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Elastomeric seismic-protection isolators —

Part 5:
Sliding seismic-protection isolators for buildings

Appareils d'appuis structuraux en élastomère pour protection sismique —

Partie 5: Isolateurs de protection sismique glissants pour bâtiments

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 45, *Rubber and Rubber Products*, Subcommittee SC 4, *Products (other than hoses)*.

A list of all parts in the ISO 22762 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 22762 series consists of five parts related to specifications for isolators. They are: ISO 22762-1 for test method, ISO 22762-2 for bridges, ISO 22762-3 for buildings, ISO/TS 22762-4 for guidance of ISO 22762-3, and ISO 22762-5 for elastomeric sliding isolators for buildings.

This document specifies minimum requirements and test methods for elastomeric sliding isolators used for buildings and the rubber material used in the manufacture of such isolators.

Elastomeric seismic-protection isolators —

Part 5:
Sliding seismic-protection isolators for buildings

1 Scope

This document specifies minimum requirements and test methods for flat sliding seismic-protection isolators used for buildings and the materials used in the manufacture of such isolators.

It is applicable to flat sliding seismic-protection isolators used to provide buildings with protection from earthquake damage. The sliders are each mounted on elastomeric bearings to provide vertical compliance and rotational flexibility about horizontal axes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 48-2, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 2: Hardness between 10 IRHD and 100 IRHD*

ISO 48-5, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 5: Indentation hardness by IRHD pocket meter method*

ISO 527, *Plastics — Determination of tensile properties*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 2039, *Plastics — Determination of hardness*

ISO 22762-1, *Elastomeric seismic-protection isolators — Part 1: Test methods*

3 Terms and definitions

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

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

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

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

3.1
breaking
rupture of elastomeric isolator due to compression (or tension)-shear loading

3.2
buckling
state when elastomeric isolators lose their stability under compression-shear loading

3.3
compressive properties
K_v
compressive stiffness for elastomeric sliding isolators

3.4
compression-shear testing machine
machine used to test sliding isolators, which has the capability of shear loading under constant compressive load

3.5
contact time
time from the end of subjecting the test piece to a compressive force to the start of subjecting a shear force when performing the compressive-shear test

3.6
cover rubber
rubber wrapped around the outside of inner rubber and reinforcing steel plates before or after curing of elastomeric isolators for the purposes of protecting the inner rubber from deterioration due to oxygen, ozone and other natural elements and protecting the reinforcing plates from corrosion

3.7
design compressive stress
long-term compressive force on the sliding isolator imposed by the structure

3.8
effective loaded area
area sustaining vertical load in elastomeric isolators, which corresponds to the area of reinforcing steel plates

3.9
effective width
smallest of the two side lengths of inner rubber to which direction shear displacement is not restricted

3.10
elastomeric sliding isolator
sliding isolator with rubber bearing which consists of multi-layered vulcanized rubber sheets and reinforcing steel plates

3.11
first shape factor
ratio of *effective loaded area* (3.8) to free deformation area of one inner rubber layer between steel plates

3.12
inner rubber
rubber between multi-layered steel plates inside an elastomeric isolator

3.13
maximum compressive stress
peak stress acting briefly on sliding isolators in compressive direction during an earthquake

3.14
routine test
test for quality control of the production isolators during and after manufacturing

3.15
second shape factor
⟨circular elastomeric isolator⟩ ratio of the diameter of the *inner rubber* (3.12) to the total thickness of the *inner rubber* (3.12)

3.16
second shape factor
⟨square or square elastomeric isolator⟩ ratio of the *effective width* (3.9) of the *inner rubber* (3.12) to the total thickness of the *inner rubber* (3.12)

3.17
shear properties of sliding isolators
comprehensive term that covers characteristics determined from isolator tests:

— initial shear stiffness, K_i, for elastomeric sliding isolator (3.10);

— friction coefficient, μ, for elastomeric sliding isolator (3.10).

3.18
sliding material
material which provides sliding functionality, when used as counterface to sliding plate

3.19
sliding plate
plate which provides sliding functionality

3.20
sliding friction coefficient
ratio of friction force versus normal compression force of sliding friction pair

3.21
standard value
value of isolator property defined by manufacturer based on the results of type test

3.22
structural engineer
engineer who is in charge of designing the structure for base-isolated buildings and is responsible for specifying the requirements for sliding isolators

3.23
type test
test for verification either of material properties and isolator performances during development of the product or that project design parameters are achieved

3.24
ultimate properties
properties at either *buckling* (3.2) or *breaking* (3.1) of an isolator under compression-shear loading

4 Symbols

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

Table 1 — Symbols and descriptions

Symbol	Description
A	effective plan area of elastomeric sliding isolator, excluding cover rubber portion
A_b	effective area of bolt
A_e	overlap area between the top and bottom elastomer area of isolator
A_{load}	effective loaded area of isolator

Table 1 *(continued)*

Symbol	Description
A_s	area of the sliding material
a	side length of square elastomeric isolator, excluding cover rubber thickness
a_e	length of the square isolator, including cover rubber thickness
a_f	side length of square flange
a_s	side length of square sliding material
a_{sp}	side length of square sliding plate
a'	length of the square isolator, including cover rubber thickness
B	effective width for bending of flange
c	bolt hole pitch circle diameter of on flange
D_s	diameter of sliding material
D'	outer diameter of circular isolator, including cover rubber
D_f	diameter of flange
d_i	inner diameter of reinforcing steel plate
d_k	diameter of bolt hole
d_0	outer diameter of reinforcing steel plate
E_{ap}	apparent Young's modulus of bonded rubber layer
E_c	apparent Young's modulus corrected, if necessary, by allowing for compressibility
$E_c{}^s$	apparent Young’s modulus corrected for bulk compressibility depending on its shape factor (S_1)
E_∞	bulk modulus of rubber
E_0	Young's modulus of rubber
G	shear modulus
$G_{eq}(\gamma)$	equivalent linear shear modulus at shear strain
H	height of sliding isolator, including mounting flange
H_n	height of sliding isolator, excluding mounting flange
K_i	initial shear stiffness
K_v	compressive stiffness
L_f	length of one side of a square flange
M	resistance to rotation
M_f	moment acting on bolt
M_r	moment acting on isolator
n	number of rubber layers
n_b	number of fixing bolts
P	compressive force
P_0	design compressive force in absence of seismic action effects
P_{max}	maximum compressive force including seismic action effects
P_{min}	minimum compressive force including seismic actions effects
Q	shear force
Q_b	shear force at break
Q_{buk}	shear force at buckling
Q_d	characteristic strength
S_1	first shape factor
S_2	second shape factor
T	temperature

Table 1 *(continued)*

Symbol	Description
T_0	standard temperature, 23 °C or 27 °C; where specified tolerance is ±2 °C, T_0 is standard laboratory temperature
T_r	total rubber thickness, given by $T_r = n \times t_r$
t_r	thickness of one rubber layer
t_{r1}, t_{r2}	thickness of rubber layer laminated on each side of plate
t_s	thickness of one reinforcing steel plate
t_{sm}	protruding length of sliding material
t_0	thickness of outside cover rubber
$U(\gamma)$	function giving ratio of characteristic strength to maximum shear force of a loop
V	uplift force
v	loading velocity
v_0	design horizontal velocity
v_{nom}	for building: nominal horizontal velocity recommended by manufacturer
W_d	energy dissipated per cycle
X	shear displacement
X_0	design shear displacement
X_b	shear displacement at break
X_{buk}	shear displacement at buckling
X_s	shear displacement due to quasi-static shear movement
X_{max}	maximum shear displacement
X_d	shear displacement due to dynamic shear movement
Y	compressive displacement
Z	section modulus of flange
α	coefficient of linear thermal expansion
γ	shear strain of laminated rubber
γ_b	shear strain at break of laminated rubber
γ_c	local shear strain due to compressive force of laminated rubber
γ_r	local shear strain due to rotation of laminated rubber
γ_u	ultimate shear strain of laminated rubber
δ_H	horizontal offset of isolator
δ_v	difference in isolator height measured between two points at opposite extremes of the isolator
ε	compressive strain of laminated rubber
ε_{cr}	creep strain
ζ	ratio of total height of rubber and steel layers to total rubber height
θ	rotation angle of isolator about the diameter of a circular bearing or about an axis through a square bearing
λ	correction factor for calculation of stress in reinforcing steel plates
η	correction factor for calculation of critical stress
κ	correction factor for apparent Young's modulus according to hardness
$\Sigma\gamma$	total local shear strain
ρ_R	safety factor for roll-out
σ	compressive stress in isolator
σ_0	design compressive stress
σ_B	tensile stress in bolt

Table 1 *(continued)*

Symbol	Description
σ_{b}	bending stress in flange
σ_{bf}	allowable bending stress in steel
σ_{cr}	critical stress in isolator
σ_{f}	allowable tensile stress in steel
σ_{max}	maximum compressive stress
σ_{min}	minimum compressive stress
σ_{nom}	nominal long-term compressive stress recommended by manufacturer for building
σ_{r}	compressive stress in laminated rubber
σ_{s}	tensile stress in reinforcing steel plate
σ_{sa}	allowable tensile stress in steel plate
σ_{sm}	compressive stress in sliding material
σ_{sm0}	design compressive stress in sliding material
$\sigma_{sm,max}$	maximum compressive stress in sliding material
$\sigma_{sm,min}$	minimum compressive stress in sliding material
$\sigma_{sm,nom}$	for building: nominal long-term compressive stress in sliding material recommended by manufacturer
σ_{sy}	yield stress of steel for flanges and reinforcing steel plates
σ_{su}	tensile strength of steel for flanges and reinforcing steel plates
t_{b}	shear stress in bolt
τ_{f}	allowable shear stress in steel
ϕ	factor for computation of buckling stability
ξ	factor for computation of critical stress
μ	friction coefficient

5 Classification

5.1 Isolator types

Sliding isolators are classified by performance, sliding friction coefficient and shape.

5.2 Classification by sliding friction coefficient

Sliding isolators are classified as the following three types by sliding friction coefficient:

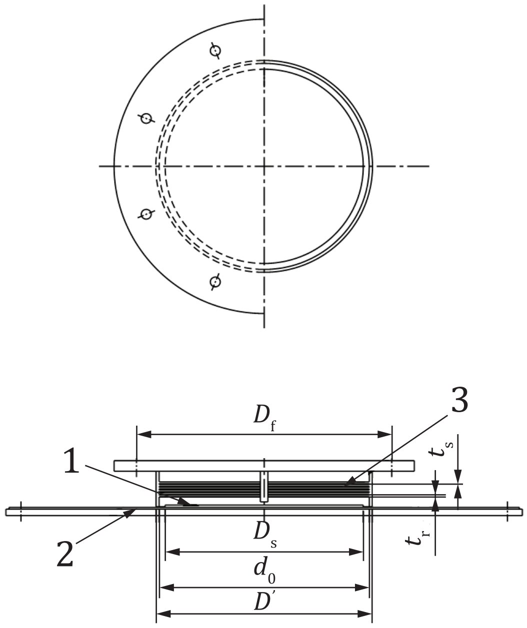
— low-friction sliding isolator: $\mu < 0{,}015$;

— intermediate-friction sliding isolator: $0{,}015 \leq \mu < 0{,}09$;

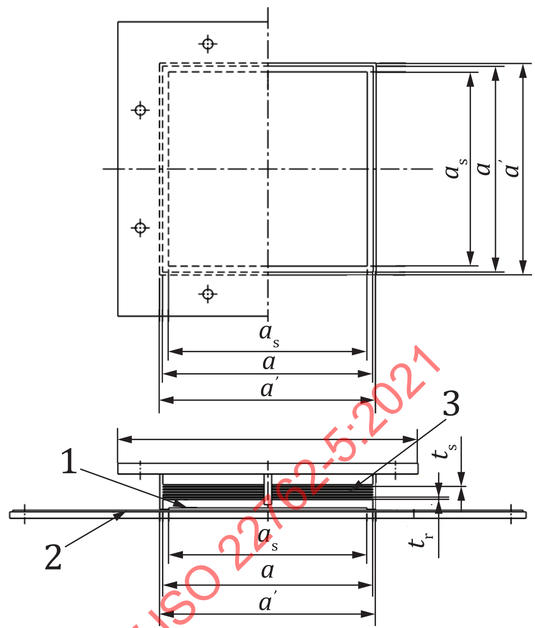
— high-friction sliding isolator: $0{,}09 \leq \mu$.

5.3 Cross-section of isolator

A typical cross-section of the isolator is given in Figure 1.



a) Circular type



b) Square type

Elastomeric sliding isolator

Key

1 sliding material
2 sliding plate
3 laminated rubber

Figure 1 — Cross-section of isolator

6 Requirements

6.1 General

Sliding isolators for buildings and the materials used in manufacture shall meet the requirements specified in this clause. For test items (see Table 2) that have no specific required values, the manufacturer shall define the values and inform the purchaser prior to production.

The standard temperature for determining the properties of elastomeric isolators is 23 °C or 27 °C in accordance with prevailing International Standards. However, it is advisable to establish a range of working temperatures taking into consideration actual environmental temperatures and possible changes in temperatures at the work site where the elastomeric isolators are installed.

NOTE Some of these properties can be determined using one of the standard test pieces detailed in Table 3 and Table 4. The standard test piece is used for non-specific product testing, such as testing for the development of new materials and products.

Table 2 — Test pieces for type testing of elastic sliding bearings

Properties	Test item	Test piece	
		Scale	Minimum number
Compressive properties	Compressive stiffness	Full-scale only	3
Shear properties	Shear stiffness Friction coefficient	Full-scale only	3
Dependency of shear properties	Compressive stress dependency	Full-scale only	3
	Velocity dependency	Scale A, STD-S	3
	Repeated loading dependency	Scale A	3
	Temperature dependency	Scale A, STD-R, SBS	3
	Vertical loading time dependency	Scale A, STD-S	2
Dependency of compressive properties	Compressive stress dependency	Scale B	3
Ultimate properties	Ultimate horizontal displacement	Scale B	3
	Ultimate compressive load	Scale B	3
Durability	Ageing	Scale A, STD-R, SBS	2
	Creep	Scale A	2

Scale A: Scaling such that, for a circular bearing, diameter of reinforcing steel plates ≥150 mm, for a square bearing, side length reinforcing steel plates ≥100 mm and, for both types, rubber layer thickness ≥1,5 mm and thickness of reinforcing steel plates ≥0,5 mm.

Scale B: Scaling such that, for a circular bearing, diameter reinforcing steel plates ≥400 mm, for a square bearing, side length reinforcing steel plates ≥400 mm and, for both types, rubber layer thickness ≥1,5 mm and thickness of reinforcing steel plates ≥0,5 mm. Minimum scale factor 0.5.

STD-S = standard test piece for sliding material and sliding plate (see Table 3).

STD-R = standard test piece for laminated rubber (see Table 4).

SBS = shear-block test piece specified in ISO 22762-1:2018, 5.8.3.

Table 3 — Standard test piece for sliding material and sliding plate

Item		Circle			Square		
Sliding material outer diameter, mm	D_s	150	250	400	—	—	—
Sliding material side length, mm	$a_s \times a_s$	—	—	—	100 × 100	240 × 240	400 × 400
Protruding length of sliding material, mm	t_{sm} [a]	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4
Sliding plate side length, mm	$a_{sp} \times a_{sp}$	400 × 400	650 × 650	1 200 × 1 200	400 × 400	650 × 650	1 200 × 1 200

NOTE Size of sliding plate should be decided by considering a displacement amplitude in the test.

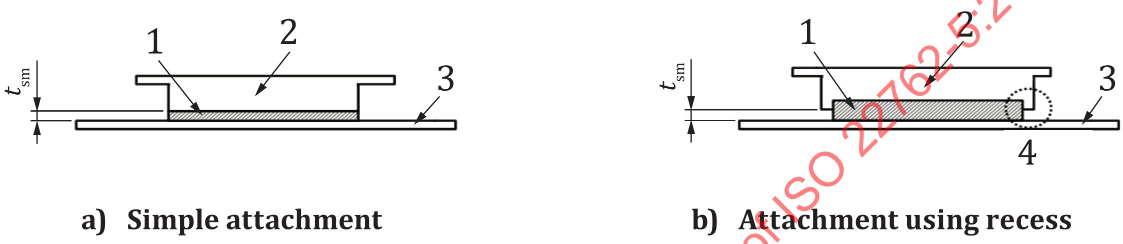
[a] t_{sm} is apparent thickness (see Figure 2).

Table 4 — Standard test piece for laminated rubber

Item		Circle			Square		
Reinforcing steel plate outer diameter, mm	d_0	150	250	400	—	—	—
Reinforcing steel plate side length, mm	$a \times a$	—	—	—	100 × 100	240 × 240	400 × 400
Reinforcing steel plate inner diameter, mm	d_i	7,5	12,5	25	7,5	12,5	25

Table 4 *(continued)*

Item		Circle			Square		
Thickness of a single reinforcing steel plate, mm	t_s	1 to 2	2 to 3	3 to 4	1 to 2	2 to 3	3 to 4
Thickness of a single rubber layer, mm	t_r	1,5	2,0	4,0	1,5	2,0	4,0
Number of rubber layers	n	20	25	25	20	25	25
Thickness of outside cover rubber, mm	t_0	4	6	8	4	6	8



Key

1 sliding material

2 steel body

3 sliding plate

4 recess

Figure 2 — Attachment method of sliding material and steel body

6.2 Type tests and routine tests

6.2.1 Testing to be carried out on sliding isolators is classified into “type tests” and “routine tests”.

6.2.2 Type tests shall be conducted either to ensure that project design parameters have been achieved (in which case the test results shall be submitted to the structural engineer for review prior to production) or to verify isolator performance and material properties during development of the product. The test piece for each type test shall be full-scale or one of the options specified in Table 3 and Table 4. The test piece shall not have been subjected to any previous test programme.

6.2.3 Previous type test results may be substituted, provided the following conditions are met.

a) Isolators are fabricated in a similar manner and from the same compound and adhesive.

b) All corresponding external and internal dimensions are within 10 % of each other. Flange plates are excluded.

c) First and second shape factors are equal to or larger than those in previous tests.

d) The test conditions, such as maximum and minimum vertical load applied in the ultimate property test (see 7.4), are more severe.

Routine tests are carried out during production for quality control. Sampling is allowed for routine testing for projects with agreement between structural engineer and manufacturer. Sampling shall be conducted randomly and cover not less than 20 % of the production of any isolator design. For a given project, tests shall cover not less than four test pieces for each size and not less than 20 test pieces in total.

6.3 Functional requirements

Sliding isolators for buildings are designed and manufactured to have the performance characteristics required so that they slide (and deform, if required) in all directions with the proper friction force (and stiffness, if required) during an earthquake.

In the application of sliding isolators, attention shall be paid to the following points.

a) The isolators shall be installed horizontally between the structure and foundation.

b) Once installed, the isolators shall not be subjected to a constant shear force.

c) The rotation at the top of the isolator caused by bending deformation shall be carefully considered.

d) Exposed steel surfaces, such as the surfaces of mounting flanges, shall be properly painted or galvanized to prevent rusting.

e) Proper maintenance shall be carried out on installed isolators to prevent any abnormalities such as distortion, cracks or rust occurring.

f) Fire protection of the isolators may be required.

g) The seismic gap shall be maintained at all times.

h) Contamination-covers on sliding plates may be required, in case of installing them on foundation side.

6.4 Design compressive force and design horizontal velocity

6.4.1 The design stress of sliding material and laminated rubber bearing are defined by Formulae (1) and (2) with the design force:

$$\sigma_{sm0} = \frac{P_0}{A_s}, \sigma_{sm,max} = \frac{P_{max}}{A_s}, \sigma_{sm,min} = \frac{P_{min}}{A_s} \quad (1)$$

$$\sigma_0 = \frac{P_0}{A}, \sigma_{max} = \frac{P_{max}}{A}, \sigma_{min} = \frac{P_{min}}{A} \quad (2)$$

6.4.2 The design compressive forces, P_0, and maximum and minimum compressive forces, respectively P_{max} and P_{min}, and the design horizontal velocity, v_o, for an isolator shall be provided by the structural engineer. If the P_0, P_{max}, P_{min} and v_o are not known at the time of type testing, the design stress and design horizontal velocity to be used for testing can be determined as given by Formulae (3) and (4):

$$\sigma_{sm0} = \sigma_{sm,nom}, \sigma_{sm,max} = 2 \cdot \sigma_{sm,nom} \quad (3)$$

$$v_0 = v_{nom} \quad (4)$$

where

$\sigma_{sm,nom}$ and v_{nom} are determined by the manufacturer.

6.5 Performance requirements

6.5.1 General

The sliding isolators shall be tested and the results recorded using the specified test methods. They shall satisfy all of the requirements listed below. The test items are summarized in Table 5, which indicates those type tests that are optional, where a material test piece may substitute an isolator, and the tests to be performed as routine tests. The standard value obtained from the tests shall be reported.

Table 5 — Tests on elastomeric sliding isolators

Property	Test item	Test method	Routine test	Type test
Compressive properties	Compressive stiffness	7.2.1	X	X
Shear properties	Shear stiffness Friction coefficient	7.2.2	X	X
Dependency of shear properties	Compressive stress dependency	7.3.1	N/A	X
	Velocity dependency	7.3.2	N/A	X(m)
	Repeated loading dependency	7.3.3	N/A	X
	Temperature dependency	7.3.4	N/A	X(m)
	Vertical loading time dependency	7.3.5	N/A	Opt.
Dependency of compressive properties	Compressive stress dependency	7.3.6	N/A	Opt.
Ultimate property	Ultimate horizontal displacement	7.4	N/A	X
	Ultimate compressive load	7.4	N/A	X
Durability	Property change	7.5.1	N/A	X(m)
	Creep	7.5.2	N/A	X

X = test to be conducted with isolators

X(m) = test can be conducted either with isolators, with standard test pieces for sliding material and sliding plate, with standard test pieces for laminated rubber or with shear-block test pieces of rubber.

N/A = not applicable

Opt. = optional. The structural engineer can request that any optional test has to be carried out.

6.5.2 Tolerance on properties

The compressive stiffness, K_v, shall be within ±30 % of the design value.

The initial shear stiffness, K_i, shall be within ±30 % of the design value.

The friction coefficient, μ, shall be within ±50 % of the design value in the case of low-friction sliding isolator.

The friction coefficient, μ, shall be within ±40 % of the design value in the case of intermediate-friction sliding isolator.

The friction coefficient, μ, shall be within ±30 % of the design value in the case of high-friction sliding isolator.

6.6 Rubber material

6.6.1 Requirements

The reference values of rubber materials used for the elastomeric sliding isolators are specified for performance items in Table 6. However, the test piece used for the rubber materials test shall be manufactured from the unvulcanized rubber material collected in the manufacturing process of the elastomeric seismic sliding isolators. Also, the ozone resistance of the cover rubber shall be no cracks on when tested according to ISO 1431-1 (ozone resistance test).

In addition to the reference values of the rubber material shall be satisfied the required performance shown in Table 6.

Table 6 — Required performance of rubber material

Property	Required item		Inner rubber NR	Inner rubber CR	Test method
Tensile properties	Tensile strength MPa		≥11	≥11	ISO 22762-1:2018, 5.3
	Elongation at break %		≥550	≥400	
	100 % modulus	Tolerance %	±40	N/A	
Hardness	Hardness	Tolerance IRHD	±5	±5	ISO 22762-1:2018, 5.5

6.7 Sliding material

6.7.1 Requirements

The reference values of the sliding materials used for the sliding isolators are determined for the performance item indicating the characteristics of each sliding material. However, the test pieces used for the sliding material test shall be manufactured from the sliding material collected during the sliding material manufacturing process.

Oil, grease, or lubricant shall only be used for low-friction sliding isolators. Their durability shall be verified.

Dimples shall only be allowed with lubricants for low-friction sliding isolators.

Required properties for sliding material are shown in Table 7.

Table 7 — Required properties of sliding material

Property	Required item		PTFE	Modified ultra-high molecular weight polyethylene	Filled PTFE	Polyamide
Density	Density Mg/m^3		2,13 to 2,19	0,93 to 0,98	1,80 to 2,80	1,00 to 1,50
Tensile properties	Tensile strength MPa		≥20	≥30	≥6	≥50
	Elongation at break %		≥200	≥250	≥70	≥2
Hardness	Hardness	HRR	≥23	≥26	≥25	≥70
		HDD	≥54	N/A	N/A	N/A
HRR (Rockwell hardness of plastics using the Rockwell R hardness scales) specified in ISO 2039-2:1987.						
HDD (hardness by means of a durometer of type D) specified in ISO 868:2003.						

6.7.2 Sliding materials tests

For the sliding materials used for the sliding bearings, their strength for vertical load bearing performance, and hardness shall be properly measured.

6.7.2.1 Tensile property tests

The tensile properties tests shall be in accordance with ISO 527. However, the test pieces shall be in accordance with ISO 22762-1.

6.7.2.2 Hardness test

The hardness test shall be in accordance with ISO 2039 or ISO 868.

6.8 Requirements on steel used for flanges, connecting flanges, key plates, steel plates, backing plates, sliding plates and base plates

Materials for flanges, connecting flanges, key plates, steel plates, backing plates, sliding plates and base plates are as shown in Table 8.

Table 8 — Materials for flanges, connecting flanges, key plates, steel plates, backing plates, sliding plates and base plates

Material	Application ISO	Designation
flange, connecting flange, key plate	ISO 630	S235 or SS400
	ISO 630	SM490A
	ISO 630	SN400 or SN490
steel plate	ISO 630	S235 or SS400
backing plate	ISO 630	S235 or SS400
sliding plate	ISO 16143-1	SUS304(X5CrNi18–10) or SUS316(X5CrNiMo17–12–2)
base plate	ISO 630	S235 or SS400

The surface of the sliding plate may be coated with fluororesin coating. For low-friction sliding isolator, oil, grease, or lubricant may be adopted to reduce the friction of the sliding plate. Their durability shall be verified.

7 Isolator tests

7.1 General

The isolators shall be tested and the results recorded using the specified test methods. They shall satisfy all of the requirements listed below. The test items are summarized in Table 5, which indicates those type tests that are optional, where a material test piece may substitute an isolator, and the tests to be performed as routine tests. The standard value obtained from the tests shall be reported.

7.2 Compression, shear stiffness and friction coefficient tests

7.2.1 Compression properties

The compression properties test shall be as specified in ISO 22762-1.

7.2.2 Compressive-shear test

7.2.2.1 Principle

A test piece is loaded with a constant compressive force and subjected to a shear displacement. Shear force, shear displacement, compressive force and compressive displacement are measured. From the measured data, shear properties (shear stiffness (before sliding occur) and friction coefficient) are determined.

The test as described in 7.2.2.2 to 7.2.2.7 shall be the type and routine tests.

7.2.2.2 Test machine

7.2.2.2.1 General

As specified in ISO 22762-1:2018, 6.2.2.2.1.

7.2.2.2.2 Force correction

The force correction shall be as specified in ISO 22762-1:2018, 6.2.2.2.2.

7.2.2.3 Test piece

The test piece shall be as specified in Table 2.

7.2.2.4 Test conditions

7.2.2.4.1 Test temperature

As specified in ISO 22762-1.

7.2.2.4.2 Conditioning time for test piece

As specified in ISO 22762-1.

7.2.2.4.3 Compressive force

Load the test piece with a compressive force that is equivalent to the design compressive stress or the pressure that has been agreed to by the structural engineer. The average compressive force applied shall be within ±5 % of that required during the test.

7.2.2.4.4 Test shear displacement amplitude

The test shear displacement amplitude shall be chosen so that shear force is larger than maximum static friction force. The shear displacement amplitude shall be chosen to ensure the occurrence of the sliding. And the shear displacement amplitude shall be chosen so that sliding of the isolator occurs at the points where the test loop crosses the shear-force axis. The tolerance shall be within ±5 % of the target shear displacement amplitude.

7.2.2.4.5 Input wave

The input wave shall be a sine wave or a triangular wave. If the shear properties are influenced by the input wave, it shall be selected with the agreement of both the structural engineer and the manufacturer.

7.2.2.4.6 Test vibration velocity

The standard test vibration velocity shall be selected from Table 9. When the input wave is sine wave, the maximum velocity of the wave shall be selected from Table 9. When any other velocity is used, it shall be selected with the agreement of both the structural engineer and the manufacturer.

Table 9 — Test velocity

Velocity mm/s	5	10	50	100	200	400	600	800	1 000

7.2.2.5 Procedure

7.2.2.5.1 Attachment of a test piece

The test piece shall be attached to the test machine by the same or a mechanically equivalent manner as in the actual application.

7.2.2.5.2 Loading

The test piece should be loaded as follows:

a) Load the test piece with constant compressive force for 1 min or more.

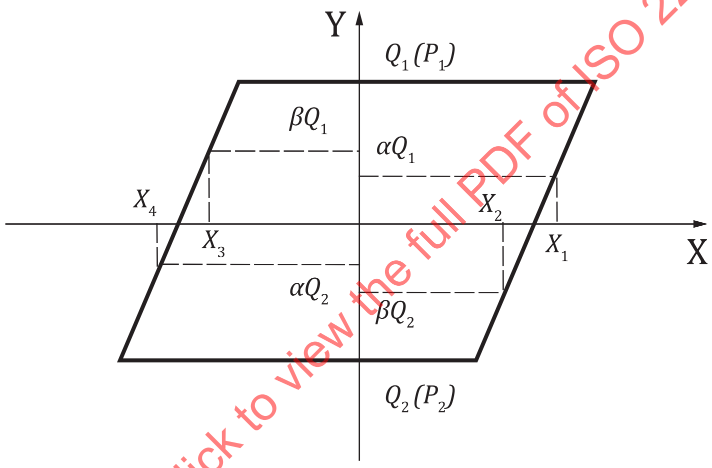
b) Load the test piece with 3 or more cycles of the reference shear displacement. The number of cycles shall be specified by the structural engineer.

7.2.2.6 Expression of results

The method used to determine shear properties shall be specified and reported.

The following method describes how to obtain shear properties from one hysteresis loop. The structural engineer shall specify how the shear properties of the isolator are to be calculated. Generally, the third loop is used.

An example of a typical hysteresis loop of a sliding isolator is shown in Figure 3.



Key

X shear displacement, *X*

Y shear force, *Q*

Figure 3 — Determination of shear stiffness for sliding isolator

Shear stiffness, K_i, frictional coefficient, μ, are given by Formulae (5) and (6):

$$K_i = \frac{1}{2} \times \left(\frac{\alpha Q_1 - \beta Q_2}{X_1 - X_2} + \frac{\alpha Q_2 - \beta Q_1}{X_4 - X_3} \right) \quad (5)$$

$$\mu = \frac{1}{2} \times \left(\frac{Q_1}{P_1} + \frac{Q_2}{P_2} \right) \quad (6)$$

where

X_1, X_2, X_3, X_4 are the force at displacement where shear force are $\alpha Q_{1,}$ $\beta Q_{2,}$ $\beta Q_{1,}$ αQ_2;

Q_1, Q_2 are the points where the loop crosses the shear-force axis, on the positive and the negative side, respectively;

P_1, P_2 are the compressive force at the same time of Q_1 or Q_2;

α are set in the range of 1 from 0 by the manufacturer;

β are set in the range of 1 from 0 by the manufacturer.

7.2.2.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration velocity;

f) direction of shear force applied to test piece;

g) compressive stress and shear displacement amplitude;

h) contact time; essential parameters, such as shear stiffness, friction coefficient, method of determination (e.g. the third loop);

i) plot of shear force versus shear displacement (hysteresis loop) for all cycles including initial shear loading;

j) test date.

7.3 Various dependence tests

7.3.1 Compressive force dependence of shear properties

7.3.1.1 Principle

A test piece is attached to a compression-shear testing machine and subjected to multiple levels of constant compressive force. In this state, the test piece is subjected to shear displacement. The shear force, the shear displacement, the compressive force and the compressive displacement are measured. The shear properties such as shear stiffness and friction coefficient are evaluated and their dependence on the compressive force (compressive stress) determined.

NOTE If the results of the repeated cycling test (7.3.3) show significant changes in the shear properties then the results obtained in 7.3.1 may not reflect just the effect of compressive stress dependency.

7.3.1.2 Test machine

7.3.1.2.1 General

As specified in ISO 22762-1:2018, 6.2.2.2.1.

7.3.1.2.2 Force correction

The force correction shall be as specified in ISO 22762-1:2018, 6.2.2.2.2.

7.3.1.3 Test piece

The test piece shall be as specified in Table 2.

7.3.1.4 Test conditions

7.3.1.4.1 Test temperature

As in ISO 22762-1.

7.3.1.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.3.1.4.3 Compressive force

The levels of compressive force, if required, shall be selected by the structural engineer in accordance with the specifications for the isolator.

Table 10 — Test compressive stress

compressive stress	0,5 σ_0	1,0 σ_0	2,0 σ_0

The tolerance shall be within ±5 % of each compressive stress.

7.3.1.4.4 Test shear displacement amplitude

As in 7.2.2.4.4.

7.3.1.4.5 Input wave

As in 7.2.2.4.5.

7.3.1.4.6 Test vibration velocity

As in 7.2.2.4.6.

7.3.1.5 Procedure

7.3.1.5.1 Attachment of a test piece

The test piece shall be attached to a compression-shear testing machine as specified in ISO 22762-1.

7.3.1.5.2 Loading of test piece

The test piece shall be loaded as follows:

a) Subject the test piece to the selected test compressive force, in each case beginning at zero force. The selected test compressive forces shall be in order of increasing magnitude.

b) Apply each test compressive force for 1 min or more, before loading the test piece with 3 or more cycles of shear displacement. The number of cycles shall be as specified by the structural engineer.

7.3.1.6 Expression of results

With the method used in 7.2.2.6, determine each property value for each test compressive stress.

7.3.1.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration velocity;

f) direction of shear force applied to test piece;

g) compressive stress and shear displacement amplitude;

h) contact time;

i) essential parameters such as shear stiffness, equivalent damping ratio, method of determination (e.g. the third loop) at each compressive stress;

j) graph showing relationship between each property and compressive stress;

k) plot of shear force versus shear displacement (hysteresis loop) for all cycles including initial shear loading;

l) test date.

7.3.2 Velocity dependence of shear properties

7.3.2.1 Principle

A test piece is attached to a compression-shear testing machine and subjected to constant compressive force. In this state, the test piece is subjected to shear displacement at multiple levels of velocities. The shear force, the shear displacement, the compressive force and the compressive displacement are measured. The shear properties, such as shear stiffness and equivalent damping ratio, are evaluated and their dependence on the velocity determined.

NOTE If the results of the repeated cycling test (7.3.3) show significant changes in the shear properties, there is a possibility that the results obtained in 7.3.2 does not reflect just the effect of shear velocity dependency.

7.3.2.2 Test machine

7.3.2.2.1 General

As specified in ISO 22762-1:2018, 6.2.2.2.1.

7.3.2.2.2 Force correction

The force correction shall be as specified in ISO 22762-1:2018, 6.2.2.2.2.

7.3.2.3 Test piece

The test piece shall be as specified in Table 2.

7.3.2.4 Test conditions

7.3.2.4.1 Test temperature

As in ISO 22762-1.

7.3.2.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.3.2.4.3 Compressive force

As in 7.2.2.4.3.

7.3.2.4.4 Test shear displacement amplitude

As in 7.2.2.4.4.

7.3.2.4.5 Input wave

As in 7.2.2.4.5.

7.3.2.4.6 Test vibration velocity

Several test vibration velocity shall be selected from the nine levels shown in Table 9.

When the input wave is sine wave, the maximum velocity of the wave shall be selected from the nine levels shown in Table 9.

Testing at the design isolation velocity may be added to the conditions.

7.3.2.5 Procedure

7.3.2.5.1 Attachment of a test piece

The test piece shall be attached to a compression-shear testing machine as specified in 7.2.2.2, except that any suitable connection system is permitted when a shear block or standard test piece is used.

7.3.2.5.2 Loading of test piece

The test piece shall be loaded as follows:

a) Subject the test piece to a compressive force, if required, that is equivalent to the design compressive stress, σ_0, as defined in 6.4 for 1 min or more.

b) Load the test piece with 3 or more cycles of shear displacement amplitude, for each velocity selected in 7.2.2.4.6. The velocity shall be applied in increasing order. The number of cycles shall be as specified by the structural engineer.

7.3.2.6 Expression of results

With the method used in 7.2.2.6, determine each property value for each vibration velocity.

The rate of change of each property shall be determined as the ratio of each value to that at the reference velocity. The reference velocity shall be one of the speeds selected in 7.3.2.4.6 or the design isolation velocity.

7.3.2.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration frequency;

f) direction of shear force applied to test piece;

g) compressive stress and shear displacement;

h) shear displacement amplitude;

i) contact time;

j) essential parameters such as shear stiffness, friction coefficient, method of determination (e.g. the third loop) at each frequency;

k) graph showing relationship between the rate of change of each property and the vibration velocity;

l) graph showing relationship between compressive force and shear displacement, if requested;

m) plot of shear force versus shear displacement (hysteresis loop) for all cycles including initial shear loading;

n) test date.

7.3.3 Repeated deformation dependence of shear properties

7.3.3.1 Principle

A test piece is attached to a compression-shear testing machine and loaded with a constant compressive force. In this state, the test piece is subjected to 50 cycles of shear displacement, or for a number of cycles specified by the structural engineer. The shear force and the shear displacement are measured. The shear properties, such as shear stiffness and friction coefficient, are evaluated and their dependence on the number of repetitions determined.

In order to differentiate between the change in properties due to temperature rise and that due to repeated deformation, the test piece is cooled down to the initial pre-load temperature after the repeated cycles of deformation. The shear properties are then evaluated again.

7.3.3.2 Test machine

7.3.3.2.1 General

As specified in of ISO 22762-1:2018, 6.2.2.2.1.

7.3.3.2.2 Force correction

The force correction shall be as specified in of ISO 22762-1:2018, 6.2.2.2.2.

7.3.3.3 Test piece

The test piece shall be as specified in Table 2.

7.3.3.4 Test conditions

7.3.3.4.1 Test temperature

As in ISO 22762-1.

7.3.3.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.3.3.4.3 Compressive force

As in 7.2.2.4.3.

7.3.3.4.4 Test shear displacement amplitude

As in 7.2.2.4.4.

7.3.3.4.5 Input wave

As in 7.2.2.4.5.

7.3.3.4.6 Test vibration velocity

As in 7.2.2.4.6, but greater than 100 mm/s.

7.3.3.5 Procedure

7.3.3.5.1 Attachment of a test piece

The test piece shall be attached to a compression-shear testing machine as specified in 7.2.2.2.

7.3.3.5.2 Loading of test piece

The test piece shall be loaded as follows:

a) Subject the test piece to a compressive force that is equivalent to the design compressive stress, σ_0, as defined in 6.4 for 1 min or more.

b) Subject the test piece with the specified number of 50 cycles or 50 m total distance of shear displacement.

c) After completion, cool the test piece down to the initial pre-load temperature. Then, load the test piece again with 3 or more cycles under the same conditions. The number of cycles shall be as specified by the structural engineer.

7.3.3.6 Expression of results

With the method used in 7.2.2.6, determine each property value from the 1st, 3rd, 5th, 10th, 30th and 50th cycle or as specified by the structural engineer. Determine the reference value of the property from the first 3 cycles in accordance with 7.2.2. Determine the change in properties after the repeated cycling from the 3 cycles of loading executed at the end of the test or as specified by the structural engineer.

The change in each property shall be expressed as the ratio of each value to the reference value.

7.3.3.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration velocity;

f) direction of shear force applied to test piece;

g) compressive stress and shear displacement amplitude;

h) contact time;

i) properties, such as shear stiffness and equivalent damping ratio, at each cycle for which they were determined;

j) change in each property with cycling;

k) graph showing relationship between the rate of change of each property and the number of repetitions;

l) graph showing relationship between compressive force and shear displacement, if requested;

m) plots of shear force versus shear displacement (hysteresis loop);

n) test date.

7.3.4 Temperature dependence of shear properties

7.3.4.1 Principle

The test piece is attached to a compression-shear testing machine. The test piece is subjected to constant compressive force. In this state, the test piece is subjected to repeated shear displacement. The shear force and the shear displacement are measured. The shear properties, such as shear stiffness, are evaluated and their dependence on the change in environmental temperature determined.

The temperature test specified in ISO 22762-1:2018, 5.8.4.1, may be substituted for this test, with the agreement of both the structural engineer and the manufacturer.

7.3.4.2 Test machine

7.3.4.2.1 General

As specified in ISO 22762-1:2018, 6.2.2.2.1.

7.3.4.2.2 Force correction

The force correction shall be as specified in ISO 22762-1:2018, 6.2.2.2.2.

7.3.4.3 Test piece

The test piece shall be as specified in Table 2.

7.3.4.4 Test conditions

7.3.4.4.1 Test temperature

The tests shall be conducted at the test temperatures defined in Table 11. The reference temperature shall be set at 23 °C or 27 °C. The tolerance shall be within ±2 °C. Test temperatures shall at least cover the range of service requirements. When considering the test for a cold district, the test shall be conducted at a temperature lower than −20 °C. Tests shall be conducted in order of decreasing temperature.

If the machine is not equipped with a suitable temperature-controlled chamber, the test piece shall have reached the test temperature in a separate chamber, and shall be transferred to the test machine sufficiently quickly for the test to be conducted while the outside of the bearing satisfies the temperature tolerance of ±2 °C. The length of time for keeping a test piece at a specific temperature shall be less than that for crystallization nucleation.

Table 11 — Test temperatures

Temperature °C	−20	−10	0	23 (or 27)	40

NOTE Isolators fabricated from elastomer susceptible to low-temperature crystallization might show an additional time-dependent stiffening if held for a prolonged period at low temperature.

7.3.4.4.2 Conditioning time for test piece

The test piece shall be conditioned as specified in ISO 22762-1:2018, 6.2.1.4.2, in a temperature-controlled environment.

7.3.4.4.3 Compressive force

As in 7.2.2.4.3 for 1 min or more.

7.3.4.4.4 Test shear displacement amplitude

As in ISO 22762-1.

7.3.4.4.5 Input wave

As in ISO 22762-1.

7.3.4.4.6 Test vibration velocity

As in ISO 22762-1.

7.3.4.5 Procedure

7.3.4.5.1 Attachment of a test piece

As in ISO 22762-1.

7.3.4.5.2 Loading of test piece

As in 7.2.2.5.2.

7.3.4.6 Expression of results

The dependence of each property, determined by the method used in ISO 22762-1:2018, 6.2.2.6, on the temperature shall be reported.

7.3.4.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22672-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration frequency;

f) direction of shear force applied to test piece;

g) compressive force and shear displacement amplitude (or compressive stress and shear strain);

h) contact time;

i) essential parameters such as shear stiffness, equivalent damping ratio, method of determination (e.g. the third loop) at each temperature;

j) fractional change in each property relative to its value at the reference temperature;

k) graph showing relationship between the normalized value of each property and temperature;

l) graph showing relationship between compressive force and shear displacement, if requested;

m) plots of shear force versus shear displacement (hysteresis loop) for all cycles including initial shear loading;

n) test date.

7.3.5 Vertical loading time dependence of shear properties

7.3.5.1 Principle

A test piece is attached to a compression-shear testing machine and subjected to constant compressive force. In this state, the test piece is subjected to shear displacement at multiple levels of vertical load retention times. The shear force, the shear displacement, the compressive force and the compressive displacement are measured. The shear properties, such as shear stiffness and equivalent damping ratio, are evaluated and their dependence on the vertical loading time determined.

7.3.5.2 Test machine

7.3.5.2.1 General

As specified in ISO 22762-1:2018, 6.2.2.2.1.

7.3.5.2.2 Force correction

The force correction shall be as specified in ISO 22762-1:2018, 6.2.2.2.2.

7.3.5.3 Test piece

The test piece shall be as specified in Table 2.

7.3.5.4 Test conditions

7.3.5.4.1 Test temperature

As in ISO 22762-1.

7.3.5.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.3.5.4.3 Compressive force

As in 7.2.2.4.3.

7.3.5.4.4 Test shear displacement amplitude

As in 7.2.2.4.4.

7.3.5.4.5 Input wave

As in 7.2.2.4.5.

7.3.5.4.6 Test vibration velocity

As in 7.2.2.4.6.

7.3.5.5 Procedure

7.3.5.5.1 Attachment of a test piece

The test piece shall be attached to a compression-shear testing machine as specified in 7.2.2.2, except that any suitable connection system is permitted when a shear block or standard test piece is used.

7.3.5.5.2 Loading of test piece

The test piece shall be loaded as follows:

a) Subject the test piece to a compressive force, if required, that is equivalent to the design compressive stress, σ_0, as defined in 6.4 for each 1 min, 10 min and 100 min.

b) Load the test piece with 3 or more cycles of shear displacement. The number of cycles shall be as specified by the structural engineer.

7.3.5.6 Expression of results

With the method used in 7.2.2.6, determine each property value for each vertical load retention time.

7.3.5.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration frequency;

f) direction of shear force applied to test piece;

g) compressive stress and shear displacement;

h) shear displacement amplitude;

i) contact time;

j) essential parameters such as first breakaway point, shear stiffness, friction coefficient, method of determination (e.g. the third loop) at each vertical load retention time;

k) graph showing relationship between the rate of change of each property and the vertical load retention time;

l) graph showing relationship between compressive force and shear displacement, if requested;

m) plot of shear force versus shear displacement all cycles (hysteresis loop);

n) test date.

7.3.6 Dependence of compressive stiffness on compressive stress range

7.3.6.1 Principle

A test piece is subjected to compression tests under three different loading conditions. The compressive stiffness is measured in each test, and the dependence of compressive stiffness on compressive force determined.

7.3.6.2 Test machine

As in ISO 22762-1.

7.3.6.3 Test piece

The test piece shall be as specified in Table 2.

7.3.6.4 Test conditions

7.3.6.4.1 Test temperature

As in ISO 22762-1.

7.3.6.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.3.6.4.3 Compressive force

The loading conditions shall be as shown in Table 12.

Table 12 — Test compressive stress

compressive stress	σ_0 ±0,3 σ_0	σ_0 ±0,5 σ_0	σ_0 ±1,0 σ_0

The tolerance shall be within ±5 % of each compressive stress.

7.3.6.4.4 Input wave

As in ISO 22762-1.

7.3.6.4.5 Test vibration velocity

As in ISO 22762-1.

7.3.6.5 Procedure

7.3.6.5.1 Attachment of a test piece

As in ISO 22762-1.

7.3.6.5.2 Loading of test piece

The loading process shall be as described in ISO 22762-1.

7.3.6.6 Expression of results

The result shall be expressed as in ISO 22762-1.

Under each loading condition, determine the compression stiffness relative to the stiffness at σ_0 ±0,3 σ_0.

7.3.6.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-5:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) input wave and vibration frequency;

f) compressive force and compressive stress (central value plus larger and smaller values);

g) compression stiffness;

h) compressive stiffness relative to stiffness under the loading condition σ_0 ±0,3 σ_0;

i) plot of vertical force versus vertical displacement under each loading condition;

j) test date.

7.4 Ultimate shear properties

7.4.1 Principle

This test establishes the shear displacement capacity of the isolator under the maximum design compressive force. A test piece is attached to a compression-shear testing machine and subjected to the required constant compressive force. Under this load, the test piece is subjected to unidirectional shear displacement until failure occurs, or until the specified displacement is reached. Failure is defined as breaking or buckling.

The elastomeric sliding isolators show stable behaviour when the sliding material is on the sliding plate, if the shear strain of the laminated rubber is within the stable range. The shear displacement capacity of the isolators is determined by the difference in size between the sliding plate and the sliding material. The compressive force capacity of the isolators is determined by no failure of the laminated rubber under the maximum design compressive force and at the maximum shear displacement of the sliding material.

7.4.2 Test machine

7.4.2.1 General

As specified in ISO 22762-1:2018, 6.2.2.2.1.

7.4.2.1.1 Force correction

The force correction shall be as specified in ISO 22762-1:2018, 6.2.2.2.2.

7.4.3 Test piece

The test piece shall be as specified in Table 2.

7.4.4 Test conditions

7.4.4.1 Test temperature

As in ISO 22762-1.

7.4.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.4.4.3 Compressive force

The levels of compressive force shall be 1,0 and 2,0 times in accordance with the specifications for the isolator.

7.4.5 Procedure

7.4.5.1 Attachment of test piece

The test piece shall be attached to a compression-shear testing machine as specified in ISO 22762-1.

7.4.5.2 Loading

The test piece shall be loaded as follows:

a) Subject the test piece to the required compressive force, as defined in 7.4.4.3.

b) Subject the test piece to unidirectional shear deformation at a constant speed until breaking or buckling of the test piece occurs, or until the ultimate horizontal displacement of the sliding bearing is achieved.

7.4.6 Expression of results

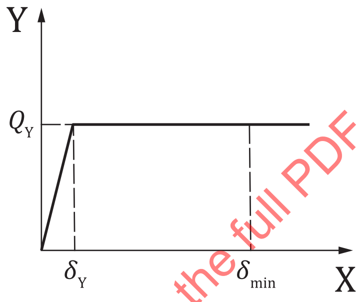
The result shall be expressed as follows:

a) The result of the ultimate test is shown in Figure 4, "Relationship diagram of shear force-horizontal displacement". Ultimate state of horizontal displacement of the sliding bearing is that the sliding material does not protrude from the sliding plate.

b) This horizontal displacement is determined by the shape and size of the sliding material and the sliding plate. The positional relationship is determined by calculation.

c) The horizontal displacement of the ultimate characteristic test shall be δ_{min} in Figure 4.

δ_{min} is the ultimate horizontal displacement.



Key

X displacement, δ

Y shear force, Q

Figure 4 — Shear force-horizontal displacement

7.4.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-1:2021;

b) type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

c) name of test machine;

d) test temperature;

e) shear speed;

f) direction of shear force applied to test piece;

g) compressive force (compressive stress);

h) relationship diagram of shear force-horizontal displacement;

i) result of visual examination;

j) test date.

7.5 Durability testing

7.5.1 Degradation test

7.5.1.1 Principle

The test piece for this test is an isolator or a rubber test piece. The test piece is aged for a given period of time at a specified temperature. After ageing, the shear properties (shear stiffness and equivalent damping ratio) and ultimate shear properties are measured. By evaluating the change during ageing as a percentage of the value before ageing, the resistance of the elastomeric isolator to thermal degradation can be assessed.

7.5.1.2 Test machine

7.5.1.2.1 Air ageing oven

As in ISO 22762-1.

7.5.1.2.2 Compression-shear testing machine

As in ISO 22762-1.

7.5.1.3 Test piece

As in ISO 22762-1.

7.5.1.4 Test conditions

As in ISO 22762-1.

7.5.1.5 Procedure

Shear properties shall be measured according to procedure given in 7.2.2, and ultimate shear properties according to procedure given in 7.4.

7.5.1.6 Expression of results

As in ISO 22762-1.

7.5.1.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-1:2021;

b) percentage change in shear properties and ultimate shear properties;

c) for isolator test pieces, type and classification, shape and dimensions, first shape factor and second shape factor of test piece;

d) for rubber test pieces, type and dimensions, and method used to ensure anaerobic ageing;

e) ageing temperature and ageing time/estimated years at 23 °C or 27 °C;

f) activation energy;

g) test date;

h) other information, if necessary.

7.5.2 Creep test

7.5.2.1 Principle

A test piece is subjected to a constant compressive force without shear displacement. During a specified length of time, the compressive displacement is measured at intervals. By measuring the change in the compressive displacement, the creep of the elastomeric isolator after many years of use can be estimated. See ISO 22762-1, Annex G.

7.5.2.2 Test machine

As in ISO 22762-1.

7.5.2.3 Test piece

The test piece shall be as specified in 7.1.

7.5.2.4 Test conditions

7.5.2.4.1 Test temperature

As in ISO 22762-1.

7.5.2.4.2 Conditioning time for test piece

As in ISO 22762-1.

7.5.2.4.3 Compressive force

As in ISO 22762-1.

7.5.2.4.4 Total measurement time and measurement intervals

As in ISO 22762-1.

7.5.2.5 Procedure

7.5.2.5.1 Attachment of test piece and compressive displacement gauges

As in ISO 22762-1.

7.5.2.5.2 Loading

As in ISO 22762-1.

7.5.2.6 Expression of results

As in ISO 22762-1.

7.5.2.7 Test report

The test report shall include the following items:

a) reference to this document, i.e. ISO 22762-1:2021;

b) drawing of test piece;

c) brief description of test machine;

d) compressive force (compressive stress);

e) graph showing relationship between surface temperature of test piece and time;

f) log-log graph showing relationship between creep strain and time;

g) estimated creep strain at specified time, t;

h) standard laboratory temperature, T_0;

i) test date;

j) other information, if necessary.

8 Rubber material tests

8.1 Tensile properties tests

The tensile property tests shall be in accordance with ISO 37.

Moulded test pieces shall be used. They shall be cured to have properties as similar as practicable to the rubber in the bulk of the isolator.

8.2 Hardness test

The hardness test shall be in accordance with ISO 48-2 or ISO 48-5.

8.3 Ozone resistance test

The ozone resistance test shall be in accordance with ISO 1431-1 (static strain test).

In addition to the ozone concentration, elongation rate of the test piece, test temperature and test time are as follows:

a) Ozone concentration: (50 ± 5) mPa [(50 ± 5) pphm];

b) Elongation rate of test piece: (20 ± 2) %;

c) Test temperature: (40 ± 2) °C;

d) Test time: 96 h.

9 Design rules

9.1 General

The sliding isolators shall be designed to meet the relevant provisions of this clause, in the serviceability limit state determined from the design compressive force and the ultimate limit state caused by an earthquake.

In the serviceability limit state, the design shall be such that the isolators will not suffer damage that would affect their proper functioning, or incur excessive maintenance costs during their intended life.

In the ultimate limit state, the strength and stability of the isolators shall be adequate to withstand the ultimate design forces and movements of the structure.

9.2 Elastic sliding bearing

9.2.1 Vertical stiffness

The vertical stiffness is given by ISO 22762-3:2018, Formula (8).

9.2.2 Horizontal properties

The horizontal load-displacement curve is shown in Figure 5.

The initial stiffness is given by ISO 22762-3:2018, Formula (11).

The load, Q_y, in sliding condition is given by Formula (7):

$$Q_y = \mu \cdot P \quad (7)$$

And the displacement, δ_0, to start sliding is given in Formula (8):

$$\delta_0 = \frac{\mu \cdot P}{K_i} \quad (8)$$

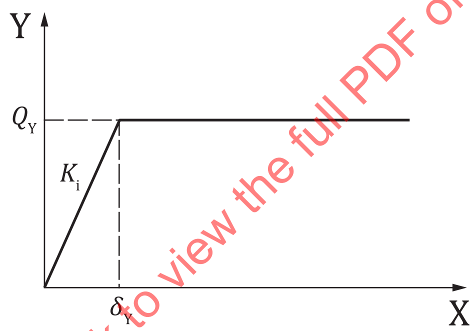


Figure 5 — Horizontal load-displacement curve of elastic sliding bearing

The design horizontal shear strain of the laminated rubber component should not be more than 50 %, when the elastomeric sliding isolator starts to slide.

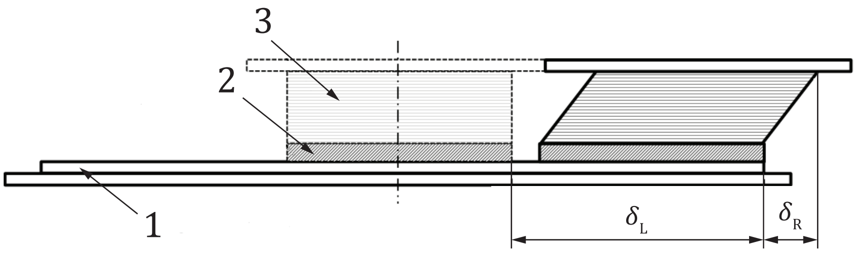
If the stability of the elastomeric sliding isolator can be confirmed, the shear strain of the laminated rubber may be 50 % or more, when the elastomeric sliding isolator starts to slide.

9.2.3 Maximum horizontal displacement

The maximum horizontal displacement, δ_{max}, is given by Formula (9) (see Figure 6).

$$\delta_{max} = \delta_L \quad (9)$$

Deformation of laminated rubber, δ_R, is not considered to δ_{max}.



Key

1 sliding plate

2 sliding material

3 laminated rubber

Figure 6 — Maximum horizontal displacement of elastic sliding bearing

9.2.4 Maximum compressive load

The maximum compressive stress, σ_{max}, of laminated rubber calculated from maximum compressive load, P_{max}, should be less than critical stress given by ISO 22762-3:2018, Formula (17).

Safety factor of the maximum compressive stress should be 2,0.

Furthermore, sliding material should not be plastically deformed under the maximum compressive stress, σ_{slmax}, calculated from maximum compressive load, P_{max}.

If breaking, buckling or any other failure doesn't occur in the test subjecting sliding bearing to maximum horizontal displacement, σ_m, under maximum compressive load, P_{max}, the area enclosed by a rectangle shown in Figure 7 shall be considered the stable range of the isolator.

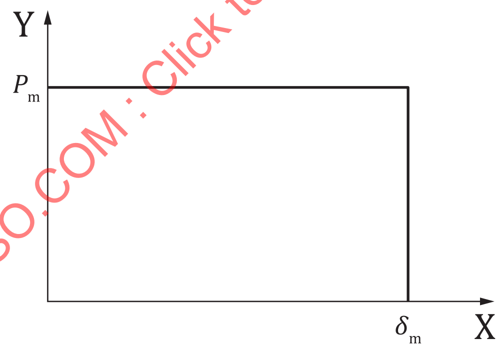


Figure 7 — Stable range of elastic sliding bearing

10 Manufacturing tolerances

10.1 General

Dimensional tolerances for sliding isolators shall be as specified below in this subclause.

Product dimensions shall be specified at a standard laboratory temperature of T_0 = 23 or 27 °C ± 5 °C. Measurements made at a different temperature shall be corrected to a standard laboratory temperature. Dimensions shall be measured at least 24 h after curing of bearing. The cooling time shall be defined according to the product size and shall be based on measurement of the internal temperature of the product or another appropriate method.

Larger bearings may need more than 24 h after curing.

