no voids in the adhesive layer and a fillet of adhesive shall be formed around the complete periphery of the austenitic sheet during the bonding process.

The flatness as required in 7.1.2 shall be achieved after bonding.

7.2.2 PTFE sheets

In the case of plane backing plates the PTFE sheets shall be confined in accordance with 7.1.1.
In addition, PTFE sheets for guides shall be bonded to assist assembling.

7.2.3 Composite material

Composite materials shall be attached by bonding supplemented by mechanical attachment outside the sliding surface.

7.3 Protection against contamination and corrosion

NOTE General requirements for corrosion protection are given in EN 1337-9. This subclause gives additional requirements for sliding elements.

Where the austenitic steel sheet is attached by full area bonding or by continuous fillet weld, provided the area covered by the austenitic steel sheet is free from rust and rust inducing contaminants, no further treatment of the backing plate behind the austenitic steel sheet is required.

Where the austenitic steel sheet is attached by screwing, counterpunched screwing or rivetting the full corrosion protection system shall be applied to the backing plate behind the austenitic steel sheet.

Areas of the backing plate behind the PTFE sheet shall be protected by one coat of primer (dry film thickness 20 μm to 100 μm).

Provision against contamination of the slidiing surface shall be made by suitable devices. Such protectioon devices shall be easily removable for the purpose of inspection.

Since hard chromium plating is not resistant to chlorides in acid solution or to fluorines and can be
damaged by air borne particles, such as occur in industrial environment, special provision shall be made to protect the surfaces in those conditions.

Prior to assembly the sliding surfaces shall be cleaned.
During assembly process, provisions shall be taken against contamination of lubricated surfaces.

7.4 Lubricating

After cleaning and prior to assembly, the dimpled PTFE sheet shall be lubricated with lubricant according to 5.7 in a way which ensures that all the dimples are filled.
For guides the sliding material shall be initially lubricated by rubbing a small amount of lubricant into the surface and wiping off the remainder.

7.5 Reference surface for bearing installation

In order to ensure bearing alignment in accordance with EN 1337-11 a reference surface or other suitable device shall be installed on the sliding element.
The deviation from parallel of the reference surface with respect to the plane sliding surface shall not exceed 1‰.

8 Conformity evaluation

8.1 General

The tests and inspections specified in this clause shall be carried out to demonstrate conformity of the product (sliding element) with this European Standard.

8.2 Control of the product and its manufacture

8.2.1 General

The extent and frequency of factory production control by the manufacturer as well as of type-testing and, if need be, of audit-testing by a third party are given in Table 15.

8.2.2 Initial type-testing

Type-testing shall be performed prior to commencing the manufacture. It shall be repeated if changes in the product or manufacturing process occur.

8.2.3 Factory production control

Factory production control procedures shall be in accordance with annex K.
In addition, it shall be checked by controlling the inspection certificates as listed in Table 16 that the incoming raw materials and components comply with this European Standard.

8.2.4 Audit testing

Audit testing shall be performed in accordance with annex L..

8.3 Raw materials and constituents

Compliance with the requirements specified in clause 5 shall be verified by means of inspection certificates in accordance with EN 10204 to the level stated in Table 16.
In addition it shall be shown that the supplier's sliding materials and lubricant have previously been subjected to type-testing within the framework of control of the product as per Table 15.

8.4 Sampling

Random samples shall be taken from the running production

Table 15 - Control and testing of the product [a]

Type of control	Subject of control	Control in accordance with	Frequency
Factory production control	Dimensions	Manufacturer's drawings	each sliding element
	Fit of confined PTFE sheets	7.1.1	
	Flatness of backing plates	7.1.2	
	Fit of sliding surfaces	7.1.3	
	Contact between austenitic steel sheet and backing plate	Manufacturer's procedure	
	Application of sealing medium		
	Attachment of austenitic steel sheets by welding		
	Protrusion of PTFE sheet	6.2.1	
	Reference surface for installation	7.5	
	Movement indicators	Manufacturer's drawings	
	Functioning [b]	Manufacturer's drawings	
	Presetting	Manufacturer's drawings	
	Provision against corrosion	7.3	
	Device against pollution of the sliding surfaces	Manufacturer's drawings	
	Marking	7.3 of EN 1337-1:2000	
	Sliding surface including materials taken from the current production of the factory of the construction product	4.1.1 D.6.1	once every year
	Fastening with adhesive for austenitic steel sheets	5.8.1	once each batch
Initial type-testing	All subjects as for factory production control	as above	once
	Sliding surfaces including a material as follows: PTFE CM1 or CM2 Lubricant	 5.1.4 [c] 5.2.3 [c] 5.7.3 [c]	 once once once
	Fastening with adhesive for austenitic steel sheets	5.8.2	once
Audit-testing	Selected subjects as for factory production control and as stated in Table 16	As for factory production control and as stated in Table 16	

[a] For CE marking purposes, only characteristics and relevant parameters thereof in Table ZA.1 should be of concern for control and testing.

[b] Testing of whether the sliding element moves within the limitations given in the drawing.

[c] Only long-term friction tests are required. Tests are required if material has never been type tested in the material combination in question (see 8.3)

Table 16 - Specific testing of raw materials and constituents.

Type of inspection certificate	Subject of control	Control in accordance with	Frequency
3.1.A	Sliding material PTFE	5.1.2 5.1.4 [a]	once each batch ≤ 500 kg
3.1.B		5.1.3	each sheet
3.1.B	Sliding material CM 1	5.2.1	once each coil
3.1.A		5.2.3 [a]	once each coil
3.1.B	Sliding material CM 2	5.2.2	once each coil
3.1.A		5.2.3 [a]	once each coil
3.1.B	Austenitic steel sheet	5.3	once each coil
	Backing plate for hard chromium plating	5.4.1	once each batch
	Hard chromium plating	5.4.2.1 5.4.2.2 5.4.2.3 5.4.2.4	every component every component every component once each delivery or if necessary after visual inspection
	Ferrous materials for backing plates	5.5	once each batch
	Aluminium alloy	5.6.1	
	Anodized aluminium	5.6.2 5.6.3	
3.1.B	Lubricant	5.7.2 [b]	once each batch ≤ 500 kg
3.1.A		5.7.2 [c] 5.7.3 [a]	once each batch ≤ 500 kg

[a] To test tribological suitability it generally suffices to perform the short term friction test. The long term friction test shall be carried out during initial type-testing of the construction product if necessary (see Table 15).

[b] without IR-spectral analysis

[c] Only IR-spectral analysis

9 Installation

After installation and completion of the superstructure, the deviation of the sliding element from the specified alignment shall not exceed 3 ‰ in accordance with EN 1337-11:1997, 6.5.

10 Criteria for in-service inspection

During inspection of items listed in prEN 1337-10:1998 the following value shall be checked:

- Protrusion h: ≥ 1 mm. (see Figure 2)

If the protrusion h of the PTFE sheet is found to be less than 1 mm, or a bulging of the austenitic sheet exceeds the measured protrusion in its vicinity, the sliding element is still deemed to be serviceable but more frequent inspections shall be conducted.

If the protrusion of the PTFE sheet is reduced to zero, the sliding element shall no longer be considered capable of accomodating movement.

Annex A
(informative)
Reduced area for sliding elements

EXAMPLE 1 Rectangular sliding surface (see Figure A.1a))

$$A = a \times b \quad \text{(A.1)}$$

$$A_r = A - 2\,e \times a = a\,(b - 2\,e) \quad \text{(A.2)}$$

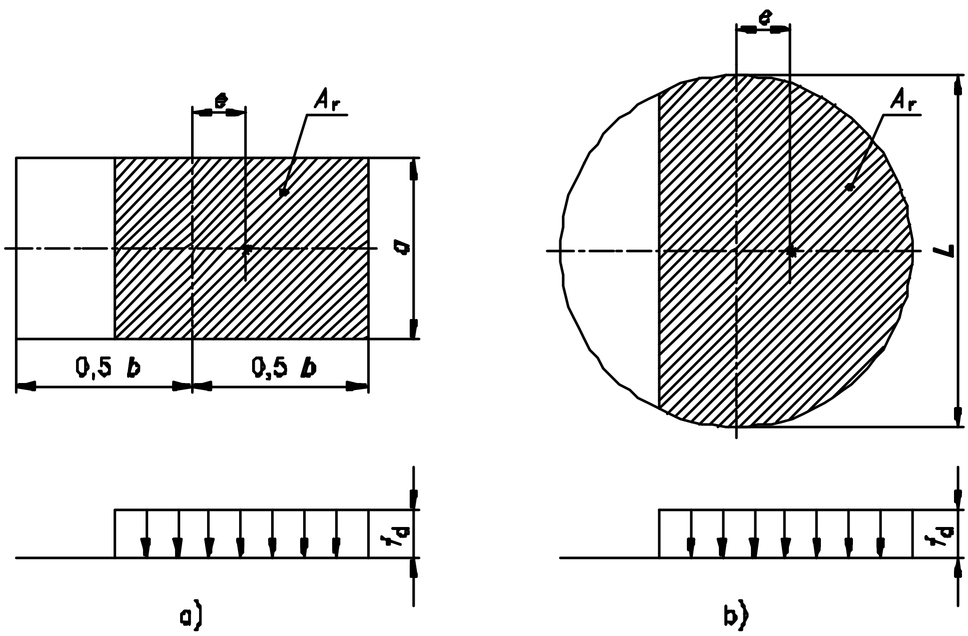


Figure A.1 - Reduced contact area for rectangular and circular sliding surfaces.

EXAMPLE 2 Circular sliding surface (See Figure A.1b))

$$A = \pi L^2/4 \quad \text{(A.3)}$$

$$A_r = \lambda A \quad \text{(A.4)}$$

The ratio $\lambda = A_r / A$ is given in Table A.1.

Intermediate values may be obtained by linear interpolation.

Table A.1 - Ratio $\lambda = A_r / A$ for circular sliding surfaces.

e / L	0,005	0,010	0,020	0,030	0,040	0,050	0,060
λ	0,990	0,979	0,957	0,934	0,912	0,888	0,865
e / L	0,070	0,080	0,090	0,100	0,110	0,120	0,125
λ	0,841	0,818	0,793	0,769	0,745	0,722	0,709
e / L	0,130	0,140	0,150	0,160	0,170	0,180	0,190
λ	0,697	0,673	0,649	0,625	0,601	0,577	0,552
e / L	0,200	0,210	0,212	0,220	0,230	0,240	0,250
λ	0,529	0,506	0,500	0,482	0,458	0,435	0,412

As an alternative to the exact values given in Table A.1, the following approximate formula an be used:

$$\lambda = 1 - 0{,}75\, \pi\, e / L \qquad \text{(A.5)}$$

Annex B
(informative)
Coefficient of friction for dimpled PTFE sheets

Values of coefficient of friction μ_{max} shown in Table 11 of this European Standard may be calculated using the following formula:

$$\mu_{max} = \frac{1{,}2k}{10 + \sigma_p} \qquad (B.1)$$

where:

$$k \begin{cases} \text{is } 1{,}0 \text{ for mating austenitic steel and hard chromium} \\ \text{is } 1{,}5 \text{ for mating aluminium alloy} \end{cases}$$

σ_p is the PTFE contact pressure

Annex C
(informative)
Method for calculating the deformation of backing plates attached to concrete

For circular steel plates attached to concrete structural members of concrete strength class C 20\25 according to ENV 1992-1-1 or greater and mortar layers of equivalent strength, the maximum relative deformation Δw_1 over the diameter L is given by the equation below:

$$\Delta w_1 = \frac{0{,}55}{L} \times k_c \times \cdot \alpha_c \times k_b \times \alpha_b \tag{C.1}$$

with

k_c=1,1 + (1,7 – 0,85 x d_b / L) x (2 – d_b / L_0) if $L_0 \leq d_b \leq 2 \times L_0$ (C.2)

k_c=1,1 if $d_b > 2 \times L_0$ (C.3)

$$\alpha_c = \frac{N_{Qd}}{E_{cd}} + \frac{N_{Gd}}{E_{crd}} \tag{C.4}$$

k_b=0,30 + 0,55 x d_b / L (C.5)

$$\alpha_b = \left(\frac{L}{L + 2xt_b}\right)^2 x \left(\frac{3xL_0}{d_b}\right)^{0{,}4} \tag{C6}$$

where

- d_b is the diameter of the backing plate
- t_b is the thickness of the backing plate; for backing plates with a concave surface the calculation may be based on the equivalent constant thickness $t'_b = t_{b,min} + 0{,}6\,(t_{b,max} - t_{b,min})$
- L is the diameter of PTFE sheet
- L_0 is the reference diameter = 300 mm
- N_{Qd} is the design axial force due to variable actions
- N_{Gd} is the design axial force due to permanent actions
- E_{cd} is the design secant modulus of elasticity of concrete
- E_{crd} is the design reduced modulus of elasticity of concrete, for the determination of creep when acted upon by permanent design actions N_{Gd} ($E_{crd} \cong 1/3\ E_{cd}$)

The above approximate procedure may also be applied to square plates and rectangular plates if they are idealised to circular plates of diameter

$d_b = 1{,}13\ a_b$ (C.7)

where a_b is the side of the square plate or the minor side of the rectangular plate.

Annex D
(normative)
Test methods for friction

D.1 Scope

This annex describes the method for determining the coefficient of friction of the sliding surfaces combined as shown in Table 9.

D.2 Terms and definitions

For the purposes of this annex the following terms and definitions apply:

static value F_{xs}
friction force at the beginning of sliding

dynamic value $F_{x,dyn}$
friction force during sliding

maximum value $F_{x,max}$
maximum friction force during sliding

NOTE For a better understanding of F_{xs} , $F_{x,dyn}$ and $F_{x,max}$ examples of typical friction force vs. sliding displacement diagrams are shown in Figure D.6.

D.3 Principle

The test consists of measuring the friction forces necessary to cause and maintain movement in the test specimen under vertical load.

D.4 Test equipment

The equipment used for the test (see Figure D.1) shall consist of:

- a compression testing machine (1) capable of applying a constant force F_z as to produce the contact pressure given in Table D.1 and Table D.3. The force F_z shall be applied centrally to the PTFE or CM specimens.
- a plate (2) moving parallel to the press platens at a specified speed. This equipment is provided with an instrumentation system which measures and records the compressive force, horizontal force (friction force) and the temperature throughout the test period with an error < 2%.
- a set of roller bearings (3) meeting the following requirements:
  - through hardened stainless rollers and plates
  - Hertz pressure not exceeding 1200 MPa
  - minimum hardness 500 HV 20 for roller and roller plate in accordance with ISO 6507-1
  - surface roughness R_{y5i} not exceeding 3 μm in accordance with ISO 4287.

The horizontal force and the stiffness of the test equipment shall not affect the sliding speed in any way.

D.5 Test specimens

The following test specimens are required as appropriate:

a) dimpled and recessed PTFE sheets in accordance with Figure 1 and D.2,

b) composite materials in accordance with Figure D.3

The mating surface shall be in accordance with the one actually used by the manufacturer within the framework of Table 9 and its machining direction shall be perpendicular to the sliding direction. The sliding surface shall be lubricated in accordance with 7.4.

D.6 Test procedure

D.6.1 Short term friction test

D.6.1.1 General

The test parameters and test conditions shall meet the requirements given in Table D.1

Table D.1 - Friction test conditions (short term test at constant speed).

Contact Pressure of PTFE	σ_p	$0{,}5\ f_d\ {}^{+3}_{0}$	MPa
Contact Pressure of CM1 and CM2	σ_{CM}	$0{,}5\ f_d\ {}^{+3}_{0}$	MPa
Temperature (Test C)	T	21 ± 1	°C
(Test D)	T	-35 ± 1	°C
(Test E)	T	0/-10/-20/-35/+21 (± 1)	°C
Temperature gradient		from 0,5 to 1,0	°C / min
Preload time	t_{pl}	1	h
Sliding distance	s	$10\ {}^{+0,5}_{0}$	mm
Dwell time at the end of the strokes	t_0	12 ± 1	s
Sliding speed	v	$0{,}4\ {}^{+0,1}_{0}$	mm / s
Number of cycles (two strokes):			
Test C and D	n	1	
Test E (see Figure D.4)	n	1 000	

D.6.1.2 PTFE sheets and lubricant

Where short term tests are intended to establish or confirm the suitability of PTFE sheets, test C, D and E shall be carried out each on new specimens in accordance with D.5 a).

D.6.1.3 Composite materials

Composite materials CM1 and CM2 shall be tested in combination with a lubricant and austenitic steel mating surface in accordance with clause 4.

The prepared test specimens as specified in D.5 b) shall be subjected to one low-temperature-programme test E.

D.6.2 Long term friction test

D.6.2.1 General

Test parameters and test conditions shall be in accordance with Table D.3.
The material of test specimens shall be selected and combined in accordance with 4.1.2 of this European Standard.

D.6.2.2 PTFE sheets for plane surfaces and lubricant

Test specimen as specified in D.5 a) shall be subjected to a long term friction test of 10 242 m total slide path consisting of 21 phases in accordance with Table D.2.

Table D.2 - Long term friction test programme

	10 242 m total slide path						
Phase Number	1	2	3	……..	19	20	21
Type	A	B	A	……..	A	B	A
Distance	22 m	1 000 m	22 m	……..	22 m	1 000 m	22 m

D.6.2.3 Sliding materials for guides and curved surfaces

Test specimens as specified in D.5 b), as appropriate, shall be subjected to a long term friction test of 2 066 m total slide path consisting of five phases in accordance with Table D.4.

Table D.3 - Friction test conditions (long term test).

Type A (phase 1, 3, 5 …. Temperature - Programme – Test) in accordance with Figure D.5 – Constant speed			
Contact Pressure of lubricated PTFE	σ_p	$0,5\ f_d\ {}^{+3}_{0}$	MPa
Contact Pressure of CM1 and CM2	σ_{CM}	$0,5\ f_d\ {}^{+3}_{0}$	MPa
Temperature	T	0/-10/-20/-35/+35/+21 (± 1)	°C
Temperature gradient		0,5 ± 1,0	°C / min
Preload time	t_{pl}	1	h
Sliding distance	s	$10\ {}^{+0,5}_{0}$	mm
Dwell time at the end of the strokes	t_0	12 ± 1	s
Number of cycles (two strokes)	n	1 000	
Sliding speed	v	$0,4\ {}^{+0,1}_{0}$	mm / s
Dwell between phases	t_0	1	h
Type B (phase 2,4,6) in accordance with Figure D.5 – Variable speed (approximately sinusoidal)			
Contact Pressure of PTFE	σ_p	$0,5\ f_d\ {}^{+3}_{0}$	MPa
Contact Pressure of CM1 and CM2	σ_{CM}	$0,5\ f_d\ {}^{+3}_{0}$	MPa
Temperature	T	21 ± 1	°C
Temperature gradient		0,5 ± 1,0	°C / min
Sliding distance	s	$8\ f\ {}^{+0,5}_{0}$	mm
Number of cycles (two strokes)	n	65 000	
Average sliding speed	v_a	2 ± 0,1	mm/s

Table D.4 - Long term test programme.

	2 066 m total slide path				
Phase Number	1	2	3	4	5
Type	A	B	A	B	A
Distance	22 m	1 000 m	22 m	1 000 m	22 m

D.7 Results

Except at the beginning of the test (the initial friction force during the first sliding movement), after the dwell between phases or any longer interruption, the mean value of the tension and compression forces shall be taken as the friction force.

The static and dynamic coefficient of friction shall be determined as follows:

$$\mu_{s,n} = \frac{F_{x,s,n,}}{F_z} \qquad (D.1)$$

$$\mu_{dyn,n} = \frac{F_{x,max,n,}}{F_z} \qquad (D.2)$$

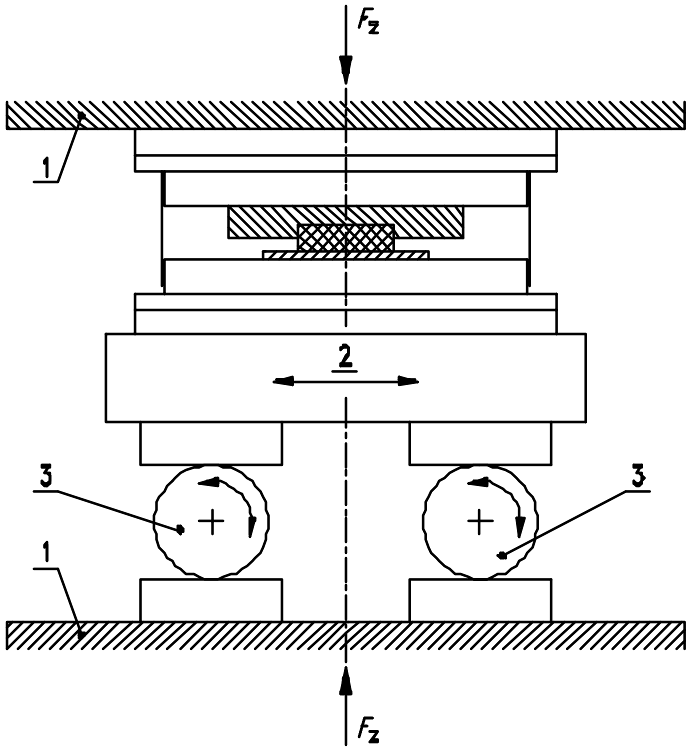
Where the dynamic value is greater than the static value,(D.1):

$$\mu_{s,n} = \mu_{dyn,n} = \mu_{max,n} = \frac{F_{x,max,n}}{F_z} \qquad (D.3)$$

D.8 Test report

The test report shall include at least the following items:

1) Identification of the test specimens and the lubricant (name of manufacturer, origin and number of manufacturing batch).
2) Dimensions, shape and arrangement of the specimens.
3) Description of surface (surface roughness R_{y5i}).
4) Date, type of test, duration, total slide path, and any other relevant test conditions.
5) Description of test equipment.
6) Complete continuous graphical record of test results showing the sliding friction profile.
7) Description of the test specimen after testing, especially wear of the sliding materials and/or change in the lubricant.
8) Any operating details not considered in the present standard and any abnormal incidents occurring during the test.
9) A reference to EN 1337-2.

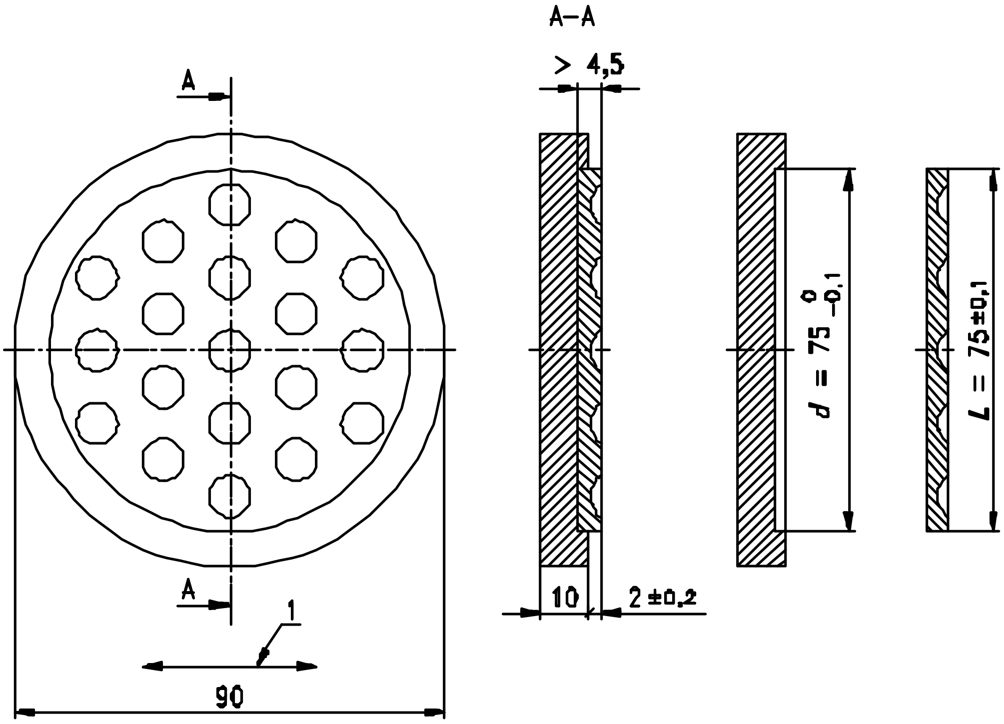


Key

1 Press plates
2 Moving plate
3 Roller bearings

Figure D.1 - Friction testing equipment.

Dimensions in millimetres



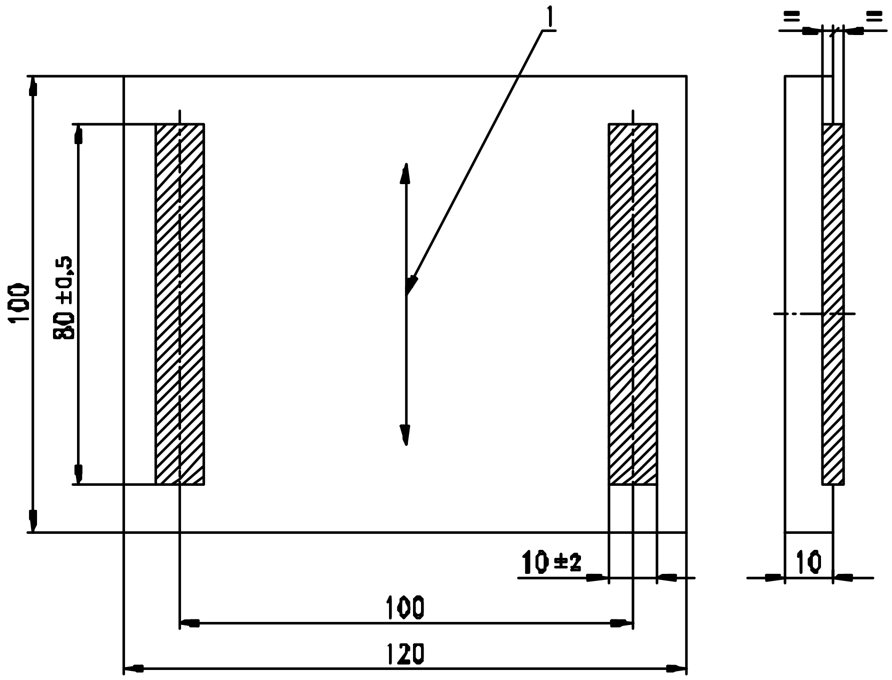
Key

1 sliding direction

NOTE The PTFE sheet may be cooled in order to fit it in the recess.

Figure D.2 - Test specimen for dimpled and recessed PTFE sheets

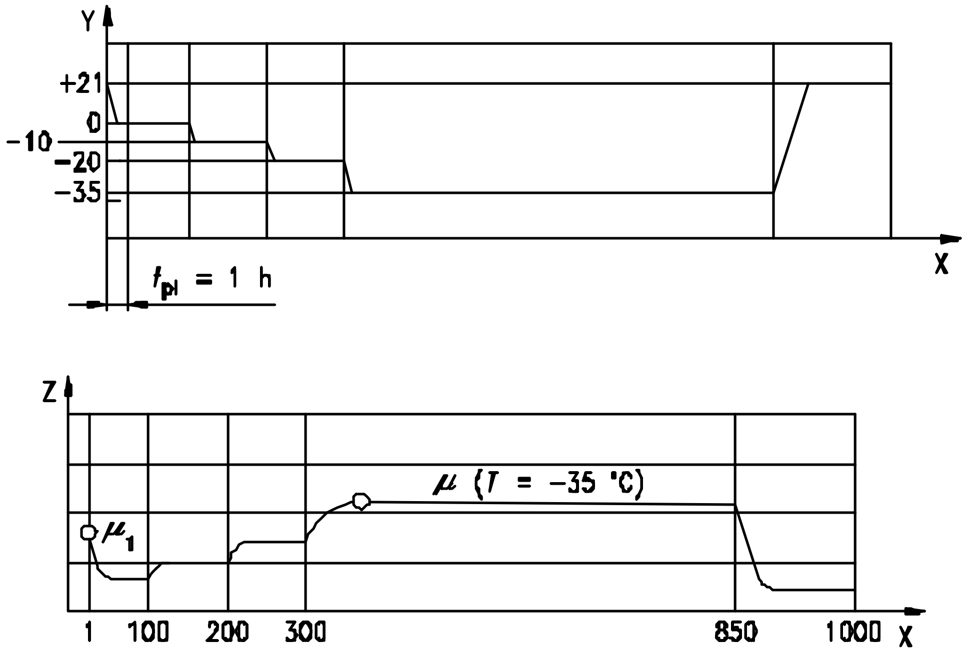
Dimensions in millimetres



Key

1 sliding direction

Figure D.3 - Test specimen for composite materials



Key

X Number of cycles n
Y Temperature T
Z Coefficient of friction μ

Figure D.4 - Schematic temperature and friction profiles of the standard short term sliding tests (Low-Temperature-Programme-Test (E))

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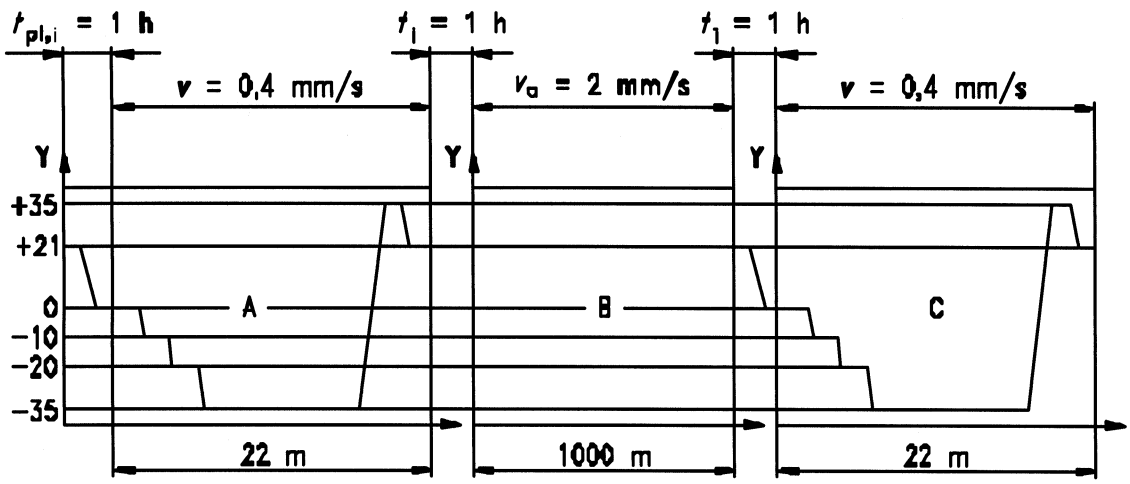
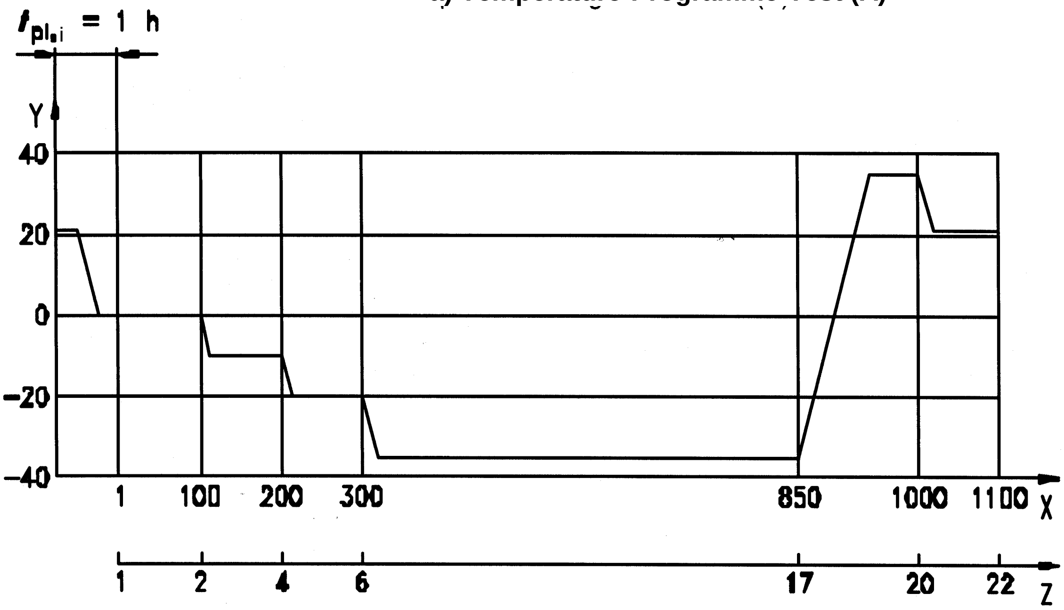


a) Temperature-Programme-Test (A)

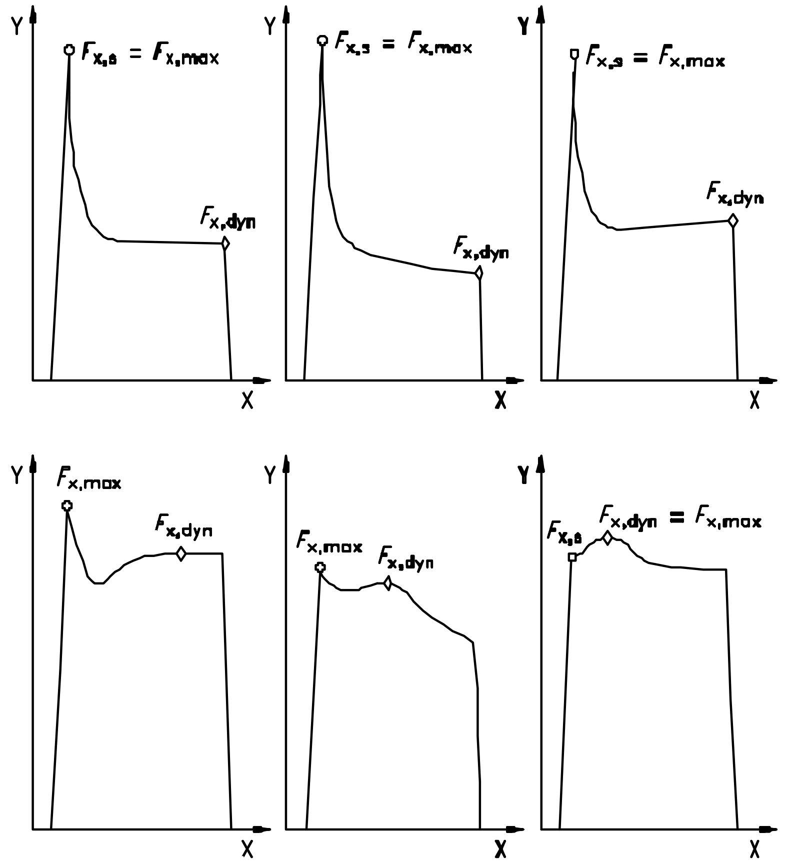


b) Total slide path

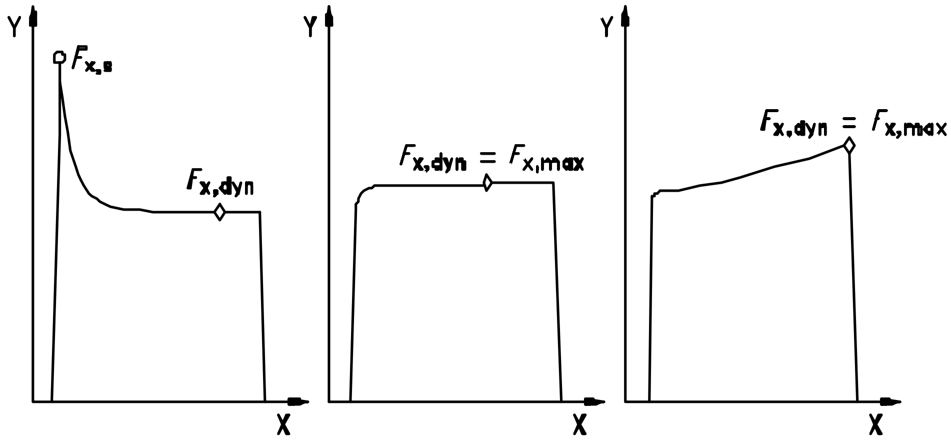
Key

X Number of cycles n
Y Temperature T (°C)

Figure D.5 - Temperature profile of the long term sliding test (only first three phases shown)



a) sliding elements with lubricated PTFE and mating austenitic steel or hard chromiium plated steel



b) Sliding elements with composite materials CM1 and CM2 and mating austenitic steel

Key

X Sliding displacement
Y Friction force

Figure D.6 - Examples of typical friction force profiles vs. sliding displacement.

Annex E
(normative)
Hard chromium plated surfaces - Ferroxyl test

E.1 Scope

This annex defines the procedure for confirming the integrity of the hard chromium layer applied to steel substrate.

E.2 Principle

The test method is based on the principle that cracks and porosity extending through the hard chromium layer to the steel substrate will be revealed as blue marks due to the reaction of Fe-II-ions with the indicator solution of potassium ferrocyanide III and sodium chloride.

E.3 Indicator solution

The ferroxyl indicator solution is composed of 10g $K_3[Fe(CN)_6]$ and 30g NaCl in 1 l of distilled water or water completely desalinated by ion exchange.

NOTE As skin contact with indicator solution shall be avoided, skin protection is required and food shall not be consumed while handling the indicator solution.

It should be noted that the indicator solution in contact with acids releases the extremely toxic prussic (hydrocyanic) acid.

E.4 Test specimens

The test shall be performed on 20% of the contact area of the sliding surface as a minimum.

E.5 Test procedure

The test shall be carried out at a temperature between 5° C and 40° C.

In order to prevent false indications, either the atmosphere in the vicinity of the test shall be free from ferrous particles or the test sample shall be covered and protected from dust.

Immediately before the test, the hard chromium layer shall be cleaned with an acid-free degreasing agent.

The hard chromium area to be tested shall be covered with white blotting paper impregnated with the indicator solution. The wet paper shall adhere firmly to the hard chromium surface without wrinkles or blisters.

The solution shall remain in contact with the surface for 1 h.

At the end of the test period before removing the blotting paper it shall be identified and checked for changes in colour.

Defective areas in the hard chromium layer will be indicated as blue-coloured marks on the paper.

After the test, the indicator solution shall be completely removed from the sample by means of water or alcohol and then the surface shall be dried.

E.6 Test report

The test report shall include at least the following items:

1) Identification of the test pieces (name of manufacturer, origin and number of manufacturing batch) and the unique serial number of the bearing , if applicable.

2) Condition of test pieces prior to and after testing (visual damages).

3) Date, duration and temperature of test.

4) Test results (in case of damage, the recordings shall be enclosed with the test report).

5) Any operating procedures not described in this clause and any abnormal incidents occurring during the test.

6) A reference to EN 1337-2.

Annex F
(normative)
Thickness measurement of the anodized surfaces

F.1 Scope

This annex describes the method for measuring anodic oxidation coatings on aluminium.

F.2 Principle

The method is non-destructive. It involves the production of eddy currents in the metallic substrate and the measurement of the reaction of those eddy currents on a test head placed on the anodized surfaces. The strength of this reaction is related to the gap between the test head and the metal surface i.e. the thickness of anodic film.
Control samples are necessary.
The instruments are only suitable for accurate determination on flat or cylindrical surfaces and any other type of curvature will only give approximate readings.
When the material to be tested has a curvature beyond the limit of the instrument, flat test pieces representative of the material in both composition and surface finish, and anodized under the same conditions as the product, shall be provided.

F.3 Test equipment

No limitations are placed on the type of apparatus, provided that it is based upon the principles given above and that it can be satisfactorily calibrated as described in F.4
In practice it is desirable to use one of the instruments that have been developed for this purpose. In most instruments the reaction in the metal is measured directly on a scale reading.
Instruments have differing degrees of sensitivity to variations such as thickness, roughness, etc. In all cases, control samples should be provided which are, as far as possible, of the same material specification as the basis metal of the test sample.
Each type of instrument has its own degree of sensitivity to the variations set out in the manufacturer's chart, and specific calibration methods are normally supplied. Particular care needs to be taken to observe recommended “warming up” times.
All instruments shall include, as a minimum, the calibration given below. For absolute determinations, calibrations shall be checked periodically during use, at least every 15 min, but the instrument may be used comparatively by employing standards of known thickness.

F.4 Test procedures

F.4.1 Calibration

Prepare a reference sample of the same material, pre-treatment and form as the sample under test, but not anodized. Samples shall have a length of not less than 100 mm.
When the samples have complex shapes, reproducible readings may be accurately obtained only within small areas which shall be carefully defined. In these cases, the small areas which are calibrated on the bare sample shall correspond to the small areas where the readings are made on the anodized samples.
Place the test head on the uncoated reference sample and adjust the scale reading to zero. The measurement of any group of zero readings on the relevant area of the reference sample shall not differ from zero by more than ± 5% of the maximum value chosen for full scale reading.
Calibrate the scale using a control sample which has been anodized and sealed under similar conditions to those of the work to be tested. The thickness of the anodic film on the control sample shall have been determined in the area adjacent to that used for calibration by the microsection method.
The thickness readings, in turn, shall be within ± 5% of the calibration value.

F.4.2 Measurement

After calibration, as specified above, take no less than five measurements at points evenly spaced over the entire significant surface of the sample.

F.5 Test report

The test report shall include at least the following items:

1) Identification of the test pieces (name of manufacturer, origin and number of manufacturing batch)

2) Description of the apparatus

3) Description of the calibration procedure

4) Date of the test

5) Test results

6) A reference to EN 1337-2.

Annex G
(normative)
Lubricant - Oil separation test

G.1 Scope

This method, by measuring the oil which separates from a lubricating grease under the test conditions, has been shown to provide a useful guide to its behaviour and storage in cans or drums.
It applies to a test sample from a full tin.

G.2 Term and definition

For the purposes of this annex the following term and definition applies:

the oil separation S
quotient of the weight of the separated oil by weight of the grease before heating.

G.3 Principle

The test consists of heating the sample in a wire-gauze cone under static conditions for the time and at the temperature required by the specification, then determining the percentage (by mass) of the oil drained through the cone.

G.4 Test equipment

The test setup (see Figure G.1) shall consist of:

I) Cone, nickel gauze, 60 mesh (holes 558 per 100 mm^2, wire 0,19 mm, openings 0,28 mm), with a wire handle.

II) Beaker, 200 ml.

III) Cover, close-fitting, with hook approximately centered on underside.

The test setup shall include an oven, capable of maintaining the specified temperature within 0,5°C.

G.5 Sampling

A representative sample shall be taken with a suitable tool from the centre of the lubricant can or drum.
The sample size shall consist of approximately 10 g of grease, weighed to within 0,1 g.

G.6 Test procedure

The test shall be conducted for 24 h at 100° C ± 0,5° C.
Testing procedure shall be as follows:

1) Determine the mass of the grease (W_g) by weighting the empty cone and the full cone with the sample.

2) Preheat oven to test temperature.

3) Weigh clean beaker (without cone and cover) to within 0,01 g.

4) Place sample in cone, so that top of specimen is smooth and convex (to prevent trapping of free oil).

5) Assemble test setup as shown in Figure G.1.

6) Heat test setup in oven for the specified time at the specified temperature .

7) Remove setup from oven, and allow it to cool to room temperature.

8) Remove cone from beaker, tapping it gently against the inside of the beaker to remove any oil adhering to its tip.
9) Determine the weight of oil collected in the beaker to within 0,01 g. (W_o)

The oil separation S (% in percentage by mass) is calculated as follows:

$$S = \frac{W_o}{W_g} \times 100 \qquad \text{(G.1)}$$

where:

Wg is the weight of the grease before heating.

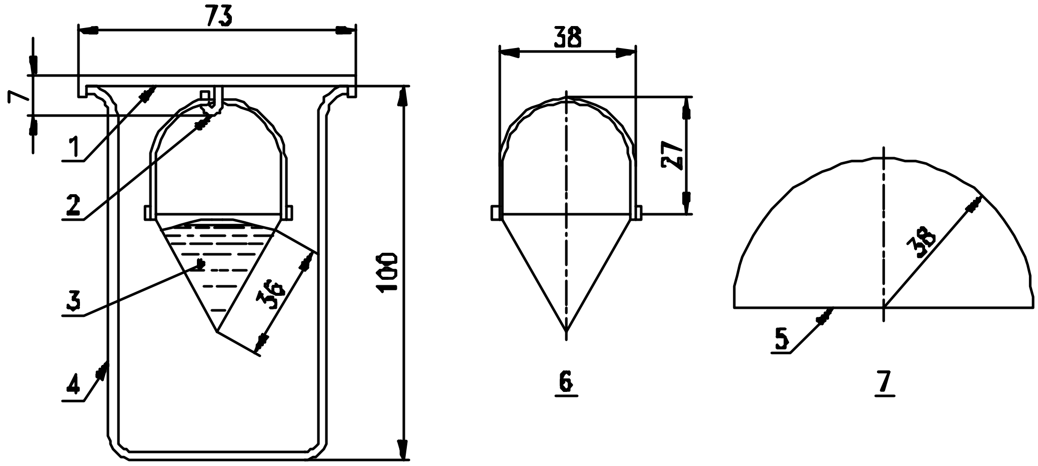
Wo is the weight of the separated oil.

G.7 Test report

The test report shall include at least the following items:

1) Identification of the test specimens (name of manufacturer, origin and number of manufacturing batch)
2) Duration and temperature of the test
3) Test result: percentage S of oil separation
4) Any operating procedures not described in this clause and any abnormal incidents occurring during the test.
5) A reference to EN 1337-2.

Dimensions in millimetres



Key

1 cover
2 hook
3 specimen
4 beaker
5 silver solder along this line
6 detail of the cone
7 development of the cone

Figure G.1 - Oil separation test setup.

Annex H
(normative)
Oxidation stability of lubricant

H.1 Scope

This annex defines the method for checking the static long-term behaviour of lubricating greases exposed to the atmosphere.

It does not give any information about the storage durability of lubricating greases in normal retail containers.

H.2 Definition

This method defines the oxidation stability as the resistance of the lubricating greases against oxygen absorption, measured as pressure drop. The smaller the pressure drop, the greater the oxidation stability.

H.3 Principle

The test consists of checking the results of the immersion of the samples in an oxygen atmosphere.

H.4 Test equipment

The parts numbered in Figure H.1 shall meet the requirements given below:

H.4.1 Manometer

The manometer (see Figure H.1, item 1) shall have a range of 0 kPa to 1000 kPa, (0 MPa to 1 MPa) class 0,6 with a housing diameter of at least 160 mm and division of the scale into 5 kPa. It should be appropriate for oxygen and be resistant against oxidation products from the oxygen.

H.4.2 Pressure vessel

The pressure vessel (see Figure H.1, item 11) shall have a volume of 185 ml + 6 ml without shell supports and glass shells including pipe to the apparatus.

The pipe (see Figure H.1, item 4) to the manometer, the head (see Figure H.1, item 9) and the pressure vessel shall be made of stainless steel according to EN 10088-2, grade X10CrNi18-8. The inner faces of the pipe, the head and the pressure vessel shall be highly polished.

H.4.3 Shells

The shells shown in Figure H.2 shall consist of thermal borosilicate glass with fire-polished edges.

H.4.4 Shell holder

The shell holder shown in Figure H.3 shall be of stainless steel with 18% chromium and 8% nickel. All sides shall be highly polished. The weight of the shell holder should be 152 g ± 3g.

H.4.5 Heating device

The heating devices shall be either a liquid heating bath or a heating block in accordance with the requirements given in H.4.6 or H.4.7 respectively.

H.4.6 Liquid heating bath

The heating bath shall be adjustable to 160 °C ± 0,5 °C.

The height shall correspond to the depth of immersion of the pressure vessel. It should be possible to circulate the bath fluid with a pump or an agitating machine. The heating is intended to warm up the bath fluid to the desired testing temperature within 60 min after immersion of the pressure vessel.

The thermometer, shall be positioned with its 96,8 °C mark level with the lid of the bath. The immersed pressure vessel shall be 50 mm beyond the fluid level. The bath shall be placed in such a way that the manometer is not exposed to temperature fluctuations.

H.4.7 Heating block

The heating block is made of a wrought aluminium alloy (pressed free of shrinkage). It can be heated electrically and regulated thermostatically. The conditions described in above paragraph have to be observed.

H.4.8 Thermometer.

The thermometer corresponds to the IP-thermometer 24 °C of the IP Standard Thermometers of the Institute of Petroleum.

H.5 Sampling

A representative sample shall be taken with a suitable tool from the center of the can or drum.

H.6 Test procedure

The test shall be performed twice requiring five shells (see Figure H.2) each.
Test procedure shall be as follows:

1) Pretreatment of the shells.
   Before use the shells have to be cleaned. They have to be washed one after the other with an organic solvent, hot soap suds and chromium sulphuric acid. Finally they are rinsed with distilled water and dried in the heating chamber. The shells shall not be touched except with shell tongs.

2) Filling of the shells.
   The five shells are filled with 4 g ± 0,01 g lubricant each but without touching them with the hands. The lubricant is distributed in the shells in even layers avoiding air bubbles; the surface is flattened.

3) Insertion of the shells and closing of the pressure vessel.
   The five shells filled with the lubricant are put into the shelves of the shell holder. The upper metal plate of the shell holder serves as a lid and prevents vaporized and recondensed materials from dripping on to the lubricant. The shell holder is then inserted into the pressure vessel. A small ball of glass wool is introduced into the pipe leading to the manometer. The pressure vessel is closed by tightening the cylinder screws slowly and evenly.

4) Filling of the test apparatus with oxygen and gas-tightness check.
   Air is removed from the test apparatus by filling it four times with oxygen with a percentage purity of at least 99,5%, up to a pressure of 700 kPa and emptying it again. After the fifth filling with oxygen up to a pressure of 700 kPa, the apparatus is left pressurised overnight to ensure it is gas-tight.

5) Procedure.
   After the gas-tightness test, the apparatus is inserted into the heating device warmed up to 160 °C ± 0,5 °C. As soon as pressure increases due to the rising temperature, oxygen is let off from valve (3) from time to time until the pressure amounts to 770 kPa ± 5 kPa. This pressure shall remain constant for at least 2 h. A pressure drop during these 2 h indicates a leak in the test apparatus. If this happens, the process shall be repeated starting out with the insertion of the test apparatus into the heating device. The pressure drop should be recorded at least every 24 h and the duration of the test is 100 h. After the testing period, the pressure drop is read.

6) Evaluation and indication of the result.
The mean value from the two single determinations is taken as a result and rounded to 1 kPa with reference to this code. It is treated as one single value. The test duration is indicated in hours.

Repeatability
(one observer, one apparatus)
If an observer determines two results under repeatability conditions, then both results are considered acceptable and conforming to standards provided they do not deviate by higher values than those given in the table below.

Comparability
(different observer, different apparatus)
If two different laboratories determine one result each under comparable conditions, then both results are considered acceptable and conforming to standards provided they do not deviate by higher values than those given in the table below.

Table H.1 - Repeatability and comparability

Results pressure drop in kPa	Repeatability in kPa	Comparability in kPa
0 to 35	10	30
over 35 to 70	20	40
over 70 to 140	30	60
over 140 to 385	50	100

The values in Table H.1 can only be used for that part of a result, where the oxygen decrease (oxygen absorption) happens evenly, i.e. before induction starts which is marked by a sudden oxygen drop (sudden rise of the oxygen absorption).

H.7 Test report

The test report shall include at least the following items:

1) Identification of the test pieces (name of manufacturer, origin and number of manufacturing batch)

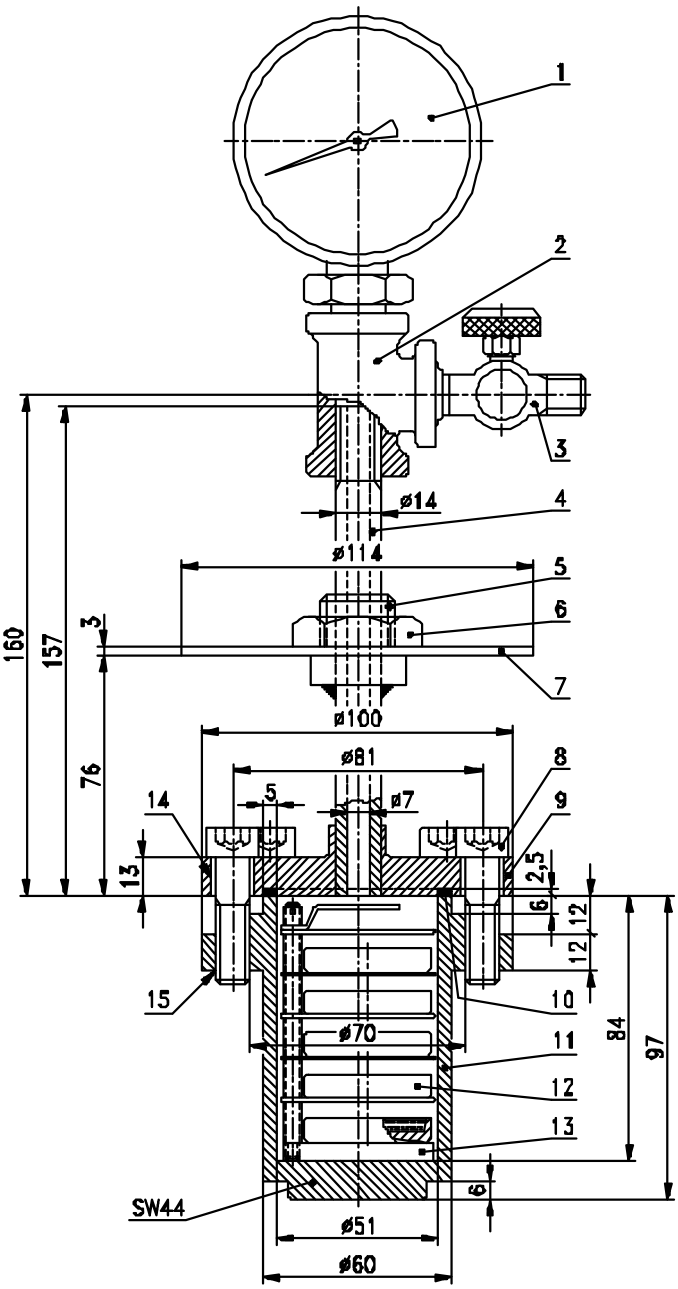
2) Date, duration and temperature of test

3) Test result: pressure drop in kilopascal

4) Any operating procedures not described in this annex and any abnormal incidents occurring during the test

5) Statement that the test was performed in accordance with this standard

6) A reference to EN 1337-2.



Key

1 pressure gauge
2 union tee
3 valve for oxygen
4 pipe
5 collared bush
6 nut
7 disc
8 screw
9 cover
10 gasket
11 vessel
12 shell
13 shell holder
14 8 holes ∅ 10,5 equally distributed around the circumference
15 8 holes tapped M 10 equally distributed around the circumference

Figure H.1 - Test equipment

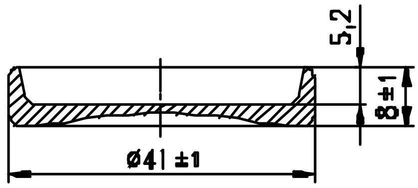


Figure H.2 - Shell

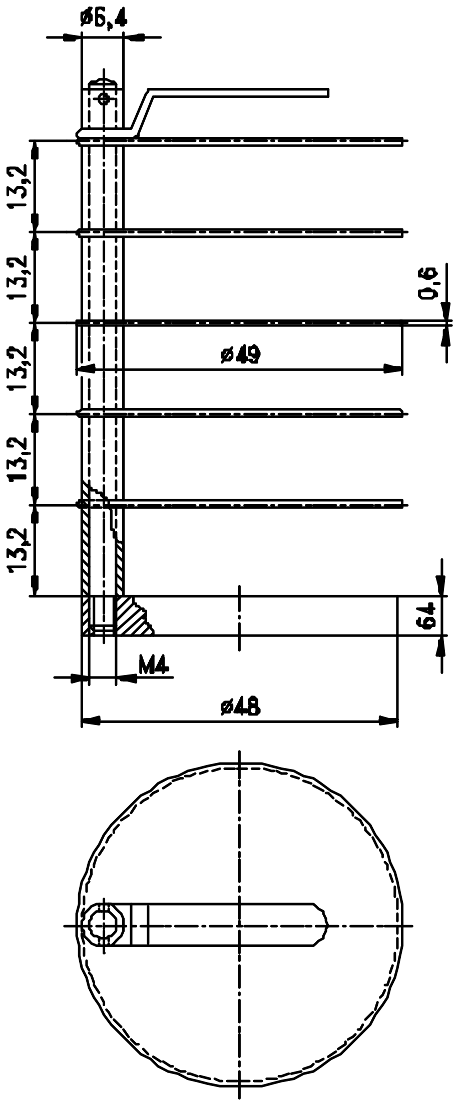


Figure H.3 - Shell holder

Annex J
(normative)
Austenitic steel sheets adhesive - Lap shear test

J.1 Scope

This annex defines the method for determining the force necessary to break the bond produced by the adherends.
It applies to specimens prepared individually.

J.2 Principle

A double lap joint (see Figure J.1) between rectangular adherends is strained to rupture by a longitudinal tensile force, i.e. a force that is parallel to the major dimensions of the adherends, the reported result being the observed force at rupture.

J.3 Test equipment

The response time of the machine shall be short enough not to affect the accuracy with which the breaking load can be measured. The range of the machine shall be such that the specimens break at loads between 15% and 85% of the full scale reading.
The grips shall be free to swivel about axes in the mean plane of the bond line. They should grip the adherends sufficiently firmly to avoid slipping but not so firmly as to cause excessive crushing. Grips that operate by bolting through the adherend shall be avoided since such grips give rise to undesirable stress concentrations.

J.4 Test specimen

The test shall be conducted in a double lap joint between rectangular adherends according to Figure J.1.

J.4.1 Description

The two outer adherends shall be of austenitic steel sheet complying with the requirements of 5.3 and the central adherend shall be of steel complying with the requirements of 5.5. Dimensions of the adherends are given in Figure J.2.
Flatness shall be within 0,05 mm over the length and width of the bonded area of the test specimen and within 1,0 mm over the length of the adherends.

> NOTE Because of the flatness requirement, it is recommended that adherends cut from large sheets should be sawn rather than sheared.

Before bonding, prepare the surfaces of the adherends in accordance with the recommendations of the adhesive manufacturer.
The adhesive shall be applied and the bond shall be made by the methods recommended by the manufacturer.
The standard length of the lap shall normally be 12,5 mm ± 0,5 mm but, if special circumstance demand, the overlap can be increased provided that any change in lap from the standard is reported in the test report.

> NOTE It is recommended that adherends should normally be prepared, stored and bonded, and the assemblies conditioned and tested, under standard conditions of temperature and humidity. In the absence of other requirements the recommended conditions are 23°C ± 2°C and 50% ± 5% r.h.

J.4.2 Preparation of test specimens

J.4.2.1 Ageing to estimate durability

The specimen shall be submitted to the following procedure:

a) Expose the specimen in the oven for 24 h at the temperature of 35°C ± 2 °C.
b) Remove specimen from the oven and place it in the cold box for 24 h at –20°C ± 2°C.
c) Repeat cycles a) and b) four more times.

NOTE The ageing process may be interrupted if it is necessary.

J.4.2.2 Ageing to estimate chemical stability

The specimen shall be submitted to the following procedure:
Submerge for 96 h in a bath of distilled water maintained at 60°C ± 2°C.

J.5 Test procedure

The machine shall be operated under substantially constant conditions throughout the test although a stress-strain diagram may indicate non-linearity at the commencement and end of the test.
The test shall be performed in an atmosphere at 23°C ± 2°C.

a) Locate the assembly symmetrically in the testing machine with each grip 50 mm ± 1 mm from the nearest edge of the overlap.
b) Place a packing piece within the grips between the adherends to avoid distorting the adherends.
c) Set the machine in motion and operate it so that the test joint is subject to a force which increases at a rate of 300 N/s up to rupture.
d) Record the highest force during the test as the breaking force of that specimen.

NOTE If no previous experience is available for the type of joint under test, preliminary tests should be carried out to establish suitable operating conditions.

Results from test specimens which show starved joints or which rupture in the adherend, shall be discarded, unless the adhesive meets the minimum requirement.

J.6 Test report

The test report shall include at least the following items:

1) Identification of the adhesive under test (name of manufacturer, origin and number of manufacturing batch)
2) Description of surface preparation.
3) Description of the bonding process including pre-curing conditions, curing time and temperature.
4) The identification number of specimens tested and the mean breaking force of each one.
5) The types of failure for each specimen (whether adhesive, cohesive or adherend and the degree of coalescence).
6) Any operating details not considered in the present annex, and the possible incidents liable to alter the results
7) A reference to EN 1337-2.

Graph recordings shall be enclosed with the test report.

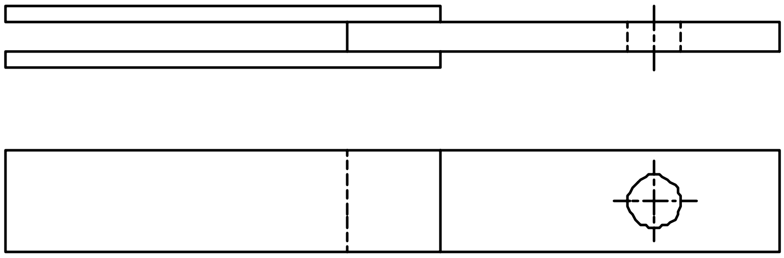
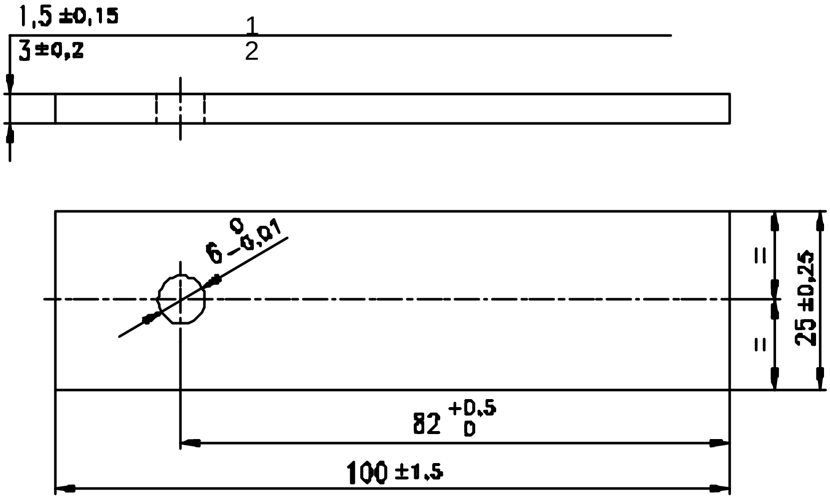


Figure J.1 - Double lap joint.

Dimensions in millimetres



Key
1 outer adherends
2 central adherends

Figure J.2 - Test adherend with locating hole

Annex K
(normative)
Factory Production Control (FPC)

K.1 General

K.1.1 Objects

The manufacturer shall exercise a permanent FPC (e.g. a quality management system based on the relevant part of the EN ISO 9000 series, or otherwise).

The manufacturer is responsible for organising the effective implementation of the FPC system. Tasks and responsibilities in the production control organisation should be documented and this documentation should be kept up-to-date.
In each factory the manufacturer may delegate the action to a person having the necessary authority to:

a) identify procedures to demonstrate conformity of the construction product at appropriate stages;

b) identify and record any instance of non-conformity;

c) identify procedures to correct instances non-conformity.

K.1.2 Documentation

The manufacturer should draw up and keep up-to-date documents defining the FPC which he applies.

The manufacturer's documentation and procedures should be appropriate to the construction product and manufacturing process. All FPC systems should achieve an appropriate level of confidence in the conformity of the construction product. This involves:

a) the preparation of documented procedures and instructions relating to FPC operations, in accordance with the requirements of this European Standard (see K.1.3):

b) the effective implementation of these procedures and instructions;

c) the recording of these operations and their results;

d) the use of these results to correct any deviations, repair the effects of such deviations, treat any resulting instances of non-conformity and, if necessary revise the FPC to rectify the cause of non-conformity.

K.1.3 Operations

FPC includes the following operations:

a) the specification and verification of raw materials and constituents;

b) the controls and tests to be carried out during manufacture of the construction product according to a frequency laid down;

c) the verifications and tests to be carried out on finished construction products according to a frequency which may be laid down in the technical specifications and adapted to the product and its conditions of manufacture.

NOTE - The operations under b) centre as much on the intermediate states of the construction product as on manufacturing machines and their adjustment, and equipment etc. These controls and tests and their frequency are chosen based on type of construction

product and composition, the manufacturing process and its complexity, the sensitivity of product features to variations in manufacturing parameters etc.
- With regard to operations under c), where there is no control of finished construction products at the time that they are placed on the market, the manufacturer shall ensure that packaging, and reasonable conditions of handling and storage, do not damage construction products and that the construction product remains in conformity with the technical specifications.
- The appropriate calibrations shall be carried out on defined measuring and test instruments.

K.2 Verifications and tests

K.2.1 General comments

The manufacturer shall have or have available the installations, equipment and personnel which enable him to carry out the necessary verifications and tests. He may, as may his agent, meet this requirement by concluding a sub-contracting agreement with one or more organisations or persons having the necessary skills and equipment.

The manufacturer shall calibrate or verify and maintain the control, measuring or test equipment in good operating condition, whether or not this equipment belongs to him, with a view to demonstrating conformity of the construction product with its technical specification. The equipment shall be used in conformity with the specification or the test reference system to which the specification refers.

K.2.2 Monitoring of conformity

If necessary monitoring is carried out of the conformity of intermediate states of the product and at the main stages of its dispatch.
This monitoring of conformity focuses where necessary on the construction product throughout the process of manufacture, so that only products having passed the scheduled intermediate controls and tests are dispatched.

K.2.3 Tests

Tests should be in accordance with the test plan (see Table 16) and be carried out in accordance with the methods indicated in this European Standard.

NOTE It is recommended that initial type tests are carried out or validated by an approved body.

The manufacturer should establish and maintain records which provide evidence that the construction products have been tested. These records should show clearly whether the construction product has satisfied the defined acceptance criteria. Where the construction products fails to satisfy the acceptance measures, the provisions for non-conforming products should be applied.

K.2.4 Treatment of construction products which do not conform

If control or test results show that the construction product does not meet the requirements, then necessary corrective action shall immediately be taken. Construction products or batches not conforming shall be isolated and properly identified. Once the fault has been corrected, the test or verification in question shall be repeated.

If construction products have been delivered before the results are available, a procedure and record should be maintained for notifying customers.

K.2.5 Recording of verifications and tests (manufacturer's register)

The results of factory production controls shall be properly recorded in the manufacture's register. The construction product description, date of manufacture, test method adopted, test results and acceptance criteria shall be entered in the register under the signature of the person responsible for control who carried out the verification.

With regard to any control result not meeting the requirements of this European Standard, the corrective measures taken to rectify the situation (e.g. a further test carried out, modification of manufacturing process, scrapping or rectifying the product) shall be indicated in the register.

In case of third party surveillance the records shall be made available to the third party for examination.

K.3 Traceability

It is the manufacturer's, or his agent's, responsibility to keep full records of individual construction products or product batches, including their related manufacturing details and characteristics, and to keep records of to whom these construction products or batches were first sold. Individual construction products or batches of products and the related manufacturing details shall be completely identifiable and retraceable. In certain cases, for example for bulk products, a rigorous traceability is not possible.

Annex L
(informative)
Audit testing

Audit testing may be required for the purpose of checking the construction product as well as verifying test results recorded in the documentation of the factory production control or declared in inspection certificates.

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