

Elastomeric seismic-protection isolators —

Part 1: Test methods

ICS 83.140.99

National foreword

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Summary of pages

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INTERNATIONAL STANDARD

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22762-1

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2005-07-15

Elastomeric seismic-protection isolators —

Part 1: Test methods

*Appareils d'appuis structuraux en élastomère pour protection
sismique —*

Partie 1: Méthodes d'essai



Reference number
ISO 22762-1:2005(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22762-1 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 4, *Products (other than hoses)*.

ISO 22762 consists of the following parts, under the general title *Elastomeric seismic-protection isolators*:

- *Part 1: Test methods*
- *Part 2: Applications for bridges — Specifications*
- *Part 3: Applications for buildings — Specifications*

Introduction

This International Standard contains two parts related to specifications for isolators — one for bridges and the other for buildings — since the requirements for isolators for bridges and for buildings are quite different, although the basic concept of the two products is similar. Therefore, when this International Standard is applied to the design of bridge isolators, Part 2 and the relevant clauses in Part 1 are used and, when it is applied to building isolators, Part 3 and the relevant clauses in Part 1 are used.

The main differences to be noted between isolators for bridges and isolators for buildings are as below:

- a) Isolators for bridges are mainly rectangular in shape and those for buildings circular in shape.
- b) Isolators for bridges are designed to be used for both rotation and horizontal displacement, while isolators for buildings are designed for horizontal displacement only.
- c) Isolators for bridges are designed to perform on a daily basis to accommodate length changes of bridges caused by temperature changes as well as during earthquakes, while isolators for buildings are designed to perform only during earthquakes.
- d) Isolators for bridges are designed to withstand dynamic loads caused by vehicles on a daily basis as well as earthquakes, while isolators for buildings are mainly designed to withstand dynamic loads caused by earthquakes only.

For structures that are neither buildings nor bridges (e.g. tanks), the structural engineer may use either Part 2 or Part 3 of this International Standard, depending on the requirements of the structure.

Elastomeric seismic-protection isolators —

Part 1: Test methods

1 Scope

ISO 22762 applies to elastomeric seismic isolators used to provide buildings or bridges with protection from earthquake damage. The isolators covered consist of alternate rubber 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.

This part of ISO 22762 specifies the test methods for determination of the characteristics of elastomeric seismic isolators and for measurement of the properties of the rubber material used in their manufacture.

The specifications cover testing for all properties required in the elastomeric isolators, such as compression and shear properties, the durability of the isolators and the physical properties of the materials used in isolators.

Annex E may be used to review those requirements needing confirmation prior to the test programme.

2 Normative references

The following referenced documents are indispensable for the application 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, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 188, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 812, *Rubber, vulcanized — Determination of low-temperature brittleness*

ISO 813, *Rubber, vulcanized or thermoplastic — Determination of adhesion to a rigid substrate — 90° peel method*

ISO 815, *Rubber, vulcanized or thermoplastic — Determination of compression set at ambient, elevated or low temperatures*

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

ISO 1827, *Rubber, vulcanized or thermoplastic — Determination of modulus in shear or adhesion to rigid plates — Quadruple shear method*

ISO 3387, *Rubber — Determination of crystallization effects by hardness measurements*

ISO 4664-1, *Rubber, vulcanized or thermoplastic — Determination of dynamic properties — Part 1: General considerations*

ISO 7500-1:2004, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 7619-2, *Rubber, vulcanized or thermoplastic — Determination of indentation hardness — Part 2: IRHD pocket meter method*

ISO 11346:2004, *Rubber, vulcanized or thermoplastic — Estimation of life-time and maximum temperature of use*

ISO 22762-2, *Elastomeric seismic-protection isolators — Part 2: Applications for bridges — Specifications*

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

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

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

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 of elastomeric isolator

compressive stiffness (K_v) for all types of rubber bearings

3.4 compressive-shear testing machine

machine used to test elastomeric isolators, which has the capability of shear loading under constant compressive load

3.5 cover rubber

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

3.6 design compressive stress

long term compressive force on the elastomeric isolator imposed by the structure

3.7 effective loaded area

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

3.8**effective width**

⟨rectangular elastomeric isolator⟩ the smaller of the two side lengths of inner rubber to which direction shear displacement is not restricted

3.9**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

NOTE Types of such isolators include high-damping rubber bearings, linear natural rubber bearings and lead rubber bearings.

3.10**first shape factor**

ratio of effectively loaded area to free deformation area of one inner rubber layer between steel plates

3.11**high-damping rubber bearing****HDR**

elastomeric isolator with relatively high damping properties obtained by special compounding of the rubber and the use of additives

3.12**inner rubber**

rubber between multi-layered steel plates inside an elastomeric isolator

3.13**lead rubber bearing****LRB**

elastomeric isolator whose inner rubber with a lead plug or lead plugs press fitted into a hole or holes of the isolator body to achieve damping properties

3.14**linear natural rubber bearing****LNR**

elastomeric isolator with linear shear force-deflection characteristics and relatively low damping properties and fabricated using natural rubber

NOTE Any bearing with relatively low damping may be treated as an LNR bearing for the purposes of isolator testing.

3.15**maximum compressive stress**

maximum compressive stress acting briefly on elastomeric isolators during an earthquake

3.16**nominal compressive stress**

long-term compressive stress recommended by the manufacturer for the isolator, including the safety margin

3.17**roll-out**

instability of an isolator with either dowelled or recessed connection under shear displacement

3.18**routine test**

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

3.19

second shape factor

⟨circular elastomeric isolator⟩ ratio of the diameter of the inner rubber to the total thickness of the inner rubber

⟨rectangular or square elastomeric isolator⟩ ratio of the effective width of the inner rubber to the total thickness of the inner rubber

3.20

shear properties of elastomeric isolators

a comprehensive term that covers characteristics determined from isolator tests:

- shear stiffness (K_h) for LNR;
- shear stiffness (K_h) and equivalent damping ratio (h_{eq}) for HDR and LRB;
- post-yield stiffness (K_d) and characteristic strength (Q_d) for LRB.

3.21

structural engineer

engineer who is in charge of designing of structure for base-isolated bridges or buildings and is responsible for specifying the requirements for elastomeric isolators

3.22

type test

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

3.23

ultimate properties

properties at either buckling, breaking, or roll-out of an isolator under compression-shear loading

3.24

ultimate property diagram

UPD

diagram giving the interaction curve of compressive stress and buckling strain or breaking strain of an elastomeric isolator

4 Symbols and abbreviated terms

For the purposes of all three parts of ISO 22762, the symbols given in Table 1 apply.

Table 1 — Symbols and definitions

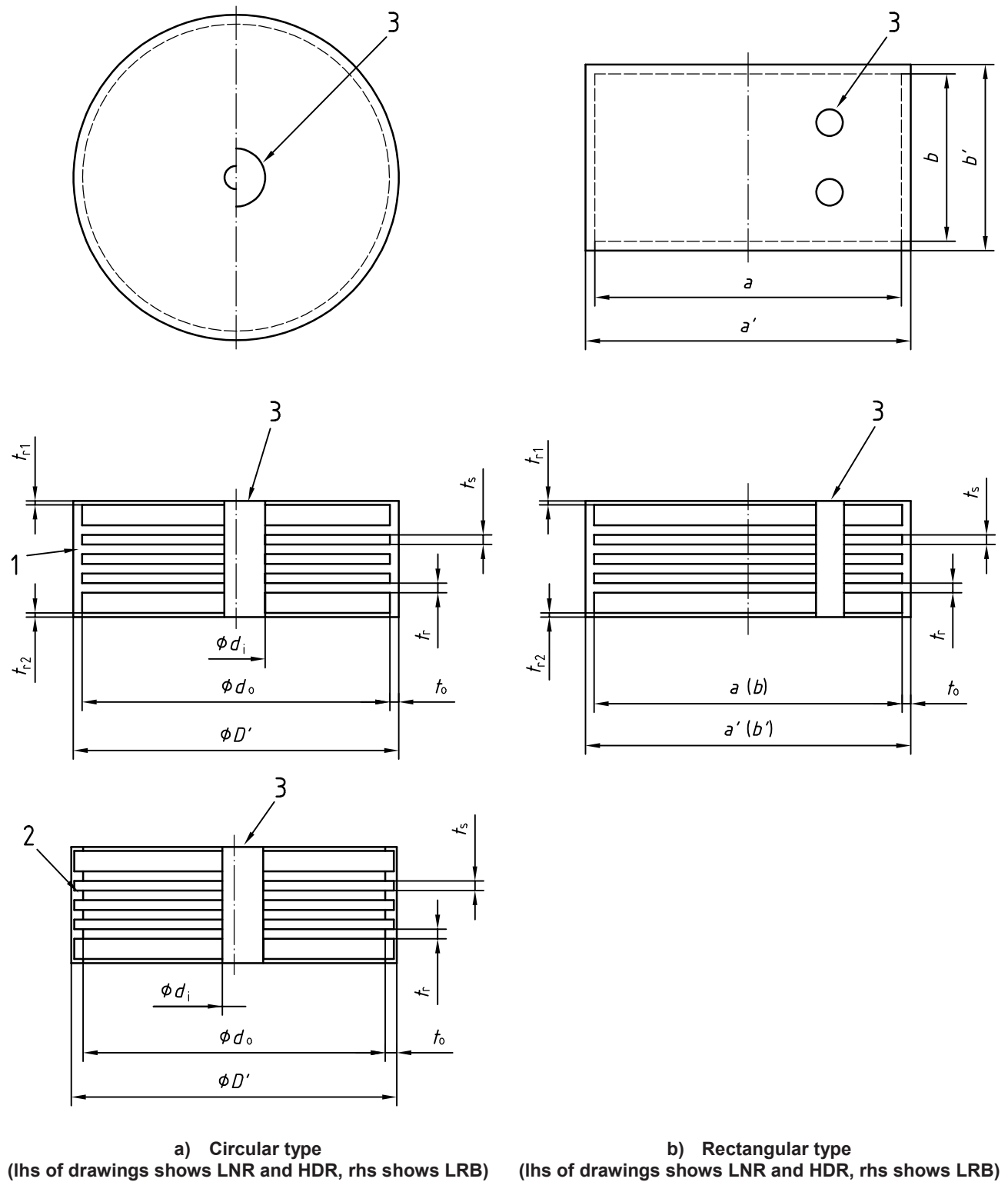
Symbol	Definition
A	effective plan area; plan area of elastomeric isolator excluding cover rubber portion
A_b	effective area of bolt
A_e	overlap area between the top and bottom elastomer area of isolator sheared under non-seismic displacement
A_{free}	load-free area of isolator
A_{load}	loaded area of isolator
A_p	area of the lead plug for a lead rubber bearing

a	side length of square elastomeric isolator excluding cover rubber thickness, or length in longitudinal direction of rectangular isolator excluding cover rubber thickness
a_e	length of the shorter side of the rectangular isolator including cover rubber thickness
a'	length in longitudinal direction of the rectangular isolator, including cover rubber thickness
B	effective width for bending of flange
b	length in transverse direction of the rectangular isolator, excluding cover rubber thickness
b'	length in transverse direction of the rectangular isolator, including cover rubber thickness
c	distance from centre of bolt hole to effective flange section
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_o	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
F_u	tensile force on isolator by uplift
G	shear modulus
$G_{eq}(\gamma)$	equivalent linear shear modulus at shear strain γ
H	height of elastomeric isolator including mounting flange
H_n	height of elastomeric isolator excluding mounting flange
h_{eq}	equivalent damping ratio
$h_{eq}(\gamma)$	equivalent damping ratio as a function of shear strain
K_d	post-yield stiffness (tangential stiffness after yielding of lead plug) of lead rubber bearing
K_h	shear stiffness
K_i	initial shear stiffness
K_p	shear stiffness of lead plug inserted in lead rubber bearing
K_r	shear stiffness of lead rubber bearing before inserting lead plug
K_t	tangential 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
$P_{\max}$	maximum design compressive force
$P_{\min}$	minimum design compressive force
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
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_o	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
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 design 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
γ_0	design shear strain
γ_a	upper limit of the total of design strains on elastomeric isolators
γ_b	shear strain at break
γ_c	local shear strain due to compressive force
γ_d	shear strain due to dynamic shear movement
$\gamma_{\max}$	maximum shear strain during earthquake
γ_r	local shear strain due to rotation
γ_s	shear strain due to quasi-static shear movement
γ_u	ultimate shear strain
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 isolator
ε_{cr}	creep strain
ε_T	tensile strain of isolator
ε_{Tb}	tensile-break strain of isolator
ε_{Ty}	tensile-yield strain of isolator
ζ	ratio of total rubber height to total height of rubber and steel layers
θ	rotation angle of isolator about the diameter of a circular bearing or about an axis through a rectangular bearing
θ_a	rotation angle of isolator in the longitudinal direction (a)
θ_b	rotation angle of isolator in the transverse direction (b)
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
σ	compressive stress in isolator
σ_0	design compressive stress
σ_B	tensile stress in bolt
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
$\sigma_{\max}$	maximum design compressive stress

$\sigma_{\min}$	minimum design compressive stress
σ_{nom}	for building: nominal long term compressive stress recommended by manufacturer
σ_s	tensile stress in reinforcing steel plate
σ_{sa}	allowable tensile stress in steel plate
σ_{sy}	yield stress of steel for flanges and reinforcing steel plates
σ_{su}	tensile strength of steel for flanges and reinforcing steel plates
σ_t	tensile stress
σ_{te}	allowable tensile stress in isolator
σ_{yi}	yield stress in steel plate
τ_B	shear stress in bolt
τ_f	allowable shear stress in steel
ϕ	factor for computation of buckling stability
ψ	factor for computation of buckling check
ξ	factor for computation of critical stress



Key

- 1 cover rubber cured with insulator
- 2 cover rubber added after insulator cured
- 3 lead plug

Figure 1 — Cross-section of isolator

5 Rubber material tests

5.1 Test items

In order to assure the required quality of elastomeric isolators, it is necessary to specify the physical properties of the rubber materials and the adhesion between the rubber and the steel plates. The basic properties of rubber materials related to performance of elastomeric isolators are shown as test items in Table 2.

Table 2 — Test items of rubber materials

Properties	Test items	Related standard(s)
Tensile properties	Tensile strength	ISO 37
	Elongation at break	
	100 % modulus	
Ageing properties	Tensile strength	ISO 188
	Elongation at break	ISO 37
	100 % modulus	
Hardness	Hardness	ISO 48 ISO 7619-2
Adhesion	90° peel strength between metal and rubber Classification of fracture mode	ISO 813
Compression set	Compression set	ISO 815
Shear properties	Shear modulus	ISO 4664-1
	Equivalent damping ratio	
	Temperature dependence of shear modulus and equivalent damping ratio	
	Repeated deformation dependence of shear modulus and equivalent damping ratio	
	Fracture strength	ISO 1827
	Fracture strain	
Brittleness point	Brittleness temperature	ISO 812
Ozone resistance (ozone cracking test on vulcanized rubber)	Inspection of deterioration	ISO 1431-1 (static strain test)
Low temperature crystallization	Hardness	ISO 3387

5.2 Test conditions and test pieces

The temperature and humidity in the laboratory, the preparation of test pieces, and methods for measuring thickness and width, etc., shall be in accordance with ISO 23529.

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.

5.3 Tensile properties

The tensile test should preferably be carried out by the method specified in ISO 37. However, the test piece specified in Table 3 can be used.

Table 3 — Test piece dimensions

Dimensions in millimetres

Width of parallel-sided section	Length of parallel-sided section	Thickness of parallel-sided section	Distance between marked lines
$5 \pm 0,1$	20	$2,0 \pm 0,2$	20

5.4 Ageing test

5.4.1 Ageing properties of inner rubber

5.4.1.1 Anaerobic ageing

A set of ageing tests shall be performed on the inner rubber under anaerobic conditions as described in Annex A. The properties monitored shall be either 100 % shear modulus and shear failure strain or the tensile properties — 100 % modulus, tensile strength and elongation at break. From the results of these tests, the activation energy is obtained based on the method specified in Annex A. Ageing conditions equivalent to the expected lifetime (60 years or the period specified by the structural engineer) at 23 °C shall be determined from this activation energy, and an ageing test shall then be performed for the properties monitored under conditions equivalent to the expected lifetime.

5.4.1.2 Air ageing

An ageing test shall be performed on the inner rubber in accordance with the method specified in ISO 188, monitoring the tensile strength and elongation at break. The test time and temperature shall be as specified in ISO 22762-2 or ISO 22762-3.

5.4.2 Ageing properties of cover rubber

An ageing test shall be performed on the cover rubber in accordance with the method specified in ISO 188, monitoring the tensile strength and elongation at break. The test time and temperature shall be as specified in ISO 22762-2 or ISO 22762-3.

5.5 Hardness

Hardness shall be measured in accordance with the method specified in ISO 48 or ISO 7619-2.

5.6 Adhesion

An adhesion test shall be carried out as specified in ISO 813.

5.7 Compression set

Compression set shall be determined in accordance with the method specified in ISO 815. The test piece shall be either a large-type or small-type cylindrical disc. Test conditions and requirements shall be as specified in ISO 22762-2 or ISO 22762-3.

5.8 Dynamic shear properties

5.8.1 General

These tests shall be carried out as specified in ISO 4664-1, except for the test piece and analysis of test results, in order to investigate the temperature, frequency, strain and repeated deformation dependence of the shear modulus and equivalent damping ratio of rubber materials.

5.8.2 Test equipment

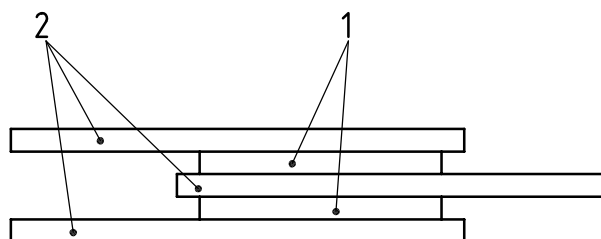
An apparatus as described in ISO 4664-1 which can measure vibration frequencies higher than 0,2 Hz and shear strain amplitudes up to 400 % shall be used.

5.8.3 Test pieces

The shape and dimensions of the test pieces are different from those specified in ISO 4664-1. Use either test piece specified below. Each test shall be performed on a previously unused test piece except when indicated otherwise.

a) Two-block lap shear type

As shown in Figure 2, this test piece consists of two rubber blocks bonded to three plates of metal. The size of one rubber block shall be 3,0 mm to 6,0 mm thick, 25 mm to 30 mm wide, and 25 mm to 30 mm long for a square pillar, or 3,0 mm to 6,0 mm thick and 25 mm to 30 mm in diameter for a cylindrical disc.



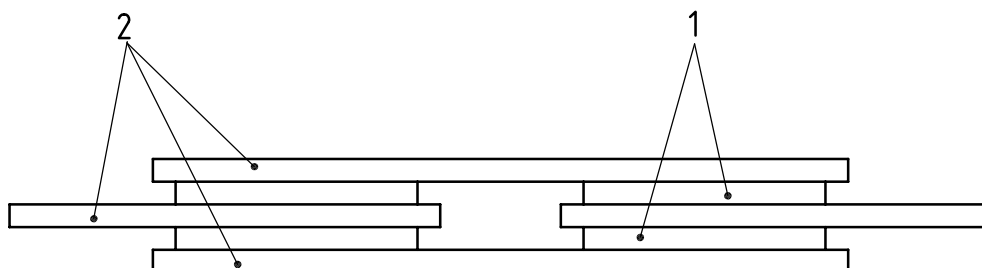
Key

- 1 rubber
- 2 metal plate

Figure 2 — Two-block lap shear type

b) Four-block lap shear type

As shown in Figure 3, this test piece consists of four rubber blocks bonded to four plates of metal. The size of one rubber block shall be 3,0 mm to 6,0 mm thick, 25 mm to 30 mm wide, and 25 mm to 30 mm long for a square pillar, or 3,0 mm to 6,0 mm thick and 25 mm to 30 mm in diameter for a cylindrical disc.



Key

- 1 rubber
- 2 metal plate

Figure 3 — Four-block lap shear type

5.8.4 Test conditions

5.8.4.1 Test temperature

Test temperatures shall at least cover the range of service requirements. The values given in Table 4 shall be included if they are within the service range. As a minimum requirement, tests shall be performed at one frequency (0,2 Hz, 0,3 Hz or 0,5 Hz or the isolation frequency) and at one strain amplitude (100 %, 175 % or the design shear strain). Tests at more than one temperature may be carried out using one test piece provided that the tests are at one frequency and one strain amplitude, and that they are conducted in order of decreasing temperature. The tolerance shall be ± 2 °C for all temperatures.

Table 4 — Test temperatures

Test temperature, °C	−20	−10	0	23	40
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5.8.4.2 Frequency

The test frequencies shall be one of the sets given in Table 5, except that the isolation frequency, if known, may replace the one closest to it in the table. If the dynamic property tests of the isolators are performed at a lower frequency, this test shall also be carried out at that same frequency. As a minimum requirement, tests shall be performed at 23 °C, and at one strain amplitude (100 %, 175 % or the design shear strain).

Tests at more than one frequency may be carried out using one test piece provided that the tests are at one temperature and one strain amplitude, and that they are conducted in order of increasing frequency.

Table 5 — Vibration frequencies

Vibration frequency, Hz	Set 1	0,05	0,2	1,0
	Set 2	0,05	0,3	1,5
	Set 3	0,1	0,5	2,0

5.8.4.3 Shear strain

The shear strains shall be selected from Table 6. The shear strains shown in Table 6 differ from those specified in ISO 4664-1. It is recommended that the four ranges 5 %, 10 %, 50 %, and 100 % be selected from them. The test strains shall range from 5 % to at least $1,5 \times$ the design shear strain. As a minimum requirement, tests shall be performed at one frequency (0,2 Hz, 0,3 Hz, 0,5 Hz or the isolation frequency) and at 23 °C. One test piece may be used to cover a range of strains, provided that the strain intervals are at least 50 % or a factor of 2 whichever is the lower, the tests are at one temperature and one frequency and they are carried out in order of increasing strain.

Table 6 — Shear strains

Shear strain, %	± 5	± 10	± 25	± 50	± 75	± 100	± 150	± 175	± 200	± 250	± 300	± 350	± 400
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5.8.4.4 Number of cycles

The number of loading cycles shall be either 3 or 11 cycles, and should be consistent with that of isolator tests.

5.8.5 Test results

The shear modulus and equivalent damping ratio shall be reported using the method specified in 6.2.2.6.

5.9 Fracture properties

A failure test shall be carried out as specified in ISO 1827. However, test pieces as specified in 5.8.3 shall be used.

5.10 Brittleness point

A brittleness temperature test shall be carried out as specified in ISO 812.

5.11 Ozone resistance

An ozone resistance test shall be carried out as specified in ISO 1431-1 (static strain test).

5.12 Low temperature crystallization

For elastomers susceptible to low temperature crystallization (e.g. those compounds based on natural rubber, polychloroprene and certain types of ethylene propylene), the resistance to this phenomenon shall be checked by measuring the change in the hardness at low temperature, if the service temperature falls within the range where crystallization may occur. Natural rubber shall be checked if the minimum service temperature T_L is $< 0\text{ }^{\circ}\text{C}$, and polychloroprene if the minimum service temperature T_L is $< 5\text{ }^{\circ}\text{C}$.

The test shall be conducted in accordance with ISO 3387, except that the test temperature and the duration of the test shall be as specified here, and a reading shall be taken after 3 h.

The duration and temperature of the test shall be set by the structural engineer in accordance with the service conditions, except that the test temperature for natural rubber shall not be below $-25\text{ }^{\circ}\text{C}$ and for polychloroprene not below $-10\text{ }^{\circ}\text{C}$. The duration of the test at a particular temperature shall relate to the period over which the minimum daily service temperature may be at or below that temperature. It is recommended that, for natural rubber isolators, subjected to the service conditions in Table 7, where the time is the cumulative total for which the isolators are exposed to the specified temperatures without the temperature rising above $+10\text{ }^{\circ}\text{C}$, a test shall be carried out for the time indicated at the test temperature corresponding to the range of the minimum service temperature as indicated in Table 7.

Table 7 — Service and test conditions for natural rubber

Minimum temperature, T_L $^{\circ}\text{C}$	$-10 \leq T_L < 0$	$-20 \leq T_L < -10$	$T_L < -20$
Time, days	t_0	t_{10}	t_{20}
Test temperature, $^{\circ}\text{C}$	-10	-20	-25
Test period	$1,5t_0$	$1,5t_{10} + 0,1t_0$	$1,5t_{20} + 0,5t_{10} + 0,05t_0$

The time and temperature of test for polychloroprene-based isolators shall be based on the service temperature conditions defined in Table 8, where the time is the cumulative total for which the isolators are exposed to the specified temperatures without the temperature rising above $+10\text{ }^{\circ}\text{C}$. A test shall be carried out for the time indicated at the test temperature corresponding to the range of the minimum service temperature as indicated in Table 8.

Table 8 — Service and test conditions for chloroprene rubber

Minimum temperature, T_L °C	$0 \leq T_L < 5$	$-5 \leq T_L < 0$	$T_L < -5$
Time, days	t_5	t_0	t_5
Test temperature, °C	0	-5	-10
Test period	$1,5t_5$	$1,5t_0 + 0,5t_5$	$1,5t_{-5} + 0,5t_0 + 0,25t_5$

NOTE Some elastomers are susceptible to crystallization if the ambient temperature is low over a prolonged period. High-damping compounds of these elastomers may be more susceptible than conventional low-damping ones. The crystallization process involves a nucleation period, during which little change in rubber stiffness occurs, followed by a rapid stiffening as the crystallites grow. The nucleation period shortens as the temperature is lowered to that at which the rate of crystallization is highest. The minimum test temperatures specified for natural rubber and polychloroprene are those at which the rate of crystallization is highest. To ensure the performance of the isolator is not compromised, it is necessary that the nucleation period is not much exceeded during any continuous exposure to low temperatures. Crystallites melt when the ambient temperature of the isolators is raised sufficiently, and thus the effects are completely reversible. If polychloroprene is used, crystallization resistant grades should be chosen where low temperature conditions are to be encountered.

6 Isolator tests

6.1 General

In order to assure the required quality of elastomeric isolators, it is necessary to specify the functional requirements. The basic properties of elastomeric isolators are shown as test items in Table 9.

When the same test piece is used for several tests, it shall be noted if the performance is influenced by repetition.

NOTE Some of these properties may be determined using one of the standard test pieces detailed in Tables 10 and 11. The standard test piece is used for non-specific product testing, such as testing for the development of new materials and products.

6.2 Compression and shear stiffness tests

6.2.1 Compression test

6.2.1.1 Principle

By measuring the compressive force and displacement, the compression stiffness and compression behaviour of the elastomeric isolator can be determined.

6.2.1.2 Test machine

The machine shown schematically in Figure 4 shall be capable of compressing the elastomeric isolator under controlled conditions. It shall also provide a method of measuring the compressive force and compressive displacement to an accuracy of less than or equal to 1 % of the maximum values recorded. The force calibration shall be based on ISO 7500-1. The machine shall maintain the parallelism of the upper and lower loading platens for the test piece attachment during the test. A Class 1 machine as defined in Clause 7 of ISO 7500-1:2004 is recommended.

In order to accurately measure the displacement of the elastomeric isolator, uniformly place two or more compressive displacement gauges around the test piece (so that they may be at the same distance from the test piece as shown in Figure 5). The average of those sensors shall be taken as a measurement value.

Table 9 — Test items for isolators

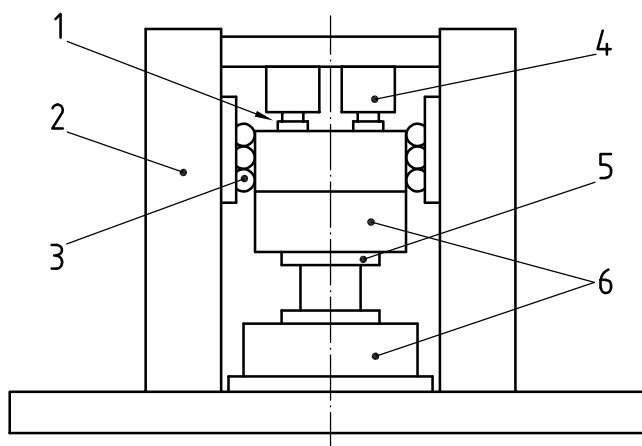
Properties	Test items	See Subclause
Compression properties	Compression stiffness	6.2.1
	Compression displacement	
Shear properties	Shear stiffness	6.2.2
	Equivalent damping ratio	
	Post-yield stiffness	
	Characteristic strength	
Dependency of shear properties	Shear strain dependency	6.3.1
	Compressive stress dependency	6.3.2
	Frequency dependency	6.3.3
	Repeated loading dependency	6.3.4
	Temperature dependency	6.3.5
Dependency of compressive properties	Shear strain dependency	6.3.6
	Compressive stress dependency	6.3.7
Ultimate shear properties	Breaking displacement (strain), force	6.4
	Buckling displacement (strain), force	
	Roll-out displacement (strain), force	
Tensile properties	Tensile breaking force	6.5
	Tensile yielding force	
	Shear strain	
Durability	Property change by ageing	6.6.1
	Creep	6.6.2
	Property change by fatigue	6.6.3
Force of reaction against low-rate deformation	Shear modulus at low-rate deformation	6.7

Table 10 — Standard test piece (square)

Item		Rubber isolator			Lead rubber isolator		
		No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
Inner steel plate side length, mm	$a \times b$	100 × 100	240 × 240	400 × 400	100 × 100	240 × 240	400 × 400
Number of lead plugs	—	—	—	—	4	4	4
Diameter of lead plug, mm	—	—	—	—	14,5	34,5	57,5
Thickness of a single inner 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	2	5	9	2	5	9
Number of rubber layers	n	6	6	6	6	6	6
Thickness of outside cover rubber, mm	t_o	5	5	10	5	5	10

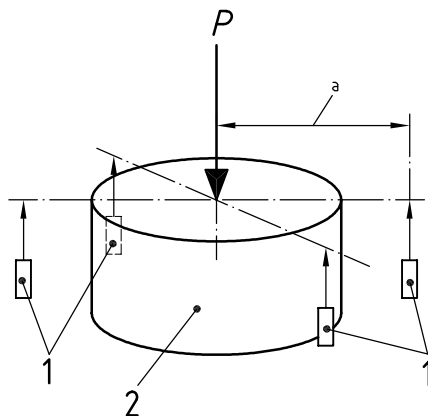
Table 11 — Standard test piece (circle)

Item		Rubber isolator			Lead rubber isolator		
Inner steel plate outer diameter, mm	d_o	150	250	500	150	250	500
Inner steel plate inner diameter, mm (diameter of lead plug)	d_i	7,5	12,5	25	30	50	100
Thickness of a single inner 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	1,8	3,5
Number of rubber layers	n	20	25	25	20	28	28
Thickness of outside cover rubber, mm	t_o	4	6	8	4	6	8

**Key**

- 1 compression force load cell
- 2 frame
- 3 bearing
- 4 actuator
- 5 test piece
- 6 upper and lower loading platens

Figure 4 — Example of compression testing machine

**Key**

P compressive force

1 displacement gauge

2 test piece

^a The distance from the core of the laminated body to each displacement gauge shall be constant.

Figure 5 — Compression displacement measurement sensor

6.2.1.3 Test piece

The test piece shall be as specified in ISO 22762-2 or ISO 22762-3.

6.2.1.4 Test conditions

6.2.1.4.1 Test temperature

The temperature of the laboratory should preferably be in accordance with ISO 23529. When the test is conducted at another temperature, the test temperature shall be recorded.

6.2.1.4.2 Conditioning time for a test piece

Test pieces < 250 mm thick shall be left for at least 24 h after vulcanization. Thicker isolators shall be left for at least 48 h.

Before a test, the test piece shall be left for 6 h to 24 h or more in the environment where the test machine is located, and the temperature of the surface of the test piece shall be recorded. The conditioning time shall be chosen so that the temperature of the test piece is the same as the environment.

6.2.1.4.3 Compressive force used in test

The maximum compressive force shall be specified by the structural engineer. If a standard test piece is employed, it shall be loaded with the compressive force that is equivalent to the design compressive stress σ_0 as defined in ISO 22762-2 or ISO 22762-3.

The relation between compressive force and compressive stress is as follows:

$$P = A_{\text{load}} \cdot \sigma$$

The tolerance shall be within $\pm 5\%$ of each compressive stress.

6.2.1.4.4 Input wave

The input wave shall be a sine wave or a triangular wave.

6.2.1.4.5 Test vibration frequency

The lowest test vibration frequency shall be 0,001 Hz.

6.2.1.5 Procedure

6.2.1.5.1 Attachment of test piece and compressive displacement gauges

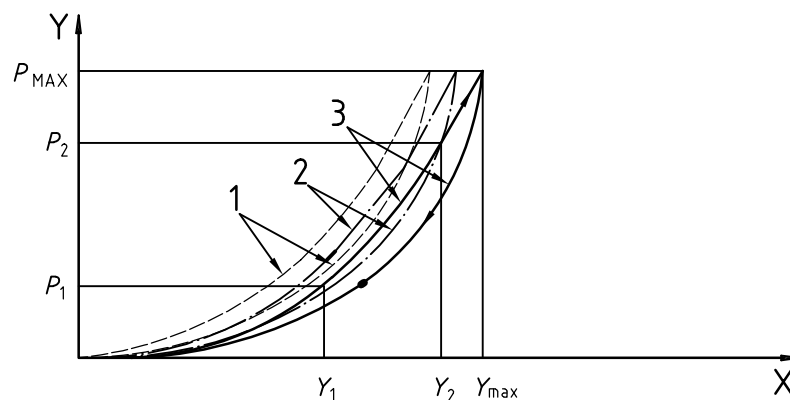
The test piece shall be attached to a test machine by the same or a mechanically equivalent manner as in the actual application. Compressive displacement gauges shall be attached to the periphery of the test piece. The compressive force at this time shall be zero, and the value of the compressive displacement shall be zero. If it is difficult to set a stable zero pressure because of machine controllability, a low arbitrary pressure could be regarded as “zero” by agreement between the structural engineer and the manufacturer.

6.2.1.5.2 Loading

An appropriate loading process shall be chosen to satisfy the requirement of the isolator design. There are two methods:

Method 1 (see Figure 6)

Load the test piece with the maximum design compressive force $P_{\max}$, and then return to a no-load state. This process shall be one cycle. Three such cycles shall be performed.



Key

X compressive displacement, Y
Y compressive force, P

- 1 first cycle
- 2 second cycle
- 3 third cycle

Figure 6 — Vertical properties (Method 1)