



International
Standard

ISO 22762-1

Elastomeric seismic-protection isolators —

Part 1: Test methods

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

Partie 1: Méthodes d'essai

Fourth edition
2024-09

Reference number
ISO 22762-1:2024(en)

Full document details: [ISO 22762-1-2024](#)

© ISO 2024  **Documents**
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Symbols and cross-section of elastomeric isolator	4
4.1 Symbols	4
4.2 Cross-section of elastomeric isolator	7
5 Rubber material tests	9
5.1 Test items	9
5.2 Test conditions and test pieces	9
5.3 Tensile properties	9
5.4 Ageing test	10
5.4.1 Ageing properties of inner rubber	10
5.4.2 Ageing properties of cover rubber	10
5.5 Hardness	10
5.6 Adhesion	10
5.7 Compression set	10
5.8 Dynamic shear properties	10
5.8.1 General	10
5.8.2 Test equipment	11
5.8.3 Test pieces	11
5.8.4 Test conditions	12
5.8.5 Test results	12
5.9 Breaking properties	13
5.10 Brittleness point	13
5.11 Ozone resistance	13
5.12 Low-temperature crystallization	13
6 Elastomeric isolator tests	14
6.1 General	14
6.2 Compression and shear stiffness tests	14
6.2.1 Compression properties	14
6.2.2 Compressive-shear test	21
6.3 Various dependence tests	27
6.3.1 Strain dependence of shear properties	27
6.3.2 Compressive force dependence of shear properties	28
6.3.3 Frequency dependence of shear properties	30
6.3.4 Repeated deformation dependence of shear properties	32
6.3.5 Temperature dependence of shear properties	34
6.3.6 Dependence of compression properties on shear strain	36
6.3.7 Dependence of compressive stiffness on compressive stress range	37
6.4 Ultimate shear properties	39
6.4.1 Principle	39
6.4.2 Test machine	39
6.4.3 Test piece	39
6.4.4 Test conditions	39
6.4.5 Procedure	39
6.4.6 Expression of results	40
6.4.7 Test report	41
6.5 Tensile testing	41
6.5.1 Principle	41
6.5.2 Test machine	41
6.5.3 Test piece	42

6.5.4	Test conditions	42
6.5.5	Procedure	42
6.5.6	Expression of results	42
6.5.7	Test report	43
6.6	Durability testing	44
6.6.1	Degradation test	44
6.6.2	Creep test	45
6.6.3	Fatigue test	49
6.7	Reaction force due to low-rate deformation	51
6.7.1	Principle	51
6.7.2	Test machine	52
6.7.3	Test piece	52
6.7.4	Test conditions	52
6.7.5	Procedure	52
6.7.6	Expression of result	53
6.7.7	Test report	53
Annex A (normative)	Determination of accelerated ageing conditions equivalent to expected life at standard laboratory temperature (23 °C or 27 °C)	55
Annex B (normative)	Inertia force correction	58
Annex C (normative)	Friction force correction	60
Annex D (normative)	Determination of coefficient linear thermal expansion	63
Annex E (informative)	Alternative methods of determining shear properties	65
Annex F (informative)	Creep test	67
Annex G (informative)	Determination of reaction force due to low-rate deformation	69
Annex H (informative)	Durability investigation of elastomeric isolators used for 10 years in a bridge	71
Annex I (informative)	Durability investigation of elastomeric isolators used for seven years in a building	73
Bibliography		77

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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 fourth edition cancels and replaces the third edition (ISO 22762-1:2018), of which it constitutes a minor revision.

The changes are as follows:

- the relation of this document to ISO 22762-5 and ISO 22762-6 have been added in Introduction;
- the normative references have been updated;
- the use of the terms "elastomeric isolators" and "seismic isolators" have been made consistent;
- the term "fracture" has been replaced by "break" throughout the document.

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

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

Introduction

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

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

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

ISO/TS 22762-4 is a guidance for the use of ISO 22762-3. ISO 22762-5 gives specifications and test methods for sliding seismic-protection isolators which are not specified as elastomeric isolators. ISO 22762-6 gives specifications and test methods for high-durability and high-performance elastomeric isolators. Three grades of requirements for each test item are introduced in ISO 22762-6.

Elastomeric seismic-protection isolators —

Part 1: Test methods

1 Scope

This document specifies the test methods for determination of

- a) the properties of the rubber material used to manufacture the elastomeric isolators, and
- b) the characteristics of elastomeric isolators.

It is applicable to elastomeric isolators used to provide buildings or bridges with protection from earthquake damage. The elastomeric 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 48-2, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 2: Hardness between 10 IRHD and 100 IRHD*

ISO 48-5, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 2: Indentation hardness by IRHD pocket meter method*

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

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

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

ISO 815-1, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 1: At ambient or elevated temperatures*

ISO 815-2, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 2: At 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 shear modulus and adhesion to rigid plates — Quadruple-shear methods*

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

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

ISO 7500-1:2018, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 22762-2, *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.

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 <https://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 isolator* (3.9) lose their stability under compression-shear loading

3.3 compressive properties

K_v
compressive stiffness for all types of *elastomeric isolator* (3.9)

3.4 compression-shear testing machine

machine used to test *elastomeric isolator* (3.9), 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 isolator* (3.9) 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

3.6 design compressive stress

long-term compressive force on the *elastomeric isolator* (3.9) imposed by the structure

3.7 effective loaded area

area sustaining vertical load in *elastomeric isolator* (3.9), 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

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

3.10

first shape factor

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

3.11

high-damping rubber bearing

HDR

elastomeric isolator (3.9) 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* (3.9)

3.13

lead rubber bearing

LRB

elastomeric isolator (3.9) whose *inner rubber* (3.12) with a lead plug or lead plugs press fitted into a hole or holes of the elastomeric isolator body to achieve damping properties

3.14

linear natural rubber bearing

LNR

elastomeric isolator (3.9) 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 elastomeric isolator testing.

3.15

maximum compressive stress

peak stress acting briefly on *elastomeric isolator* (3.9) in compressive direction during an earthquake

3.16

nominal compressive stress

long-term stress acting on *elastomeric isolator* (3.9) in compressive direction as recommended by the manufacturer for the elastomeric isolator, including the safety margin

3.17

post-yield stiffness

shear stiffness of LRB after yielding of lead plug

3.18

roll-out

instability of an *elastomeric isolator* (3.9) with either dowelled or recessed connection under shear displacement

3.19

routine test

test for quality control of the production *elastomeric isolator* (3.9) during and after manufacturing

3.20

second shape factor

<circular elastomeric isolator> ratio of the diameter of the inner rubber to the total thickness of the inner rubber

3.21

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

3.22**shear properties**

comprehensive term that covers characteristics determined from *elastomeric isolator* (3.9) 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

3.23**structural engineer**

engineer who is in charge of designing the structure for seismically isolated bridges or buildings and is responsible for specifying the requirements for *elastomeric isolator* (3.9)

3.24**ultimate properties**

property at either buckling, breaking, or roll-out of an *elastomeric isolator* (3.9) under compression-shear loading

4 Symbols and cross-section of elastomeric isolator**4.1 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 elastomeric isolator
A_{free}	load-free area of elastomeric isolator
A_{load}	loaded area of elastomeric 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 elastomeric isolator, excluding cover rubber thickness
a_e	length of the shorter side of the rectangular elastomeric isolator, including cover rubber thickness
a'	length in longitudinal direction of the rectangular elastomeric isolator, including cover rubber thickness
B	effective width for bending of flange
b	length in transverse direction of the rectangular elastomeric isolator, excluding cover rubber thickness
b'	length in transverse direction of the rectangular elastomeric isolator, including cover rubber thickness
c	distance from centre of bolt hole to effective flange section
D'	outer diameter of circular elastomeric 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

Table 1 (continued)

Symbol	Description
F_u	tensile force on elastomeric isolator by uplift
G	shear modulus
$G_{eq}(\gamma)$	equivalent linear shear modulus as a function of 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 elastomeric isolator
n	number of rubber layers
n_b	number of fixing bolts
P	compressive force
P_0	design compressive force in absence of seismic action effects
P_{max}	maximum compressive force including seismic action effects
P_{min}	minimum compressive force including seismic actions effects
Q	shear force
Q_b	shear force at breaking
Q_{buk}	shear force at buckling
Q_d	characteristic strength
S_1	first shape factor
S_2	second shape factor
T	Temperature
T_L	minimum temperature
T_0	standard temperature, 23 °C or 27 °C where specified tolerance is ± 2 °C, it 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	loading velocity
W_d	energy dissipated per cycle
X	shear displacement
X_0	design shear displacement

Table 1 (continued)

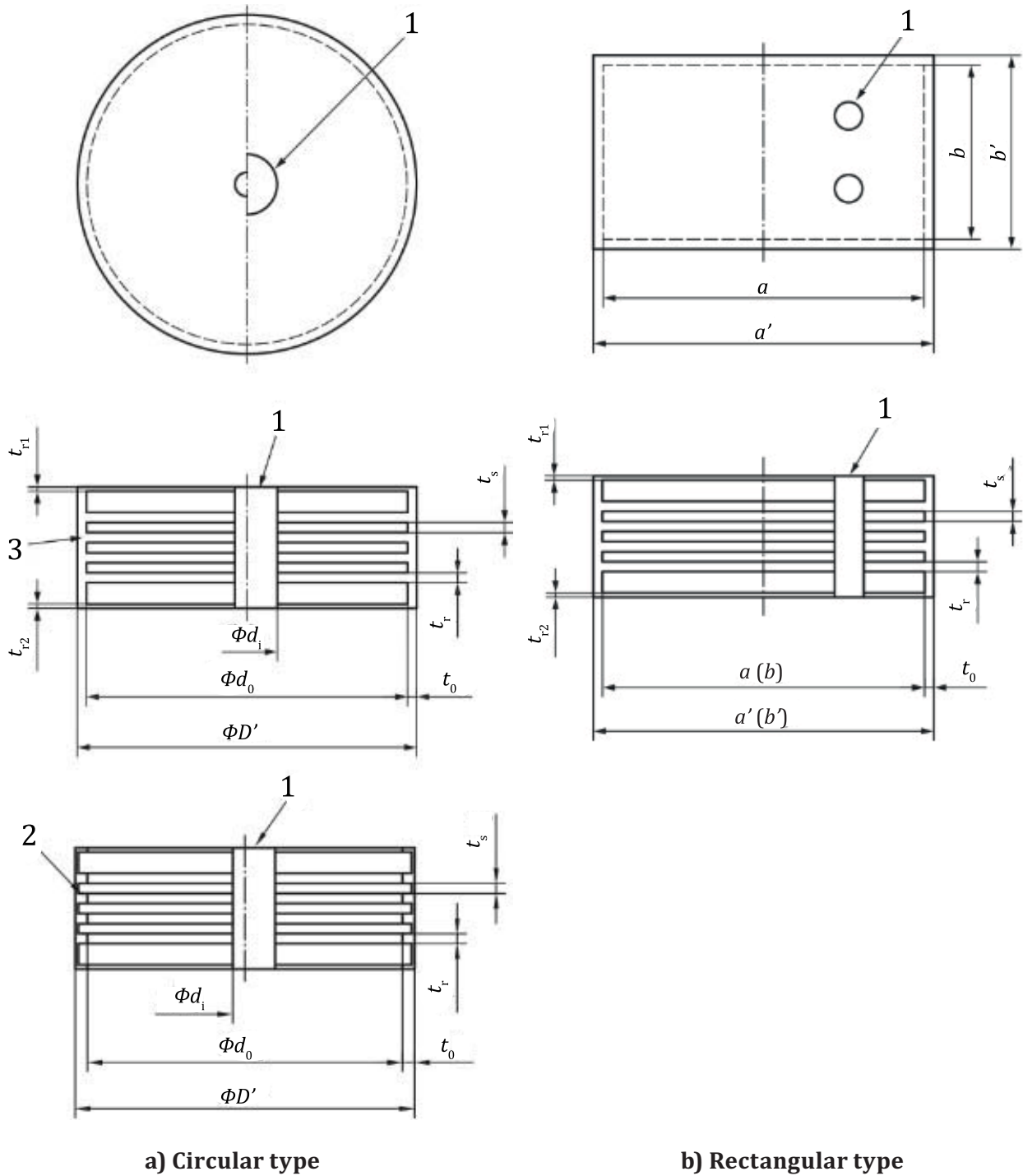
Symbol	Description
X_b	shear displacement at break
X_{buk}	shear displacement at buckling
X_s	shear displacement due to quasi-static shear movement
X_{max}	maximum shear displacement
X_d	shear displacement due to dynamic shear movement
Y	compressive displacement
Z	section modulus of flange
α	coefficient 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 breaking
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 elastomeric isolator
δ_v	difference in isolator height measured between two points at opposite extremes of the elastomeric isolator
ε	compressive strain of rubber
ε_{cr}	creep strain
ε_T	tensile strain of elastomeric isolator
ε_{Tb}	tensile-breaking strain of elastomeric isolator
ε_{Ty}	tensile-yield strain of elastomeric isolator
ζ	ratio of total height of rubber and steel layers to total rubber height
θ	rotation angle of elastomeric isolator about the diameter of a circular bearing or about an axis through a rectangular bearing
θ_a	rotation angle of elastomeric isolator in the longitudinal direction (a)
θ_b	rotation angle of elastomeric 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 elastomeric 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 elastomeric 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

Table 1 (continued)

Symbol	Description
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 elastomeric 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

4.2 Cross-section of elastomeric isolator

A typical cross-section of the elastomeric isolator is given in [Figure 1](#).



Key

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

NOTE The left-hand side of the figure shows LNR and HDR, the right-hand side shows LRB.

Figure 1 — Cross-section of isolator

5 Rubber material tests

5.1 Test items

In order to ensure 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

Property	Test item	Related International Standard
Tensile properties	Tensile strength	ISO 37
	Elongation at breaking	
	100 % modulus	
Ageing properties	Tensile strength	ISO 188
	Elongation at breaking	ISO 37
	100 % modulus	
Hardness	Hardness	ISO 48-2 ISO 48-5
Adhesion	90° peel strength between metal and rubber Classification of breaking mode	ISO 813
Compression set	Compression set	ISO 815-1 ISO 815-2
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	
	Breaking strength	ISO 1827
	Breaking strain	
Brittleness point	Brittleness temperature	ISO 812
Ozone resistance	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 elastomeric isolator.

5.3 Tensile properties

The tensile test should be carried out by the method specified in ISO 37. However, the test piece specified in [Table 3](#) can be used as an alternative.

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 breaking. 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 or 27 °C shall be determined from this activation energy. 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 breaking. 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 breaking. 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 48-2 or ISO 48-5.

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 815-1 and ISO 815-2. 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

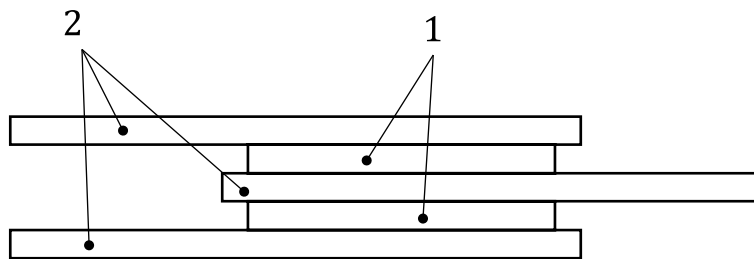
An apparatus, as described in ISO 4664-1, which can measure vibration frequencies higher than 0,2 Hz and shear strain amplitudes up to 400 % shall be used.

5.8.3 Test pieces

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

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. The thickness of the plates shall be 5 mm or more.



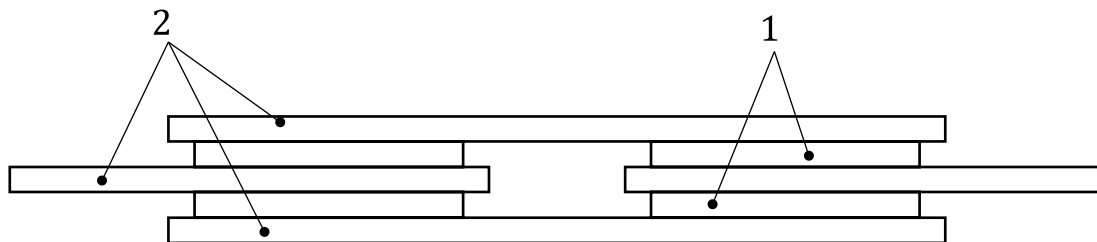
Key

- 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. The thickness of the plates shall be 5 mm or more.



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 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 or 27	40
------------------------	-----	-----	---	----------	----

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 elastomeric 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 or 27 °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 the tests are at one temperature and one strain amplitude, and 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 or 27 °C. One test piece may be used to cover a range of strains, provided 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
-------------------	----	-----	-----	-----	-----	------	------	------	------	------	------	------	------

5.8.4.4 Number of cycles

The number of loading cycles shall be either 3 cycles or 11 cycles, and should be consistent with that of the 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 Breaking 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, chloroprene rubber 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 can occur. Natural rubber shall be checked if the minimum service temperature, T_L , is $< 0\text{ }^{\circ}\text{C}$, and chloroprene rubber, 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 in this subclause, 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 chloroprene rubber 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. For natural rubber isolators, subjected to the service conditions in [Table 7](#), where the time is the cumulative total for which the elastomeric 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 $^{\circ}\text{C}$	Time days	Test temperature $^{\circ}\text{C}$	Test period
$-10 \leq T_L < 0$	t_0	-10	$1,5t_0$
$-20 \leq T_L < -10$	t_{-10}	-20	$1,5t_{-10} + 0,1t_0$
$T_L < -20$	t_{-20}	-25	$1,5t_{-20} + 0,5t_{-10} + 0,05t_0$

The time and temperature of test for chloroprene rubber-based isolators shall be based on the service temperature conditions defined in [Table 8](#), where the time is the cumulative total for which the elastomeric 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 $^{\circ}\text{C}$	Time days	Test temperature $^{\circ}\text{C}$	Test period
$0 \leq T_L < 5$	t_5	0	$1,5t_5$
$-5 \leq T_L < 0$	t_0	-5	$1,5t_0 + 0,5t_5$
$T_L < -5$	t_{-5}	-10	$1,5t_{-5} + 0,5t_0 + 0,25t_5$

Some elastomers are susceptible to crystallization if the ambient temperature is low over a prolonged period. High-damping compounds of these elastomers can 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 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 chloroprene rubber are those at which the rate of crystallization is highest. To ensure that the performance of the elastomeric isolator is not compromised, it is necessary that the nucleation period not be greatly exceeded during any continuous exposure to low temperatures. Crystallites melt when the ambient temperature of the elastomeric isolators is raised sufficiently, and thus the effects are completely reversible. If chloroprene rubber is used, crystallization resistant grades should be chosen where low temperature conditions are to be encountered.

NOTE The service temperature can be taken as that occurring at the elastomeric isolator location averaged over a 24 h period. The bulk of an elastomeric isolator does not usually experience shorter term fluctuations of temperature. For elastomeric isolators installed outside, the temperature experienced at the site in a normal year can be used, unless the structure is regarded as critically important.

6 Elastomeric isolator tests

6.1 General

In order to ensure 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 can 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 properties

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 ISO 7500-1:2018, Clause 7, 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 (such that they are 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 elastomeric isolators

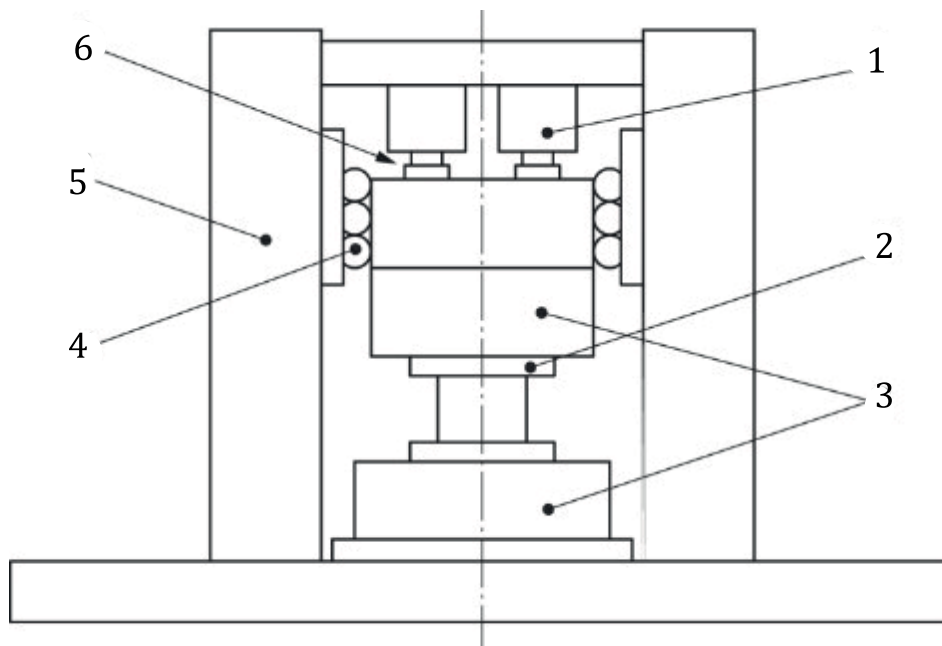
Property	Test item	Subclause
Compression properties	Compression stiffness	6.2.1
	Compression displacement	
Shear properties	Shear stiffness	6.2.2
	Equivalent damping ratio	
	Post-yield stiffness	
	Characteristic strength	
Dependence of shear properties	Shear strain dependence	6.3.1
	Compressive stress dependence	6.3.2
	Frequency dependence	6.3.3
	Repeated loading dependence	6.3.4
	Temperature dependence	6.3.5
Dependence of compressive properties	Shear strain dependence	6.3.6
	Compressive stress dependence	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 (degradation test)	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_0	5	5	10	5	5	10

Table 11 — Standard test piece (circle)

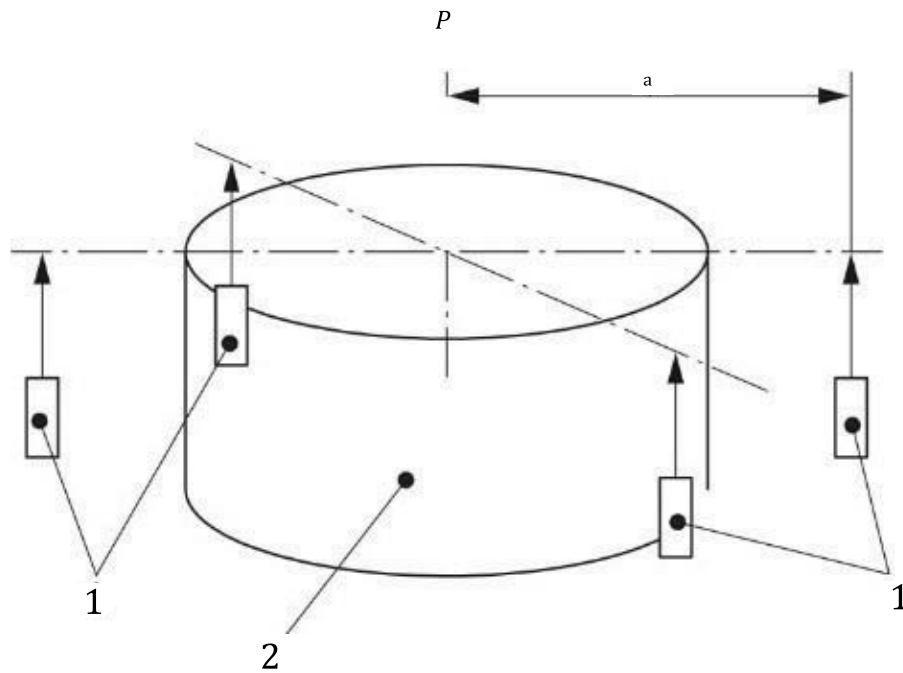
Item		Rubber isolator			Lead rubber isolator		
Inner steel plate outer diameter, mm	d_0	150	250	500	150	250	500
Inner steel plate inner diameter (diameter of lead plug), mm	D_i	7,5	12,5	25	30	50	100
Thickness of a single inner steel plate, mm	T_s	1 to 2	2 to 3	3 to 4	1 to 2	2 to 3	3 to 4
Thickness of 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_0	4	6	8	4	6	8



Key

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

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 test piece

Test pieces < 250 mm thick shall be left for at least 24 h after vulcanization. Thicker elastomeric 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 longer 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 such 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 relationship between compressive force and compressive stress is expressed as [Formula \(1\)](#):

$$P = A_{\text{load}} \cdot \sigma \quad (1)$$

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

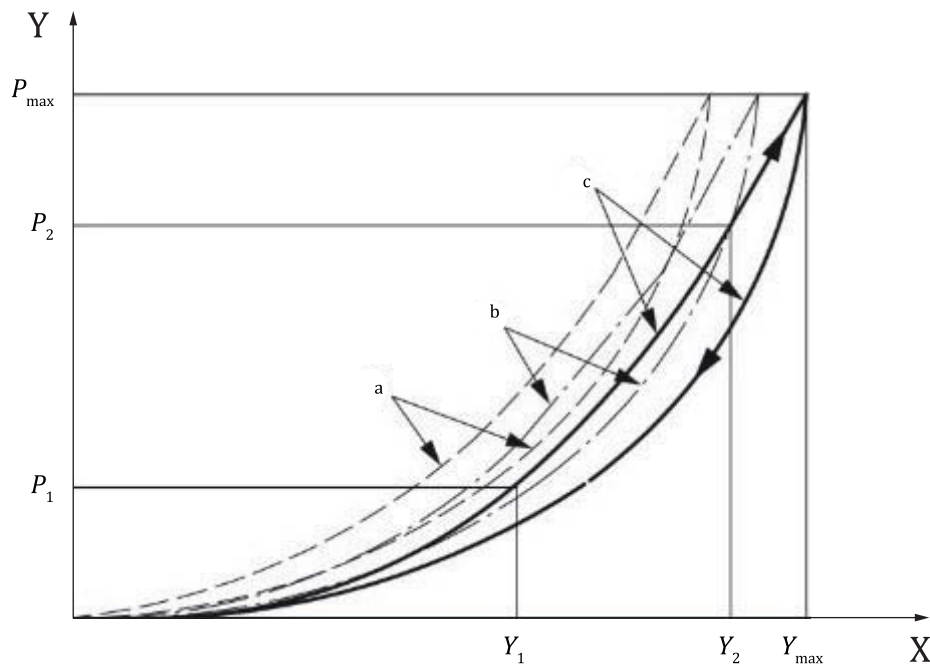
The test piece shall be attached to a test machine by the same or a mechanically equivalent manner as in the actual application. Compressive displacement gauges shall be attached to the periphery of the test piece. The compressive force at this time shall be zero, and the value of the compressive displacement shall be zero. If it is difficult to set a stable zero pressure because of machine controllability, a low arbitrary pressure may 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 elastomeric isolator design. There are two methods.

6.2.1.5.2.1 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

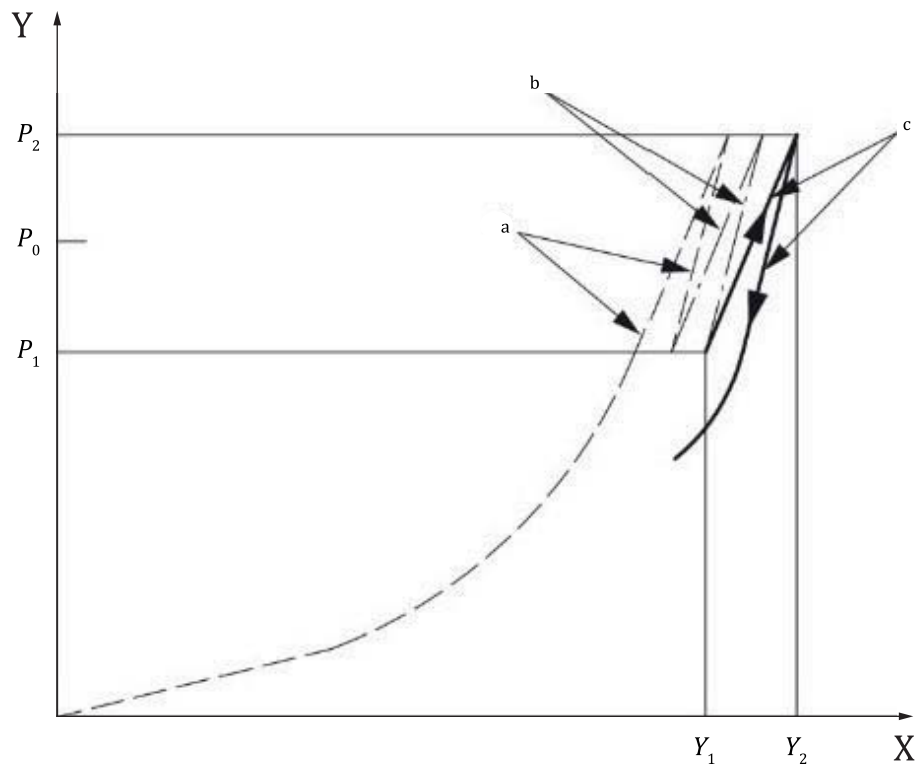
- X compressive displacement, Y
- Y compressive force, P
- a First cycle.
- b Second cycle.
- c Third cycle.

Figure 6 — Vertical properties — Method 1

6.2.1.5.2.2 Method 2 (see [Figure 7](#))

Load the test piece with a compressive force, P_0 , which is equivalent to the design compressive stress, σ_0 .

Load the test piece with three cycles of compressive force between P_2 and P_1 , which are equivalent to σ_0 plus/minus a certain per cent (e.g. $\pm 30\%$). The loading sequence shall be as follows: 0, P_0 , P_2 , P_0 , P_1 (first), P_0 , P_2 , P_0 , P_1 (second), P_0 , P_2 , P_0 , P_1 (third). P_2 shall be the maximum design force.

**Key**

- X compressive displacement, Y
 Y compressive force, P
 a First cycle.
 b Second cycle.
 c Third cycle.

Figure 7 — Vertical properties — Method 2

A visual check of the test piece shall be conducted during cyclic loading period and any signs of bond failure, surface cracks or other defects, misaligned reinforcing plates or non-uniform corrugations (if visible) due to bulging of rubber layers shall be recorded.

6.2.1.6 Expression of results

The amount of compressive displacement under compressive force shall be measured and the compressive stiffness, K_v , calculated using [Formula \(2\)](#):

$$K_v = \frac{P_2 - P_1}{Y_2 - Y_1} \quad (2)$$

where

- P_1 is the smaller compressive force, expressed in kilonewtons, in the third cycle;
 P_2 is the larger compressive force, expressed in kilonewtons, in the third cycle;
 Y_1 is the smaller displacement, expressed in millimetres, in the third cycle;
 Y_2 is the larger displacement, expressed in millimetres, in the third cycle.

See [Figures 6](#) and [7](#).