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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

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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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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:

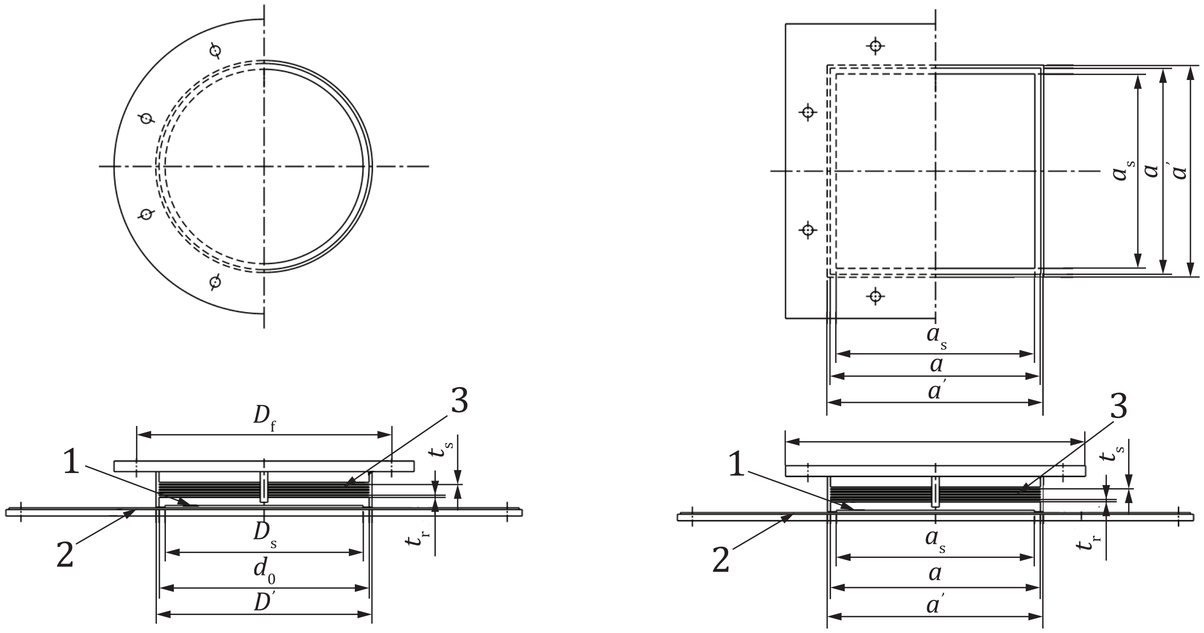
— low-friction sliding isolator: $\mu < 0{,}015$;

— 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

a) Simple attachment **b) Attachment using recess**

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.