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European Assessment Document for

Spherical and cylindrical bearing with special sliding material made of ultra-high-molecular-weight polyethylene

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD covers spherical as well as cylindrical bearings with special sliding material made of Ultra High Molecular Weight Polyethylene (UHMWPE), in the following referred to, as relevant, as “spherical bearings", "cylindrical bearings" or "spherical and cylindrical bearings”, which permit rotation and displacement movements by a flat and a curved sliding surface between bearing plates of steel (see Figure 1.1.1 and Figure 1.1.2). The subject of the EAD is the complete spherical or cylindrical bearing, including, if relevant, the necessary guides or restraints. As an alternative to Figure 1.1.1, the bearing may also be used upside down, i.e., with flat sliding surfaces lying below (meaningful, for example in the case of steel bridges).

The spherical and cylindrical bearings can be combined with sliding elements according to EN 1337-2 [1] as shown in EN 1337-1. Instead of PTFE according to EN 1337-2 a special sliding material made of UHMWPE is used for the sliding surfaces of the bearing, which has a melting temperature [2] of at least 50 °C higher than the maximum operating temperature T_{max} for which the bearing is intended to be used and which is suitable for low and high temperatures outside the scope of EN 1337-2 with improved wear resistance and load-bearing capacity. The geometrical conditions of the UHMWPE sliding material sheets are given in Annex A. This EAD also applies to special sliding materials made of High Molecular Weight Polyethylene (HMWPE).

For the types of the spherical and cylindrical bearings covered by this EAD, the drawings given in EN 1337-7, Clause 3.1.2 and Clause 3.1.9, apply. The components are indicated as given in Figure 1.1.1 and Figure 1.1.2.

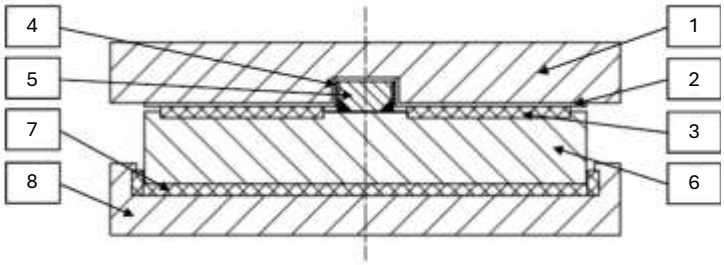

Figure 1.1.1: Cylindrical bearing

Legend for Figure 1.1.1:	
1 Sliding plate 2 Mating surface (here: austenitic steel sliding sheet 3 Dimpled UHMWPE sliding material 4 Undimpled UHMWPE sliding material or composite material strip [a)]	5 Guide 6 Cylindrical rotational element 7 Dimpled UHMWPE sliding material 8 Backing plate
a) see Table 1.1.1	

1 All undated references to standards in this EAD are to be understood as references to the dated versions listed in chapter 4.

2 The minimum melting temperature is determined by testing on three specimens prepared from fully finished sheet in accordance with EN ISO 11357-3.

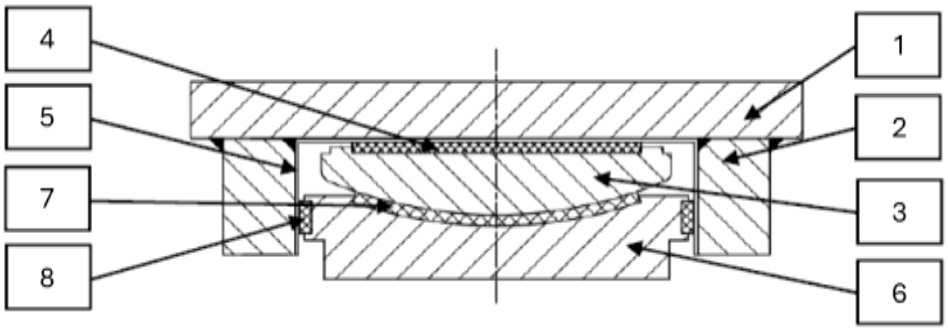

Figure 1.1.2: Spherical bearing

Legend for Figure 1.1.2:	
1 Sliding plate 2 Guide 3 Spherical rotational element 4 Dimpled UHMWPE sliding material	5 Mating surface (here: austenitic steel sliding sheet) 6 Backing plate 7 Dimpled UHMWPE sliding material sheet [a)] 8 Undimpled sliding material sheet or composite material strip [a)]
a) see Table 1.1.1	

The sliding materials in the bearing are combined as shown in Table 1.1.1. Only one combination is used in a sliding surface. Lubricant in accordance with EN 1337-2, Clause 5.8, is used in the sliding surfaces, applied in accordance with EN 1337-2, Clause 7.4.

Table 1.1.1: Combination of materials for permanent applications as sliding surfaces for spherical and cylindrical bearings

Flat surface [a)]		**Curved surface**		**Guides**	
• Dimpled UHMWPE sliding material	• Austenitic steel • Aluminium sliding alloy [b)]	• Dimpled UHMWPE sliding material	• Austenitic steel • Hard chromium • Aluminium sliding alloy [b)]	• Undimpled UHMWPE sliding material • CM1 [c)] • CM2 [c)]	• Austenitic steel • Aluminium sliding alloy [b)]

a) The sliding surface can be subdivided in two restrained parts above and below the rotation element permitting in total the design movement.

b) Also covered by this EAD, as an alternative to austenitic steel or hard chromium.

c) Instead of the undimpled UHMWPE sliding material sheets, only where self-alignment between the mating parts of the bearing is possible, composite materials in accordance with either Clause 5.3.1 or 5.3.2 of EN 1337-2 can be used.

The mating surfaces are made of either austenitic steel in accordance with EN 1337-2, Clause 5.4, or hard chromium plating in accordance with EN 1337-2, Clause 5.5. Attachment of sliding materials is in accordance with EN 1337-2, Clause 7.2. As alternative to austenitic steel or hard chromium plating, this EAD covers the use of an aluminium sliding alloy as mating surface.

The ferrous materials used for backing plates of the sliding surfaces are in accordance with EN 1337-2, Clause 5.6, or in accordance with EN 10250, parts 1 to 4, as relevant. This EAD covers only backing plates with a maximum deformation in accordance with Annex B.

All metal parts do not contain more than 1,0 % by weight or volume (whichever is the highest) of homogeneously distributed organic material.

Sliding surfaces with a diameter of the circumscribing circle of sliding material sheets less than 75 mm or greater than 3000 mm or working at long-term temperatures less than − 50 °C or greater than + 48 ºC, are outside the scope of this EAD (see 1.2.1).

The EAD covers also sliding surfaces intended for working at short-term temperatures above + 48 ºC and up to + 80 ºC (see 1.2.1). If composite materials in accordance with EN 1337-2, Clauses 5.2 and 5.3, are used in guides (see Table 1.1.1), the maximum short-term temperature is limited to + 48 °C.

Spherical and cylindrical bearings with an included angle 2 θ > 60° and 2 θ > 75°, respectively, are beyond the scope of this EAD (see Clause 1 and Figure 6 of EN 1337-7).

Furthermore, the assessment methods covered by this EAD are based on the following assumptions:

- The notional modulus of elasticity E_{tp} of the UHMWPE sliding material assessed in tests in accordance with Annex C.2 is less than 2 % of the modulus of elasticity E_a of the aluminium sliding alloy [3].
- The yield strength $R_{p0,2}$ of the aluminium sliding alloy [3] is equal or larger than the characteristic compressive strength $f_k\,(T_0)$ of the UHMWPE sliding material.
- The UHMWPE sliding material made of UHMWPE meets the boundary conditions for relevant material characteristics given in Table 1.1.2.

Table 1.1.2: Boundary conditions for relevant material characteristics

Property	Boundary condition	Test method
Protrusion after loading [mm]	1 mm ≤ h_r ≤ 0,66 h_0 a)	Annex C.1
Decrease of protrusion per hour at the end of loading b)	< 0,5 ‰ · h_0	Annex C.1
Ratio (stress at break / stress at yield)	< 2,5	Clause 3.4.1
Ratio (strain at break / yield deformation)	> 13	Clause 3.4.1

a) h_0 is the height of the protrusion in the initial (unloaded) condition; h_r is the height of protrusion after 48 hours of constant load according to Annex C.1

b) after 48 hours of constant load according to Annex C.1

The construction product is not fully covered by the harmonised European standard EN 1337-7:

- Instead of PTFE in accordance with EN 1337-2, referred to in EN 1337-7, a low-friction sliding polymer made of UHMWPE (Ultra high molecular weight polyethylene) is used as sliding material.
- The effective bearing temperatures are extended to a range from − 50 °C up to + 80 °C.
- The main sliding surfaces comprise a diameter of the circumscribing circle of sliding material from 75 mm to 3000 mm.
- The maximum deformation of backing plates formula is adapted to the sliding material covered by this EAD (see Annex B).
- Thicknesses and protrusions specifications of sliding material sheets in accordance with EN 1337-2, Clause 6.2.1.1, referred to in EN 1337-7, are changed as stated in Table A.1.1.

Furthermore, the construction product is not fully covered by the European Assessment Document EAD 050004-00-0301:

- An aluminium sliding alloy is added as additional mating material.
- Assessment of reaction to fire is included.
- Provisions for the assessment of the load-bearing capacity for short-term loads as due to seismic actions are covered.

3 The modulus of elasticity E_{tp} and the yield strength $R_{p0,2}$ of the special metal sliding alloy are taken from standards EN 485-2 or EN 755-2 for wrought aluminium alloys or determined in accordance with EN ISO 6892-1.

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product, as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations, e.g., with regard to the intended end use conditions, having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA as long as the details of the assessment methods as laid down in this EAD are respected.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The spherical and cylindrical bearings are intended to be used for the support of bridges or building works in accordance with the scope of EN 1337-1, Clause 1, where the requirements on the individual bearings are critical.

They are suitable for all types of structures but especially for non-rigid structures with relatively large and frequent displacements caused by working loads, next for superstructures that induce fast sliding displacements in bearings, e.g., in bridges for high-speed railways.

The spherical and cylindrical bearings are intended to be used in environments with long-term temperatures from − 50 °C to + 48 °C and in environments with short-term temperatures of up to + 80 ºC as due to the daily temperature cycle.

The bearings are intended to be used in structures subjected to short-duration load (e.g., due to accidental action or seismic action), when the load-bearing capacity for short-term load (see Clause 1.3.2) is assessed.

1.2.2 Working life/Durability

The assessment methods included or referred to of this EAD have been written based on the manufacturer's request to take into account a working life of the spherical and cylindrical bearings for the intended use as to be expressed in the European Technical Assessment in terms of years depending on the total slide path assessed according to Clause 2.2.3 and related Annexes D and E. These provisions are based upon the current state of the art and the available knowledge and experience.

The working life of the bearing is reduced to 10 years if in bearing's guides the composite materials in accordance with EN 1337-2 are used instead of the UHMWPE sliding material.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[4].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

4 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

1.3 Specific terms used of this EAD

For the purposes of this EAD, the specific terms and definitions given in EN 1337-2, Clause 3, and EN 1337-7, Clause 3, apply.

1.3.1 Long-term load

Load of long duration as due to permanent actions or variable actions (see EN 1990, Clause 4.1.1, (1)P, first and second bullet points).

1.3.2 Short-term load

Load of short duration (on the order of seconds) as due to accidental actions or to seismic actions (see EN 1990, Clause 4.1.1, (1)P, third bullet point) in addition to permanent actions and/or variable actions (see EN 1990, Clauses 6.4.3.3 and 6.4.3.4).

1.3.3 Long-term temperature

Operating temperature of the bearing during long periods (e.g., years).

1.3.4 Short-term temperature

Operating temperature of the bearing during short periods as due to the daily temperature variations.

1.3.5 Symbols

Symbol	Definition	Unit
a	Width of undimpled UHMWPE sliding material strip used in guides	mm
A	Contact area of the sliding surface	mm^2
A_r	Reduced contact area of the sliding surface	mm^2
E_a	Modulus of elasticity of the aluminium sliding alloy	MPa
e_t	Total eccentricity of the axial force	-
E_{tp}	Notional modulus of elasticity of UHMWPE sliding material sheet	GPa
$f_k\,(T)$	Temperature-dependent, nominal compressive strength of the UHMWPE sliding material for long-term loads used as characteristic value (in this EAD referred to as (temperature-dependent) characteristic compressive strength (for long-term loads))	MPa
$f_k\,(T_0)$	Nominal compressive strength of the UHMWPE sliding material at temperature T_0 for long-term loads used as characteristic value (i this EAD referred to as characteristic compressive strength (for long-term loads) at T_0). $f_k\,(T_0)$ is valid for all effective bearing temperatures between T_{min} and +35°C.	MPa
$f_k\,(T_{max})$	Nominal compressive strength of the UHMWPE sliding material at temperature T_{max} for long-term loads used as characteristic value (in this EAD referred to as characteristic compressive strength (for long-term loads) at T_{max})	MPa
$f_{k,s\text{-}t}\,(T)$	Temperature-dependent, nominal compressive strength of the UHMWPE sliding material for short-term loads used as characteristic value (in this	MPa

Symbol	Definition	Unit
	EAD referred to as (temperature-dependent) characteristic compressive strength (for short-term loads))	
$f_{k,s\text{-}t}$ ($T_{max,seismic}$)	Nominal compressive strength of the UHMWPE sliding material for short-term loads at $T_{max,seismic}$ used as characteristic value (in this EAD referred to as characteristic compressive strength (for short-term loads) at $T_{max,\ seismic}$)	MPa
h	Height of protrusion of UHMWPE sliding material sheet under load	mm
h_0	Initial height of protrusion of the UHMWPE sliding material sheet in unloaded condition	mm
h_r	Height of residual protrusion after 48 hours of constant load in accordance with Annex C.1, but before removing the load	mm
k	Compliance coefficient of UHMWPE sliding material sheet	-
L	Diameter of the projected area of circumscribing circle of single or multiple UHMWPE sliding material sheets; length of UHMWPE sliding material or composite materials sheets of guides	mm
n	Number of cycles	-
N_S	Axial force on the bearing	kN
$N_{R,curved}$	Load-bearing capacity of the curved sliding surface for long-term axial load	kN
$N_{R,curved,s\text{-}t}$	Load-bearing capacity of the curved sliding surface for short-term axial load	kN
$N_{R,flat}$	Load-bearing capacity of the flat sliding surface for long-term axial load	kN
$N_{R,flat,s\text{-}t}$	Load-bearing capacity of the flat sliding surface for short-term axial load	kN
$N_{R,max}$	Load-bearing capacity for long-term axial load	kN
$N_{R,max,s\text{-}t}$	Load-bearing capacity for short-term axial load	kN
$R_{p0,2}$	Yield strength	MPa
S	Standard deviation of series under consideration	Depends on the characteristic
s	Sliding distance	mm
$S_{T,D1}$	Total slide path of sliding material (cumulated slide path of type B phases)	m
$S_{T,PTFE}$	Total slide path of PTFE according to EN 1337-2 (cumulated slide path of type B phases)	m
T_{max}	Maximum effective bearing temperature	°C
$T_{max,seismic}$	Maximum effective bearing temperature at which a seismic event is expected (for the assessment of the short-term loads compressive strength)	°C
T_0	Effective bearing temperature between T_{min} and 35 ºC	°C
T_{min}	Minimum effective bearing temperature	°C
t_c	Loading cycle time	s
t_p	Thickness of UHMWPE sliding material sheet	mm
$t_{p,max}$	Maximum thickness of UHMWPE sliding material sheet covered by assessments	mm

Symbol	Definition	Unit
t_{pl}	Preload time	h
t_r	Resting time	s
t_0	Dwell time at the end of the strokes	s
v	Sliding speed in test phases of friction tests	mm/s
v_a	Sliding speed at phases B	mm/s
$V_{R,guide}$	Load-bearing capacity of guides for long-term lateral load	kN
$V_{R,guide,s-t}$	Load-bearing capacity of guides for short-term lateral load	kN
$V_{R,max}$	Load-bearing capacity for long-term lateral load	kN
$V_{R,max,s-t}$	Load-bearing capacity for short-term lateral load	kN
$V_{R,support}$	Load-bearing capacity for lateral load of the steel components supporting the guides in guided spherical or cylindrical bearings	kN
WL	Working life of structural bearings incorporating sliding elements with UHMWPE sliding material	year
WL_{PTFE}	Working life of structural bearings incorporating sliding elements made of PTFE according to EN 1337-2	year
Δh	Variation of the protrusion height under load	mm
Δh_m	Mean variation of the protrusion height under load in test of load-deformation behaviour	mm
Δh_k	Characteristic variation (95th percentile) of the protrusion height under load in test of load-deformation behaviour	mm
Δw_1	Deflection of backing plate above the UHMWPE sliding material sheet	mm
Δw_2	Deflection of backing plate under the UHMWPE sliding material sheet	mm
Δw_{lim}	Maximum deformation of the backing plates	mm
α_{max}	Maximum rotation angle of the spherical and cylindrical bearing	rad
$\alpha_{max,geom.}$	Maximum geometrically determined rotation angle of the spherical and cylindrical bearing	rad
$\alpha_{inc.rot.}$	Additional rotation angle in accordance with EN 1337-1, Clause 5.4	rad
σ_p	Average contact pressure of sliding material	MPa
μ_{max}	Maximum coefficient of friction	-
$\mu_{s,1}$	Static coefficient of friction at the first cycle	-
$\mu_{dyn,1}$	Dynamic coefficient of friction at the first cycle	-
$\mu_{s,T}$	Static coefficients of friction for the relevant temperatures at subsequent cycles	-
$\mu_{dyn,T}$	Dynamic coefficients of friction for the relevant temperatures at subsequent cycles	-
θ	Half included angle of sliding elements with curved surfaces	º
axial	Refers to the load direction perpendicular to the plane on which the primary sliding surface of the spherical or cylindrical bearing has been projected	-
lateral	Refers to the load direction parallel to the plane on which the primary sliding surface has been projected	-

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of the spherical and cylindrical bearings is assessed in relation to the essential characteristics.

Table 2.1.1: Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Load-bearing capacity	2.2.1	Level: • $N_{R,max}$ [MPa] • $V_{R,max}$ [MPa] • $N_{R,max,s\text{-}t}$ [MPa] • $V_{R,max,s\text{-}t}$ [MPa] • k [-] • E_{tp} [MPa]
2	Rotation capability	2.2.2	Level: • α_{max} [rad]
3	Displacement capacity	2.2.3	Level: $S_{T,i}$ [m]
4	Coefficient of friction	2.2.4	Level: $\mu_{max}\ (T_{min},i)$ [-]
Basic Works Requirement 2: Safety in case of fire			
5	Reaction to fire	2.2.5	Class
Aspects of durability			
6	Durability aspects		
	- Protection against contamination of sliding surfaces	2.2.6.1	Description
	- Corrosion resistance	2.2.6.2	Description, Level: • Durability range (EN ISO 12944-1, Clause 5.5) and corrosivity category (EN ISO 12944-2, Clause 5.1) of corrosion protection systems applied on structural steel • Durability rating (EN 1999-1-1, Table 3.1a or Table 3.1b) for aluminium sliding alloy
	- Ageing resistance	2.2.6.3	Level: Average deviation [%]
	- Resistance against chemical and environmental influences	2.2.6.4	Level: Average deviation [%]

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer, and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Load-bearing capacity

Purpose of the assessment

The purpose is to assess the load-bearing capacity of the spherical or cylindrical bearing:

(a) Load-bearing capacity for long-term load:

- load-bearing capacity for axial load: $N_{R,max}$
- load-bearing capacity for lateral load $V_{R,max}$

(b) Load-bearing capacity for short-term load (when seismic uses are assessed):

- load-bearing capacity for axial load: $N_{R,max,s\text{-}t}$
- load-bearing capacity for lateral load $V_{R,max,s\text{-}t}$

Furthermore, the purpose is to assess the load-deformation behaviour of the UHMWPE sliding material, which may serve as input for users and designers (EN 1337-2, Clause 6.9.2) in accordance with Annex B, by the determination of the compliance factor *k* and the notational elastic modulus E_{tp}.

Assessment method

The load-bearing capacity for long-term loads shall be assessed in accordance with Clause 2.2.1.1.

The load-bearing capacity for short-term loads (when seismic uses are intended) shall be assessed in accordance with Clause 2.2.1.2.

The compliance factor *k* and the notational elastic modulus E_{tp} shall be assessed in accordance with Annex C.2.

Expression of results

The load-bearing capacity at the relevant temperatures for axial load ($N_{R,max}$ and, when relevant for seismic uses, $N_{R,max,s\text{-}t}$) shall be stated in the ETA and expressed in kN.

For guided spherical bearings type 3.3 and 3.4, and guided cylindrical bearings type 7.2 and 7.3 in accordance with EN 1337-1, Table 1, the load-bearing capacity at the relevant temperatures for lateral load ($V_{R,max}$ and, when relevant for seismic uses, $V_{R,max,s\text{-}t}$) shall be stated in the ETA and expressed in kN.

The compliance factor *k* and the notational elastic modulus E_{tp} shall be stated in the ETA.

2.2.1.1 Load-bearing capacity for long-term load

2.2.1.1.1 Axial load

The load-bearing capacity of the spherical and cylindrical bearings for long-term axial loads $N_{R,max}$ shall be assessed as the minimum (see equation (*2.2.1.1.1.1*) between the load-bearing capacity of the curved sliding surface $N_{R,curved}$ and that of the flat sliding surface $N_{R,flat}$.

$$N_{R,max} = \min\left(N_{R,curved}\,;\,N_{R,flat}\right) \qquad (2.2.1.1.1.1)$$

The assessment shall be performed by referring to the maximum diameter of the sheet of sliding material to be covered in the ETA and to each of the temperatures assessed in accordance with Annex C.1.

$N_{R,curved}$ and $N_{R,flat}$ shall be assessed in accordance with Clauses 6.2.1 and 6.2.2 of EN 1337-7 and Clause 6.8.1 to Clause 6.8.3 of EN 1337-2 with the following adaptations accounting for the essential characteristics of the UHMWPE sliding material:

- Possible material combinations are given in Table 1.1.1.
- The load-bearing capacity for long-term axial load N_R of a sliding surface shall be defined as follows (equation (*2.2.1.1.1.2*):

$$N_R = f_k(T) \times A_r \qquad (2.2.1.1.1.2)$$

Where:

$f_k(T)$: Characteristic compressive strength of the UHMWPE sliding material for long-term loads (see Annex C, Table C.1.1.1).

A_r: Reduced contact area in accordance with EN 1337-7, Clause 6.2.3, and EN 1337-2, Clause 6.8.3.

- The load-bearing capacity shall be assessed using the relevant values of the temperature-dependent characteristic compressive strength $f_k\ (T)$ for long-term load of the sliding material assessed in accordance with Annex C.1 (see Table C.1.1.1).
- When calculating the total eccentricity e_t of the axial force N_S, the frictional resistance of the sliding surfaces shall be determined using the coefficients of friction of the sliding material assessed in accordance with Clause 2.2.4.

2.2.1.1.2 Lateral load

The load-bearing capacity of guided spherical and cylindrical bearings (type 3.3, 3.4, 7.2 and 7.3 in accordance with EN 1337-1, Table 1) for long-term lateral loads $V_{R,max}$ shall be determined under the assumption that the load-bearing capacity of the steel components supporting the guide elements $V_{R,support}$ is greater than the load-bearing capacity of the guide $V_{R,guide}$. Therefore, inequation (*2.2.1.1.2.1*) and equation (*2.2.1.1.2.2*) apply.

$$V_{R,support} > V_{R,guide} \qquad (2.2.1.1.2.1)$$

$$V_{R,max} = \min\left(V_{R,support}; V_{R,guide}\right) = V_{R,guide} \qquad (2.2.1.1.2.2)$$

The load-bearing capacity of guides $V_{R,guide}$ shall be assessed in accordance with EN 1337-2, Clauses 6.8.1 and 6.8.2, with the following adaptations accounting for the essential characteristics of the UHMWPE sliding material:

- Possible material combinations are given in Table 1.1.1.
- Load-bearing capacity for lateral load is defined as follows (equation (*2.2.1.1.2.3*):

$$V_{R,guide} = f_k(T) \times A \qquad (2.2.1.1.2.3)$$

Where:

$f_k(T)$: Characteristic compressive strength of the UHMWPE sliding material for short-term loads (see Annex C, Table C.1.1.1).

A: Area of the sliding surface (in accordance with EN 1337-2, Clause 6.8.3, eccentricity can be neglected for guides).

- If UHMWPE sliding material sheets are used in guides, the load-bearing capacity shall be assessed using the relevant values of the temperature-dependent characteristic compressive strength $f_k\ (T)$ for long-term load of the sliding material assessed in accordance with Annex C.1 (see Table C.1.1.1).

- If composite material CM1 or CM2 in accordance with EN 1337-2, Clause 5.3, is used as sliding material in guides, the appropriate value of the characteristic compressive strength shall be taken from Table 10 in Clause 6.6 of EN 1337-2.

2.2.1.2 Load-bearing capacity for short-term load

2.2.1.2.1 Axial load

The load-bearing capacity of the spherical and cylindrical bearings for short-term axial loads $N_{R,max,s-t}$ shall be assessed as the minimum (see equation (*2.2.1.2.1.1*) between the load-bearing capacity of the curved sliding surface $N_{R,curved,s-t}$ and that of the flat sliding surface $N_{R,flat,s-t}$.

$$N_{R,max,s-t} = \min\left(N_{R,curved,s-t}\,;N_{R,flat,s-t}\right) \qquad (2.2.1.2.1.1)$$

The assessment shall be performed by referring to the maximum diameter of the sheet of sliding material to be covered by the ETA and to each of the temperatures assessed in accordance with Annex C.3.

$N_{R,curved,s-t}$ and $N_{R,flat,s-t}$ shall be assessed in accordance with Clauses 6.2.1 and 6.2.2 of EN 1337-7 and Clause 6.8.1 to Clause 6.8.3 of EN 1337-2 with the following adaptations accounting for the essential characteristics of the UHMWPE sliding material:

- Possible material combinations are given in Table 1.1.1.
- The load-bearing capacity for short-term axial loads $N_{R,s-t}$ of a sliding surface shall be defined as follows (equation (*2.2.1.2.1.2*)):

$$N_{R,s-t} = f_{k,s-t}(T) \times A_r \qquad (2.2.1.2.1.2)$$

Where:

$f_{k,s-t}(T)$: Characteristic compressive strength of the UHMWPE sliding material for short-term loads (see Annex C, Table C.3.1.1).

A_r: Reduced contact area in accordance with EN 1337-7, Clause 6.2.3 and EN 1337-2, Clause 6.8.3.

- The load-bearing capacity shall be assessed using the relevant values of the temperature-dependent characteristic compressive strength for short-term load $f_{k,s-t}(T)$ of the sliding material assessed in accordance with Annex C.3 (see Table C.3.1.1).
- When calculating the total eccentricity e_t of the axial force N_S, the frictional resistance of the sliding surfaces shall be determined using the coefficients of friction of the sliding material assessed in accordance with Clause 2.2.4.

2.2.1.2.2 Lateral load

The load-bearing capacity of guided spherical and cylindrical bearings (type 3.3, 3.4, 7.2 and 7.3 in accordance with EN 1337-1, Table 1) for short-term lateral loads $V_{R,max,s-t}$ shall be determined under the assumption that the load-bearing capacity of the steel components supporting the guide elements $V_{R,support}$ is greater than the load-bearing capacity of the guide $V_{R,guide,s-t}$. Therefore, inequation (*2.2.1.2.2.1*) and equation (*2.2.1.2.2.2*) apply.

$$V_{R,support} > V_{R,guide,s-t} \qquad (2.2.1.2.2.1)$$

$$V_{R,max,s-t} = \min\left(V_{R,support}; V_{R,guide,s-t}\right) = V_{R,guide,s-t} \qquad (2.2.1.2.2.2)$$

The load-bearing capacity of guides for short-term lateral loads $V_{R,guide,s-t}$ shall be assessed in accordance with EN 1337-2, Clauses 6.8.1 and 6.8.2, with the following adaptations accounting for the essential characteristics of the UHMWPE sliding material:

- Possible material combinations are given in Table 1.1.1.
- Load-bearing capacity for short-term lateral load is defined as follows (equation (*2.2.1.2.2.3*):

$$V_{R,guide,s-t} = f_{k,s-t}(T) \times A \qquad (2.2.1.2.2.3)$$

Where:

$f_{k,s-t}(T)$: Compressive strength of the UHMWPE sliding material for short-term loads (see Annex C, Table C.3.1.1).

A: Area of the sliding surface (in accordance with EN 1337-2, Clause 6.8.3, eccentricity can be neglected for guides).

- If UHMWPE sliding material sheets are used in guides, the load-bearing capacity shall be assessed using the relevant values of the temperature-dependent characteristic compressive strength for short-term loads $f_{k,s-t}(T)$ for short-term loads of the sliding material assessed in accordance with Annex C.3 (see Table C.3.1.1).
- If composite material CM1 or CM2 in accordance with EN 1337-2, Clause 5.3, is used as sliding material in guides, the appropriate value of the characteristic compressive strength shall be taken from Table 10 in Clause 6.6 of EN 1337-2.

2.2.2 Rotation capability

Purpose of the assessment

The purpose is to assess the maximum rotation angle of the spherical and cylindrical bearings.

Assessment method

The rotation capability shall be assessed geometrically taking into account the most unfavourable displacement of the flat sliding surface. The maximum geometrical rotation angle $\alpha_{max,geom.}$ is the lowest value of the following:

- Maximum rotation angle for which there is no contact between the sliding plate (No. 1 in Figure 2.2.2.1) and the backing plate (No. 6 Figure 2.2.2.1) or any other metallic component, in accordance with EN 1337-7, Clause 6.2.4, which means that the tilting gap is > 0;
- Maximum rotation angle for which the sliding material sheet in the curved sliding surface is still covered by the mating material, in accordance with EN 1337-7, Clause 6.2.4;
- In case of guided bearings without rotational element for guides in accordance with EN 1337-2, Clause 6.4: Maximum rotation angle at which the differential deformation of the sliding material sheet in guides across its smallest dimension is < 0,2 mm;
- In case of guided bearings with rotational elements for guides in accordance with EN 1337-2, Clause 6.4: Maximum rotation angle at which the rotational element for guides in accordance with EN 1337-2, Clause 6.4, reaches the limit of its rotational capacity.

The maximum rotation angle α_{max} shall be calculated by subtracting the increased rotation $\alpha_{inc.rot.}$ in accordance with EN 1337-1, Clause 5.4, from $\alpha_{max,geom.}$ as shown in equation (2.2.2.1)

$$\alpha_{max} = \alpha_{max,geom.} - \alpha_{inc.rot.} \qquad (2.2.2.1)$$

The possible material combinations of curved sliding surfaces are given in Table 1.1.1.

Expression of results

The rotation capability shall be stated in the ETA by means of maximum rotation angle α_{max} expressed in radians.

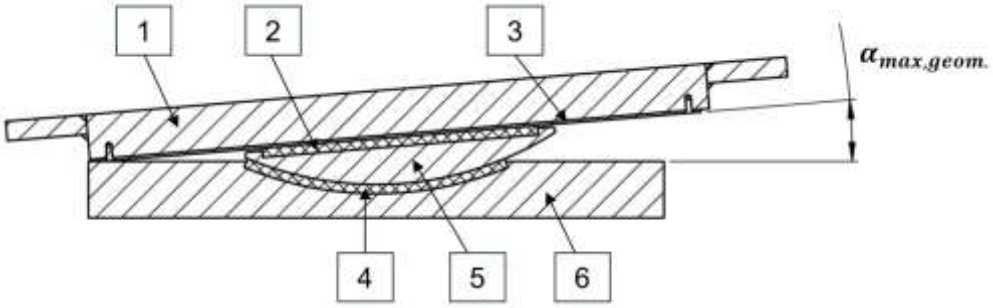

Figure 2.2.2.1: Determination of the maximum rotation angle $\alpha_{max,geom.}$ in a free spherical bearing

Legend for Figure 2.2.2.1:	
1 Sliding plate 2 Dimpled UHMWPE sliding material 3 Mating surface (here: austenitic steel sliding sheet)	4 Dimpled UHMWPE sliding material 5 Spherical rotational element 6 Backing plate

2.2.3 Displacement capacity

Purpose of the assessment

The purpose is to assess:

- the maximum displacement and
- the total slide path

of the spherical and cylindrical bearings.

Assessment method

The single, maximum displacement shall be assessed by check of the geometrical conditions and in accordance with EN 1337-2, Clause 6.5.1.

The total slide path of the spherical and cylindrical bearings for each combination of sliding materials following Clause 1.1, Table 1.1.1, shall be assessed in accordance with Annex D.

Expression of results

The single, maximum displacement [in mm] shall be stated in the ETA.

The total slide path [in m] for each combination of sliding materials in accordance with Table 1.1.1 shall be stated in the ETA, together with the sliding speed (v_a) used in type B phases of the long-term friction test, expressed [in mm/s].

If composite materials CM1 or CM2 in accordance with EN 1337-2, Clause 5.3, are used as sliding material in guides, the total slide path for this combination shall be stated in the ETA in accordance with EN 1337-2, Table 4.

2.2.4 Coefficient of friction

Purpose of the assessment

The purpose of the assessment is to determine the sliding behaviour of the product.

Assessment method

The sliding behaviour of the spherical and cylindrical bearings at the assessed temperatures shall be determined by the maximum coefficient of friction μ_{max} for each sliding element and for each combination to be covered by the ETA in accordance with Table 1.1.1.

The friction coefficients assessed by friction tests with UHMWPE sliding material in combination with either austenitic steel sheets or hard chromium plating as mating material are considered as equivalent in accordance with the assumption made in EN 1337-2, Clause 4.1. Therefore, only one of the two needs to be assessed.

The coefficient of friction of curved and flat sliding surfaces incorporating dimpled and lubricated UHMWPE sliding material sheets shall be assessed in accordance with Clause 2.2.4.1.

The coefficient of friction of guides incorporating undimpled UHMWPE sliding material sheets shall be assessed in accordance with Clause 2.2.4.2.

Expression of results

For each relevant material combinations given in Table 1.1.1, the coefficient of friction of sliding elements incorporating dimpled and lubricated UHMWPE sliding material sheets assessed in the long-term friction test shall be expressed in the ETA in form of levels, expressing the maximum coefficient of friction μ_{max} as a function of the average pressure σ_p (MPa) on the sliding material sheet. Based on the assessment of the test results in accordance with Clause 2.2.4.1, the maximum friction coefficient μ_{max} shall be stated for the following temperature ranges, determined by the minimum effective bearing temperature T_{min}:

(a) moderately low temperature: $T_{min} = -5$ °C

(b) low temperature: $T_{min} = -35$ °C

(c) very low temperature: $T_{min} = -50$ °C

Alternatively, the highest maximum coefficient of friction μ_{max} of all assessed material combinations incorporating dimpled and lubricated UHMWPE sliding material sheets may be stated in the ETA as a function of the average pressure σ_p (MPa) for each temperature range as overall maximum friction coefficients μ_{max}, enveloping all assessed material combinations given in Table 1.1.1.

If the range of operating temperatures is extended to T_{max} with + 48 °C < T_{max} ≤ + 80 °C and the additional tests prescribed in Clause 2.2.4.1 are performed, two cases shall be differentiated:

- If the maximum coefficients of friction assessed in the short-term friction test with lubricant previously exposed to T_{max} + 10 °C for 60 days, and if the maximum coefficients of friction in both phases A_1 of the high-temperature friction test are enveloped by the values assessed at the relevant temperatures in the long-term friction test, it is not necessary to state any additional level in the ETA.
- If the maximum coefficients of friction assessed in the short-term friction test with lubricant previously exposed to T_{max} + 10 °C for 60 days, or if the maximum coefficients of friction in any phase A_1 of the high-temperature friction test exceed the values assessed at the relevant temperatures in the long-term friction test, then the maximum values shall be separately stated in the ETA by means of level, as two ranges of coefficient of friction, as follows:

  (I) for use up to + 48 °C

  (II) for use at + 48 °C < T ≤ + 80 °C.

The coefficient of friction of guides incorporating undimpled UHMWPE sliding material sheets assessed in the long-term friction test shall be stated in the ETA and expressed in form of levels, expressing the maximum coefficient of friction μ_{max} at the relevant temperatures. Based on the assessment of the test results in accordance with Clause 2.2.4.2, the maximum friction coefficient μ_{max} of guides shall be stated for the following temperature ranges, determined by the minimum effective bearing temperature T_{min}:

(a) moderately low temperature: $T_{min} = -5$ °C

(b) low temperature: $T_{min} = -35$ °C

(c) very low temperature: $T_{min} = -50$ °C

The coefficient of friction of guides incorporating composite materials CM1 or CM2 in accordance with EN 1337-2, Clause 5.3, shall be stated in the ETA in accordance with EN 1337-2, Clause 6.7.

2.2.4.1 Assessment of friction coefficients for sliding elements incorporating dimpled and lubricated UHMWPE sliding material sheets

Main flat sliding elements with material combinations given in Table 1.1.1 incorporating dimpled and lubricated UHMWPE sliding material sheets shall be assessed by means of a long-term friction test in accordance with the structure of test phases shown in Annex D, Table D.1. Test parameters and test conditions shall be in accordance with Annex D, Table D.4.

After the assessment of the total slide path, static and dynamic coefficients of friction ($\mu_{s,T}$ and $\mu_{dyn,T}$) shall be assessed at – 10 °C, – 25 °C and + 21 °C at the pressure levels 1/3 $f_k(T_0)$, 1/6 $f_k(T_0)$ and 1/12 $f_k(T_0)$ following the test procedure A_1 of Annex D, Table D.4, where $f_k(T_0)$ is the characteristic compressive strength of the UHMWPE sliding material at temperature $T_0 \leq 35$ °C assessed in accordance with Annex C.1. Coefficients of friction at the temperature of – 25 °C shall be obtained by linear interpolation between the measured values at temperatures of – 20 °C and – 35 °C (in accordance with Annex D, Table D.4).

The maximum friction coefficients (μ_{max}) are the greatest values of the measured parameters $\mu_{s,T}$ and $\mu_{dyn,T}$ for each pressure level (1/3 $f_k(T_0)$, 1/6 $f_k(T_0)$ and 1/12 $f_k(T_0)$) and each temperature (- 10 °C, – 25 °C and + 21 °C):

- The assessment at + 21 °C is related to the assessment of the friction coefficients for sliding elements incorporating dimpled and lubricated UHMWPE sliding material sheets at moderate low temperatures ($T_{min} = -5$ °C).
- The assessment at – 10 °C is related to the assessment of the friction coefficients for sliding elements incorporating dimpled and lubricated UHMWPE sliding material sheets at low temperatures ($T_{min} = -35$ °C).
- The assessment at – 25 °C is related to the assessment of the friction coefficients for sliding elements incorporating dimpled and lubricated UHMWPE sliding material sheets at very low temperatures ($T_{min} = -50$ °C).

If the coefficients of friction in any phase of the long-term friction test exceed the respective values at the end of the long-term friction test at 1/3 $f_k(T_0)$, the assessed maximum coefficients of friction of all pressure levels shall be increased by an equivalent percentage of this exceeding amount.

The sliding behaviour of sliding elements with material combinations given in Table 1.1.1 incorporating dimpled and lubricated UHMWPE sliding material sheets used in curved sliding surfaces shall only be assessed by a long-term friction test that comprises a total slide path equivalent to 1/5 of the total slide path of the main flat sliding surfaces. The principles of the test phases are given in Annex D, Table D.2 for an example of 10 000 m total slide path.

If the spherical and cylindrical bearings are assessed with effective bearing temperatures up to T_{max} with + 48 °C < $T_{max} \leq$ + 80 °C, two additional tests shall be performed:

(a) A short-term friction tests (phase A_1 in accordance with Annex D, Table D.4) with lubricant previously exposed to T_{max} + 10 °C for 60 days.

(b) A high-temperature friction test, in accordance with Annex D, Table D.3.

2.2.4.2 Assessment of friction coefficients for guides incorporating undimpled and initially lubricated UHMWPE sliding material sheets

For guides incorporating undimpled and initially lubricated UHMWPE sliding material sheets, the coefficient of friction shall be assessed by means of the long-term friction test performed in accordance with Annex D,

Table D.2, on a total slide path equivalent to 1/5 of the total slide path of the dimpled and lubricated UHMWPE sliding material sheet (see Clause 2.2.4.1). Test parameters and test conditions shall be in accordance with Annex D, Table D.4.

After the assessment of the total slide path of guides, static and dynamic coefficients of friction ($\mu_{s,T}$ and $\mu_{dyn,T}$) shall be assessed at – 10 °C, − 25 °C and + 21 °C at the pressure level of 1/3 $f_k(T_0)$ following the test procedure A_1 of Annex D, Table D.4. Coefficients of friction at the temperature of – 25 °C shall be obtained by linear interpolation between the measured values at temperatures of – 20 °C and – 35 °C (in accordance with Annex D, Table D.4).

The maximum friction coefficients (μ_{max}) are the greatest values of the measured parameters $\mu_{s,T}$ and $\mu_{dyn,T}$ for each temperature (- 10 °C, – 25 °C and + 21 °C):

- The assessment at + 21 °C is related to the assessment of the friction coefficients for guides at moderate low temperatures (T_{min} = − 5 °C).
- The assessment at – 10 °C is related to the assessment of the friction coefficients for guides at low temperatures (T_{min} = − 35 °C).
- The assessment at − 25 °C is related to the assessment of the friction coefficients guides at very low temperatures (T_{min} = − 50 °C).

If the maximum coefficients of friction in any phase A_1 of the long-term friction test exceed the respective values at the end of the long-term friction test at 1/3 $f_k(T_0)$, the greatest values of the coefficients of friction shall be stated as maximum friction coefficients (μ_{max}) for the different temperature ranges at 1/3 $f_k(T_0)$.

2.2.5 Reaction to fire

Purpose of the assessment

The purpose of the assessment is to determine the reaction to fire of the product and its components.

Assessment method

Reaction to fire of the product shall be assessed by considering the reaction to fire of the components (sliding materials and metal parts) in order to be classified in accordance with Commission Delegated Regulation (EU) 2016/364 in connection with EN 13501-1.

The metal parts are considered to satisfy the requirements of class A1 of the reaction to fire performance in accordance with the Commission Decision 96/603/EC, as amended by Commission Decisions 2000/605/EC and 2003/424/EC, without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

The sliding material shall be tested with the lubricant, using the method(s) relevant for the corresponding reaction to fire class in accordance with EN 13501-1. Mounting and fixing provisions and extended applications of test results are given in Annex F.

The spherical or cylindrical bearing shall be classified based on the worst class of any component (i.e., sliding materials) obtained as stated above.

Expression of results

The reaction to fire classes of the product and its components (sliding materials and metal parts) shall be stated in the ETA.

2.2.6 Durability aspects

2.2.6.1 Protection against contamination of sliding surfaces

Purpose of the assessment

The purpose of the assessment is to determine the capability of the spherical or cylindrical bearing to remain serviceable during its lifetime in relation to its protection against contamination of sliding surfaces.

Assessment method

The protection against contamination of sliding surfaces shall be assessed in accordance with EN 1337-2, Clause 7.3; notably the provision against contamination of the sliding surface shall be described.

Expression of results

The protection against contamination of sliding surfaces shall be stated in the ETA by means of description.

2.2.6.2 Corrosion resistance

Purpose of the assessment

The purpose of the assessment is to determine the capability of the spherical or cylindrical bearing to remain serviceable during its lifetime in relation to its corrosion resistance.

Assessment method

The corrosion resistance of the corrosion protection system applied on the parts made of structural steel shall be assessed in accordance with Clause 4 of EN 1337-9, with the following deviation:

- Corrosion test by neutral salt spray shall be performed in accordance with EN ISO 9227.

In addition, the level of the corrosion protection of the corrosion protection system applied on the parts made of structural steel shall be assessed by categorisation in accordance with EN ISO 12944-5 or in accordance with corrosion testing in accordance with EN ISO 12944-6.

The corrosion protection of sliding elements with regard to the attachment of austenitic sliding steel sheets shall be assessed in accordance with EN 1337-2, Clause 7.3.

The corrosion resistance of the aluminium sliding alloy shall be assessed in accordance with EN 1999-1-1, Clause 4 and Annex D. Corrosion resistance to effects of the environment shall be assessed in accordance with EN 1999-1-1, Annex D, Clauses D.3.1 and D.3.2. Corrosion resistance due to contact with other metals and non-metallic materials shall be assessed in accordance with Annex D of EN 1999-1-1, Clauses D.3.3 and D.3.4.

Expression of results

For parts made of structural steel, the compliance with EN 1337-9, Clause 4, shall be stated in the ETA.

In addition, the corrosion protection of the corrosion protection system applied on the parts made of structural steel shall be stated in the ETA by means of levels expressed by the durability range in accordance with EN ISO 12944-1, Clause 5.5, and the corrosivity category in accordance with EN ISO 12944-2, Clause 5.1.

The measures for corrosion protection in sliding elements regarding the attachment of austenitic sliding steel sheets shall be stated in the ETA by means of description.

For aluminium sliding alloy, the durability rating in accordance with Table 3.1a or Table 3.1b of EN 1999-1-1 shall be stated in the ETA.

2.2.6.3 Ageing resistance

Purpose of the assessment

The purpose of the assessment is to determine the capability of the spherical or cylindrical bearing to remain serviceable during its lifetime in relation to its ageing resistance.

Assessment method

The ageing resistance of the cylindrical and spherical bearing depends on the ageing resistance of the UHMWPE sliding material.

For assessment of ageing effects of the UHMWPE sliding material at standard atmosphere, the material shall be subjected to accelerated ageing by exposure to T_{max} [5] for a duration of 168 hours. After that, the material properties tensile modulus, stress at yield, stress at break, strain at break and ball indentation hardness shall be assessed as given in Annex G, Table G.1.2.1. Number of specimens and further test specifications are given in Clauses G.2 and G.3.

Expression of results

The ageing resistance shall be stated in the ETA by defining the average deviation (%) of aged specimens from virgin specimens for the property's tensile modulus, stress at yield, stress at break, strain at break and ball indentation hardness in accordance with Table G.1.2.1.

2.2.6.4 Resistance against chemical and environmental influences

Purpose of the assessment

The purpose of the assessment is to determine the capability of the spherical or cylindrical bearing to remain serviceable during its lifetime in relation to its resistance against chemical and environmental influences.

Assessment method

The resistance against chemical and environmental influences of the cylindrical and spherical bearing depends on the resistance against chemical and environmental influences of the UHMWPE sliding material.

The resistance against chemical and environmental influences of the UHMWPE sliding material blend shall be assessed in accordance with EN ISO 175 by separate exposure of test specimens described below for 60 days at + 23 ºC ± 2 ºC to the following media:

- Silicone grease (in accordance with EN 1337-2, Clause 5.8),
- Distilled water,
- Sodium chloride (saturated aqueous solution) (EN ISO 175, Annex A, Table A.1),
- Chromium chloride (saturated aqueous solution),
- Ferric chloride (saturated aqueous solution),
- Zinc chloride (saturated aqueous solution).

Additionally, the resistance against change of material properties due to exposure to silicon grease in accordance with EN 1337-2, Clause 5.8, shall be assessed by exposure of test specimens described below for 14 days at + 70 ºC ± 2 ºC.

After each exposure, the change of volume and change of mass in accordance with EN ISO 175, Clauses 5.4 and 5.5, shall be measured on five specimens each [6].

Test specimen for weight and volume measurements:

- Plate with 50 mm x 25 mm x 1 mm, prepared from fully finished sheet without dimples.

Furthermore, after each exposure, the strain at break shall be measured on five specimens each in accordance with EN ISO 527-3 and Clause G.2.

If the range of operating temperature shall be extended to T_{max}, with + 48 °C < T_{max} ≤ + 80 °C, specimens as described above shall further be exposed to silicon grease in accordance with EN 1337-2, Clause 5.8, in two separate tests:

- for 90 days at T_{max},
- for 21 days at T_{max} + 10 °C

5 T_{max} is the maximum operating temperature required by the manufacturer, with + 48 °C ≤ T_{max} ≤ + 80 °C.

6 Alternatively, the specimen volume may be calculated from the quotient of the mass (determined according to EN ISO 175, Clause 5.4) and the mass density (determined according to EN ISO 1183-1).

After each exposure, the change of volume and change of mass in accordance with EN ISO 175, Clauses 5.4 and 5.5, shall be measured on five specimens each [6]. Furthermore, after each exposure, the strain at break in accordance with EN ISO 527-3 and Clause G.2 shall be measured on five specimens each.

Expression of results

The resistance against chemical and environmental influences shall be stated in the ETA by defining the average deviation (%) for each determined property (volume, mass and strain at break) of exposed specimens from virgin specimens, per each exposure.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 95/467/EC, as amended by 2001/596/EC, 2002/592/EC and 2010/679/EU.

The system is 1.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the spherical and cylindrical bearings in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1: Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC)					
1	Spherical and cylindrical bearings				
	Spherical and cylindrical bearings	EN 1337-7, Annex ZA EN 1337-2, Clause 8	According to control plan	According to control plan	EN 1337-2, Clause 8, Tables 15 and 16
2	UHMWPE sliding material				
2.1	Tensile properties	3.4.1.2	3.4.1.2	5	Once each batch ≤ 500 kg [1)]
2.2	Ball indentation hardness	3.4.1.3	3.4.1.3	3	
2.3	Mass density	3.4.1.4	3.4.1.4	3	
2.4	Melting temperature and melting enthalpy	3.4.1.5	3.4.1.5	1	
2.5	Sliding behaviour	3.4.2	3.4.2	1	
2.6	Geometrical properties of UHMWPE sliding material sheet	3.4.3	3.4.3	---	Each sheet
2.7	Chemical composition [2)]	Control of 2.1 certificate of compliance in accordance with EN 10204	According to control plan	According to control plan	Each batch
3	Aluminium sliding alloy				
	Aluminium sliding alloy	Control of 3.1 inspection certificate in accordance with EN 10204	According to control plan	According to control plan	Each batch

1) *Note: If supported by relevant data and in accordance with the control plan agreed between TAB and manufacturer, the test batch size may be increased to the actual size of the production batch.*

2) *The control of material composition is used with regard to the assessment in Clause 2.2.5 – reaction to fire.*

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance of the spherical and cylindrical bearings are laid down in Table 3.3.1.

The extent of initial inspection of the manufacturing plant as well as of factory production control and the frequency of factory production control are given for the product and for the raw materials and constituents in EN 1337-7. The details for the UHMWPE sliding material are laid down in the control plan for the manufacturer.

Table 3.3.1: Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	The Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the spherical and cylindrical bearings	Verification of the complete FPC, as described in the control plan agreed between the TAB and the manufacturer	According to control plan	According to control plan	When starting production or a new production line
Continuous surveillance, assessment and evaluation of factory production control					
2	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1	According to control plan	According to control plan	Twice a year

3.4 Special methods of control and testing used for the assessment and verification of constancy of performance

3.4.1 Material properties of the UHMWPE sliding material

3.4.1.1 General

The definition of the material properties, referred to in the following clauses, is given in Annex G.1.1, Table G.1.1.1.

3.4.1.2 Tensile properties

The tensile modulus, stress at yield, stress at break and strain at break of the UHMWPE sliding material shall be checked in accordance with the methods specified in Annex G, Clause G.1.2 and Clause G.2, by means of levels. The results of the testing shall comply with the levels laid down in the control plan with consideration of the following tolerances:

- Tensile modulus: ± 20 %,
- Stress at yield: ± 10 %,
- Stress at break: Minimum value,
- Strain at break: Minimum value.

3.4.1.3 Ball indentation hardness

The ball indentation hardness of the UHMWPE sliding material shall be checked in accordance with the methods specified in Annex G, Clause G.1.2 and Clause G.3, by means of a level.

The results of the testing shall comply with the level laid down in the control plan with consideration of the following tolerances:

- Ball indentation hardness: ± 20 %.

3.4.1.4 Mass density

The mass density of the UHMWPE sliding material shall be checked in accordance with the methods specified in in Annex G, Clause G.1.2 and Clause G.4, by means of a level.

The results of the testing shall comply with the level laid down in the control plan with consideration of the following tolerances:

- Mass density: ± 2 %.

3.4.1.5 Melting temperature and melting enthalpy

The melting temperature and melting enthalpy of the UHMWPE sliding material shall be checked in accordance with the methods specified in Annex G, Clause G.1.2 and Clause G.5, by means of levels.

The results of the testing shall comply with the levels laid down in the control plan with consideration of the following tolerances:

- Melting temperature: Minimum value,
- Melting enthalpy: ± 3 %.

3.4.2 Sliding behaviour of the UHMWPE sliding material

The sliding behaviour of the UHMWPE sliding material shall be checked in a short-term friction test in accordance with the method given in Annex H by means of levels.

The coefficients of friction in each phase of the short-term friction test shall not exceed the values given in the control plan in accordance with Annex H, Table H.2.1 based on the initial assessment for issuing the ETA.

3.4.3 Geometrical properties of the UHMWPE sliding material sheet

The control of geometrical properties (thickness t_p and dimensions, shape and pattern of dimples) of the UHMWPE sliding material sheet shall be carried out in accordance with Annex A, Clause A.1.

4 REFERENCE DOCUMENTS

EN 485-2:2016+A1:2018	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
EN 755-2:2025	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 2: Mechanical properties
EN 1337-1:2000	Structural bearings - Part 1: General design rules
EN 1337-2:2004	Structural bearings - Part 2: Sliding elements
EN 1337-5:2005	Structural bearings - Part 5: Pot bearings
EN 1337-7:2004	Structural bearings - Part 7: Spherical and cylindrical PTFE bearings
EN 1337-9:1997	Structural bearings - Part 9: Protection
EN 1990:2023	Eurocode - Basis of structural and geotechnical design
EN 1999-1-1:2023	Eurocode 9 - Design of aluminium structures - Part 1-1: General rules
EN 10204:2004	Metallic products - Types of inspection documents
EN 10250-1:2022	Open die steel forgings for general engineering purposes - Part 1: General requirements
EN 10250-2:2022	Open die steel forgings for general engineering purposes - Part 2: Non-alloy quality and special steels
EN 10250-3:2022	Open die steel forgings for general engineering purposes - Part 3: Alloy special steels
EN 10250-4:2021	Open die steel forgings for general engineering purposes - Part 4: Stainless steels
EN 13238:2010	Reaction to fire tests for building products - Conditioning procedures and general rules for selection of substrates.
EN 13501-1:2018	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests
EN 13823:2020+A1:2022	Reaction to fire tests for building products - Building products excluding floorings exposed to the thermal attack by a single burning item
EN ISO 175:2010	Plastics - Methods of tests for the determination of the effects of immersion in liquid chemicals (ISO 175:2010)
EN ISO 527-1:2019	Plastics - Determination of tensile properties - Part 1: General principles (ISO 527-1:2019)
EN ISO 527-3:2018	Plastics - Determination of tensile properties - Part 3: Test conditions for films and sheets (ISO 527-3:2018)
EN ISO 1183-1:2025	Plastics - Methods for determining the density of non-cellular plastics - Part 1: Immersion method, liquid pycnometer and titration method (ISO 1183-1:2019, Corrected version 2019-05)
EN ISO 2039-1:2003	Plastics - Determination of hardness - Part 1: Ball indentation method (ISO 2039-1:2001)
EN ISO 6892-1:2019	Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2019)
EN ISO 9227:2022+A1:2024	Corrosion tests in artificial atmospheres - Salt spray tests (ISO 9227:2022+Amd1:2024)
EN ISO 11357-3:2025	Plastics - Differential scanning calorimetry (DSC) - Part 3: Determination of temperature and enthalpy of melting and crystallization (ISO 11357-3:2025)
EN ISO 11925-2:2020	Reaction to fire tests - Ignitability of products subjected to direct impingement of flame - Part 2: Single-flame source test (ISO 11925-2:2020)
EN ISO 12944-1:2017	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction (ISO 12944-1:2017)
EN ISO 12944-2:2017	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments (ISO 12944-2:2017)
EN ISO 12944-5:2019	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 5: Protective paint systems
EN ISO 12944-6:2018	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 6: Laboratory performance test methods

ANNEX A: GEOMETRICAL CONDITIONS OF THE UHMWPE SLIDING MATERIAL

The figures given in Clause A.1 and Table A.1.1 of this Annex establish the geometrical conditions for sheets of the UHMWPE sliding material for which this EAD applies (see also Clause 1.1).

A.1 Recessed UHMWPE sliding material sheets

The UHMWPE sliding material sheets are recessed into a backing plate as shown in Figure A.1.1 below. The shoulders of the recess are sharp and square to restrict the flow of the sliding material. The radius at the root of the recess does not exceed 1 mm. Intermittent gap between the edge of the sheet of sliding material and the recess do not exceed the values given in Table 12 of EN 1337-2 at room temperature. For diameters *L* between 1500 and 3000 mm the gaps are limited to *L* [mm] / 1250.

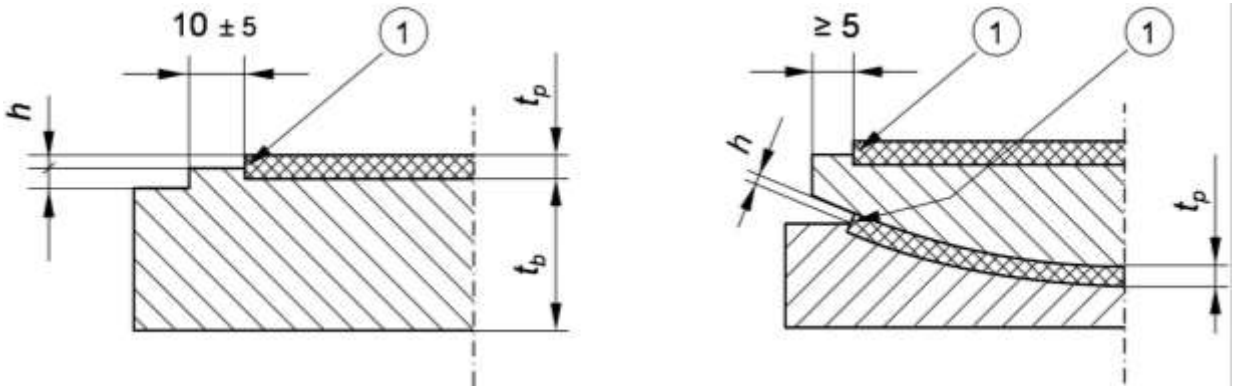

Figure A.1.1: Details of UHMWPE sliding material recess and relief (see Figure 2 of EN 1337-2)

Legend for Figure A.1.1:
(1) sharp edge

Table A.1.1: Geometrical conditions thickness t_p and protrusion h of UHMWPE sliding material sheets

	Flat and curved sliding surfaces	Guides (d)
Thickness t_p	$2{,}65 \times h_0 \le t_p \le t_{p,max}$ with $t_{p,max} \le 10{,}0$ mm (a)	8,0 mm ≤ t_p ≤ 10,0 mm
Protrusion h_0	$h_0 = 2{,}50 + L / 3000$ (mm) (b, c)	h_0 = (3,0 ± 0,2) mm

(a) The maximum sheet thickness is limited to the lowest thickness t_p of specimens (L = 155 mm, dimpled UHMWPE sliding material) used in the tests for the assessment of compressive strength in accordance with Annex C.1 and Annex C.3 and for the assessment of load-deformation behaviour in accordance with Annex C.2.
(b) The protrusion h_0 is limited to $h_0 \le t_{p,max} / 2{,}65$, see (a).
(c) *L* is the diameter of the projected area of circumscribing circle of single or multiple UHMWPE sliding material sheets
(d) The width of the guide strips is not less than 15 mm, and the modified shape factor calculated as per EN 1337-2,

The tolerance on the protrusion h_0 is ± 0,2 mm for $L \le 1200$ mm and ± 0,3 mm for $L > 1200$ mm. The protrusion shall be assessed at marked measuring points, where the corrosion protection coating shall not exceed 300 µm. There shall be at least two measuring points, suitably located.

UHMWPE sliding material sheets used in the main flat or curved sliding surface shall be provided with a uniform pattern of dimples to retain the lubricant. The dimension, shape and arrangement of the dimples in the unloaded and unused condition, and the alignment respect to the main direction of sliding, shall be in accordance with the provisions in Figure 1 of EN 1337-2.

A.2 Flat UHMWPE sliding material sheets

For flat UHMWPE sliding material sheets the provisions for flat PTFE sheets given in EN 1337-2, Clause 6.2.1.1, apply.

A.3 Curved UHMWPE sliding material sheets

For curved UHMWPE sliding material sheets the provisions for curved PTFE sheets for cylindrical and spherical sliding surfaces given in EN 1337-2, Clause 6.2.1.2, apply, with the following adaptations:

- If circular UHMWPE sliding material sheets for spherical sliding surfaces are subdivided in a disc and an annulus, the disc is not less than 2/3 L for sheets with a diameter larger than 1500 mm;
- The absence of two symmetrical circular segments for not subdivided sheets is permissible, if the limitation for the included angle given in the scope and the proof of not separation of the sliding surface given in EN 1337-2, Clause 6.8.2, is fulfilled for both the main axes.

The curved UHMWPE sliding material sheet may be attached to either the convex or the concave backing plate of the curved sliding surface.

A.4 Additional provisions

As an alternative to the geometrical rules given above and/or in Clause 6.2.1 of EN 1337-2 flat and curved surfaces of spherical bearings made of UHMWPE sliding material may consist of one centric circular sheet with diameter "a" and one or more concentric annuli with a constant width "b". The dimensions "a" and "b" are not smaller than 50 mm. The radial distance between the individual sheets is not less than 10 mm and not greater than twice the thickness of the backing plate, of the UHMWPE sliding material or the mating material, whichever is least.

The differential deformation across the smallest dimension of a sheet made of UHMWPE sliding material in guides, due to predicted rotation about a transverse axis, where subject to un-factored characteristic actions should be limited to 0,2 mm. When, in accordance with EN 1337-2, Clause 6.4, this limit is exceeded, a rotation element is included in the backing plate. The material combination of this rotation element is in accordance with the requirements of the mating surfaces of guides given in this EAD or pot to piston contact surfaces given in EN 1337-5, Clause 6.2.3.

ANNEX B: BACKING PLATES OF SPHERICAL AND CYLINDRICAL BEARINGS

The metal backing plates of the sliding surfaces are in accordance with EN 1337-2, Clause 6.9, with adaptations accounting for the essential characteristics of the UHMWPE sliding material:

The sum of the maximum deformations $\Delta w_1 + \Delta w_2$ (see EN 1337-2, Figure 9) of the backing plate does not exceed the value Δw_{lim} calculated by equation B.1 for the values of the relevant material characteristics fulfilling the boundary conditions given in Table 1.1.2.

$$\Delta w_{\lim} = \frac{3}{2}\left[0{,}9 \cdot h_0 - \left(2\,k\sqrt{\frac{(0{,}9 \cdot h_0)^3}{L}}\right) - \left(h_{r,basis} + h_{r,flatTol}\right)\right] \qquad \text{(B.1)}$$

Where:

h_0 Initial height of protrusion of the sheet of sliding material in unloaded condition [mm]

k Pressure-dependent compliance coefficient assessed in accordance with Annex C.2

L Diameter of the circumscribing circle of UHMWPE sliding material sheet [mm]

$h_{r,basis}$ Basic limit value of the sliding gap; $h_{r,basis}$ = 1,0 mm in accordance with EN 1337-2, Clause 10.

$h_{r,flatTol}$ Additional term considering the unevenness of the backing plates. In accordance with tolerance given in EN 1337-2, Clause 7.1.2, this calculates to: $h_{r,flatTol}$ = 0,0003 mm × L or 0,2 mm, whichever value is higher.

The backing plates with concave surfaces take into account dimensional limitations shown in Figure 7 of EN 1337-7.

ANNEX C: ASSESSMENT OF COMPRESSIVE STRENGTH AND LOAD-DEFORMATION BEHAVIOUR

C.1 Compressive strength for long-term loads

C.1.1 Description

The temperature dependent characteristic compressive strength for long-term loads $f_k(T)$ of the UHMWPE sliding material is defined at the following temperatures:

$T = T_0$: $f_k(T_0)$

T = 48 °C: $f_k(T_{48})$

If the range of operating temperature shall be extended up to T_{max}, with + 48 °C < T_{max} ≤ + 80 °C:

T = 60 °C: $f_k(T_{60})$

T = 70 °C: $f_k(T_{70})$

T = 80 °C: $f_k(T_{80})$

with $T \leq T_{max}$

The characteristic compressive strength for long-term loads shall be expressed by means of levels in accordance with Table C.1.1.1.

Table C.1.1.1: Characteristic compressive strength for long-term loads of UHMWPE sliding material

Characteristic compressive strength [MPa]	*Main sliding Surface:* - Permanent and variable loads	$f_k(T)$
	Guides: - Variable loads	
	Guides: - Permanent loads - Effects of temperature, shrinkage and creep	$f_k(T) / 3$

For bearings exposed to a maximum effective bearing temperature in excess of T_0 and up to + 48 °C, the characteristic compressive strength shall be calculated by linear interpolation of the values $f_k(T_0)$ and $f_k(T_{48})$.

For bearings exposed to a maximum effective bearing temperature in excess of + 48 °C and up to + 80 °C, the characteristic compressive strength shall be calculated by linear interpolation of the values above $f_k(T_{48})$.

C.1.2 Determination of the characteristic compressive strength for long-term loads

The temperature dependent characteristic compressive strength for long-term loads $f_k(T)$ shall be assessed by a long-term compression test, under the application of a uniform pressure on the specimen of sliding material equal to the characteristic compressive strength $f_k(T)$ defined in Annex C.1.1.

- General test set-up:
  - Austenitic steel in accordance with EN 1337-2, Clause 5.4, as mating partner,
  - Rigid backing plates in accordance with EN 1337-2, Clause 6.9.

- Specification for specimens made of dimpled UHMWPE sliding material:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material with dimples in accordance with EN 1337-2, Clause 5.2.3.2,
  - L = 155 mm,
  - t_p = maximum value in accordance with Table B.1.1 [mm],
  - t_p - h_0 = value in accordance with Table B.1.1 [mm],
  - Lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- Specification for specimens made of UHMWPE sliding material sheets for guides:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material without dimples,
  - L × a = 200 mm × 15 mm,
  - t_p = 8 mm,
  - t_p - h_0 = 5 mm,
  - Initial lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- Temperature:
  - T_0 = + 35 °C and T = +48 °C,
  - If the range of operating temperature shall be extended to T_{max}, with +48 °C < T_{max} ≤ + 80 °C: Additionally, T = + 60 °C, T = + 70 °C and T = + 80 °C, with $T \leq T_{max}$,
  - Tolerance for all temperature levels: ± 2 °C.
- Number of tests: ≥ 3 per each temperature level
- Loading time: 48 hours
- Pressure: $p = f_k(T)$ as given in Annex C.1.1

Test specimen shall be placed in a temperature-controlled environment (e.g., climatic chamber) during the whole test that maintains the operation temperature.

Deflection of the specimen shall be continuously recorded by at least three transducers equally spaced along the perimeter of recessed backing plate. The total deflection during the period of constant loading is obtained as the average of the measures of the transducers. The decrease of the protrusion of the specimen is eventually assessed as the total deflection Δh measured during the test.

The decrease of protrusion shall be defined as ended, if the change in height per hour in relation to the initial value of protrusion is less than 0,5 ‰. The decrease of protrusion shall end before 48 hours of constant loading. The remaining protrusion shall be greater than 1 mm and less than 2/3 of initial value of protrusion (see Table 1.1.2).

C.2 Load-deformation behaviour

The load deformation behaviour of the UHMWPE sliding material is assessed by a long-term compression test. Under a compressive stress p = 0,25 $f_k\,(T_0)$ and p = 0,5 $f_k\,(T_0)$ the decrease Δh of the protrusion after 48 h of constant loading shall be determined.

- General test set-up:
  - Austenitic steel in accordance with EN 1337-2, Clause 5.4, as mating partner,
  - Rigid backing plates in accordance with EN 1337-2, Clause 6.9.
- Specification for specimens made of dimpled UHMWPE sliding material:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material with dimples in accordance with EN 1337-2, Clause 5.2.3.2,
  - L = 155 mm,
  - t_p = value [mm] as assessed in accordance with Annex C.1,
  - t_p - h_0 = value [mm] as assessed in accordance with Annex C.1,
  - Lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- Temperature: T = + 23 °C ± 2 °C
- Number of tests: ≥ 3 for each pressure level
- Loading time: > 48 hours
- Pressure: p = 0,25 $f_k\,(T_0)$ and p = 0,5 $f_k\,(T_0)$

Test specimen shall be placed in a temperature-controlled environment (e.g., climatic chamber) during the whole test that maintains the operation temperature.

Deflection of the specimen shall be continuously recorded by at least three transducers equally spaced along the perimeter of recessed backing plate. The total deflection during the period of constant loading is obtained as the average of the measures of the transducers. The decrease of the protrusion of the specimen is eventually assessed as the total deflection Δh measured during the test.

The measured values Δh_i as difference between the initial values $h_{0,i}$ in unloaded condition and the final values $h_{r,i}$ under load after 48 hours shall be directly adopted for the statistical evaluation of the corresponding mean value and 95th percentile, respectively Δh_m and Δh_k, in accordance with EN 1990, Annex D "Design assisted by testing", clause D.7.2, in the case of coefficient of variation unknown. Subsequently, the following characteristics shall be calculated:

- Compliance coefficient: $k = \frac{\Delta h_k}{h_0}\sqrt{S} = \frac{\Delta h_k}{h_0}\sqrt{\frac{L}{4h_0}}$
- Notational elastic modulus: $E_{tp} = p\,\frac{t_p}{\Delta h_m}$

For the assessment of the pressure-dependent compliance coefficient k and notional elastic modulus E_{tp} over the considered pressure range, values determined at p = 0,25 $f_k\,(T_0)$ and p = 0,5 $f_k\,(T_0)$ shall be interpolated linearly.

C.3 Compressive strength for short-term loads

C.3.1 Definition

The temperature dependent short-term characteristic compressive strength for short-term loads of the UHMWPE sliding material $f_{k,s\text{-}t}\,(T_{max,seismic})$ is defined as the maximum average pressure on the sliding surface during short-terms loads as due to seismic events at effective bearing temperatures of up to $T = T_{max,seismic}$.

If two or more levels of $f_{k,s\text{-}t}\,(T)$ are assessed at different maximum bearing temperatures $T_{max,seismic}$, the short-term compressive strength for any intermediate temperature shall be calculated by linear interpolation of the single values assessed at the temperatures enveloping the temperature under consideration.

The characteristic compressive strength for short-term loads shall be expressed by means of levels in accordance with Table C.3.1.1.

Table C.3.1.1: Characteristic compressive strength for short-term loads of UHMWPE sliding material

Maximum bearing temperature for short-term loads		$T_{max,seismic}$
short-term compressive strength [MPa]	*Main sliding Surface:* - Short-term loads	$f_{k,s\text{-}t}\,(T_{max,seismic})$
	Guides: - Short-term loads	

C.3.2 Determination of the characteristic compressive strength for short-term loads

The temperature dependent short-term characteristic compressive strength for short-term loads shall be assessed by a short-term compression test with cycling loading up to the short-term compressive strength $f_{k,s\text{-}t}\,(T_{max,seismic})$, where $T_{max,seismic}$ is defined as the maximum bearing temperature at which seismic events are to be expected:

- General test set-up:
  - Austenitic steel in accordance with EN 1337-2, Clause 5.4 as mating partner,
  - Rigid backing plates in accordance with EN 1337-2, Clause 6.9.
- Specification for specimens made of dimpled UHMWPE sliding material:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material with dimples in accordance with EN 1337-2, Clause 5.2.3.2,
  - L = 155 mm,
  - t_p = value [mm] as assessed in accordance with Annex C.1,
  - t_p - h_0 = value [mm] as assessed in accordance with Annex C.1,
  - Lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- Specification for specimens made of UHMWPE sliding material sheets for guides:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material without dimples,
  - L × a = 200 mm × 15 mm,
  - t_p = 8 mm,
  - t_p - h_0 = 5 mm,
  - Initial lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- Number of tests: ≥ 3 per each temperature level

Test parameters and test conditions for sliding elements combined with UHMWPE sliding material are given in Table C.3.2.1.

Test specimen shall be placed in a temperature-controlled environment (e.g., climatic chamber) during the whole test that maintains the operation temperature.

Deflection of the specimen shall be continuously recorded by at least three transducers equally spaced along the perimeter of recessed backing plate. The total deflection during the period of constant loading is obtained as the average of the measures of the transducers. The decrease of the protrusion of the specimen is eventually assessed as the total deflection Δh measured during the test.

After the cyclic loading and the resting time t_r the protrusion h shall be greater than 1 mm at the pressure $0{,}33 \cdot f_k\,(T_0)$. During the short-term compression test, no cracks shall occur in the sliding material.

Table C.3.2.1: Short-term compression test conditions for UHMWPE sliding material in accordance with Figure C.3.2.1

Temperature	T	$T_{max,\ seismic}$ [1] (± 2 °C)	°C
Base contact pressure of lubricated UHMWPE sliding material	σ_p	$0{,}33 \cdot f_k(T_0)\ ^{+3}_{0}$	MPa
Preload time	t_{pl}	1 [2]	h
Maximum contact pressure of lubricated UHMWPE sliding material during cyclic loading	σ_p	$f_{k,\ s\text{-}t}\ (T_{max,\ seismic})$ [3]	MPa
Number of cycles (corresponds to No. of pressure peaks)	N	10	
Loading cycle time	t_c	$4 \le t_c \le 20$ [4]	s
Loading type		Sinusoidal or linear	
Dwell time at the end of the strokes	t_0	≤ 20	s
Resting time	t_r	1	h

[1] If requested by the manufacturer, different maximum bearing temperatures $T_{max,\ seismic}$ for the assessment of different levels of short-term compressive strength are assessed

[2] Including temperature adjustment phase

[3] To be expressed by means of a level and stated in the European Technical Assessment

[4] Depending on the maximum loading speed of the testing machine

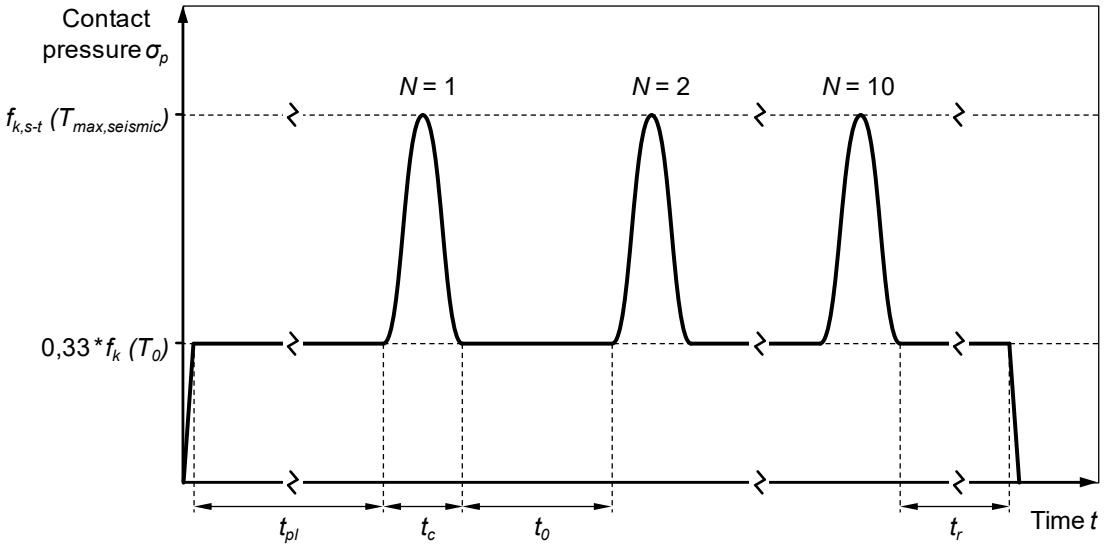

Figure C.3.2.1: Example of contact pressure profile during short-term compression test

ANNEX D: ASSESSMENT OF SLIDING BEHAVIOUR

The principles of assessing the sliding behaviour of the sliding surfaces, the terms and definitions as well as the test equipment and specimens are shown in EN 1337-2, Annex D. The friction tests shall be conducted as follows with adaptations accounting for the essential characteristics of the UHMWPE sliding material:

- General test set-up:
  - Combinations and mating surfaces in accordance with Clause 1.1, Table 1.1.1,
  - Backing plates in accordance with EN 1337-2, Clause 6.9.
- Specification for specimens made of dimpled UHMWPE sliding material:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material with dimples in accordance with EN 1337-2, Clause 5.2.3.2,
  - L = 75 mm,
  - t_p = value [mm] in accordance with Table B.1.1,
  - t_p - h_0 = value [mm] in accordance with Table B.1.1,
  - Lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- Specification for specimens made of UHMWPE sliding material sheets for guides:
  - Specimens shall be prepared from fully finished sheet of UHMWPE sliding material without dimples,
  - $L \times a$ = 200 mm × 15 mm,
  - t_p = value [mm] in accordance with Table B.1.1,
  - t_p - h_0 = value [mm] in accordance with Table B.1.1,
  - Initial lubrication in accordance with EN 1337-2, Clause 5.8 and Clause 7.4.
- The test procedure shall be carried out under the following conditions:
  - Test parameters and test conditions for sliding elements combined with UHMWPE sliding material are given in Table D.4. The temperature profile of the specimen during the long-term friction tests specified in Table D.4 is shown schematically in Figure D.1.
  - Specimens shall be placed in a temperature-controlled environment (e.g., climatic chamber on the testing machine) during the whole test that follows temperature parameters defined in Table D.4. The temperature at the specimen interface between the sliding material sheet and the mating surface shall be measured and recorded by an instrumentation system with an error < 1 ºC.
  - Loads shall be applied in accordance with Figure D.1 of EN 1337-2.
  - The fitting for the test specimen for guides with undimpled and initially lubricated UHMWPE sliding material sheets shall correspond in principle to those of composite materials as shown in EN 1337-2, Figure D.3.

Static and dynamic coefficients of friction shall be determined in accordance with EN 1337-2, Clause D.7. Examples of friction force profiles vs. sliding displacement given in EN 1337-2, Figure D.6, apply.

Test specimens with dimpled and lubricated UHMWPE sliding material for the assessment of sliding elements used in main flat sliding surfaces shall be subjected to a long-term friction test, whereas the principles of the test phases are given in Table D.1 for an example of 50 000 m total slide path.

Test specimens with dimpled and lubricated UHMWPE sliding material for the assessment of sliding elements used in curved sliding surfaces shall only be subjected to a long-term friction test that comprises a total slide path equivalent to 1/5 of the total slide path of the main flat sliding surfaces. The principles of the test phases are given in Table D.2 for an example of 10 000 m total slide path.

Table D.1: Long-term friction test programme for dimpled and lubricated flat surfaces

	Example for 50 000 m total slide path						
Phase Number	1	2	3	.....	19	20	21
Type	A_1	B	A_1	.....	A_1	B	A_1
Distance	22 m	≥ 1 000 m and ≤ 11 000 m	22 m	.....	22 m	≥ 1 000 m and ≤ 11 000 m	22 m

Undimpled and initially lubricated test specimens used for the assessment of guides shall be subjected to a long-term friction test that comprises a total slide path equivalent to 1/5 of the total slide path of the main flat sliding surfaces. The principles of the test phases are given in Table D.2 for an example of 10 000 m total slide path.

Table D.2: Long-term friction test programme for initially lubricated guides and for the main curved sliding surfaces

	Example for 10 000 m total slide path				
Phase Number	1	2	3	4	5
Type	A_1	B	A_1	B	A_1
Distance	22 m	≥ 1 000 m and ≤ 6 000 m	22 m	≥ 1 000 m and ≤ 6 000 m	22 m

If the range of operating temperature shall be extended up to a maximum temperature of T_{max}, with + 48 °C ≤ T_{max} ≤ + 80 °C, a test specimen as given above with dimpled and lubricated UHMWPE sliding material sheet shall be subjected to a high temperature programme test consisting of 3 phases in accordance with Table D.3 of this Annex.

Table D.3: High temperature friction test programme for dimpled and lubricated surfaces

	166 m total slide path				
Phase Number	1	2			3
Type	A_1	F			A_1
T [°C]	0/-10/-20/-35/-50/+35/+21	+ 21	+ T_{max} [1) 2)]	+ 21	0/-10/-20/-35/-50/+35/+21
Distance	22 m	6 m	110 m [1)]	6 m	22 m

[1)] Including heating and cooling phase
[2)] Depending on the maximum operating temperature requested by the manufacturer

The high-temperature programme test shall show the influence of high temperature during sliding movements on the change of friction behaviour. Evaluation of 166 m according to Table D.3: 50 % of 11 phases (for the long-term friction test according to Table D.1 for 50 km) of 22 m equal to rounded 122 m plus the initial and end phase of both 22 m gives 166 m. The contact pressure in phase F of the friction test is 0,33 $f_k(T)$ at T_{max} [°C] due to the respectively reduced compressive strength of the UHMWPE sliding material at high temperature.

Table D.4: Friction test conditions for UHMWPE sliding material in accordance with Figure D.1 of this Annex

Type A_1 (phase 1,3,5 ... Temperature-Programme Test) according to Figure D.1			
Contact pressure of lubricated UHMWPE sliding material	σ_p	$0{,}33 \cdot f_k(T_0)\ ^{+3}_{0}$	MPa
Temperature	*T*	0/-10/-20/-35/-50/+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*	1 100	
Sliding speed (constant)	*v*	$0{,}4\ ^{+0,1}_{0}$	mm/s
Dwell between phases	t_0	1	h
Type B (phase 2, 4, 6 ...) according to Figure D.1			
Contact pressure of lubricated UHMWPE sliding material	σ_p	$0{,}33 \cdot f_k(T_0)\ ^{+3}_{0}$	MPa
Temperature	*T*	21 ± 1	°C
Temperature gradient		0,5 ± 1,0	°C/min
Sliding distance [1)]	*s*	$8\ ^{+0,5}_{0}$	mm
Number of cycles (two strokes)	*n*	62 500 per 1 000 m slide path	
Sliding speed (constant)	v_a	15 (± 0,1)	mm/s
Type F (High-Temperature-Programme Test)			
Contact pressure of lubricated UHMWPE sliding material	σ_p	$0{,}33 \cdot f_k(T_{max})\ ^{+3}_{0}$ [2)]	MPa
Temperature	*T*	+21 / +T_{max} [2)] / +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*	300 / 5 500 [3)] / 300	
Sliding speed (constant)	*v*	$0{,}4\ ^{+0,1}_{0}$	mm/s
Dwell between phases	t_0	1	h

1) Depending on the characteristics of the testing equipment, the sliding distance S may be increased up to *s* = 40 mm, and the total number of cycles *N* arranged accordingly, in order to maintain the same total slide path of the phase.

2) Depending on the maximum operating temperature to be covered by the ETA

3) Including heating and cooling phase

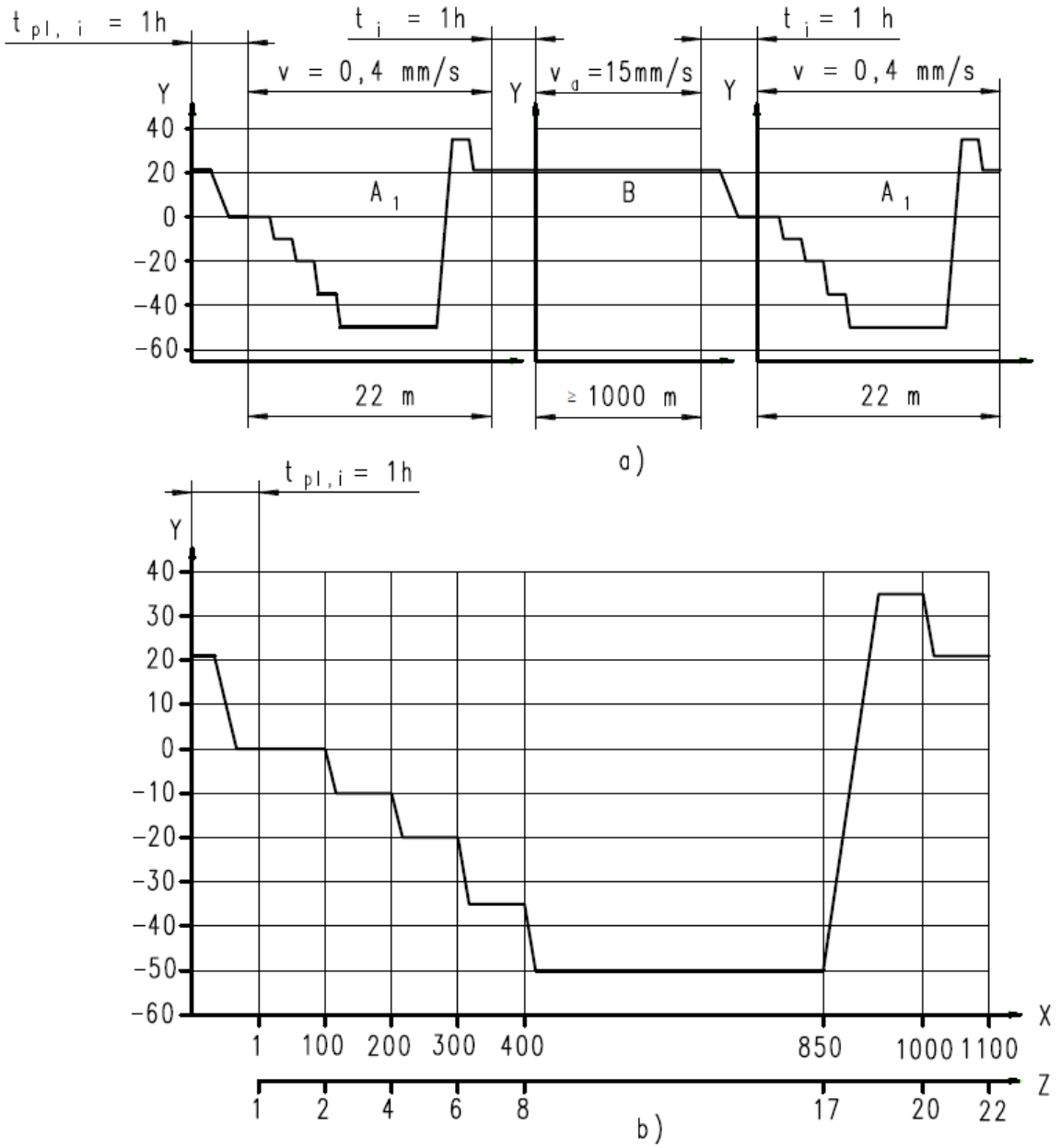

Figure D.1: a) Temperature profile of the long-term friction tests (only first 3 phases shown); b) Temperature profile of phase A_1 (Temperature-Programme-Test)

Legend for Figure D.1:
X Number of cycles *n*
Y Temperature *T* [°C]
Z Total slide path [m]

ANNEX E: WORKING LIFE OF THE CONSTRUCTION PRODUCT

The working life of structural bearings with sliding elements depends in particular on wear in the sliding surface by imposed movements combined with external loads. The durability of the sliding material is additionally affected by the sliding speed and the operating temperature.

Therefore, the singular case of intended use affects the expected working life.

Structural bearings with sliding elements made of PTFE in accordance with EN 1337-2 are to be assumed suitable at least for the minimum working life of 10 years as per Table 2.1 of EN 1990 (working life category 2).

Based on these assumptions the working life of spherical and cylindrical bearings as per Clause 1.2.2 shall be calculated as follows:

$$WL = WL_{PTFE} \cdot \frac{S_{T,D1}}{S_{T,PTFE}} \; [Years]$$

Where:

WL	Working life of spherical and cylindrical bearings with UHMWPE sliding material [years]
WL_{PTFE}	Working life of structural bearings with sliding elements made of PTFE in accordance with EN 1337-2; (WL_{PTFE} = 10 years)
$S_{T,D1}$	Total slide path of Type B phases assessed by long-term friction test in accordance with Clause 2.2.4 and Table D.1 of Annex D [m] [7]
$S_{T,PTFE}$	Total slide path of Type B phases in accordance with EN 1337-2, Table D.2; ($S_{T,PTFE}$ = 10 000 m) [7]

As example, for an assessed total slide path of $S_{T,D1}$ = 50 000 m the working life calculates to:

$$WL = WL_{PTFE} \cdot \frac{S_{T,D1}}{S_{T,PTFE}} = 10 \cdot \frac{50\,000\ \text{m}}{10\,000\ \text{m}} = 50\ \text{years}$$

[7] The comparison slide paths $S_{T,D1}$ and $S_{T,PTFE}$ shall be determined by the addition of all single “Type B” long-distance friction phases of the corresponding long-term friction test. Taking the value $S_{T,PTFE}$ in accordance with EN 1337-2, Table D.2, as an example, this calculates to $S_{T,PTFE}$ = 10 × 1000m = 10 000m.

ANNEX F: MOUNTING AND FIXING PROVISIONS AS WELL AS EXTENDED APPLICATION RULES FOR THE RELEVANT REACTION TO FIRE TESTS

F.1 Small ignition source test (EN ISO 11925-2)

F.1.1 Test specimen

The test specimen shall be prepared from fully finished sheet of UHMWPE sliding material. The specimen used in the test assembly shall include lubricant in accordance with EN 1337-2, Clause 5.8, applied in accordance with EN 1337-2, Clause 7.4.

The dimensions of the test specimens shall be as prescribed in Clause 5.2 of EN ISO 11925-2.

F.1.2 Mounting and fixing of the test assembly

The sliding material shall be mounted and fixed in accordance with EN ISO 11925-2. The flame is applied on the surface of the board, in accordance with Clause 7.3.3.1 of EN ISO 11925-2.

F.1.3 Extended applications of test results

The results of tests considering the parameters of the specimen are also valid for sliding materials:

- with less quantity of lubricant.

F.2 Single burning item test (EN 13823)

F.2.1 Dimensions of the test rig

The test rig shall consist of a corner with a short and a long wing. The nominal assembly dimensions of the specimens shall be:

	Length	Height
Short wing	500 mm	1500 mm
Long wing	1000 mm	1500 mm

F.2.2 Test specimen

The specimen used in the test assembly shall include lubricant in accordance with EN 1337-2, Clause 5.8, applied in accordance with EN 1337-2, Clause 7.4.

F.2.3 Mounting and fixing of the test assembly

The sliding material shall be fixed mechanically to a steel sheet substrate as defined in EN 13238.

F.2.4 Extended applications of test results

The results of tests considering the parameters of the specimen are also valid for sliding materials:

- with less quantity of lubricant.

ANNEX G: MECHANICAL AND PHYSICAL PROPERTIES OF THE UHMWPE SLIDING MATERIAL

G.1 General

G.1.1 Definitions

Table G.1.1.1 Definition of material properties

Property	Reference
Tensile modulus	EN ISO 527-1, Clause 3.9
Stress at yield	EN ISO 527-1, Clause 3.6.1
Stress at break	EN ISO 527-1, Clause 3.6.4
Strain at break	EN ISO 527-1, Clause 3.7.2
Strain at yield	EN ISO 527-1, Clause 3.7.1
Ball indentation hardness	EN ISO 2039-1, Clause 3.1
Mass density	EN ISO 1183-1, Clause 3.3
Melting temperature	EN ISO 11357-3, Clause 3.1
Melting enthalpy	EN ISO 11357-3, Clause 3.3

G.1.2 Test methods

Material properties of the UHMWPE sliding material shall be assessed in accordance with the methods specified in the following clauses and expressed by means of levels in accordance with Table G.1.2.1.

The test specimens shall be prepared from fully finished sheet, but without dimples, and shall be tested at + 23 °C ± 2 °C, except for the assessment of melting temperature and melting enthalpy.

Table G.1.2.1 Material properties of UHMWPE sliding material

Property	Testing standard	Result
Tensile modulus	EN ISO 527-1 and -3	Level
Stress at yield		Level
Stress at break		Level
Strain at break		Level
Ball indentation hardness	EN ISO 2039-1	Level
Mass density	EN ISO 1183-1	Level
Melting temperature and melting enthalpy	EN ISO 11357-3	Level

G.2 Tensile properties

The test for tensile modulus, stress at yield, stress at break and strain at break shall be conducted on five specimens Type 5 in accordance with Figure 2 of EN ISO 527-3. The thickness of the specimens shall be 2 mm ± 0,2 mm and the test speed shall be 50 mm/min ±10% for stress at break, strain at break and stress at yield, and 1 mm/min ±20% for tensile modulus[8]. The given tolerances of the test speeds are in accordance with EN ISO 527-1, Table 1.

G.3 Ball indentation hardness

A total of 10 ball indentation hardness tests shall be conducted using at least three specimens with a minimum of three tests per specimen; the nominal thickness of the specimens shall be at least 7 mm.

G.4 Mass density

The test shall be conducted on three specimens in accordance with EN ISO 1183-1 (method A – immersion method).

G.5 Melting temperature and melting enthalpy

The melting temperature and melting enthalpy of the sliding material shall be determined on one specimen by means of differential scanning calorimetry (DSC) in accordance with EN ISO 11357-3.

8 The speed of testing for determining the tensile modulus can be selected differently within the values of EN 527-1, Table 1. This speed shall remain the same for all measurements within the context of a European Technical Assessment.

ANNEX H: TEST METHOD OF FRICTION COEFFICIENT OF THE UHMWPE SLIDING MATERIAL

This Annex describes the test method used within the factory production control as defined in Table 3.2.1, item 2.5, in accordance with the assessment given in Annex D.

H.1 Method of assessment

To check the sliding behaviour of the UHMWPE sliding material as element of the factory production control it suffices to perform a short-term friction test with 1 phase of 22 m sliding distance of type A_1 in accordance with Annex D, Table D.4, on a specimen with dimpled and lubricated UHMWPE sliding material combined with austenitic steel.

H.2 Criteria

The coefficients of friction in each phase of short-term friction testing of phase A_1 shall not exceed the levels in accordance with to Table H.2.1.

Table H.2.1: Maximum friction coefficients in short-term tests of dimpled and lubricated UHMWPE sliding material sheets in combination with austenitic steel (pressure level: $f_k\,(T_0)\,/\,3$)

Temperature	Total slide path			
	0 to 22 m			
	$\mu_{s,1}$	$\mu_{dyn,1}$	$\mu_{s,T}$	$\mu_{dyn,T}$
− 50 °C	-	-	Level	Level
− 35 °C	-	-	Level	Level
0 °C	Level	Level	-	-

NOTE $\mu_{s,1}$ and $\mu_{dyn,1}$ are the static and dynamic coefficients of friction at the first cycle, $\mu_{s,T}$ and $\mu_{dyn,T}$ the corresponding coefficients for the relevant temperatures at subsequent cycles.
Levels to be stated in the control plan, based on results from long-term friction test according to Annex D, first phase A_1