
**Elastomeric seismic-protection
isolators —**

**Part 2:
Applications for bridges —
Specifications**

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

Partie 2: Applications pour ponts — Spécifications



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Contents

	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols	3
5 Classification	6
5.1 General	6
5.2 Classification by construction	6
5.3 Classification by tolerances on shear stiffness	7
6 Requirements	7
6.1 General	7
6.2 Type tests and routine tests	7
6.3 Functional requirements	10
6.4 Design compressive force and design shear displacement	10
6.5 Performance requirements	10
6.5.1 General	10
6.5.2 Compressive properties	11
6.5.3 Rotation properties	11
6.5.4 Shear properties	11
6.5.5 Tensile properties	12
6.5.6 Dependencies of shear properties	13
6.5.7 Shear displacement capacity	14
6.5.8 Durability	14
6.5.9 Cyclic compressive fatigue properties	15
6.5.10 Reaction force characteristics at low-rate deformation	15
6.6 Rubber material requirements	15
6.6.1 General	15
6.6.2 Tensile properties	15
6.6.3 Properties after ageing in air	16
6.6.4 Hardness	17
6.6.5 Adhesion properties	17
6.6.6 Compression set	17
6.6.7 Ozone resistance	18
6.6.8 Other properties	18
6.7 Dimensional requirements	18
6.8 Requirements on steel used for flanges and reinforcing plates	18
7 Design rules	18
7.1 General	18
7.2 Shape factor	20
7.2.1 First shape factor	20
7.2.2 Second shape factor	20
7.3 Compressive and shear properties	21
7.3.1 Compressive stiffness	21
7.3.2 Shear stiffness and equivalent damping ratio	21
7.4 Shear strain due to horizontal displacements	22
7.5 Total local shear strain	22
7.5.1 Local shear strain due to compressive force	22
7.5.2 Local shear strain due to compressive force	22
7.5.3 Total local shear strain	23
7.6 Tensile stress on reinforcing steel plates	23
7.7 Stability	23

7.7.1	Maximum compressive stress in non-seismic condition	23
7.7.2	Rotation performance check	23
7.7.3	Buckling check	24
7.7.4	Tensile stress on isolator	24
7.8	Force, moment and deformation affecting structures	24
7.8.1	Shear force affecting structures due to movement	24
7.8.2	Resistance to rotation	24
7.8.3	Compressive displacement due to compressive force	25
7.9	Design of fixings	25
7.9.1	External forces affecting joint members	25
7.9.2	Fixings and stresses to be checked	25
7.9.3	Allowable stress	26
8	Manufacturing tolerances	26
8.1	General	26
8.2	Measuring instruments	26
8.3	Plan dimensions of isolator body	27
8.3.1	Measurement method (see Figure 1)	27
8.3.2	Tolerances	27
8.4	Product height	28
8.4.1	Measurement method	28
8.4.2	Tolerances	29
8.5	Flatness of products	30
8.5.1	Measurement method	30
8.5.2	Tolerances	30
8.6	Horizontal offset	30
8.6.1	Measurement method	30
8.6.2	Tolerances	30
8.7	Plan dimensions of flanges	30
8.8	Flange thickness	31
8.9	Tolerances on positions of flange bolt holes	31
9	Marking and labelling	32
9.1	Information to be provided	32
9.2	Additional requirements	32
9.3	Marking and labelling examples	33
10	Test methods	33
11	Quality assurance	33
Annex A (normative)	Tensile stress in reinforcing steel plate	34
Annex B (normative)	Buckling stability	36
Annex C (normative)	Allowable tensile stress in isolator	37
Annex D (informative)	Dependency of ultimate properties on shape factor	38
Annex E (informative)	Minimum recommended tensile properties for rubber materials	42
Annex F (informative)	Compressive stiffness	43
Annex G (informative)	Determination of shear properties of elastomeric isolators	47
Annex H (informative)	Determination of local shear strain due to compression	52
Annex I (informative)	Maximum compressive stress	55
	Bibliography	56

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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)*.

This third edition cancels and replaces the second edition (ISO 22762-2:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the definitions of some symbols in [Clause 4](#) have been changed.

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

ISO 22762 series includes two parts related to specifications for isolators, i.e. ISO 22762-2 for bridges and ISO 22762-3 for buildings. This is because the isolator requirements for bridges and buildings are quite different, although the basic concept of the two products is similar. Therefore, ISO 22762-2 and the relevant clauses in ISO 22762-1 are used when ISO 22762 (all parts) is applied to the design of bridge isolators whereas ISO 22762-3 and the relevant clauses of ISO 22762-1 are used when it is applied to building isolators.

The main differences to be noted between isolators for bridges and isolators for buildings are the following.

- a) Isolators for bridges are mainly rectangular in shape and those for buildings are 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 other than buildings and bridges (e.g. tanks), the structural engineer uses either ISO 22762-2 or ISO 22762-3, depending on the requirements of the structure.

Elastomeric seismic-protection isolators —

Part 2:

Applications for bridges — Specifications

1 Scope

This document specifies minimum requirements and test methods for elastomeric seismic isolators used for bridges, as well as rubber material used in the manufacture of such isolators.

It is applicable to elastomeric seismic isolators used to provide bridges with protection from earthquake damage. The isolators covered consist of alternate elastomeric layers and reinforcing steel plates, which 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 630 (all parts), *Structural steels*

ISO 22762-1:2018, *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 terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

breaking

rupture of *elastomeric isolator* (3.9) due to compression- (or tension-) shear loading

3.2

buckling

state when *elastomeric isolators* (3.9) lose their stability under compression-shear loading

3.3

compressive stiffness

K_v

compressive stiffness for all types of rubber bearings

3.4

cover rubber

rubber wrapped around the outside of inner rubber and reinforcing steel plates before or after curing of *elastomeric isolators* (3.8) 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

3.5

design compressive stress

long-term compressive force on the *elastomeric isolators* (3.8) imposed by the structure

3.6

effective loaded area

area sustaining vertical load in *elastomeric isolators* (3.8), which corresponds to the area of reinforcing steel plates

3.7

effective width

<rectangular elastomeric isolator> the 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

inner rubber

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

3.12

lead rubber bearing

LRB

elastomeric isolator (3.8) whose *inner rubber* (3.11) with a lead plug or lead plugs press fitted into a hole or holes of the isolator body to achieve damping properties

3.13

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.

3.14

maximum compressive stress

peak stress acting briefly on *elastomeric isolators* (3.8) in compressive direction during an earthquake

3.15

nominal compressive stress

long-term stress acting on *elastomeric isolators* (3.8) in compressive direction as recommended by the manufacturer for the isolator, including the safety margin

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 to the total thickness of the inner rubber

3.19**second shape factor**

<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**

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 the structure for base-isolated bridges or buildings and is responsible for specifying the requirements for *elastomeric isolators* (3.8)

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 (see Annex D).

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; 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
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

Table 1 (continued)

Symbol	Description
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
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 rectangular 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 (the minimum may be negative; ie the minimum force may be tensile)
Q	shear force
Q_b	shear force at break
Q_{buk}	shear force at buckling

Table 1 (continued)

Symbol	Description
Q_d	characteristic strength
S_1	first shape factor
S_2	second shape factor
T	temperature
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_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
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
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
γ_{max}	maximum design 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 rubber
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 height of rubber and steel layers to total rubber height

Table 1 (continued)

Symbol	Description
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
σ_{max}	maximum design compressive stress
σ_{min}	minimum design compressive stress
σ_{nom}	for building: nominal 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
τ_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

5 Classification

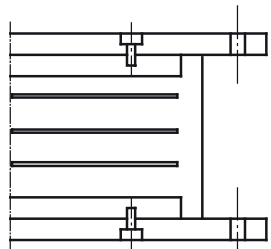
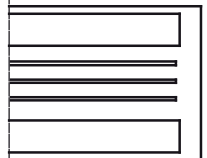
5.1 General

Elastomeric isolators are classified by construction, their ultimate properties and tolerances on their performance.

5.2 Classification by construction

Elastomeric isolators are classified by construction, as shown in [Table 2](#). The structural engineer shall specify which construction is to be used.

Table 2 — Classification by construction

Type	Construction	Illustration
Type I	Mounting flanges are bolted to connecting flanges, which are bonded to the laminated rubber.	
Type II	Mounting flanges are directly bonded to the laminated rubber.	
Type III	Isolators without mounting flanges	

5.3 Classification by tolerances on shear stiffness

Elastomeric isolators may be classified by their tolerance on shear stiffness, as shown in [Table 3](#). The structural engineer shall specify the tolerance required.

Table 3 — Classification by tolerance on shear stiffness

Class	Tolerance %
S-A	±10
S-B	±20

6 Requirements

6.1 General

Elastomeric isolators for bridges and the materials used in their manufacture shall meet the requirements specified in this clause. For test items (see [Table 4](#)) 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 temperature at the work site where the elastomeric isolators are installed.

6.2 Type tests and routine tests

6.2.1 Testing to be carried out on elastomeric isolators is classified into

- a) type tests, and

b) 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 an isolator. The test piece for each type test shall be full-scale or one of the options specified in [Table 4](#). The test piece shall not have been subjected to any previous test programme. The tests shall be performed on test pieces not subjected to any scragging, unless the production isolators are to be supplied after scragging. In that case, the test pieces shall be subjected to the same scragging procedure as the production isolators.

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.
- c) The second shape factors are within ± 10 %.
- d) The test conditions such as maximum and minimum vertical load applied in the ultimate property test, as described in [6.5.7](#), are more severe.

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Table 4 — Tests on products

Properties	Test item	Test method in ISO 22762-1:2018	Routine test	Type test	Test piece ^a
Compressive properties Rotation performance	Compressive stiffness Compressive deflection	6.2.1, method 1	X	X	Full-scale only
Shear properties	Shear stiffness Equivalent damping ratio Post-yield stiffness (for LRB) Characteristic strength (for LRB)	6.2.2	X	X	Full-scale only
Tensile properties	Tensile fracture strength Shear strain	6.5	N/A	Opt.	Scale B
Dependency of shear properties	Shear strain dependency	6.3.1	N/A	X	Scale B
	Compressive stress dependency	6.3.2	N/A	Opt.	Scale B
	Frequency dependency	6.3.3 5.8	N/A	X(m)	Scale A, STD, SBS
	Repeated loading dependency	6.3.4	N/A	X	Scale B
	Temperature dependency	6.3.5 5.8	N/A	X(m)	Scale A, STD, SBS
Shear displacement capacity	Breaking strain Buckling strain Roll-out strain	6.4	N/A	X	Scale B
Durability	Ageing	6.6.1 5.8	N/A	X(m)	Scale A, STD, SBS
	Creep	6.6.2	N/A	X	Scale A
Cyclic compressive fatigue	Shear stiffness	6.6.3	N/A	X	Scale B
Reaction force characteristics at low-rate deformation	Shear stiffness or shear force	6.7	N/A	Opt.	Scale A

X: Test to be conducted with isolators.

X(m): Test can be conducted either with isolators or with shear-block test pieces.

N/A: Not applicable.

Opt.: Optional.

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

Scale B: Scaling such that, for a circular bearing, diameter ≥ 450 mm, for a rectangular bearing, side length ≥ 400 mm and, for both types, rubber layer thickness $\geq 1,5$ mm and thickness of reinforcing steel plates $\geq 0,5$ mm.

STD: Standard test piece (see Tables 12 and 13 of ISO 22762-1:2018).

SBS: Shear-block test piece specified in ISO 22762-1:2018, 5.8.3. With LRB, SBS shall only be used for ageing tests.

^a Test piece may in all cases be a full-scale isolator. This column indicates other options, where these exist.

6.2.4 Routine tests are carried out during production for quality control. Sampling is allowed for routine testing. 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. If isolators are supplied after scragging, the routine test shall be performed on scragged isolators.

6.3 Functional requirements

6.3.1 Elastomeric isolators for bridges have the conventional basic functions of bridge rubber bearings, such as supporting the weight of the structure and live loads, absorbing the expansion, contraction, rotation and deflection of the superstructure. In addition, elastomeric isolators have more sophisticated functions in order to improve the deformation performance characteristics of superstructures, regulate the inherent period of superstructures, and effectively distribute inertial forces and reduce vibration energies using the spring and shock damping performance of rubber materials or a combination of rubber materials and lead plugs.

6.3.2 The elastomeric isolators shall function correctly when they are subjected to normal environmental conditions and maintenance, during an economically reasonable design service life. Where exceptional environmental and application conditions are encountered, additional precautions shall be taken. The conditions shall then be precisely defined.

6.3.3 Although seismic rubber bearings are designed to accommodate shear movements, they should not be used to provide permanent resistance to a constantly applied shear force.

6.3.4 Some caution is necessary if bearings are designed to accommodate tensile forces. The limiting values are given in [Annex C](#).

6.4 Design compressive force and design shear displacement

The design stress and strain of an isolator are defined by the following relationships between the design force and the displacement:

$$\sigma_0 = \frac{P_0}{A}, \sigma_{\max} = \frac{P_{\max}}{A_e}, \sigma_{\min} = \frac{P_{\min}}{A}$$

and

$$\gamma_0 = \frac{X_0}{T_r}, \gamma_{\max} = \frac{X_{\max}}{T_r}$$

The design compressive forces P_0 , $P_{\max}$ and $P_{\min}$ and design shear displacements X_0 and $X_{\max}$ for an isolator shall be provided by the structural engineer.

6.5 Performance requirements

6.5.1 General

The isolators shall be tested and the results recorded using the specified test methods. They shall satisfy the requirements listed below. The design value for each isolator shall be specified prior to the tests. The test items are summarized in [Table 4](#), which indicates the type tests that are optional, where a scaled isolator or a material test piece may substitute an isolator, and the tests to be performed as routine tests. Double-shear configuration testing, as described in 6.2.2 of ISO 22762-1:2018, can be employed with the approval of the structural engineer.

Some of these properties may be determined using one of the standard test pieces detailed in Tables 10 and 11 of ISO 22762-1:2018. The standard test pieces are used for non-specific product tests, such as testing in the development of new materials and products.

6.5.2 Compressive properties

6.5.2.1 General requirements

6.5.2.1.1 The maximum compressive displacement at the design load shall exceed the design requirement specified by the structural engineer.

6.5.2.1.2 When a compressive stiffness constant is required, the compressive stiffness, K_v , shall be within $\pm 30\%$ of the design requirement.

6.5.2.1.3 The values of P_1 and P_2 necessary to calculate K_v are obtained from [Formulae \(1\)](#) and [\(2\)](#):

$$P_1 = A_{\text{load}} \times \sigma_1 \quad (1)$$

$$P_2 = A_{\text{load}} \times \sigma_2 \quad (2)$$

whereby the recommended values of σ_1 and σ_2 should be as below:

- a) σ_1 : 1,5 N/mm²;
- b) σ_2 : 6,0 N/mm².

The values of σ_1 and σ_2 can also be given by the structural engineer.

6.5.2.2 Test piece

The test piece shall be a full-scale isolator for the type test and a production isolator for the routine test.

6.5.2.3 Test conditions

The standard test temperature, T_0 , is 23 °C or 27 °C. If the test is carried out at a different temperature, the result shall be corrected to the value of the property at T_0 by an appropriate method.

6.5.3 Rotation properties

6.5.3.1 General requirements

The deflection measured during compressive tests at the design load shall exceed the rotation deflection specified by the structural engineer. Static rotation tests can be carried out as an option using a test piece and test method agreed with the structural engineer.

6.5.3.2 Test piece

The test piece shall be a full-scale isolator for the type test and a production isolator for the routine test.

6.5.4 Shear properties

6.5.4.1 General requirements

6.5.4.1.1 The shear strain shall be 100 %, 175 % or a shear strain as selected by the structural engineer.

6.5.4.1.2 The shear stiffness shall be within the tolerance selected from [Table 3](#) for the design requirement.

6.5.4.1.3 The equivalent damping ratio shall satisfy the requirement specified by the structural engineer.

6.5.4.1.4 The test items required for determination of shear properties are given in [Table 5](#).

Table 5 — Shear property test items

Isolator type	Test item	No. of loading cycles	Data loop
LNR	Shear stiffness, K_h	3	Third cycle
HDR	Shear stiffness, K_h Equivalent damping ratio, h_{eq}	3 or 11	Third cycle or average of the second to the eleventh. The data may be determined from a single loop (preferably the third) or from the average response over the second to eleventh loops, depending on the decision of the structural engineer.
LRB	Shear stiffness, K_h , and equivalent damping ratio h_{eq} or post-yield stiffness K_d , and characteristic strength, Q_d	3 or 11	Third cycle or average of the second to the eleventh. The data may be evaluated from a single loop (preferably the third) or from the average response over the second to eleventh loops, depending on the decision of the structural engineer.

6.5.4.2 Test piece

The test piece shall be a full-scale isolator for the type test and a production isolator for the routine test.

6.5.4.3 Test conditions

The standard temperature, T_0 , is 23 °C or 27 °C. If the test is carried out at a different temperature, the result shall be corrected to the value of the property at T_0 by an appropriate method.

6.5.5 Tensile properties

6.5.5.1 General requirements

The test piece shall not break at the force specified by the structural engineer.

6.5.5.2 Test piece

The test piece shall be a full-scale or a scale B isolator.

6.5.5.3 Test conditions

The test piece shall be subjected to the shear strain specified by the structural engineer, and the force specified by the structural engineer to pull the isolator shall then be applied.

6.5.6 Dependencies of shear properties

6.5.6.1 Shear-strain dependency

6.5.6.1.1 General requirements

The shear-strain dependency shall be within a specified range agreed by both the structural engineer and the manufacturer.

6.5.6.1.2 Test piece

The test piece shall be a full-scale or a scale B isolator.

6.5.6.1.3 Test conditions

The shear properties at $0,5\gamma_0$, $1,0\gamma_0$, $1,5\gamma_0$ or the maximum shear strain shall be determined. Tests can also be performed at shear strains of $0,1\gamma_0$ and $0,2\gamma_0$.

6.5.6.2 Compressive stress dependency

6.5.6.2.1 General requirements

The compressive stress dependency shall be within a specified range agreed on by both the structural engineer and the manufacturer.

6.5.6.2.2 Test piece

The test piece shall be a full-scale or a scale B isolator.

6.5.6.2.3 Test conditions

The shear properties at 0 , $0,5\sigma_0$, $1,0\sigma_0$, $1,5\sigma_0$ and the maximum tensile stress, if applicable, shall be determined, and the results normalized using the value corresponding to the design stress.

6.5.6.3 Frequency dependency

6.5.6.3.1 General requirements

The frequency dependency shall be within a specified range agreed by both the structural engineer and the manufacturer.

6.5.6.3.2 Test piece

The test piece shall be a full-scale or a scale A isolator, a standard test piece or a shear-block test piece.

6.5.6.4 Repeated loading dependency

6.5.6.4.1 General requirements

The repeated loading dependency shall be within a specified range agreed by both the structural engineer and the manufacturer.

6.5.6.4.2 Test piece

The test piece shall be a full-scale or a scale B isolator.

6.5.6.4.3 Test conditions

The shear strain amplitude shall be γ_0 .

6.5.6.5 Temperature dependency

6.5.6.5.1 General requirements

The temperature dependency shall be within a specified range agreed by both the structural engineer and the manufacturer.

6.5.6.5.2 Test piece

The test piece shall be a full-scale or a scale A isolator, a standard test piece or a shear-block test piece.

6.5.6.5.3 Test conditions

The shear strain amplitude shall be γ_0 .

6.5.7 Shear displacement capacity

6.5.7.1 General requirements

6.5.7.1.1 The test piece shall be subjected to shear deformation under the constant compressive force given in the design requirements until breaking, buckling or roll-out occurs in one direction. The shear deformation and shear force at occurrence of break or buckling shall be recorded.

6.5.7.1.2 The vertical forces shall be $P_{\max}$ and $P_{\min}$ in the case of dowelled or recessed bearings.

6.5.7.1.3 For bolted bearings where $P_{\min}$ is tensile, an additional test at that load shall be performed if requested by the structural engineer. The test at $P_{\min}$ can be carried out by the procedure given in 6.5 of ISO 22762-1:2018, the shear strain applied shall be $\gamma_{\max}$ and the isolator shall not fail under the load $P_{\min}$.

6.5.7.2 Test piece

The test piece shall be a full-scale or a scale B isolator.

6.5.8 Durability

6.5.8.1 Ageing

6.5.8.1.1 General requirements

The change in the shear stiffness and in the damping properties shall be within $\pm 30\%$.

6.5.8.1.2 Test piece

The test piece shall be a full-scale or a scale A isolator, a standard test piece or a shear-block test piece.

If the production isolators are to be supplied after scragging, the test pieces shall be subjected to the same scragging procedure as the production isolators. The durability test shall be carried out directly after scragging.

6.5.8.2 Creep

6.5.8.2.1 General requirements

The creep strain [see ISO 22762-1:2018, 6.6.2.6 b) for definition] shall be less than 10 % after 60 years.

6.5.8.2.2 Test piece

The test piece shall be a full-scale or a scale A isolator.

6.5.9 Cyclic compressive fatigue properties

6.5.9.1 General requirements

The change in shear stiffness after the fatigue test shall be within ± 15 %.

It shall be confirmed that there are no cracks visible on the test piece exterior.

6.5.9.2 Test piece

The test piece shall be a full-scale or a scale B isolator.

6.5.9.3 Test conditions

The shear strain shall be 70 % and, optionally, an additional test can be carried out at 0 %. Compressive shear test as described in 6.2.2 of ISO 22762-1:2018 can be employed with the approval of the structural engineer.

6.5.10 Reaction force characteristics at low-rate deformation

6.5.10.1 General requirements

The shear stiffness or shear force at low-rate deformation shall be within a specified range agreed by both the structural engineer and the manufacturer.

6.5.10.2 Test piece

The test piece shall be a full-scale or a scale A isolator.

6.6 Rubber material requirements

6.6.1 General

The rubber materials used in the manufacture of elastomeric isolators shall be tested as required in [Table 6](#). The test results shall be properly recorded to verify that the specified requirements are satisfied. The frequency of each required routine test shall be determined in accordance with the manufacturer's quality control.

6.6.2 Tensile properties

The recommended minimum values are given in [Annex E](#).

6.6.3 Properties after ageing in air

6.6.3.1 General requirements

The requirements for tensile strength and elongation at break shall be the following:

- change in tensile strength: within ± 25 %;
- change in elongation at break: maximum -50 %.

EXAMPLE Original 600 %, elongation at break after ageing shall not be less than 300 %.

6.6.3.2 Test conditions

6.6.3.2.1 The recommended conditions for natural rubber- and chloroprene-based rubber materials should be as the following:

- natural rubber: 70 °C for 168 h;
- chloroprene rubber: 100 °C for 72 h.

6.6.3.2.2 Other conditions can be used by agreement between the structural engineer and the manufacturer. Test conditions and requirements for other elastomers shall be recommended by the manufacturer and agreed to by the structural engineer.

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Table 6 — Test items for rubber material

Property	Test item	Test method in ISO 22762-1:2018	Routine test		Type test	
			Inner rubber	Cover rubber	Inner rubber	Cover rubber
Tensile properties	Tensile strength	5.3	X	X	X	X
	Elongation at break		X	X	X	X
	100 % modulus		N/A	N/A	X	X
Air ageing properties	Tensile strength	5.4	Opt.	Opt.	X	X
	Elongation at break		Opt.	Opt.	X	X
	100 % modulus		N/A	N/A	X	X
Hardness	Hardness	5.5	Opt.	Opt.	Opt.	Opt.
Adhesion properties	90° peel strength	5.6	X	N/A	X	X
Compression set	Compression set	5.7	Opt.	N/A	X	N/A
Shear properties	Shear modulus	5.8	Opt.	N/A	X	N/A
	Equivalent damping ratio		Opt.	N/A	X	N/A
	Temperature dependency of shear modulus and loss factor		N/A	N/A	X	N/A
Brittleness point	Brittleness temperature	5.10	N/A	N/A	Opt.	X
Ozone resistance	Observation of cracks	5.11	N/A	X	N/A	X
Low-temperature crystallization	Hardness	5.12	N/A	N/A	X ^a	X ^a

X: Test to be carried out.

N/A: Not applicable.

Opt.: Optional.

^a Test is required, unless elastomer is not susceptible to crystallization in range of service temperatures (see 5.12 of ISO 22762-1:2018).

6.6.4 Hardness

Hardness may be used as a quality control test and for other purposes when a relationship has been established with the appropriate shear modulus. Hardness should not be used for primary design purposes.

6.6.5 Adhesion properties

The requirements for adhesion properties shall be 90° peel strength: minimum 7,0 N/mm.

6.6.6 Compression set

6.6.6.1 The recommended test conditions for NR-based compounds are 70 °C for 24₋₂⁰ h, 25 % compression.

6.6.6.2 The corresponding requirements shall be as follows:

- a) for LNR and other low-damping isolators, compression set ≤ 35 %;
- b) for HDR, compression set ≤ 60 %.

6.6.6.3 The test conditions and requirements for other elastomers shall be as recommended by the manufacturer and agreed by the structural engineer.

6.6.7 Ozone resistance

6.6.7.1 There shall be no cracks on the cover rubber.

6.6.7.2 The test conditions shall be: 50 pphm (50 mPa), 20 % elongation, 40 °C for 96 h.

6.6.8 Other properties

Properties other than the ones listed above shall be determined by the test methods listed in [Table 6](#). Each test result shall be within the tolerances specified prior to testing.

6.7 Dimensional requirements

6.7.1 Typical dimensions of elastomeric isolators are given in [Table 7](#) as a guide for the design of elastomeric isolators.

6.7.2 The thickness of the cover rubber should be 5 mm or more and should always meet the requirements of service environments and conditions.

6.7.3 The thickness of the reinforcing steel plate should satisfy the stress check specified in [7.6](#), and stability against large displacements in the event of an earthquake should also be considered.

6.8 Requirements on steel used for flanges and reinforcing plates

6.8.1 Steel plates used for flanges, end plates and inner plates shall meet the strength requirements specified in [Table 8](#).

6.8.2 ISO 630 (all parts) or any other International Standard shall be used, as long as the steel specified satisfies the requirements given in [Table 8](#) or is approved by the structural engineer.

7 Design rules

7.1 General

7.1.1 The elastomeric isolators shall be designed to meet the relevant provisions of this clause, in the serviceability limit state determined from the total compressive force (dead plus live force), restraint of thermal displacement and wind force, and more frequent earthquakes than the design level earthquake frequency, and the ultimate limit state caused by the design level earthquake.

7.1.2 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.

7.1.3 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.

Table 7 — Typical dimensions of elastomeric isolators

Dimension <i>a</i> or <i>d</i> ₀ mm	Thickness mm		Second shape factor <i>S</i> ₂	Lead plug ratio (for LRB only) <i>A</i> _p / <i>A</i> %		
	Rubber layer <i>t</i> _r			Steel plate <i>t</i> _s		
	min.	max.		min.	max.	
400	9	16	3 (see 7.6)	4	3	10
450	10	18				
500	11	20				
550	12	22				
600	13	25				
650	14	27				
700	15	29				
750	16	31				
800	17	33				
850	18	35				
900	19	37				
950	20	39				
1 000	21	41				
1 050	22	43				
1 100	23	45				
1 150	24	47				
1 200	25	50				
1 250	27	52				
1 300	28	54				
1 350	29	56				
1 400	30	58				
1 450	31	60				
1 500	32	62				

Table 8 — Hot- and cold-rolled sheet and strip for flanges and reinforcing steel plates

Designation	Yield stress σ_{sy} N/mm ²			Tensile strength σ_{su} N/mm ²
	Thickness of steel plate t_s mm			
	$t_s \leq 16$	$16 < t_s \leq 40$	$40 < t_s$	
SS400	$\sigma_{sy} \geq 245$	$\sigma_{sy} \geq 235$	$\sigma_{sy} \geq 215$	$400 \leq \sigma_{su} \leq 510$
SM490A	$\sigma_{sy} \geq 325$	$\sigma_{sy} \geq 315$	$\sigma_{sy} \geq 295$	$490 \leq \sigma_{su} \leq 610$

7.2 Shape factor

7.2.1 First shape factor

7.2.1.1 The first shape factor, S_1 , of a rubber layer is defined as the ratio of the effective loaded area, A_{load} , to the free surface area, A_{free} , including holes in the layer of rubber. This can be expressed by [Formula \(3\)](#):

$$S_1 = \frac{A_{\text{load}}}{A_{\text{free}}} \quad (3)$$

7.2.1.2 The loaded area of rubber layer, A_{load} , can be expressed as follows.

$$\text{Circular isolator: } A_{\text{load}} = A = \frac{\pi}{4} \left\{ d_0^2 - (n_h \times d_h^2 + n_p \times d_p^2) \right\} \quad (4)$$

$$\text{Rectangular isolator: } A_{\text{load}} = A = a \times b - \frac{\pi}{4} (n_h \times d_h^2 + n_p \times d_p^2) \quad (5)$$

where A_{load} is the same as the effective plan area A .

7.2.1.3 The load-free area of rubber layer, A_{free} , can be expressed as follows.

$$\text{Circular isolator: } A_{\text{free}} = \pi (d_0 + n_h \times d_h) t_r \quad (6)$$

$$\text{Rectangular isolator: } A_{\text{free}} = [2(a + b) + \pi \times n_h \times d_h] t_r \quad (7)$$

where

d_h is the diameter of holes;

n_h is the number of holes;

d_p is the diameter of lead plugs;

n_p is the number of lead plugs.

7.2.1.4 If the holes are adequately plugged with rubber or lead, the rubber layer can be treated as having no holes in calculating the load-free area, A_{free} .

7.2.1.5 For the rubber layer without holes and lead plugs, the first shape factor is given as follows.

$$\text{Circular isolators: } S_1 = \frac{d_0}{4t_r} \quad (8)$$

$$\text{Rectangular isolators: } S_1 = \frac{a \times b}{2(a + b)t_r} \quad (9)$$

7.2.2 Second shape factor

The second shape factor, S_2 , is defined as the ratio of the effective width to the total thickness of the inner rubber.

a) For circular isolators:

$$S_2 = \frac{d_0}{T_r} \quad (10)$$

b) For rectangular isolators:

When there is restriction of movement in the transverse direction:

$$S_2 = \frac{a}{T_r} \quad (11)$$

When there is no restriction of movement in the transverse direction:

$$S_2 = \frac{a}{T_r} \quad (a \leq b) \quad (12)$$

or

$$S_2 = \frac{b}{T_r} \quad (a > b)$$

7.3 Compressive and shear properties

7.3.1 Compressive stiffness

The compressive stiffness, K_v , is expressed as [Formula \(13\)](#):

$$K_v = \frac{E_c \times A}{T_r} \quad (13)$$

where E_c is as given in [Annex F](#).

7.3.2 Shear stiffness and equivalent damping ratio

7.3.2.1 The shear stiffness is expressed as [Formula \(14\)](#):

$$K_h = G \frac{A}{T_r} \quad (14)$$

7.3.2.2 When the shear strain dependency on shear modulus is considered, the shear stiffness is expressed as [Formula \(15\)](#):

$$K_h = G_{eq}(\gamma) \times \frac{A}{T_r} \quad (15)$$

where $G_{eq}(\gamma)$ is determined as indicated in [Annex G](#).

7.3.2.3 The equivalent damping ratio, h_{eq} , is expressed as [Formula \(16\)](#):

$$h_{eq} = \frac{1}{2\pi} \times \frac{W_d}{K_h \times X^2} \quad (16)$$

as shown in [Annex G](#).

7.4 Shear strain due to horizontal displacements

The shear strain due to horizontal displacements is given by the following formulae.

- a) When the shear strain is caused not by an earthquake, but by other effects such as thermally-induced movement, concrete shrinkage, warp of bridge:

$$\gamma_s = \frac{X_s}{T_r} \leq 70 \% \quad (17)$$

- b) During an earthquake:

$$\gamma_d = \frac{X_d}{T_r} \leq \frac{\gamma_u}{1,2} \quad (18)$$

7.5 Total local shear strain

7.5.1 Local shear strain due to compressive force

The local shear strain due to compressive force is given by the following formulae:

- a) for rectangular isolators:

$$\gamma_c = \frac{8,5 \times S_1 \times P_{\max}}{E_c^s \times A_e} \quad (19)$$

- b) for circular isolators:

$$\gamma_c = \frac{6,0 \times S_1 \times P_{\max}}{E_c^s \times A_e} \quad (20)$$

where

E_c^s is as given in Annex H;

$P_{\max}$ is the maximum compressive force;

A_e is the overlap area associated with non-seismic displacements.

7.5.2 Local shear strain due to beam rotation

The local shear strain due to beam rotation is expressed as [Formulae \(21\)](#) and [\(22\)](#):

- a) For rectangular isolators:

$$\gamma_r = \frac{a^2 \times \theta_a + b^2 \times \theta_b}{2t_r^2 n} \quad (21)$$

- b) For circular isolators:

$$\gamma_r = 6,0 \times S_1^2 \times \theta / n \quad (22)$$

NOTE [Formulae \(21\)](#) and [\(22\)](#) assume the rubber is incompressible. The effect of the finite compressibility is to increase the shear strain. The formulae lead to an error generally less than 10 % for $S_1 < 8$.

7.5.3 Total local shear strain

The total local shear strain shall satisfy [Formula \(23\)](#):

$$\sum \gamma = \gamma_c + \gamma_s + \gamma_r \leq \gamma_a \quad (23)$$

where

$\sum \gamma$ is the total local shear strain;

γ_a is the upper-limit design strain value (see [Annex F](#)).

7.6 Tensile stress on reinforcing steel plates

The tensile stress on the reinforcing steel plates shall satisfy [Formula \(24\)](#):

$$\sigma_s = 2\lambda \times \frac{P_{\max} \times t_r}{A \times t_s} \leq \sigma_{sa} \quad (24)$$

where

λ is as given in [Annex A](#);

σ_{sa} is as specified by the structural engineer;

A is the overlap area associated with non-seismic displacements.

7.7 Stability

7.7.1 Maximum compressive stress in non-seismic condition

The maximum compressive stress is given by [Formula \(25\)](#):

$$\sigma_{\max} = \frac{P_{\max}}{A} \quad (25)$$

where

$P_{\max}$ is the maximum compressive force;

A is the overlap area associated with non-seismic displacements.

It is recommended that the maximum compressive stress in non-seismic condition meet the requirements given in [Annex I](#).

7.7.2 Rotation performance check

The rotation performance by the combination of compressive stress with beam rotational loading shall satisfy [Formulae \(26\)](#) and [\(27\)](#).

a) For rectangular isolators:

$$\frac{1}{C_1} \times \frac{P}{Kv} \geq \frac{a \times \theta_a + b \times \theta_b}{2} \quad (26)$$

b) For circular isolators:

$$\frac{1}{C_1} \times \frac{P}{K_v} \geq \frac{d_0 \times \theta}{2} \quad (27)$$

where

C_1 is a safety factor, the value of which shall be taken as 1 and 3;

P is compressive force in non-seismic condition.

NOTE The safety factor, C_1 , allows for uncertainty in the value of K_v .

7.7.3 Buckling check

The buckling stability due to compressive forces under non-seismic and earthquake conditions shall satisfy [Formulae \(28\)](#) and [\(29\)](#).

a) For rectangular isolators:

$$\frac{P_{\max}}{A_c} \leq \frac{1}{\phi} \times \frac{a_c \times G \times S_1}{T_r} \quad (28)$$

b) For circular isolators:

$$\frac{P_{\max}}{A_e} \leq \frac{1}{\phi} \times \frac{d_0 \times G \times S_1}{T_r} \quad (29)$$

where ϕ is as given in [Annex B](#).

7.7.4 Tensile stress on isolator

The tensile stress caused by uplift forces on the isolator shall satisfy [Formula \(30\)](#):

$$\sigma_t = \frac{V}{A_e} \leq \sigma_{te} \quad (30)$$

where

σ_{te} is as given in [Annex C](#);

A_e is the overlap area associated with non-seismic and seismic displacements.

7.8 Force, moment and deformation affecting structures

7.8.1 Shear force affecting structures due to movement

The shear force, Q , affecting structures due to shear movement is given by [Formula \(31\)](#):

$$Q = K_h \times X \quad (31)$$

7.8.2 Resistance to rotation

7.8.2.1 The spring-back moment due to axial rotations through the centre of an elastomeric isolator and parallel to the direction of the dimension, b , of the isolator is given by [Formulae \(32\)](#) and [\(33\)](#).

a) For rectangular isolators:

$$M = \frac{G}{\gamma_m} \times \frac{\theta \times a^5 \times b}{n \times t_r^3 \times K_s} \quad (32)$$

b) For circular isolators:

$$M = \frac{G}{\gamma_m} \times \frac{\pi \times \theta \times D^6}{512 \times n \times t_r^3} \quad (33)$$

where

$$\gamma_m = 1;$$

K_s is a factor as given in [Table 9](#).

Table 9 — K_s factors

b/a	0,5	0,75	1	1,2	1,25	1,3	1,4	1,5
K_s	137	100	86,2	80,4	79,3	78,4	76,7	75,3
b/a	1,6	1,7	1,8	1,9	2	2,5	10	∞
K_s	74,1	73,1	72,2	71,5	70,8	68,3	61,9	60

NOTE [Formula \(32\)](#) above for rectangular isolators is applicable to axial rotations parallel to b even when $b < a$.

7.8.2.2 The spring-back moment values calculated using the above formulae are sufficient for most purposes. However, they shall be determined experimentally if detailed information on these values is necessary. For large vertical compressive forces, P , the stiffness in rotation of rubber bearings can be higher than that given by the formulae, owing to the decrease in the effective thickness of the rubber layers.

7.8.3 Compressive displacement due to compressive force

The compressive displacement, Y , due to compressive forces is given by [Formula \(34\)](#):

$$Y = \frac{P}{K_v} \quad (34)$$

7.9 Design of fixings

7.9.1 External forces affecting joint members

The following are the necessary items and combinations selected as external forces to be considered in designing joint members:

- compressive reactions (dead force reaction, live force reaction, negative reaction, lift during earthquakes, etc.);
- shear forces caused by movement under service loads, wind, seismic loads and other actions;
- overturning moments determined by multiplying the shear force by the effective height of the isolator;
- eccentric moments caused by the shear displacement and compressive reaction.

7.9.2 Fixings and stresses to be checked

Stresses in fixings to be checked are given in [Table 10](#) for bolts, in [Table 11](#) for shear keys and in [Table 12](#) for flanges.

Table 10 — Bolts

	External force	Cross-section to be considered
Tensile	Tensile force resisting moment plus uplift compressive force	Cross-sectional area of bolts contributing to tensile force
Shear	Shear force	Overall area of cross-section

NOTE When calculating the tensile stress resisting moment and the cross-sectional area of bolts contributing to it, a method considered as reasonable upon discussion between the structural engineer and the manufacturer can be adopted. For example, the bending theory for single-reinforcement concrete is applicable.

Table 11 — Shear keys

	External force	Cross-section to be considered
Compression	Shear force	Compression area common to key and flange
Shear	Shear force	Key cross-sectional area

Table 12 — Mounting flanges

	External force	Cross-section to be considered
Compression	Shear force	Compression area common to key and flange
Bending	Tensile force from resisting moment plus uplift force	Effective width of flange × thickness

7.9.3 Allowable stress

The allowable stress shall be specified by the structural engineer.

8 Manufacturing tolerances

8.1 General

Dimensional tolerances for elastomeric isolators for bridges shall be as specified below.

Product dimensions shall be specified at a standard temperature of T_0 [= (23 or 27) °C] $\pm$ 5 °C. Measurement made at a different temperature shall be corrected to a standard 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.

8.2 Measuring instruments

The following can be used as measuring instruments:

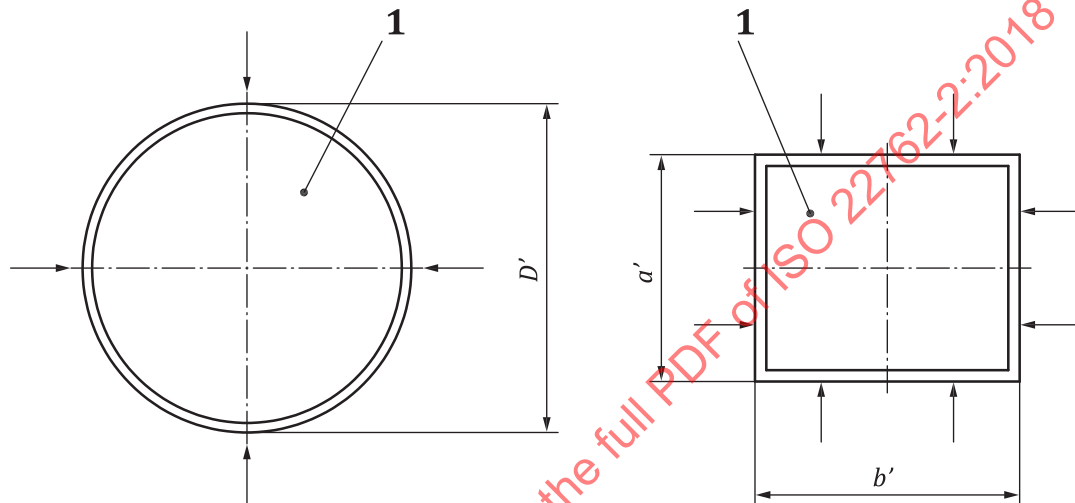
- vernier calipers;
- calipers;
- height gauge;
- limit gauge, to be calibrated with a gauge certified to match the upper and lower tolerance limits;
- straight rule;
- other instruments, such as a tape measure.

8.3 Plan dimensions of isolator body

8.3.1 Measurement method (see Figure 1)

The measurement method to determine the plan dimensions of circular and rectangular isolators shall be as follows.

- For circular isolators: the plan dimensions shall be determined by measuring the diameter at two different locations.
- For rectangular isolators: the plan dimensions shall be measured at two positions on each side.



Key

1 reinforcing steel plate

NOTE The measurement points are indicated by arrows.

Figure 1 — Examples of plan dimension measurement positions

8.3.2 Tolerances

Tolerances on plan dimensions (width a' , length b' and diameter D') are specified for Type I, Type II and dowelled Type III isolators in Table 13 according to the nominal dimensions of the product.

For recessed Type III isolators, the tolerance shall be ± 2 mm, or $\pm 0,4$ % of the plan dimension, whichever is the greater.

Table 13 — Tolerances on plan dimensions (a' , b' and D') of products

Nominal plan dimensions (a' , b' , D') mm		Tolerance
Above	Maximum	
—	500	± 5 mm
500	1 500	± 1 %
1 500	—	± 15 mm

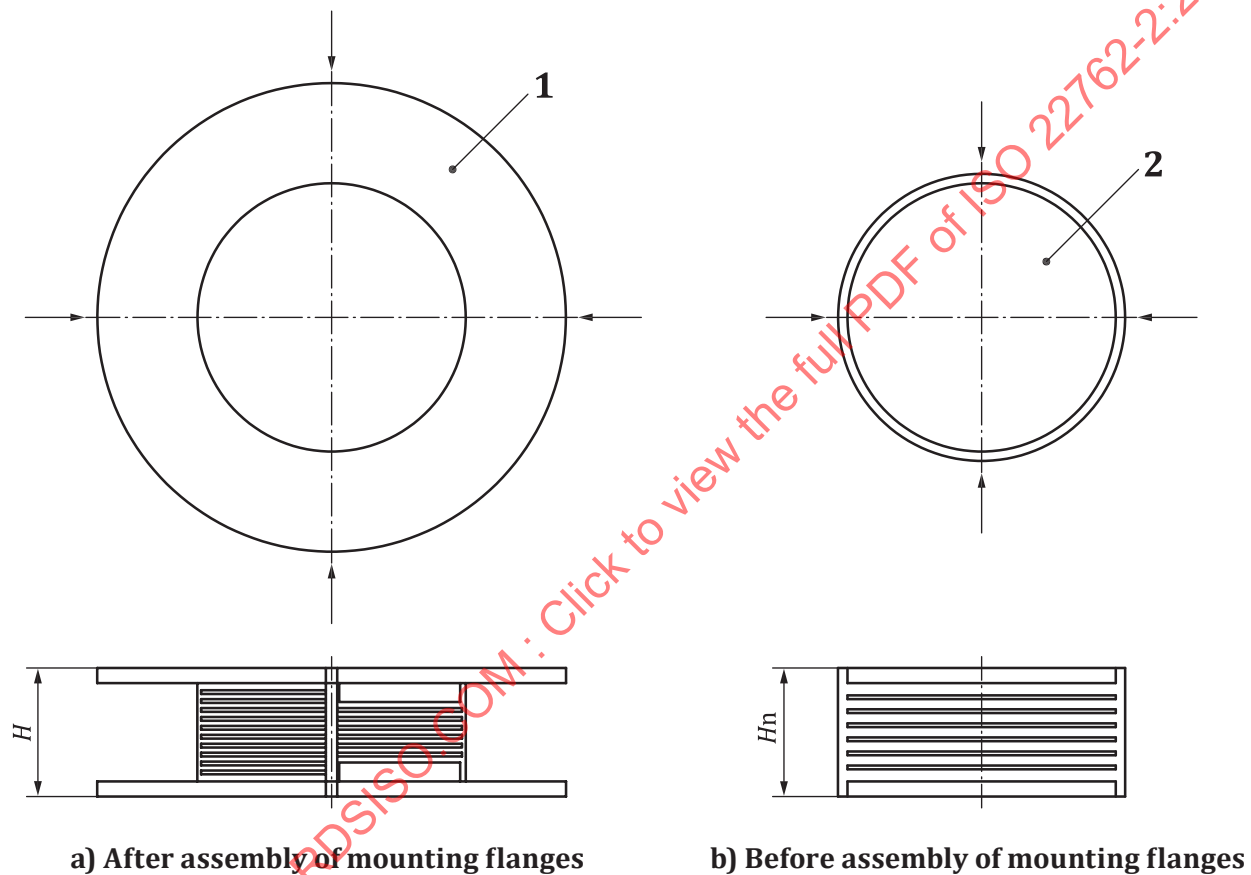
8.4 Product height

8.4.1 Measurement method

The method to measure the height of circular and rectangular isolators shall be as follows.

- For circular isolators: the height shall be measured at the four points where two straight lines at right angles to each other which pass through the centre of the circular cross-section intersect the outer circumference (see [Figure 2](#)).
- For rectangular isolators: the height shall be measured at each of the four corners (see [Figure 3](#)).

The product height shall be taken as the arithmetic mean of the four measured values.

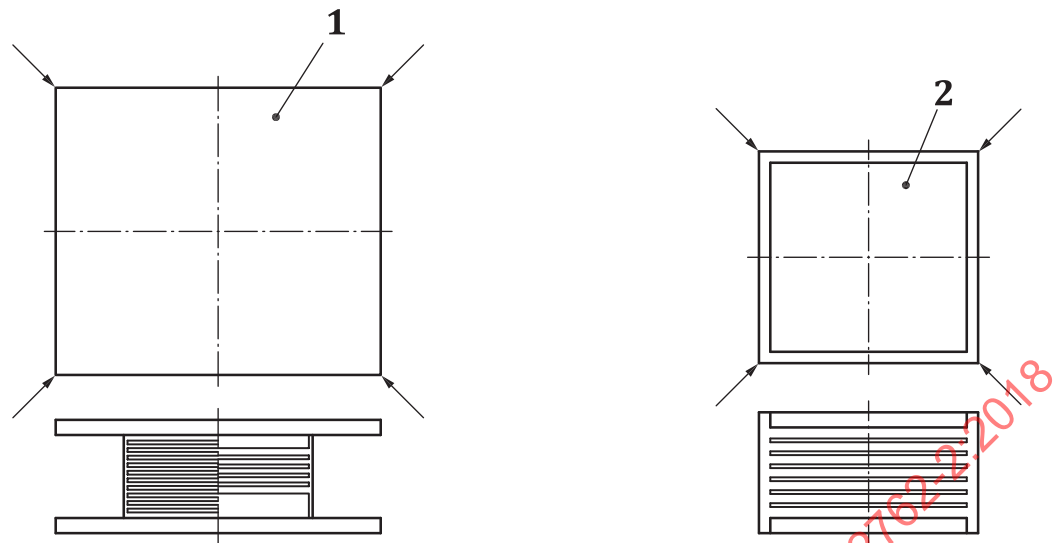


Key

- 1 flange
- 2 connecting plate

NOTE The measurement points are indicated by arrows

Figure 2 — Height measurement positions for circular isolators

**Key**

- 1 flange
2 connecting plate

NOTE The measurement points are indicated by arrows.

Figure 3 — Height measurement positions for rectangular isolators

8.4.2 Tolerances

Tolerances on the product height are specified according to the nominal dimensions and shall be as given in [Tables 14](#) and [15](#). [Table 15](#) is not applicable to Type III bearings.

Table 14 — Tolerances on product height of isolator body, H_n

Nominal dimensions Product height, H_n mm		Tolerance
Above	Maximum	
20	160	$\pm 2,5 \%$
160	—	$\pm 4 \text{ mm}$

Table 15 — Tolerances on total product height, H_n

Nominal dimensions Flange diameter, D_f or side length, L_f mm		Tolerance mm
Above	Maximum	
—	1 500	$\pm(H_n \times 0,025 + 1,5)$
1 500	—	$\pm(H_n \times 0,025 + 2,5)$
For D_f and L_f , see Figure 5 .		

8.5 Flatness of products

8.5.1 Measurement method

The flatness is the maximum difference in height at four points on the circumference of the isolator. The measurement positions shall be the same as those for product height (H_n) measurements.

8.5.2 Tolerances

The tolerance on the flatness of products is determined according to the nominal dimensions and shall be as shown in [Table 16](#).

Table 16 — Tolerances on flatness of elastomeric isolators

Dimensions in millimetres

Nominal dimensions Plan dimensions, (a' , b' , D')		Tolerance
Above	Maximum	
—	1 000	1
1 000	—	$(a', b' \text{ and } D')/1\,000$

8.6 Horizontal offset

8.6.1 Measurement method

The horizontal offset is measured between the top and bottom edges of the product at two positions. For rectangular isolators, the positions shall be on adjacent sides, and for circular isolators on orthogonal diameters.

8.6.2 Tolerances

Referring to [Figure 4](#), the horizontal offset, δ_H , of elastomeric isolators shall be as follows.

$$\delta_H \leq 5,0 \text{ (mm)}$$

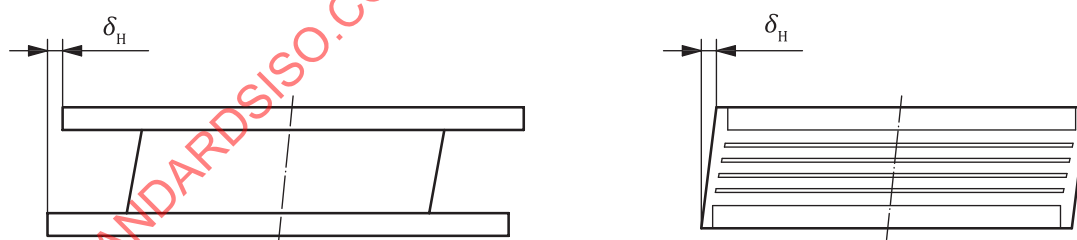


Figure 4 — Measurement of horizontal offset

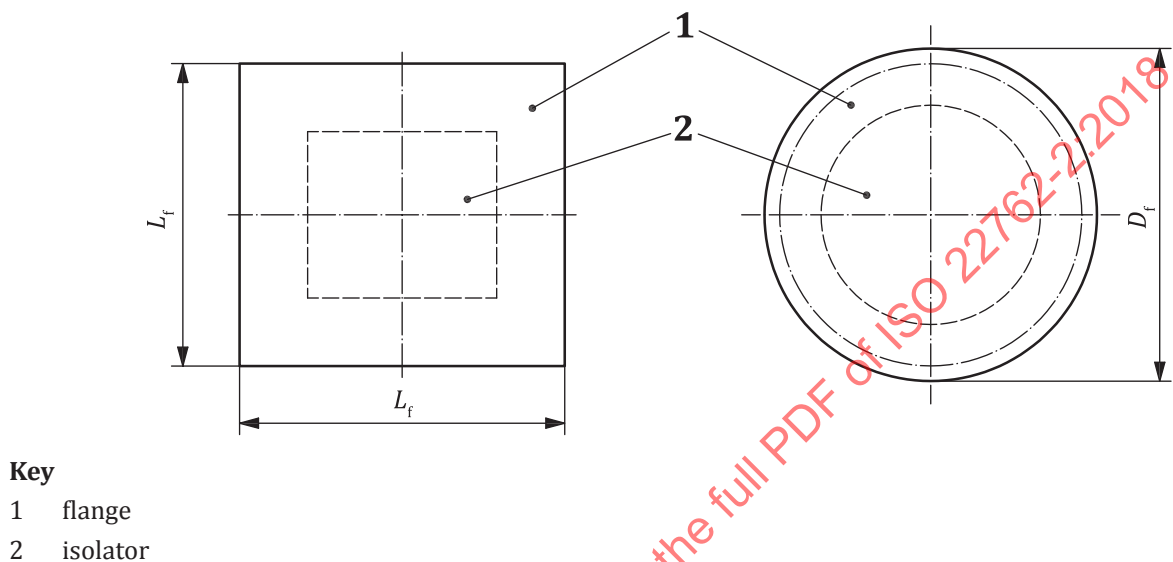
8.7 Plan dimensions of flanges

The tolerances on the plan dimensions of flanges shall be as specified in [Table 17](#).

Table 17 — Tolerances on flange diameter and side length

Dimensions in millimetres

Thickness		D_f (or L_f) < 1 000	$1\ 000 \leq D_f$ (or L_f) < 3 150	$3\ 150 \leq D_f$ (or L_f) < 6 000
Above	Maximum			
6	27	$\pm 2,0$	$\pm 2,5$	$\pm 3,0$
27	50	$\pm 2,5$	$\pm 3,0$	$\pm 3,5$
50	100	$\pm 3,5$	$\pm 4,0$	$\pm 4,5$

**Figure 5 — Measurement of plan dimensions of flanges**

8.8 Flange thickness

The tolerances on flange thickness shall be as specified in [Table 18](#).

Table 18 — Tolerances on thickness of flanges (mounting flanges and connecting flanges)

Dimensions in millimetres

Nominal dimension		D_f (or L_f) < 1 600	$1\ 600 \leq D_f$ (or L_f) < 2 000
Above	Maximum		
16,0	25,0	$\pm 0,65$	$\pm 0,75$
25,0	40,0	$\pm 0,70$	$\pm 0,80$
40,0	63,0	$\pm 0,80$	$\pm 0,95$
63,0	100,0	$\pm 0,90$	$\pm 1,10$

8.9 Tolerances on positions of flange bolt holes

The tolerances on the positions of flange bolt holes, including the positions of tapped holes on the connecting plate, shall be as specified in [Table 19](#).

Table 19 — Tolerances on positions of flange bolt holes

Dimensions in millimetres

Nominal dimension		Class M (Medium)	Class N (Non-critical)
Above	Maximum		
400	1 000	±0,8	±2,0
1 000	2 000	±1,2	±3,0
2 000	—	±2,0	±4,0

9 Marking and labelling

Marking and labelling are required for the purpose of identification of a product and its properties, and to ensure traceability of the product's history after installation. Therefore, marking and labelling are considered to be very important for quality control of a product.

9.1 Information to be provided

The following information shall be provided for marking and labelling of elastomeric isolators.

- The manufacturer's name or corporate emblem.
- The type of elastomeric isolator. Types of elastomeric isolator shall be identified as in [Table 20](#).

Table 20 — Identification of elastomeric isolators according to types and designations

Type	Designation
Linear natural rubber bearing	LNR
High-damping rubber bearing	HDR
Lead rubber bearing	LRB

- The serial number or manufacturing number.
- The size (optional).

EXAMPLE 1 Cross-sectional area circular and diameter 800 mm: size code D-800.

EXAMPLE 2 Cross-sectional area square and side length 800 mm × 800 mm: size code 800 × 800 or S-800.

9.2 Additional requirements

Additional requirements for marking and labelling include the following.

- Marking shall be on lateral surfaces.
- Marking shall be water-resistant and abrasion-resistant.
- Marking shall be large enough to be easily identified. The size of the characters shall be larger than 5 mm in width and height.

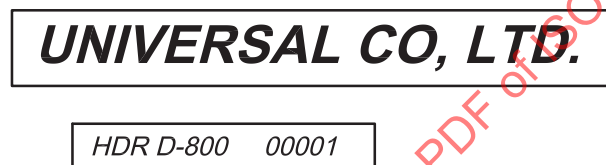
9.3 Marking and labelling examples

Marking may be in one line, as in Example 1, or in two lines, as in Example 2.

EXAMPLE 1



EXAMPLE 2



10 Test methods

Test methods prescribed in this clause shall be in accordance with ISO 22762-1.

11 Quality assurance

A quality assurance programme to ensure consistent manufacturing of the isolators, including, but not limited to, preparation of reinforcing steel plates, uniformity of the thickness of the reinforcing steel plates and uniformity of the vulcanized rubber layers, shall be proposed by the manufacturer and approved by the structural engineer.

Annex A (normative)

Tensile stress in reinforcing steel plate

A.1 Method for checking strength of reinforcing steel plate

The tensile stress in the reinforcing steel plates shall satisfy [Formula \(A.1\)](#):

$$\sigma_s = 2\lambda \times \frac{P_{\max} \times t_r}{A \times t_s} \leq \sigma_{sa} \quad (\text{A.1})$$

where λ is a correction factor, including a safety margin, obtained from experimental data as follows:

- a) for plates without holes: $\lambda = 1,0$;
- b) for plates with holes ($A_p/A = 0,03$ to $0,1$): $\lambda = 1,5$.

A.2 Verification of [Formula \(A.1\)](#) by compressive failure testing of isolators

A.2.1 General

The test described below was carried out to verify the applicability of [Formula \(A.1\)](#).

A.2.2 Test pieces

The test pieces used are described in [Table A.1](#). The test pieces were square, measuring 240 mm × 240 mm, the thickness of one rubber layer being 5,0 mm and the test pieces having six layers of laminated rubber. The thickness of the reinforcing steel plate was 2,3 mm made of SS400 mild steel (see [6.8](#)). One isolator had no hole in the steel plate (RB-1), whereas the other had four holes of diameter 34,5 mm which were plugged with lead cores (RB-2). Two isolators for each type (with or without hole) were subjected to the testing.

Table A.1 — Dimensional characteristics of test pieces

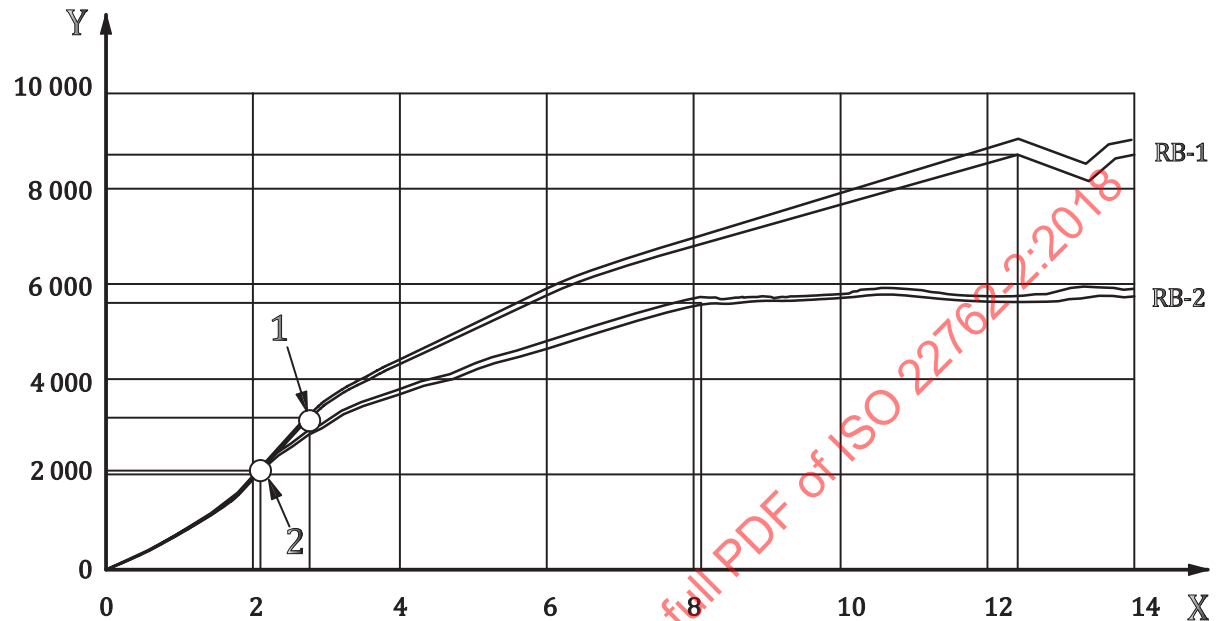
	RB-1	RB-2
Type	LNR	LRB
Plan dimension ($a \times a$), mm	240 × 240	
Hole diameter, d , mm	0	4 × 34,5
Thickness of one rubber layer, t_r , mm	5	
Number of layers	6	
Reinforcing plate thickness, t_s , mm	2,3	

A.2.3 Test conditions

Isolators were subjected to compressive loading until failure was indicated by the force-deflection curve. The horizontal displacement was maintained at zero during testing. The compressive loading rate was 32 kN/s.

A.2.4 Test results

A.2.4.1 Figure A.1 shows the plots of the force-deflection curve obtained during testing. The yield point of the plate was determined as the point on the curve where the second-order derivative of the curve was zero.



Key

- X compressive deflection, δ , expressed in millimetres
- Y compressive force, P , expressed in kilonewtons
- 1 yield point of plate for RB-1
- 2 yield point of plate for RB-2

Figure A.1 — Compressive force-deflection curve for isolator

A.2.4.2 The tensile stresses in the plates calculated from the compressive force at the observed yield point using Formula (A.1) are summarized in Table A.2.

Table A.2 — Summary of test results

	RB-1	RB-2	RB-1/RB-2
A Compressive force, P , at yield point, expressed in kN	3 200	2 100	0,66
B Compressive stress, σ , at yield point, expressed in N/mm ²	55,6	36,5	0,66
C Yield stress in plate, expressed in N/mm ² , computed from P and Formula (A.1)	241,6	237,9	1,016
D Design yield stress of plate, expressed in N/mm ²	235	235	—

A.2.4.3 Comparing the values of C and D in Table A.2, the applicability of Formula (A.1) can be seen to be verified.

For further details, see Reference [3].

Annex B (normative)

Buckling stability

The values of factor for computation of buckling stability, ϕ , shall be as given below:

- a) for non-seismic: $\phi = 2,5$;
- b) during earthquake: $\phi = 1,5$.

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Annex C

(normative)

Allowable tensile stress in isolator

The values of the allowable tensile stress in an isolator, σ_{te} , based on experimental data, are as given below (in this annex):

- a) for non-seismic conditions: $\sigma_{te} = 0 \text{ N/mm}^2$;
- b) during earthquake:
 - $\sigma_{te} = 1,6 \text{ N/mm}^2$ (modulus G : $0,8 \leq G < 1,0 \text{ MPa}$);
 - $\sigma_{te} = 2,0 \text{ N/mm}^2$ (modulus $G < 1,0 \text{ MPa}$ and above);
 - σ_{te} is determined by experiment when modulus G is less than $0,8 \text{ MPa}$.

Annex D (informative)

Dependency of ultimate properties on shape factor

D.1 General

The ultimate properties of elastomeric isolators depend on the shape of the isolator.

This annex shows the shape factor dependency of the ultimate properties.

D.2 Specification of test pieces

To confirm the influence of the shape factor on the ultimate properties, five test pieces of different shapes were subjected to an ultimate property test. The specification and geometry of the test pieces were as shown in [Table D.1](#) and [Figure D.1](#).

Table D.1 — Test pieces

Ultimate property test	Shape No.				
	1	2	3	4	5
Rubber material	NR (shear modulus $G = 1,0$ MPa)				
Effective side length (mm)	400 × 400				
Thickness of outside cover rubber (mm)	10				
Thickness of one inner steel plate (mm)	3,2				
Thickness of one rubber layer (mm)	18	9	6,5	9,5	9
Number of rubber layers	3	6	8	12	4
Total thickness of rubber layers (mm)	54	54	52	114	36
Height of test piece, h , (mm)	60,4	70	74,4	149,2	45,6
First shape factor, S_1	5,6	11,1	15,4	10,5	11,1
Second shape factor, S_2	7,4	7,4	7,7	3,5	11,1
Number of test pieces	3				

Dimensions in millimetres

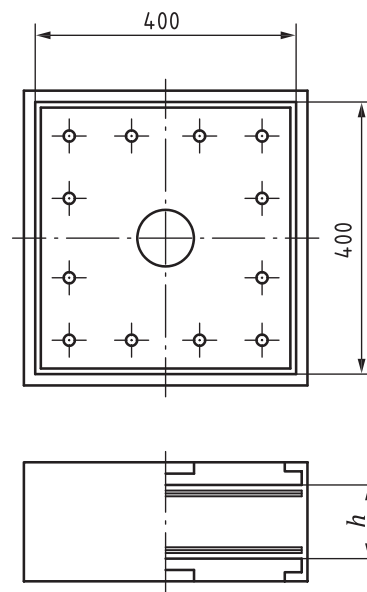


Figure D.1 — Test piece

D.3 Test conditions

The horizontal load was applied at a constant speed in one direction until the elastomeric isolator was broken. The test conditions were as shown in [Table D.2](#).

Table D.2 — Test conditions

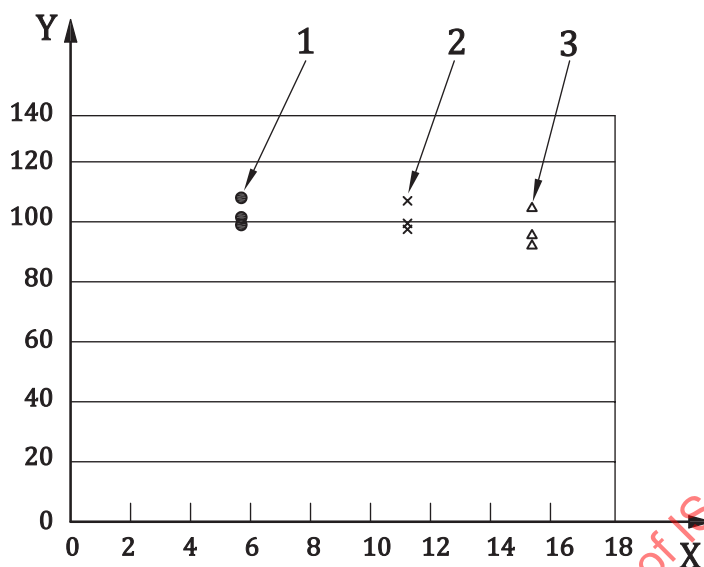
Test parameter	Shape No.				
	1	2	3	4	5
Compressive stress (N/mm ²)	6,0				
Compressive force (kN)	960				
Shear strain rate (%/s)	7,0				
Shear rate (mm/s)	3,8	3,8	3,6	8,0	2,5

D.4 Dependency of ultimate properties on shape factor

D.4.1 The dependency of the first and the second shape factors on breaking shear strain are shown in [Figures D.2](#) and [D.3](#), respectively.

D.4.2 The first shape factor has a limited dependency, whereas the second shape factor has a large dependency. The breaking shear strain is increased by an increase in the second shape factor.

D.4.3 These results cover S_1 from 5,6 to 15,4 and S_2 from 3,5 to 11,1, and the performance of the isolators having S_1 or S_2 outside this range shall be confirmed by additional tests. (See Reference [4] for details.)



Key

X first shape factor, S_1

Y normalized breaking shear strain (with average value of ISO standard specimen as 100)

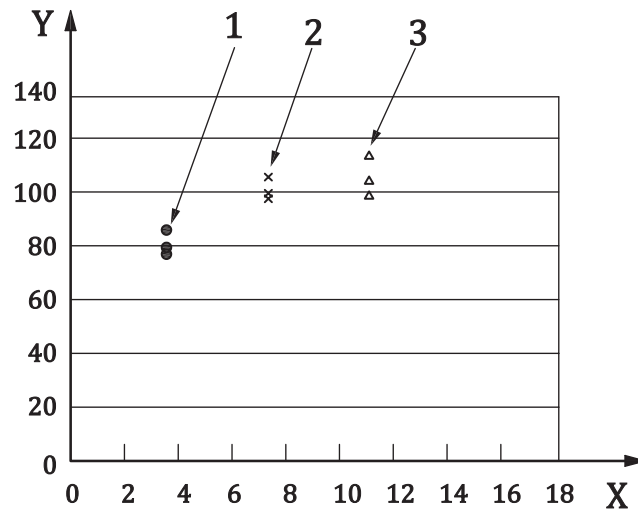
1 shape No.1

2 shape No. 2 [ISO standard specimen; see Table 13 of ISO 22762-1: 2018]

3 shape No. 3

NOTE S_2 was constant at either 7,4 or 7,7.

Figure D.2 — Dependency on first shape factor

**Key**

X second shape factor, S_2

Y normalized breaking shear strain (with average value of ISO standard specimen as 100)

1 shape No.4

2 shape No. 2 [ISO standard specimen; see Table 13 of ISO 22762-1:2018]

3 shape No. 5

NOTE S_1 was constant at either 11,1 or 10,5.

Figure D.3 — Dependency on second shape factor

Annex E

(informative)

Minimum recommended tensile properties for rubber materials

The minimum recommended tensile properties of rubber materials are as described in [Table E.1](#).

Table E.1 — Recommended tensile properties of rubber materials

Property	Shear modulus G MPa ^a		
	0,8	1,0	1,2
Tensile strength (MPa)			
HDR			
Moulded test piece		≥10	
Test piece from isolator		≥8	
LNR			
Moulded test piece		≥15	
Test piece from isolator		≥13	
Elongation at break (%)			
HDR			
Moulded test piece	≥650	≥600	≥550
Test piece from isolator	≥600	≥550	≥500
Low-damping chloroprene rubber			
Moulded test piece	≥450	≥450	≥450
Test piece from isolator	≥400	≥400	≥400
LNR and LRB natural rubber			
Moulded test piece	≥550	≥550	≥500
Test piece from isolator	≥500	≥500	≥450
^a The shear modulus, G , is that at 100 % to 175 % of the shear strain. NOTE γ_a in 7.5 can be obtained from the values of the elongation at break of test pieces taken from an isolator with a safety factor of 1.5. For example, for HDR ($G = 0,8$), $\gamma_a = 600/1,5$.			

Annex F (informative)

Compressive stiffness

F.1 Compressive stiffness, K_v

The compressive stiffness, K_v , is given by [Formula \(F.1\)](#):

$$K_v = \frac{E_c \times A}{T_r} \quad (\text{F.1})$$

F.2 Apparent Young's modulus, E_c

F.2.1 The apparent Young's modulus, E_c , is calculated using [Formula \(F.2\)](#):

$$E_c = \left(\frac{1}{E_{ap}} + \frac{1}{E_\infty} \right)^{-1} \quad (\text{F.2})$$

F.2.2 Various formulae have been proposed for determining, E_{ap} , such as in [F.2.2.1](#) and [F.2.2.2](#) [[Formulae \(F.3\)](#) and [\(F.4\)](#)]:

F.2.2.1 [Formula 1](#):

$$E_{ap} = E_0 \times (1 + 2\kappa S_1^2) \quad (\text{F.3})$$

where E_0 may be taken to be approximately equal to $3G$, where G is the shear modulus of rubber.

Examples of constants for several natural rubber compounds are listed in [Table F.1](#). In practice, manufacturers apply their own constants for the design of isolators.

Table F.1 — Examples of constants for design of elastomeric isolators (see Reference [5])

IRHD	E_0 MPa	G MPa	κ	E_∞ MPa
30	0,92	0,30	0,93	$1,00 \times 10^3$
40	1,50	0,45	0,85	$1,00 \times 10^3$
50	2,20	0,64	0,73	$1,03 \times 10^3$
60	5,34	1,06	0,57	$1,15 \times 10^3$
70	7,34	1,72	0,53	$1,27 \times 10^3$

F.2.2.2 [Formula 2](#):

$$E_{ap} = 3G_{eq}(\gamma) \times (1 + 2S_1^2) \quad (\text{F.4})$$

where

$G_{eq}(\gamma)$ is the shear modulus at the average shear strain, γ , produced by the compressive load;
 γ can be determined from [Formula \(F.5\)](#):

$$\gamma = \sqrt{6} S_1 \varepsilon \quad (F.5)$$

where ε is the compressive strain in the rubber layer.

Neither of the formulae proposed in [F.2.2.1](#) or [F.2.2.2](#) considers the non-linearity introduced when ε becomes greater than about 0,1.

For isolators with an unplugged central hole, formulae for the compression stiffness are given in Reference [6]. Expressions for compression stiffness based on the first shape factor, S_1 , modified to take account of the hole may not give reliable results.

F.3 Empirical expressions for apparent Young's modulus, E_c

The following empirical expressions for apparent Young's modulus, E_c , have been derived from tests on bridge isolators.

a) For rectangular isolators:

$$E_c = \beta \times S_1 \times G \quad (F.6)$$

b) For circular isolators:

$$E_c = 0,75 \beta \times S_1 \times G \quad (F.7)$$

where

β is an empirical factor, based on the test data (see [Figures F.1](#), [F.2](#) and [F.3](#)), which modifies E_c ;

for LNR $\beta = 35$;

for HDR and LRB $\beta = 45$.

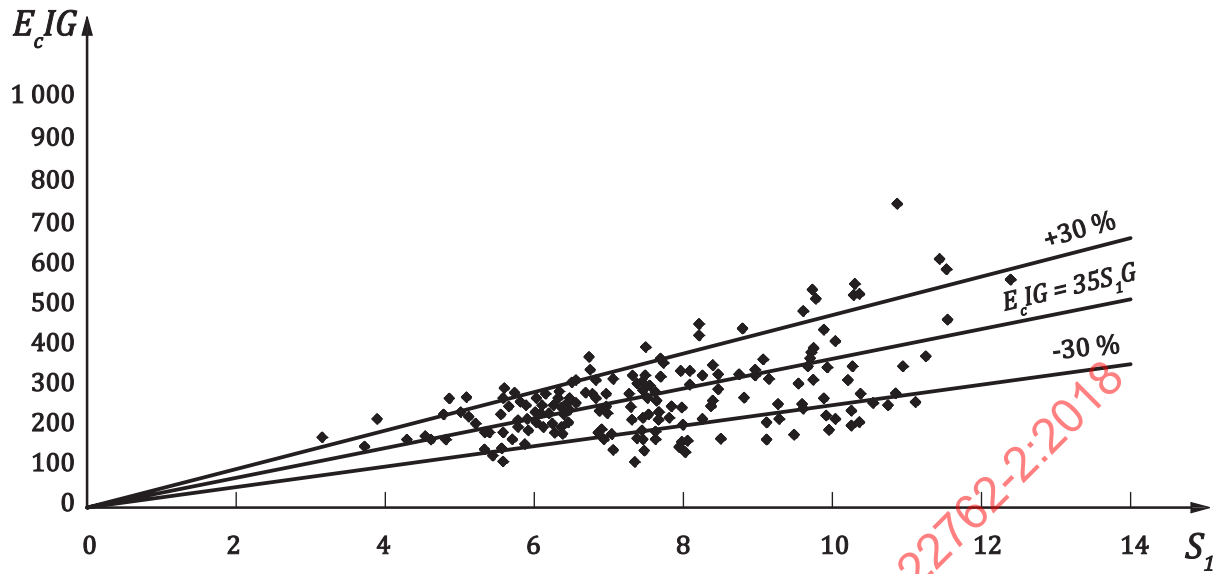


Figure F.1 — S_1 versus E_c/G for LNR

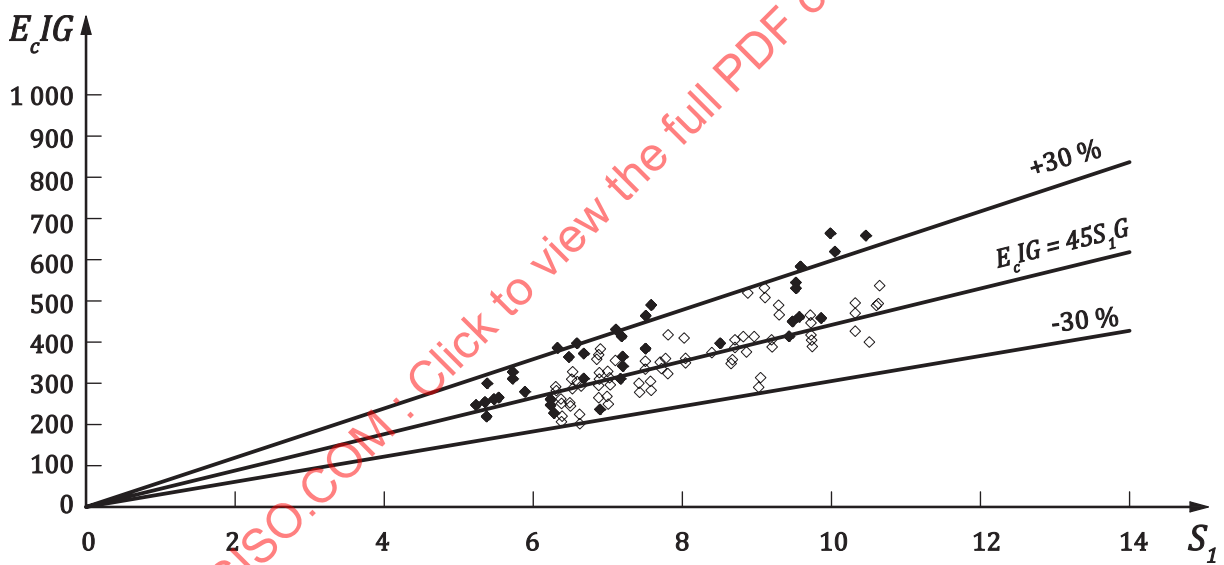


Figure F.2 — S_1 versus E_c/G for HDR