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Elastomeric seismic-protection isolators —

Part 6: High-durability and high-performance specifications and test methods

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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

This document specifies requirements and test conditions for elastomeric seismic isolators used for important buildings and buildings which can be subjected to frequent, large earthquakes; the requirements and test conditions for the rubber material used in the manufacture of such isolators are also specified.

Three grades of requirements for each test item are introduced. Grade I requirements for each test item conform with the requirements given in ISO 22762-3 and are appropriate for standard buildings unlikely to be subjected to frequent, large earthquakes. Grade II and grade III requirements for each test item have to meet the more stringent requirements and be subjected to the more severe test conditions given in this document. Grade III requirements for each test item are intended for the most important buildings, and sites where large earthquakes can be particularly frequent.

There are a wide variety of requirements for seismic isolated buildings; there is no need to request the same grade for all test items in the same project. Structural engineers may select grade II or III for each test item in their requirements in order to perform the optimum building design.

Instances where this document differs from ISO 22762-3 include:

a) the number of test pieces to be used in type testing;

b) smaller tolerances allowed between measured properties and design characteristics;

c) smaller variations, due to effects such as temperature and compressive load, allowed in shear properties.

Elastomeric seismic-protection isolators —

Part 6:
High-durability and high-performance specifications and test methods

1 Scope

This document specifies specifications and test methods for elastomeric seismic isolators used for buildings to guarantee high durability and high performance.

It is applicable to elastomeric seismic isolators used to provide buildings with protection from earthquake damage. The isolators covered consist of alternate elastomeric layers and reinforcing steel plates. They are placed between a superstructure and its substructure to provide both flexibility for decoupling structural systems from ground motion, and damping capability to reduce displacement at the isolation interface and the transmission of energy from the ground into the structure at the isolation frequency.

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 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 22762-1:2018, *Elastomeric seismic-protection isolators — Part 1: Test methods*

ISO 22762-3:2018, *Elastomeric seismic-protection isolators — Part 3: Applications for buildings — Specifications*

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
allowable tensile strain
tensile strain whose influence on shear properties does not exceed a certain range

3.2
breaking
rupture of *elastomeric isolator* (3.8) due to compression- (or tension-) shear loading

3.3
buckling
state when *elastomeric isolators* (3.8) lose their stability under compression-shear loading

3.4
compressive properties
K_v
compressive stiffness for all types of rubber bearings

3.5
cumulative shear strain
sum of shear strain of a seismic-protection isolator when it is repeatedly deformed many times

3.6
design compressive stress
long-term compressive force on the *elastomeric isolator* (3.8) imposed by the structure

3.7
effective width
rectangular *elastomeric isolator* (3.8) smaller of the two side lengths of inner rubber to which direction shear displacement is not restricted

3.8
elastomeric isolator
rubber bearing, for seismic isolation of buildings, bridges and other structures, which consists of multi-layered vulcanized rubber sheets and reinforcing steel plates

EXAMPLE High-damping rubber bearings, linear natural rubber bearings and lead rubber bearings.

3.9
first shape factor
ratio of effectively loaded area to free deformation area of one inner rubber layer between steel plates

3.10
high-damping rubber bearing
HDR
elastomeric isolator (3.8) with relatively high damping properties obtained by special compounding of the rubber and the use of additives

3.11
horizontal biaxial loading dependency
horizontal biaxial loading effect on various properties

3.12
horizontal shear creep test and residual shear strain test
changes in horizontal deformation that occur when the *elastomeric isolator* (3.8) is subjected to a constant horizontal force for a long time due to strong winds such as a typhoon, and residual deformation after unloading

3.13
inner rubber
rubber between multi-layered steel plates inside an *elastomeric isolator* (3.8)

3.14
lead rubber bearing
LRB
elastomeric isolator (3.8) with a lead plug or lead plugs press fitted into a hole or holes of the isolator body to achieve damping properties

3.15
linear natural rubber bearing
LNR
elastomeric isolator (3.8) with linear shear force-deflection characteristics and relatively low damping properties, fabricated using natural rubber

Note 1 to entry: Any bearing with relatively low damping can be treated as an LNR bearing for the purposes of isolator testing.

3.16
roll-out
instability of an isolator with either dowelled or recessed connection under shear displacement

3.17
routine test
test for quality control of the production isolators during and after manufacturing

3.18
second shape factor
<circular elastomeric isolator> ratio of the diameter of the *inner rubber* (3.13) to the total thickness of the inner rubber

3.19
second shape factor
<rectangular or square elastomeric isolator> ratio of the *effective width* (3.7) of the *inner rubber* (3.13) to the total thickness of the inner rubber

3.20
shear strain dependency of allowable tensile strain
influence of the *allowable tensile strain* (3.1) due to a change of shear strain of *elastomeric isolator* (3.8)

3.21
shear strain dependency of tensile yield strength
influence of the tensile yield strength due to a change of shear strain of *elastomeric isolator* (3.8)

3.22
standard value
value of the isolator property defined by the manufacturer based on the results of the type test

3.23
structural engineer
engineer in charge of designing the structure for base-isolated bridges or buildings and responsible for specifying the requirements for *elastomeric isolators* (3.8)

3.24
tensile fracture strain
strain at which *elastomeric isolator* (3.8) breaks in the tensile direction

3.25
type test
test for the verification of either material properties and isolator performances during the development of the product or the achievement of the project design parameters

3.26
ultimate property
property at either *buckling* (3.3), *breaking* (3.2), or *roll-out* (3.16) of an isolator under compression-shear loading

3.27
ultimate properties under horizontal biaxial loading test
critical characteristics of *elastomeric isolators* (3.8) when loaded in two directions in the horizontal plane

3.28
ultimate property diagram
UPD
diagram giving the interaction curve of compressive stress and *buckling* (3.3) strain or *breaking* (3.2) strain of an *elastomeric isolator* (3.8)

4 Symbols

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

Table 1 — Symbols and descriptions

Symbol	Description
h_{eq}	equivalent damping ratio
K_d	post-yield stiffness (tangential stiffness after yielding of lead plug) of lead rubber bearing
K_h	shear stiffness
P_{Tb}	tensile force at break of isolator
P_{Ty}	tensile yield force
Q_d	characteristic strength
S_1	first shape factor
S_2	second shape factor
γ_{max}	maximum shear displacement
γ_0	design shear strain
γ_φ	maximum torsion strain
γ_b	ultimate shear strain under horizontal biaxial loading
γ_{max}	maximum design shear strain during earthquake
γ_u	ultimate shear strain under horizontal uniaxial loading
ε_{Tl}	allowable limit of tensile strain
τ_B	shear stress in bolt
τ_s	shear static stress

5 Classification

The requirements for each test item of elastomeric seismic-protection isolators are classified into three grades, grade III, grade II, and grade I, depending on durability and performance. Grade III and grade II are high-endurance and high-performance specifications stipulated in this document, and the grade I is a general specification prescribed by ISO 22762-3. In addition, grade III is more durable and has higher performance specification than grade II.

The classification of each grade is shown in Table 2. Requirements for grade III and grade II are listed in 6.5.

Structural engineers may select grade II or III for each test item in their requirements in order to perform the optimum building design.

Table 2 — Classification of each grade

Grade	Required items of performance evaluation	Required performance level	Required specimens
I	Required items of performance evaluation are as in ISO 22762-3:2018, Table 5.	Required performance level is as in ISO 22762-3:2018, Table 3.	Required specimens are as in ISO 22762-3:2018, Table 4.
II	Some new performance items such as tensile property are added to those of grade I.	For some performance items, required performance level is specified severer than grade I.	For some performance items, required number and size of specimens are larger than grade I. In addition, for some performance items, required test condition is severer than grade I.
III		For some performance items, required performance level is specified severer than grade II.	For some performance items, required number and size of specimens are larger than grade II. In addition, for some performance items, required test condition is severer than grade II.

6 Requirements

6.1 General

Elastomeric isolators for buildings and the materials used in manufacture shall meet the requirements specified in this clause. Test items for type test of isolators are shown in Table 3.

6.2 Type tests and routine tests

Type tests and routine tests are specified in ISO 22762-3:2018, 6.2.

6.3 Functional requirements

Functional requirements of elastomeric isolators used for buildings are specified in ISO 22762-3:2018, 6.3.

6.4 Design compressive force and design shear displacement

The design compressive forces, the design shear displacements, the design stress and the design strain of an isolator are defined in ISO 22762-3:2018, 6.4.

6.5 Performance requirements

6.5.1 General

The performance requirements of grade II and III are shown below.

The isolators shall be tested and the results recorded using the specified test methods. They shall satisfy all of the requirements of Grade II and III listed in Table 3. The test items are summarized in Table 3 for type tests and routine tests. The standard value obtained from the tests shall be reported. The standard temperature for determining the properties of elastomeric isolators is specified in ISO 22762-3:2018, 6.1. Double-shear configuration testing (see ISO 22762-1:2018, 6.2.2.2) can be employed with the approval of the structural engineer.

The standard values obtained from the tests satisfy the requirements shown in Table 4, Table 5 and Table 6 depending to the type of isolators.

Table 3 — Tests on elastomeric isolators

Property	Test item	Test method	Routine test	Type test
Compressive properties	Compressive stiffness	ISO 22762-1:2018, 6.2.1, method 2	X	X
Shear properties	Shear stiffness Equivalent damping ratio Post-yield stiffness (for LRB) Characteristic strength (for LRB)	ISO 22762-1:2018, 6.2.2	X	X
Tensile properties	Tensile yield strength	ISO 22762-1:2018, 6.5	N/A	X
	Allowable tensile strain	8.4.1	N/A	X
Dependency of shear stiffness	Shear strain dependency	ISO 22762-1:2018, 6.3.1	N/A	X
	Compressive stress dependency	ISO 22762-1:2018, 6.3.2	N/A	X
	Frequency dependency	ISO 22762-1:2018, 6.3.3	N/A	X
	Repeated loading dependency –1	ISO 22762-1:2018, 6.3.4	N/A	X
	Repeated loading dependency –2	8.2.1	N/A	X
	Temperature dependency	ISO 22762-1:2018, 6.3.5 ISO 22762-1:2018, 5.8	N/A	X
	Horizontal biaxial loading dependency	8.2.2	N/A	X
Dependency of compressive stiffness	Shear strain dependency	ISO 22762-1:2018, 6.3.6	N/A	X
	Compressive stress dependency	ISO 22762-1:2018, 6.3.7	N/A	X
Dependency of tensile properties	Shear strain dependency of tensile yield strength	8.4.2	N/A	X
	Shear strain dependency of allowable tensile strain	8.4.3	N/A	X
Shear strain and displacement capacity	Ultimate shear strain, breaking strain, buckling strain, Ultimate property diagram (UPD) or Ultimate shear displacement, breaking displacement, buckling displacement, Ultimate property diagram (UPD)	ISO 22762-1:2018, 6.4 See Annex A and Annex B for information.	N/A	X
	Ultimate shear strain under horizontal biaxial loading	8.3	N/A	X
Tensile capacity	Tensile fracture strength	ISO 22762-1:2018, 6.5	N/A	X
	Tensile fracture strain	8.4.4	N/A	X
Durability	Property change	ISO 22762-1:2018, 6.6.1	N/A	X
	Compressive creep	ISO 22762-1:2018, 6.6.2	N/A	X
	Cumulative shear strain	8.5.1	N/A	X
	Horizontal shear creep test and residual shear strain test	8.5.2	N/A	X
X = test to be conducted with isolators; N/A = not applicable.				

Table 4 — Performance requirement of LNR

Property	Test item		Grade	
			III	II
Compressive properties	Compressive stiffness	Tolerance	±15 %	±20 %
Shear properties [a]	Shear stiffness	Tolerance	±10 %	±15 %
Tensile properties	Tensile yield strength	Values at design shear strain	No requirement	No requirement
	Allowable tensile strain	Values at design shear strain	≥ 5 %	≥ 5 %
Dependency of shear stiffness	Shear strain dependency	Allowable range of change with respect to property value at design shear strain	−15 % to +10 %	−20 % to +15 %
	Compressive stress dependency [b]	Allowable range of change with respect to property value at design compressive stress	−15 % to +8 %	−30 % to +20 %
	Frequency dependency	Percentage change with respect to value at design frequency [g]	−5 % to +5 %	−10 % to +10 %
	Repeated loading dependency −1 [c]	Maximum decrease allowed with respect to property value at 3rd cycle	5 %	5 %
	Repeated loading dependency −2	Change in property with respect to value at 3rd cycle	No requirement value	No requirement value
	Temperature dependency [d]	Allowable change with respect to value at design temperature [g]	±5 %	±10 %
	Horizontal biaxial loading dependency	Change with respect to value in one directional deformation test	No requirement value	Test not required

[a] Values of shear properties are calculated based on ISO 22762-3:2018, Annex F.

[b] Effect of compressive stress on shear properties is measured by tests under compressive stress of 0,5 σ_0 and 2,0 σ_0. (Refer to ISO 22762-3:2018, Annex D.)

[c] Requirement is based on property values measured for 50th cycle.

[d] Effect of temperature on shear properties is measured by tests at 0 °C and 40 °C.

[e] Ultimate shear strain corresponds to the smaller of breaking strain and buckling strain. (Refer to ISO 22762-3:2018, Annex G.)

[f] Reduction ratio of ultimate shear strain under horizontal biaxial loading to that under horizontal uniaxial loading is calculated. (Refer 8.3.6.)

[g] This is the average value of each measurement used in determining change.

[h] X_{max} is the maximum shear displacement defined in ISO 22762-3.

Table 4 *(continued)*

Property	Test item		Grade	
			III	II
Dependency of compressive stiffness	Shear strain dependency	Change with respect to value at zero shear strain	No requirement value	No requirement value
	Compressive stress dependency	Change with respect to value at 30 % of design compressive strain	No requirement value	No requirement value
Dependency of tensile properties	Shear strain dependency of tensile yield strength	Change with respect to value at design shear strain	No requirement value	No requirement value
	Shear strain dependency of allowable tensile strain	Change with respect to value at design shear strain	No requirement value	No requirement value
Shear strain and displacement capacity	Ultimate shear strain [e] Breaking strain, buckling strain, Ultimate property diagram (UPD) or Ultimate shear displacement Breaking displacement, buckling displacement, Ultimate property diagram (UPD)	Strain under design compressive stress	Shear strain capacity: Buckling strain ≥ 3/4 × S_2 × 100 % Breaking strain ≥ 450 % or Shear displacement capacity: Buckling and breaking displacement ≥ 1,7 X_{max} [h]	Shear strain capacity: Buckling strain ≥ 2/3 × S_2 × 100 % Breaking strain ≥ 400 % or Shear displacement capacity: Buckling and breaking displacement ≥ 1,5 X_{max} [h]
	Ultimate shear strain under horizontal biaxial loading[f]		No requirement value	Test not required
Tensile capacity	Tensile fracture strength	Values at design shear strain	No requirement value	No requirement value
	Tensile fracture strain	Values at design shear strain	≥ 100 %	≥ 50 %

[a] Values of shear properties are calculated based on ISO 22762-3:2018, Annex F.

[b] Effect of compressive stress on shear properties is measured by tests under compressive stress of 0,5 σ_0 and 2,0 σ_0. (Refer to ISO 22762-3:2018, Annex D.)

[c] Requirement is based on property values measured for 50th cycle.

[d] Effect of temperature on shear properties is measured by tests at 0 °C and 40 °C.

[e] Ultimate shear strain corresponds to the smaller of breaking strain and buckling strain. (Refer to ISO 22762-3:2018, Annex G.)

[f] Reduction ratio of ultimate shear strain under horizontal biaxial loading to that under horizontal uniaxial loading is calculated. (Refer 8.3.6.)

[g] This is the average value of each measurement used in determining change.

[h] X_{max} is the maximum shear displacement defined in ISO 22762-3.

Table 4 *(continued)*

Property	Test item		Grade	
			III	II
Durability	Change of shear stiffness	Maximum increase with respect to initial value [g]	10 %	10 %
	Change of ultimate property	Maximum decrease with respect to initial value [g]	15 %	20 %
	Compressive creep		≤6 %	≤8 %
	Cumulative shear strain	Change in property with respect to value at 3rd cycle	No requirement value	No requirement value
	Horizontal shear creep test and residual shear strain test		No requirement value	No requirement value

[a] Values of shear properties are calculated based on ISO 22762-3:2018, Annex F.

[b] Effect of compressive stress on shear properties is measured by tests under compressive stress of 0,5 σ_0 and 2,0 σ_0. (Refer to ISO 22762-3:2018, Annex D.)

[c] Requirement is based on property values measured for 50th cycle.

[d] Effect of temperature on shear properties is measured by tests at 0 °C and 40 °C.

[e] Ultimate shear strain corresponds to the smaller of breaking strain and buckling strain. (Refer to ISO 22762-3:2018, Annex G.)

[f] Reduction ratio of ultimate shear strain under horizontal biaxial loading to that under horizontal uniaxial loading is calculated. (Refer 8.3.6.)

[g] This is the average value of each measurement used in determining change.

[h] X_{max} is the maximum shear displacement defined in ISO 22762-3.

Table 5 — Performance requirement of HDR

Property	Test item		Grade	
			III	II
Compressive properties	Compressive stiffness	Tolerance	±15 %	±30 %
Shear properties [a]	Shear stiffness Equivalent damping ratio	Tolerance	±10 %	±15 %
	Design value of equivalent damping ratio		0,15 to 0,30	
Tensile properties	Tensile yield strength	Values at design shear strain	No requirement	No requirement
	Allowable tensile strain	Values at design shear strain	≥ 5 %	≥ 5 %

[a] Values of shear properties are calculated based on ISO 22762-3:2018, Annex F.

[b] Effect of compressive stress on shear properties is measured by tests under compressive stress of 0,5 σ_0 and 2,0 σ_0. (Refer to ISO 22762-3:2018, Annex D.)

[c] Requirement is based on property values measured for 50th cycle.

[d] Effect of temperature on shear properties is measured by tests at 0 °C and 40 °C.

[e] Ultimate shear strain corresponds to the smaller of breaking strain and buckling strain. (Refer to ISO 22762-3:2018, Annex G.)

[f] Reduction ratio of ultimate shear strain under horizontal biaxial loading to that under horizontal uniaxial loading is calculated. (Refer 8.3.6.)

[g] Average value of each measurement used in determining change.

[h] X_{max} is the maximum shear displacement defined in ISO 22762-3.