TECHNICAL REPORT

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Lifts and escalators subject to seismic conditions — Compilation report

Ascenseurs et escaliers mécaniques soumis aux conditions sismiques — Rapport de compilation

Reference number
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Foreword

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

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

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

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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

ISO/TR 25741 was prepared by Technical Committee ISO/TC 178, *Lifts, escalators and moving walks*.

0 Introduction

0.1 When an earthquake occurs, it releases energy in the form of waves that radiate from the earthquake source in all directions. The different types of energy waves shake the ground in different ways and travel through the earth at different velocities. The fastest wave, and therefore, the first to arrive at a given location, is called the P wave. The P wave, or compressional wave, alternately compresses and expands material in the direction in which it is travelling. The S wave is slower than the P wave and arrives next, shaking the ground up and down and back and forth perpendicular to the direction in which it is travelling. Surface waves follow the P and S waves. Source: NEIC [16].

0.2 Earthquake magnitudes are measured on different scales, namely, Richter and Modified Mercalli Intensity. The Richter Scale is considered more accurate. Approximate values are summarised in Table 1.

Sources: California Institute of Technology [17] and Wiegel [14].

Table 1 — The Richter Scale

Richter magnitude	Mercalli intensity	Acceleration	Approximate radius of perceptibility	Effect
8,5	XII	$> 1{,}0g$	—	Total damage
8	XI	$0{,}8g$	580 km	General damage
7	IX to X	$0{,}5g$	385 km	Considerable damage
6	VII to VIII	$0{,}15g$	210 km	Frightening; some broken chimneys; damage to weak buildings
5	VI to VII	$0{,}05g$	145 km	Felt by all; some fallen plaster; chimney damage
4	V	$0{,}01g$	130 km	Felt by most; some broken windows; cracked plaster
3	III	—	15 km	Quite noticeable indoors
2	I to II	—	0 km	Barely felt

0.3 The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. An increase of one magnitude unit on the Richter Scale corresponds to a ten times greater ground motion. An increase of two magnitude units corresponds to a 100 times greater ground motion, and so on, in a logarithmic series.

0.4 The strongest earthquakes, measured on the Richter Scale, over the last century include those shown in the worldwide map in Clause 5 and in Table 2 below.

Table 2 — The strongest earthquakes

Location	Year	Magnitude
Chile	1960	9,5
Alaska	1964	9,2
Russia	1952	9,0
Banda Aceh, Indonesia	2004	9,0
Alaska	1957	8,8
Kuril Islands	1958	8,7
Alaska	1965	8,7
India	1950	8,6
Chile	1922	8,5
Indonesia	1938	8,5
Great Kanto, Japan	1923	8,3
Gujrat, India	2001	8,1
Mexico	1985	8,0
Southern Peru	2001	7,9
San Francisco, CA, USA	1906	7,8
Bolivia	1994	7,7
El Salvador	2001	7,7
Taiwan	1999	7,6
Tangshan, China	1976	7,5
Sakhalin	1995	7,5
Taiwan	1935	7,4
Izmit, Turkey	1999	7,4
Southern Italy	1980	7,2
Fukui, Japan	1948	7,2
Miyagi, Japan	2005	7,2

Source: U.S. Geological Survey

0.5 Seismic-induced ground motions can have an adverse effect on the operational and physical integrity of building supports and vertical transportation equipment. Experience in the U.S. from the San Fernando, California, earthquake on February 9, 1971 with a magnitude of 6,6 on the Richter Scale resulted in significant damage to buildings and vertical transportation systems. The most notable damage included the following, shown in Table 3.

Table 3 — Damage to vertical transportations systems

Description	**Quantity** (Number of lifts)
Counterweights out of guide rails	674
Counterweights out of guide rails; damaged cars	109
Cars damaged	102
Rope systems damaged	100
Motor generators (moved; some damaged armatures)	174
Counterweight guide rail brackets broken/damaged	174
Roller guide shoes (broken or loose)	286

Source: Elevator World's Annual Study [13].

0.6 In response to earthquake experience on different continents, some codes and standards organizations have included a level of seismic protection in their national standards. ISO/TC 178 recognised that it would be beneficial to promote worldwide guidance in order to ensure the safety of people, as well as equipment, taking seismic forces into consideration for design and construction. The experiences of those national codes and standards organizations that have already adopted seismic protection requirements would benefit the rest of the worldwide elevator community through the compilation of such design safeguards.

0.7 The scope of this effort is the compilation of special specifications for lifts and escalators situated in areas subject to seismic conditions in order to ensure safe operation of the vertical transportation equipment within commonly occurring, i.e. non-catastrophic, ground motion excitation.

0.8 ISO/TC 178 took a Resolution on May 15, 1998, as follows:

"Resolution 156 — Study Group for Lifts and Escalators Working Under Seismic Conditions. On a proposal by WG 6, ISO/TC 178 agreed to create a study group under the leadership of Mr. Gibson (USA) to establish the essential safety requirements and dimensional considerations for lifts and escalators working under seismic conditions. This is to be confirmed by an inquiry among ISO/TC 178 members."

0.9 A new work item proposal covering the preparation of a Compilation Report was issued in document No. ISO/TC 178 N319 on August 27, 1999. The results of the voting on this Item showed that 17 P-members supported the programme of work. These members included Australia, Austria, Belgium, Canada, France, Germany, India, Israel, Italy, Republic of Korea, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom and USA. The following P-members agreed to participate in the development of the work: Australia, Austria, Canada, Italy, Spain and USA.

0.10 ISO/TC 178 took a Resolution on March 25, 2004, as follows:

"Resolution 231/2004. ISO/TC 178 agreed WG 6 to submit a draft Technical Report (compilation of existing documents) by October 2004."

0.11 ISO/TC 178 has included a global essential safety requirement (GESR) in ISO/TS 22559-1 as follows:

> *"6.1.12 Effects of earthquake. In areas subject to earthquakes, means shall be provided to minimize the risk to users, when inside the LCU, and authorized persons, of the foreseeable effects of earthquakes on the lift equipment."*

NOTE 1 The effects on the safety of users and authorized persons need to be considered at all stages: during the earthquake (as much as possible), during rescue from a stalled LCU, and when the lift is returned to normal operation. This assumes that there is no major building failure.

NOTE 2 LCU refers to load-carrying unit (lift car).

0.12 This Compilation Report has been prepared to document current seismic design rules/specifications pertaining to vertical transportation equipment in different geographic regions, which regional experiences have shown to be effective in providing a reasonable degree of seismic protection. Only those requirements in lift safety standards are included.

0.13 Requirements in building codes are not included in this report; however, where applicable, references are given to some building codes.

Lifts and escalators subject to seismic conditions — Compilation report

1 Scope

This Technical Report provides a compilation of relevant safety standards pertaining to protection of the user and vertical transportation equipment during seismic activity.

2 United States

2.1 ASME A17.1-2004 [1]

The ASME A17.1-2004, which includes the ASME A17.1a-2005 Addenda[1)], specifies safety requirements for all elevators (lifts) with counterweights, and direct-plunger hydraulic elevators, including escalators and moving walks, where these systems are installed in buildings that are designed and built to meet seismic risk zone 2 or greater as defined by the applicable building codes. The requirements of Sections 8.4 and 8.5 are in addition to the requirements specified in other parts of the ASME A17.1 Code, unless otherwise specified. The outline of the seismic requirements are listed below, in terms of the ASME A17.1 rule/clause numbers and title. For the complete text, the reader should consult the ASME A17.1-2004 Code [1].

Under predecessor building codes, i.e. those in effect throughout the late 1990s, the United States was divided into five seismic zones, namely 0 to 4. The weakest seismic ground motion activity was designated 0, 4 indicated the strongest seismic activity in terms of magnitude. To put this into context with the ground-motion-producing accelerations, the ASME A17.1 rules indicate the magnitude of the associated accelerations.

ASME A17.1, Section 8.4
Elevator Safety Requirements For Seismic Risk Zone 2 or Greater

8.4.1	Horizontal Car and Counterweight Clearances.
8.4.1.1	Between Car and Counterweight and Counterweight Screen.
8.4.2	Machinery and Sheave Beams, Supports, and Foundations.
8.4.2.1	Beams and Supports.
8.4.2.2	Overhead Beams and Floors.
8.4.2.3	Fastenings and Stresses.
8.4.3	Guarding of Equipment.
8.4.3.1	Rope Retainers.
Fig. 8.4.3.1.3	Arc of Contact.
8.4.3.2	Guarding of Snag Points.
8.4.4	Car Enclosures, Car Doors and Gates, and Car Illumination.
8.4.4.1	Top Emergency Exits.
8.4.5	Car Frames and Platforms.
8.4.5.1	Guiding Members and Position Restraints.
8.4.5.2	Design of Car Frames, Guiding Members, and Position Restraints.

1) ASME is the registered trademark of the American Society of Mechanical Engineers. The A17.1 rule numbers and titles shown below are summarised from the ASME A17.1-2004 Safety Code for Elevators and Escalators; copyright © 2004 by the American Society of Mechanical Engineers. All rights reserved. It includes the ASME A17.1a-2005 Addenda; copyright © 2005 by the American Society of Mechanical Engineers. All rights reserved.

ASME A17.1-2004, Section 8.5
Escalator And Moving Walk Safety Requirement For Seismic Risk Zone 2 or Greater

8.5.1	Balustrade Construction.
8.5.2	Truss Members.
8.5.2.1	Lateral forces.
8.5.2.1.1	The Seismic Zone and NEHRP Maps.
8.5.2.2	Vertical Forces.
8.5.2.3	Truss Calculations.
8.5.3	Supporting Connections Between the Truss and the Building.
8.5.4	Earthquake Protective Devices.

2.2 Seismic safety for buildings

The following abbreviations are defined:

FEMA Federal Emergency Management Agency

NEHRP National Earthquake Hazards Reduction Program

NFPA National Fire Protection Association

NIST National Institute of Standards and Technology

NSF National Science Foundation

USGS United States Geological Survey

The Model Building Codes in the U.S. have a greater impact on the quality of construction and how structures will withstand the forces of nature than any other NEHRP activity.

Over the past twenty years, the NSF and the USGS have accumulated a significant body of basic research work in the areas of earthquake engineering, geoscience and seismology. This fundamental research work and the use of earthquake monitoring networks by USGS have allowed the development of detailed seismic hazard maps by USGS and the development of significant earthquake engineering knowledge by NSF.

Concurrently, FEMA and NIST have developed and continued to refine the NEHRP Recommended Provisions, a guidance document for the seismic design of structures, directly incorporating the results of scientific advances of NIST, NSF and USGS. The seismic hazard maps developed by USGS are directly referenced in the NEHRP Recommended Provisions, and NSF research results are used throughout the document. This guidance document within the engineering profession is regarded as the state of the art in earthquake design guidance.

National implementation of new design standards is done through the adoption and enforcement of building codes. FEMA and USGS work with state and local governments and multi-state consortia to improve hazard identification and to promote the adoption of building codes in seismically at-risk communities and states. In addition, the NEHRP Recommended Provisions was selected by model code organizations as the basis for the seismic design provisions of the *International Building Code* [5] and the *International Residential Code*, and the *NFPA 5000: Building Construction and Safety Code* [6].

2.3 The seismic maps

The NEHRP is the U.S. Federal Government's programme to reduce the risks to life and property from earthquakes. The National Earthquake Hazards Reduction Program agencies are the Federal Emergency Management Agency, the National Institute of Standards and Technology (the lead agency), the National Science Foundation and the United States Geological Survey.

2.4 NEHRP and FEMA seismic criteria applicable to new buildings

The *NEHRP Recommended Provisions for Seismic Regulations for New Buildings* [18][19].

Guide to Application of the 1991 Edition of the *NEHRP Recommended Provisions in Earthquake Resistant Building Design* [20].

A Non-Technical Explanation of the NEHRP Recommended Provisions [21].

Seismic Considerations for Communities at Risk [22].

Seismic Considerations: Apartment Buildings [23].

Seismic Considerations: Elementary and Secondary Schools [24].

Seismic Considerations: Health Care Facilities [25].

Seismic Considerations: Hotels and Motels [26].

Seismic Considerations: Office Buildings [27].

Societal Implications: Selected Readings [28].

2.5 NEHRP and FEMA seismic criteria applicable to existing buildings

NEHRP Guidelines for the Seismic Rehabilitation of Buildings [29] [30].

Case Studies: An Assessment of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings [31].

Planning for Seismic Rehabilitation: Societal Issues [32] and *Example Applications of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings* [33].

NEHRP Handbook of Techniques for the Seismic Rehabilitation of Existing Buildings [34].

NEHRP Handbook for the Seismic Evaluation of Existing Buildings [35].

An Action Plan for Reducing Earthquake Hazards of Existing Buildings [36].

2.6 Civil engineering design criteria

ASCE 7-02 [3] gives current requirements for dead, live, soil, flood, wind, snow, rain, ice and earthquake loads and their combinations, which are suitable for inclusion in building codes and other documents.

The earthquake load provisions in that edition of ASCE 7-02 for the first time are now referenced in the *2003 International Building Code* [5] and the *NFPA 5000: Building Construction and Safety Code* [6]. All other ASCE 7 provisions continue to be referenced in the *2003 International Building Code*. Also included is a detailed commentary on the standard, containing explanatory and supplementary information designed to assist building code committees and regulatory authorities.

Architects, structural engineers and those engaged in preparing and administering local building codes will find the structural load requirements provided by this standard essential. The document uses both SI units and Imperial units.

2.7 Reference publications

ASME A17.1-2004/ASME A17.1a-2005 Addenda [1]. Available from the American Society of Mechanical Engineers.

AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings [2]. Available from the American Institute of Steel Construction.

ASCE 7-02, Minimum Design Loads for Buildings and Other Structures [3]. Available from the American Society of Civil Engineers.

NEHRP Maps [4]. Available from the Building Seismic Safety Council and the U.S. Federal Emergency Management Agency.

2003 International Building Code [5]. Available from the International Code Council.

2002 NFPA 5000, Building Construction and Safety Code [6]. Available from the National Fire Protection Association.

2.8 Procurement information

2.8.1 American Institute of Steel Construction
1 East Wacker Drive, Suite 3100
Chicago, IL 60601
USA
Tel: ++ 312-670-2400
Web: http://www.aisc.org

2.8.2 American National Standards Institute, Inc.
25 West 43rd Street
New York, NY 10036
USA
Tel: ++ 212-642-4900
Web: http://www.ansi.org

2.8.3 American Society of Civil Engineers
ASCE Publications
1801 Alexander Bell Drive
Reston, VA 20191
USA
Tel: ++ 800-548-2723
Web: http://www.asce.org

2.8.4 American Society of Mechanical Engineers
ASME Order Department
22 Law Drive
Box 2300
Fairfield, NJ 07007-2300
USA
Tel (US & Canada): 800-843-2763, ext. 848
Tel (Outside North America): ++ 973-882-1167, ext. 848
Tel (Mexico): ++ 95-800-843-2763, ext. 848
E-mail: infocentral@asme.org
Web: http://www.asme.org/catalog

2.8.5 Building Seismic Safety Council
National Institute of Building Sciences
1090 Vermont Avenue, N.W., Suite 700
Washington, D.C. 20005
USA
Tel: ++ 202-289-7800
Fax: ++ 202-289-1092
Web: http://www.nibs.org
E-mail: bssc@nibs.org

2.8.6 Federal Emergency Management Agency (FEMA)
500 C Street, SW
Washington, DC 20472
USA
Tel: ++ 202-566-1600
Web: http://www.fema.gov

2.8.7 International Code Council
5203 Leesburg Pike
Suite 600
Falls Church, VA 22041
USA
Tel: ++ 703-931-4533
Web: http://www.iccsafe.org

2.8.8 National Fire Protection Association (NFPA)
1 Batterymarch Park
P. O. Box 9101
Quincy, MA 02269-9101
USA
Tel: ++ 617-770-3000
Web: http://www.nfpa.org

2.8.9 National Institute of Standards and Technology (NIST)
100 Bureau Drive, Stop 3460
Gaithersburg, MD 20899-3460
USA
Tel: ++ 301-975-6478
Email: inquiries@nist.gov
Web: http://www.nist.gov

2.8.10 U.S. Geological Survey (USGS)
Web: http://www.usgs.gov

3 Japan

3.1 Guide for Earthquake Resistant Design & Construction of Vertical Transportation [7]

This guide applies to elevators (lifts) and escalators to be installed in buildings. The text of the provisions were translated into English by the Japan Elevator Association for use as a reference document. The outline of the seismic requirements are listed below, in terms of the rule/clause numbers and title.

1	Basic Provision
1.1	The Application Scope
1.2	The Object of Earthquake Resistance
1.3	The Earthquake Resistant Design and Construction
1.4	The Allowable Stress
Table 1-2	Design Safety Rate of Anchor Bolt

2	Seismic Force for Design
2.1	The Calculation of the Seismic Force for Design
2.2	The Horizontal Seismic Intensity for Design
Table 2-1	Standard Seismic Intensity, K_s
Table 2-2	Coefficient of Usage, I
Fig. 2-2	Coefficient in Consideration to the Amplification Rate of Elevator Equipment
2.3	Guide Rail
Table 2-4	Reduction Rate, β
Table 2-5	Reduction Rate, α
Fig. 2-4	Engagement Dimension between Guide Shoe (Off-Stopper) and Rail
Table 2-7	Section Performance & Stress Intensity, Allowable Value of Deflection of Guide Rail
Fig. 2-5	Load Given to the Tie Bracket
2.4	The Equipment of the Machine Room
Fig. 2-6	Load and Dimensions of Equipment
2.5	The Structure of Sheave
Table 2-9	Earthquake Resistant Class and Sheave Structure
Fig. 2-62	Installation Standard of Rope Guard
Fig. 2-63	Relation between Sheave Rope Groove and Rope Radius
2.6	The Hoistway Equipment
Table 2-10	Protection Measures to the Projections
Fig. 2-70	Hoistway Equipment & Protection Measures against the Projections
2.7	The Control Operating Device in the Occurrence of an Earthquake
Table 2-12	Setting Value of Earthquake Sensor
4	Others
5	The Earthquake Measures for the Existing Elevators

3.2 Anti-earthquake design and construction in Japan [8]

This document outlines and explains the important requirements contained in the Guide for Earthquake Resistant Design & Construction of Vertical Transportation [7]. The followings points are covered:

— summary of modification;

— anti-earthquake classification and requirements;

— classification and standard seismic intensity for design, K_s;

— equations for horizontal seismic force, F_H, and horizontal seismic coefficient, K_H;

— coefficient of usage, I, and horizontal seismic coefficient, K_H;

— engagement dimension between guide shoe (off-stopper) and rail;

— installed position of intermediate stopper;

— structure of sheave;

— rope guard installation standard;

— classification height;

— protection measures;

— structure for preventing drop-out of counterweight blocks;

— anti-earthquake standard of hydraulic piping for hydraulic elevators;

— setting value of earthquake sensor;

— anti-earthquake design and construction for escalator;

— example for fixing method of pedestal and truss supporting angle.

3.3 Reference publications

Japan Elevator Association [7], [8].

Architecture Standard Law, enacted June 1, 1981, Japan.

3.4 Procurement information

3.4.1 Japan Elevator Association
5-11-2 Minami-Aoyama
Minato-Ku
Tokyo
Japan
Tel: ++ (81) 3-3407-6471
Fax: ++ (81) 3-3407-2259

4 New Zealand

4.1 New Zealand Standard NZS 4332 [9]

This standard specifies safety requirements for the design, construction, operation and testing of passenger-carrying lifts and goods lifts with car controls, but does not include lifts in single-unit dwellings. It applies to new building work, either the installation of a new lift or new work associated with an existing installation. The requirements are in addition to those specified in other parts of the NZS 4332 Code, unless otherwise specified. The outline of the seismic requirements is given below, in terms of the NZS 4332 rule/clause numbers and title. For the complete text, the reader should consult the NZS 4332 Code.

NOTE 1 The NZS rule numbers and titles shown below are summarised from NZS 4332:1997, copyright © by Standards New Zealand.

NOTE 2 Annex C contains actual text from the NZS 4332, copyright © by Standards New Zealand.

Part I	GENERAL REQUIREMENTS
2.1	Earthquake loadings.
Table 2.1	Risk factors.
Part 2	ELECTRIC LIFTS: PASSENGERS AND GOODS
5.2	Electric lift particulars to be documented — Seismic categories
25.8	Operation of lifts under earthquake conditions
25.8.1	Major component displacement detector
25.8.2	Operation
Figure 25.1	Major component displacement detector
Part 3	ELECTROHYDRAULIC LIFTS
31.2	Drawings and particulars — Seismic categories
Annex D	SEISMIC ZONES
Figure D.1	Seismic zones

4.2 Reference publications

NZS 4332 [9].

NZS 4203 [10].

NZS 4203 CORR1 [11].

4.3 Procurement information

4.3.1 Standards New Zealand
155 The Terrace
Private Bag 2439
Wellington, New Zealand
Tel: ++ (04) 498 5990
Tel: ++ (04) 498 5991
E-mail: snz@standards.co.nz
Web: http://www.standards.co.nz

5 Major earthquakes of the world

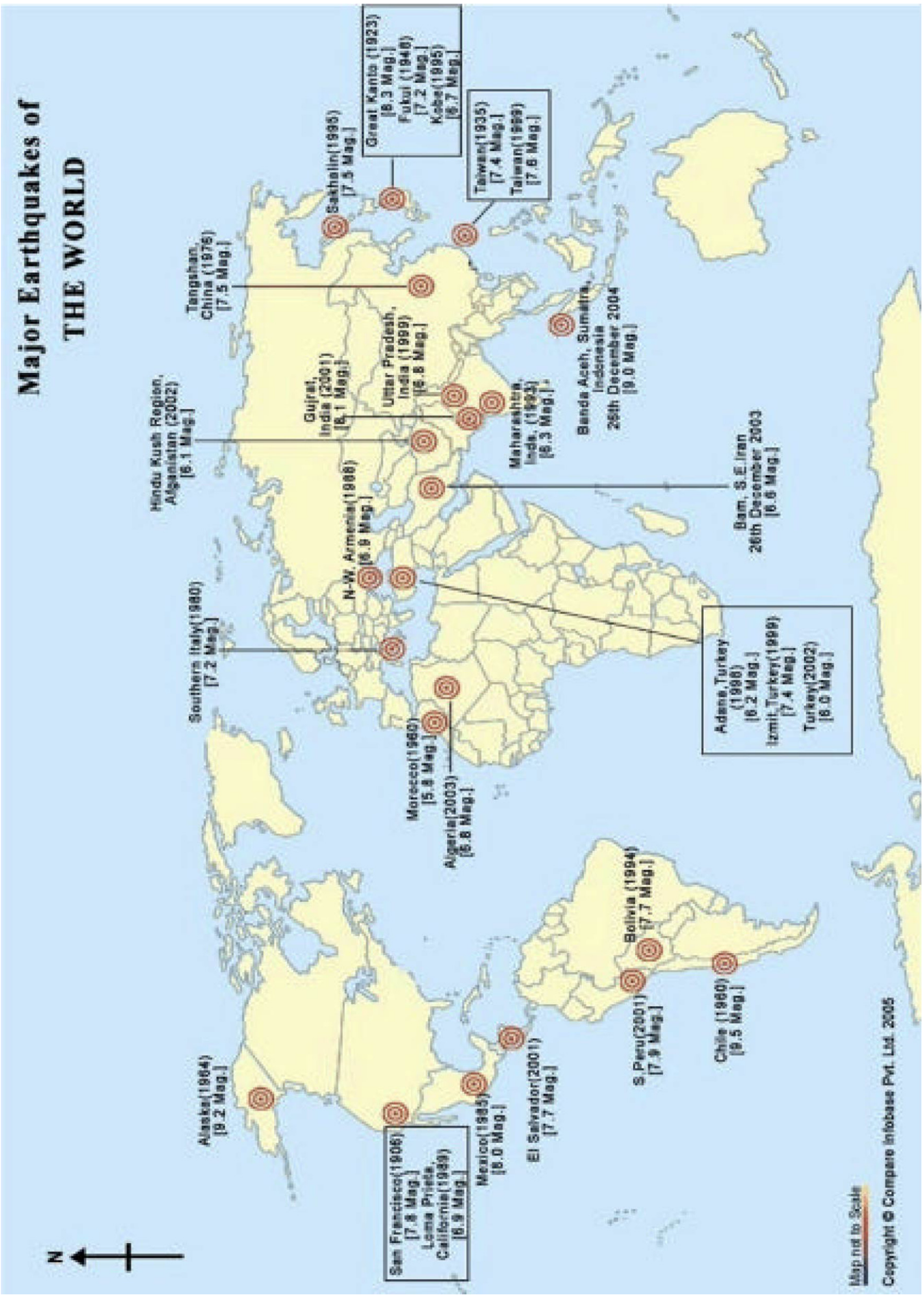


Figure 1 — Major earthquakes of the world

Annex A
(normative)

Guide for Earthquake Resistant Design & Construction of Vertical Transportation (1998 Edition) Japan Elevator Association [JEA Guide]

A.1 Basic provision

A.1.1 The application scope

a) This guide applies to elevators and escalators (herein referred to as “Vertical Transportation”) to be installed in the buildings.

b) For some of the buildings which anti-earthquake design and construction are conducted based on the special investigations and studies, the item above may not be applied.

A.1.2 The object of earthquake resistance

a) The vertical transportation should continue to provide safe operation without any trouble, even after the occurrence of an earthquake, by assuming that a middle scale earthquake would frequently hit the building during its useful life.

b) The elevator should ensure the safety of passengers even if it gets damaged by assuming that a large scale earthquake might often hit the building during its useful life.

c) The escalator should not be detached and should not fall from the supporting material or beam of the building, even if it gets damaged, assuming that a large-scale earthquake might often hit the building during its useful life.

A.1.3 Earthquake resistant design and construction

a) Taking the seismic force for design into consideration, the design and construction of the elevator must be conducted so that the stress and deflection of the equipment and the material will be less than the allowable unit stress of the material or remain within the required scope.

b) Against the seismic force for design, the equipment of the elevator must be designed and installed so that shift, overturn or detachment of the equipment, will not be caused.

c) The main ropes of the sheaves must not be detached by the shaking caused by the earthquake.

d) Protection measures should be taken so that the mobile cables will not be damaged by the projections in the hoistway when the earthquake occurs.

e) The escalator must be designed and installed so that it will not be detached or will not fall from the supporting material or beam of the building even if the seismic force for design and the deformation between floors in the building occur.

A.1.4 The allowable stress

a) The allowable stress of the steel and concrete conforms to the regulations of the Architectural Standard Law, and under the earthquake the allowable stress for the short term is used.

b) The allowable load of the anchor bolt for concrete being given for the installation of equipment in the machine room and the hoistway is obtained by dividing the pulling strength by the safety rate shown in Table A.1. (The pulling strength was determined by experiment.)

Table A.1 — Design safety rate of anchor bolt

Application of anchor bolt	Safety rate to pulling strength
Installation of equipment in the machine room	7
Installation of equipment in the hoistway	4

A.2 Seismic force for design

A.2.1 The calculation of the seismic force for design

NOTE Equation numbers correspond to those in the JEA Guide.

A.2.1.1 The horizontal seismic force F_{H} for design is calculated by the following formula and the point of action is defined as the centre of gravity of the equipment:

$$F_{\mathrm{H}} = K_{\mathrm{H}} \times M \times g$$

$$F_{\mathrm{H}} = K_{\mathrm{H}} \times W \qquad (2\text{-}1)$$

where

F_{H} is the horizontal seismic force in newtons;

K_{H} is the horizontal seismic intensity for design;

g is acceleration due to gravity (981 cm/s^2);

M is the mass of the equipment in kilograms;

W is the weight of the equipment in kilograms force.

A.2.1.2 For the machine room equipment, calculate by the following formula, taking the vertical seismic force F_{V} for design into consideration.

$$F_{\mathrm{V}} = K_{\mathrm{V}} \times M \times g$$

$$F_{\mathrm{V}} = K_{\mathrm{V}} \times W \qquad (2\text{-}2)$$

$$K_{\mathrm{V}} = \tfrac{1}{2} K_{\mathrm{H}} \qquad (2\text{-}3)$$

where

F_{V} is measured in newtons;

K_{V} is the vertical earthquake intensity for design;

W is as defined in A.2.1.1.

A.2.2 The horizontal seismic intensity for design

A.2.2.1 The horizontal seismic intensity K_H for design of the elevator that is installed in a building of a height less than 60 m should be established based on the standard seismic intensity of each earthquake resistant class and should be greater than the value calculated by the following formula.

$$K_H = Z\ K_s\ l \tag{2-4}$$

where

Z is the local coefficient (refer to JEA Guide:1998, Table 2-3);

K_s is the standard seismic intensity for design (see Table A.2);

I is the coefficient of usage.

Table A.2 — Standard seismic intensity, K_s

Application equipment		**Earthquake resistant class for application equipment**		
Classification	Floor to be installed	S	A	B (standard class)
Machine room equipment	Floors over 2nd floor	2,0	1,5	1,0
	1st Floor and basement	1,0	0,6	0,4
Hoistway equipment	Floors over 2nd floor	1,0		0,6
	1st Floor and basement	0,6		0,4

Table A.3 — Coefficient of usage, I

Type of elevator	**Application equipment**	
	Machine room equipment	**Hoistway equipment**
Elevator for passenger and bed type	1,0	1,0
Freight elevator	1,0	0,75

However, when the floor response acceleration (hereafter referred to as floor response) based on the earthquake motion for design of the building, is used for the calculation of the seismic intensity for design, it can be obtained by the following.

A.2.2.2 The horizontal seismic intensity for design of the elevator that is installed in a building of a height greater than 60 m, with a structural isolation system and structural control system, should be greater than the value calculated by the following formula based on the floor response F_R.

However, for the building to be installed at a height lower than 60 m, with a structural isolation system and structural control system, it is allowed to calculate the horizontal seismic intensity for design by employing the (2-4) formula based on the standard seismic intensity for design.

$$K_H = \frac{F_R}{g} \times K_2 \times l \tag{2-5}$$

where

K_H is the horizontal seismic intensity for design;

F_R is the maximum value of floor response of each floor in metres per second per second;

g is acceleration due to gravity (981 cm/s^2);

K_2 is the coefficient in consideration of amplification ratio of equipment;

I is the coefficient of usage (see to Table A.3).

But,

1) F_R value applies a maximum value of the floor response based on the elasticity response analysis of the building.

2) K_2 value should be obtained by Figure A.1, complying to the rate f_b/f_m of the fundamental frequency of the building and equipment.

Where

f_b is the fundamental frequency of building;

f_m is the fundamental frequency of equipment.

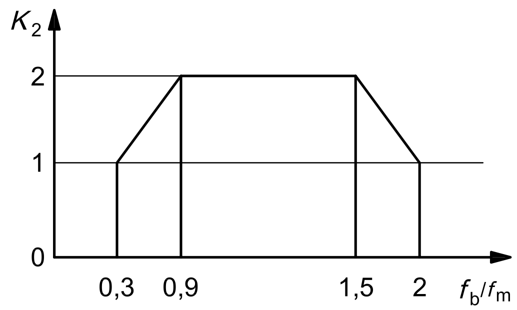


Figure A.1 — Coefficient in consideration to the amplification rate of elevator equipment

A.2.3 Guide rail

In the calculation of the guide rail, obtain the load to be given to the guide rail through the car or counterweight by the seismic intensity. By this, calculate the stress and deflection produced in the guide rail and the supporting materials and make sure that they will remain below the allowable value.

A.2.3.1 The load given to the guide rail.

Obtain by the following formula the load to be given to the guide rail through the car and the counterweight by the seismic intensity.

$$P_x = F_H \times \varepsilon = K_H \times W_\varepsilon \quad (2\text{-}8)$$

$$P_y = \frac{1}{2} F_H \times \varepsilon = \frac{1}{2} K_H \times W_\varepsilon \quad (2\text{-}9)$$

where

P_x is the load to x direction of guide rail in kilograms force;

P_y is the load to y direction of guide rail in kilograms force;

F_H is the horizontal seismic force for design in newtons;

K_H is the horizontal seismic intensity for design;

W is the equivalent weight of car or counterweight in kilograms force;

ε is the load ratio of upper and lower guide shoes (0,6).

Use the value (equivalent weight) obtained by the following formula:

$$W = W_1 + \alpha W_2 \tag{2-10}$$

where

W_1 is the car dead load in kilograms force;

W_2 is the car capacity load in kilograms force;

α is the reduction rate (refer to JEA Guide:1998, Table 2-5).

NOTE 1 The multiple effect of β_1 or β_2 is not allowed.

NOTE 2 Regarding the mark *, the figure shall be 0,7 in case of using a ditch (groove)-type middle stopper.

NOTE 3 In the case of rails mentioned in JEA Guide:1998,Table 2-6, reduction rates β_1 and β_2 are defined according to rail type and installation configuration. If not mentioned, one of two methods can be applied.

The reduction factors can be calculated using the section coefficients Z_x and Z_y according to the formula (2-63) $\zeta = Z_x/(2Z_y)$.

In case of $\zeta \geqslant 0,67$, $\beta_1 = 0,67$.

In case of $\zeta > 0,67$, $\beta_1 = \zeta$. Or through application to the agency.

As for β_2 without ditch (groove), in case of $\zeta \leqslant 0,7$, $\beta_2 = 0,7$ and in case of $\zeta > 0,7$, $\beta_2 = \zeta$.

For an elevator to be installed in a steel structure building of a height greater than 60 m, the forced deformation force caused by a maximum layer deformation angle must be considered in the elastic response of the building.

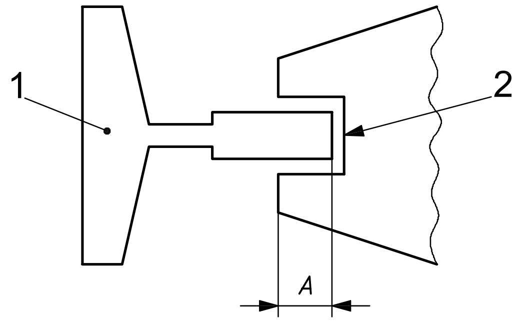
A.2.3.2 Allowable scope of the stress intensity and deflection.

The stress intensity and deflection of the guide rail are as follows:

Stress intensity $\sigma \leqslant$ allowable stress intensity in kilograms force per square centimetre (2-13)

Deflection $\delta \leqslant A - 1,5$ in centimetres (2-14)

where A is the engagement dimension between guide shoe (or off-stopper) and guide rail.



Key

1 guide rail

2 guide shoe or off-stopper

Figure A.2 — Engagement dimension between guide shoe (off-stopper) and rail

A.2.3.3 JEA Guide:1998, Table 2-7 shows the section performance, stress intensity and allowable value of deflection of the guide rail which is used in the ordinary case.

Table A.4 — Reduction rate, α

Elevator type	α
Elevator for passenger and bed-type	0,25
Freight elevator	0,5

A.2.3.4 The calculation of guide rail.

Calculation of the stress intensity and the deflection.

As for the normal elevator, the stress intensity and the deflection are calculated by use of the following formula to the load P_x or P_y being given to the guide rail through the car and the counterweight by the seismic intensity.

Regarding the special elevators such as a fork type (industrial truck) elevator, the calculation should be made based on its structure.

Stress Intensity, $\sigma = \frac{7}{40} \times \frac{\beta P L}{Z}$ (2-11)

Deflection, $\delta = \frac{11}{960} \times \frac{\beta P L^3}{Z}$ (2-12)

where

P is load P_x or P_y loaded on the guide rail in kilograms force;

L is the distance of the rail bracket in centimetres;

Z is section modulus Z_x or Z_y of the guide rail in cubic centimetres (Refer to Table A.6);

E is Young's modulus of elasticity of the guide rail in kilograms force per square centimetre;

I is the geometrical moment of inertia I_x or I_y of the guide rail in centimetres to the fourth (see Table A.6);

β is the load reduction rate by tie bracket or middle stopper (see Table A.5).

However, β applies to β_1 or β_2 of Table A.5.

In case of not installing the tie bracket or the middle stopper, $\beta = 1$.

Table A.5 — Reduction rate, β

Rail name	In case of installation of tie bracket, β_1	In case of installation of middle stopper, β_2
5 kg rail 8 kg rail 13 kg rail 24 kg rail 30 kg rail	0,67	0,7
18 kg rail 37 kg rail	0,78	0,78[a]
50 kg rail	0,92	0,92[a]
37A, 50PS, 50N rail	1,0	1,0[a]

[a] See A.2.3.1 NOTE 2.

Table A.6 — Section performance and stress intensity, allowable value of deflection of guide rail

Rail name	Geometrical moment of inertia cm^4		Section modulus cm^3		Allowable stress kgf/cm^2	Engagement dimension A of guide shoe cm	Allowable deflection δ cm
	I_x	I_y	Z_x	Z_y			
5 kg rail	*	*	*	*	2 400	3,0	1,5
8 kg rail	29,9	26,1	7,56	6,71	2 400	3,0	1,5
13 kg rail	59,5	50,4	14,3	11,3	2 400	3,5	2,0
18 kg rail	179	108	29,7	19,1	2 400	4,0	2,5
24 kg rail	199	226	31,1	35,6	2 400	4,0	2,5
30 kg rail	400	314	52,8	44,9	2 400	4,5	3,0
37 kg rail	539	349	76,7	49,9	2 400	4,5	3,0
50 kg rail	999	461,2	120,8	66	2 400	4,5	3,0

NOTE 1 The marked value is established based on the performance evaluation of “Elevator & Entertainment Facility Performance Evaluation Committee” of Japan Architecture Center.

NOTE 2 As for the value of the allowable stress, the value of the yield point approved by the above performance evaluation can be used without concerning the value shown in this table.

NOTE 3 As for the exception of the rails mentioned as above, the application standard should be based on the above performance evaluation.

NOTE 4 The engagement dimension of the guide shoe (off-stopper) is greater than the value to be added the clearance dimension to the engagement dimension mentioned as above.

A.2.3.5 Calculation of the guide rail supporting materials.

Assuming that the load (P_x or P_y) given to the guide rail is loaded on the supporting materials through the guide rails, calculate the stress intensity and deflection of the supporting materials and the pulling load of the anchor bolt and make sure their values will be less than the allowable value.

1) The calculation formula:

— an adequate calculation must be made based on the shape or structure of the supporting materials.

2) The allowable scope of the stress intensity and deflection:

— the allowable scope of the stress intensity and deflection is as follows:

Stress Intensity, $\sigma \leqslant$ Allowable Stress Intensity in kilograms force per square centimetre (2-15)

Deflection, $\delta_B \leqslant 0{,}5$ cm (2-16)

Pulling load of anchor bolt $\leqslant \dfrac{\text{Pulling strength of anchor belt}}{4}$ in kilograms force per square centimetre (2-17)

Shearing unit stress of anchor bolt $\leqslant$ allowable stress intensity of shear in kilograms force per square centimetre.

A.2.3.6 The calculation of tie bracket.

In the case of installing the tie brackets in the guide rails of the counterweight, the stress intensity and the deflection are obtained by the following formula, and select the allowable supporting materials. (See Figure A.3.)

Stress Intensity, $\sigma = \dfrac{P_x\, l_1}{2Z_t}$ in kilograms force per square centimetre (2-19)

Deflection, $\delta_t = \dfrac{P_x\, l_1{}^2(2l_1 + 3l_2)}{3E_t I_t}$ in centimetres (2-20)

where

P_x is the load on the guide rail in kilograms force;

Z_t is the section modulus of the supporting material in cubic centimetres;

I_t is the geometrical moment of inertia in centimetres to the fourth;

l_1 is the dimension of tie bracket in centimetres;

l_2 is the dimension of tie bracket in centimetres;

E_t is Young’s modulus of tie bracket in kilograms per square centimetre.

The allowable scope of the stress intensity and deflection:

$\sigma_t \leqslant$ allowable stress intensity in kilograms force per square centimetre (2-21)

$\delta_B \leqslant \delta$ in centimetres (2-22)

But, δ is defined as a deflection of the guide rail under the condition that a tie bracket is not installed.

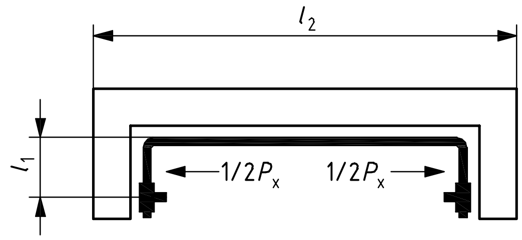


Figure A.3 — Load given to the tie bracket

A.2.4 The equipment of the machine room

Make sure by calculation that the traction machine, the motor alternator and the control cabinet to be installed in the machine room will not overturn or be displaced by an earthquake.

A.2.4.1 The calculation of overturn.

Safety against overturn is obtained by comparing the overturning moment given to the equipment with the restoring moment. The calculation formulae are given in (2-67) and (2-68).

If installed with the special structure and engineering method, the calculation method must be adopted based on them.

Overturn moment, $M_e = F_H \times H$

$$M_e = K_H \times w \times H \tag{2-67}$$

Restoring moment, $M_f = (W - K_v \times W) \times A + F_r \times B$

$$M_f = (l - K_v) \times W \times A + F_r \times B \tag{2-68}$$

where

M_f is the restoring moment in kilograms force centimetre;

F_H is the horizontal seismic force for design in kilograms force;

F_v is the vertical seismic force for design in kilograms force;

K_H is the horizontal seismic intensity for design;

K_v is the vertical seismic intensity for design;

W is the equipment weight in kilograms force;

A is the horizontal distance from the steady point of gravity in centimetres;

B is the interval of the steady point in centimetres;

F_r is the allowable tension load of the vibration rubber or allowable pulling load of the anchor bolt in kilograms;

H is the height of the gravity in centimetres.

The condition of no-overturn is $M_r > M_e$.

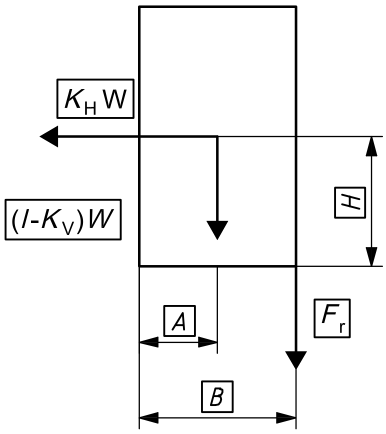


Figure A.4 — Load and dimension of equipment

A.2.4.2 The calculation of displacement (shifted position).

Safety against the displacement of equipment in the machine room must be studied by comparing the horizontal seismic force given to the equipment with the vibration rubber, fitting bolt, anchor bolt of the equipment or the allowable shear load of the stopper. In case of fixing the traction machine with vibration-proof supports, the machine beam should be welded with steel angles. The calculation is according to the following formulae.

If the specific equipment is installed by specific engineering methods, the calculation must be correctly made based on that.

The condition not to cause displacement is as follows.

$$F_s > F_H \qquad (2\text{-}69)$$

$$F_H = K_H \times W \qquad (2\text{-}70)$$

where

F_H is the horizontal seismic force for design in kilograms force;

W is the equipment weight in kilograms force;

K_H is the horizontal seismic intensity;

F_s is the allowable shear load of vibration rubber, fitting bolt, anchor bolt or stopper in kilograms force.

A.2.4.3 The allowable load of anchor bolt

The allowable load of the anchor bolt used to fix equipment installed in the machine room is obtained using the following formula.

$$\text{Allowable pulling load} = \frac{\text{Pulling strength determined by experiment}}{\text{Safety rate (7)}} \text{ in kilograms} \qquad (2\text{-}71)$$

Allowable shearing load = effective cross section area of bolt × allowable shearing unit stress in kilograms (2-72)

A.2.4.4 The reinforcement of earthquake resistant stopper.

If these conditions cannot be satisfied, increase the strength of the vibration rubber or fitting bolt, otherwise install a stopper.

A.2.5 The structure of sheave

Install the rope guards so that the main rope will not be removed from the sheave by shaking. However, as for the earthquake resistant class “B”, deepening of the rope groove of the sheave is allowed.

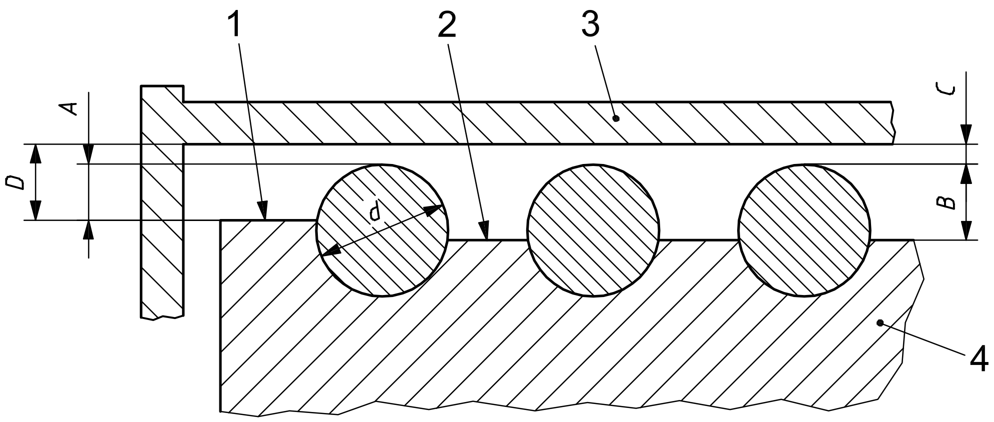
Table A.7 — Sheave structure

Earthquake-resistant class	Sheave structure
B	Install the rope guard or deepen the rope groove of sheave
A and S	Install the rope guard

Protection measures against detachment of the winding drum, governor rope and compensating rope are to deepen the rope ditch (groove) of the sheave or install the rope guard for any earthquake-resistant classification.

Figure A.5 describes the structure of the rope guard mentioned as above. The depth of the rope ditch (groove) of the sheave (including deflector sheave and suspension sheave)must satisfy the following standard.

See Figure A.5.



Key

1 edge

2 outer sheave

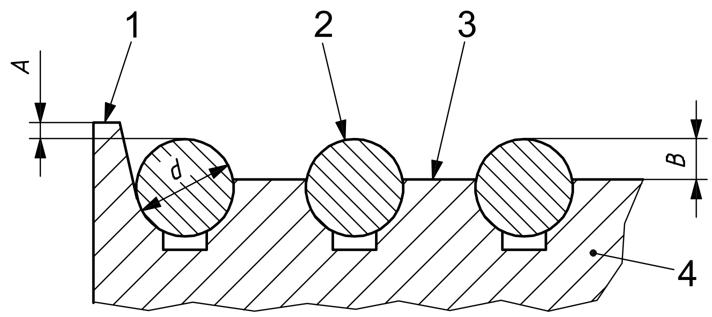
3 rope guard

4 sheave

$A \leqslant 2/3\ d$; $B \leqslant 2/3\ d$; $C \leqslant 3$ mm; $D \leqslant 3/4\ d$

Figure A.5 — Installation standard of rope guard

As for the earthquake resistant “B” class, if the rope guard is not installed, the rope ditch (groove) of sheave in depth must satisfy the following standard:



Key

1 edge
2 rope
3 outer sheave
4 sheave

$A \geqslant 0$; $B \leqslant 1/2\ d$

Figure A.6 — Relation between sheave edge, groove and rope

A.2.6 The hoistway equipment

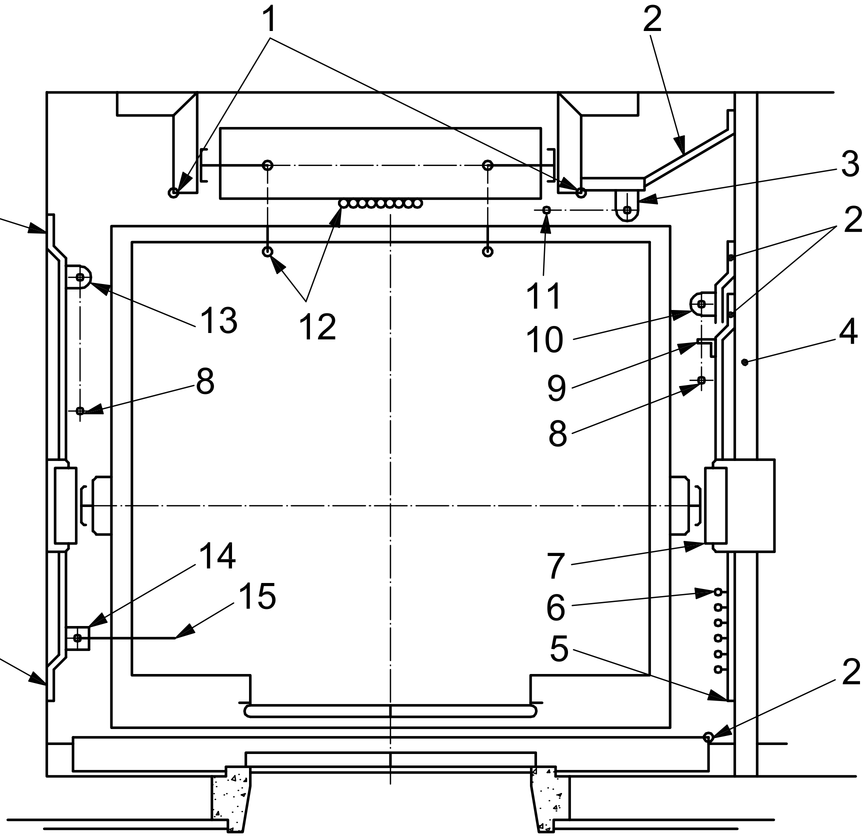
Protection measures must be conducted, taking into account that equipment and fitting materials will not excessively deform and that the ropes and the cables will not be damaged by projections in the hoistway.

A.2.6.1 The installation of the equipment in the hoistway.

In order to securely install equipment in the hoistway, enough strength against the seismic force must be provided to prevent excessive deformation of equipment, based on the horizontal seismic intensity for design regulated in 2.2.

A.2.6.2 Protection measures against projections in the hoistway.

Protection measures against the projections in the hoistway must be taken according to Table A.8 and Figure A.7.



Key

1 rail bracket protection wire of counterweight
2 protection or protection wire
3 governor rope guide
4 intermediate beam
5 tail code protection mesh cover or protector
6 tail code
7 rail bracket protection wire of cage
8 cage governor rope
9 inductor plate
10 rope guide
11 counterweight governor rope
12 compensating rope or chain
13 governor rope guide
14 steel tape guide
15 steel tape

Figure A.7 — Hoistway equipment and protection measures against the projections

A.2.6.3 Prevention of counterweight block.

The structure of the counterweight block should be designed so as not be detached even if earthquake motion occurs.

A.2.6.4 Oil piping system.

The oil piping system of the hydraulic elevator must have high strength in order to resist the earthquake and must be installed so that it will not become damaged.

Table A.8 — Protection measures against projections

Full height of hoistway	Item No. [a]	Protected equipment	Protection measures	Construction scope
< 10 m			Not necessary due to very small shake (displacement) of buildings.	
< 60 m but > 10 m	1	Travelling cable	Stretch a protection wire in the corner of the rail bracket near the travelling cables.	Area lower than the intermediate point of the travel.
	2	Travelling cable	Install a protection mesh cover or protector in the middle beam of the travelling cables; but, the use of the protector is permitted only for the elevators below 105 m/min speed.	In the case of placing the tail code along the middle beam, lower than the middle of the travel.
	3	Compensating chain Compensating rope Counterweight governor rope	Stretch a protection wire in the corner of the rail bracket of the counterweight.	Full travel in case of installing either of the compensating chain or compensating rope or counterweight governor.
< 60 m but > 10 m	4	Governor rope	Install a rope guide and protector. Otherwise use protection wire.	Keep pitch below 20 m to the return rope; but, in the case of installing the governor rope on the inductor plate, below 15 m pitch, install around the surroundings so that the rope will not touch the hoistway switch.
	5	Steel rope	Install a tape guide and protector. Otherwise use protection wire.	Keep pitch below 20 m to the return rope; but, in case of installing the steel rope on the inductor plate below 15 m pitch, install around the surroundings so that the rope will not touch the hoistway switch.
> 60 m	1 to 5	Ditto	Ditto	
	6	Travelling cable	Install a protector or a protection wire.	Install in the sill and the header edge in the travelling cable (below the intermediate area of the travel distance).
[a] Items correspond to key numbers in Figure A.7.				

A.2.7 The control operating device in the occurrence of an earthquake

In order to achieve the maximum effect, the control operating device should be designed in coordination with the control system of the elevator and the protection measures for each item of equipment. Therefore, for the determination of the sensitivity setting value of the earthquake sensor, the control system of the elevator is needed, as well as the characteristics of building and the earthquake safety for all equipment.

A.2.7.1 Control operation in earthquake.

The control operation of normal elevator and emergency elevator in earthquake must comply with Figure 2-81 and Figure 2-82, respectively, of the JEA Guide:1998.

A.2.7.2 The setting value of earthquake sensor.

For the setting value of the earthquake sensor to be applied for the control operating device, as a rule the value mentioned in Table A.9 should be used.

Table A.9 — Setting value of earthquake sensor

Height of buildings	Special low setting value gal [a]	Low setting value gal [a]	High setting value gal [a]
< 60 m	80 or P Wave Detection	120	150
< 120 m but > 60 m	30, 40, 60 or P Wave Detection	60, 80 or 100	100, 120 or 150
> 120 m	25, 30 or P Wave Detection	40, 60 or 80	80, 100 or 120

[a] gal or Galileo; 1 gal = 10^{-2} m s^{-2} acceleration.

NOTE 1 For a normal elevator without an express zone, a double setting of the low and special low should be established.

NOTE 2 For a normal elevator with an express zone and an emergency elevator, a triple setting of the special low, low and high should be established. However, if the normal elevator with the express zone can land on the nearest floor within 10 s or on the emergency exit in the express zone, the double setting of special low and low should be established.

NOTE 3 For a hydraulic elevator whose machine room is located in the basement or around the first floor, the special low setting value should be 30 gal or P wave detection, and the low setting value should be 60 gal as a standard.

NOTE 4 If an elevator, manufactured before the application of the Architecture Standard Law enacted on June 1, 1981, is not retrofitted to be earthquake-proof, the special low 60 gal or P wave detection, and the low 100 gal setting values should be used as the standard.

A.3 Others

To keep the function of elevator and ensure the safety of passengers, it is desirable to provide earthquake resistant for the structures and facilities of buildings.

A.4 The earthquake measures for the existing elevators

For elevators installed before the application of the Architecture Standard Law (June 1,1981) which requires the reinforcement of anti-earthquake standards, this guide is not applicable. However, it is desirable that earthquake safety measures will be taken as much as possible based on this guideline to ensure the safety of the passengers and to keep the function of the elevators.

Annex B
(informative)

Anti-earthquake design and construction in Japan (Japan Elevator Association)

B.1 Summary of modifications

B.1.1 Direction of the anti earthquake design and construction for elevators and escalators.

B.1.2 Three (S, A, B) classifications for anti-earthquake has been introduced.

B.1.3 Reinforcement of equipment.

B.1.3.1 Engagement of guide shoes + 5 mm.

B.1.3.2 Rope guards of sheave for Classes S and A.

B.1.3.3 Reinforcement of protection measures for the projections in the hoistway.

B.1.3.4 Counterweight for dropout prevention of counterweight blocks.

B.1.3.5 Anti-earthquake standard of hydraulic piping for hydraulic elevators.

B.1.4 Setting value of earthquake sensor

B.1.4.1 (Low) 120 gal → 150 gal.

B.1.4.2 (High) 150 gal → 200 gal.

B.2 Anti-earthquake classification requirements

B.2.1 Dropout prevention from supporting material

Table B.1 — Dropout prevention

Class	Requirements
S	Secures minimum requirements for safety, prompt function recovery of equipment in the hoistway and machine room
A	Secures minimum requirements for safety, prompt function recovery of equipment in hoistway
B	Secures minimum requirements for safety standard

B.2.2 Classification and standard seismic intensity for design (K_S)

Table B.2 — Seismic intensity

Equipment		Up to now		Revised (classification)		
		Passenger and bed elevator	Freight elevator	S	A	B
Machine room	Floor over 2F	0,1	1,0	2,0	1,5	1,0
	1F and Basement	0,4	0,4	1,0	0,6	0,4
Hoistway	Floors over 2F	0,6	0,45	1,0		0,6
	1F and Basement	0,4	0,4	0,6		0,4

B.2.3 Formulae

$$F_H = K_H \times M \times g$$

$$K_H = Z \times K_S \times I$$

where

K_S is the standard seismic intensity for design;

F_H is the horizontal seismic force for design in newtons;

K_H is the horizontal seismic intensity for design;

M is the mass of the equipment in kilograms;

g is acceleration due to gravity (981 cm/s^2);

Z is the local coefficient;

I is the coefficient of usage.

B.2.4 Coefficient of usage, I

Table B.3 — Equipment coefficient of usage, I

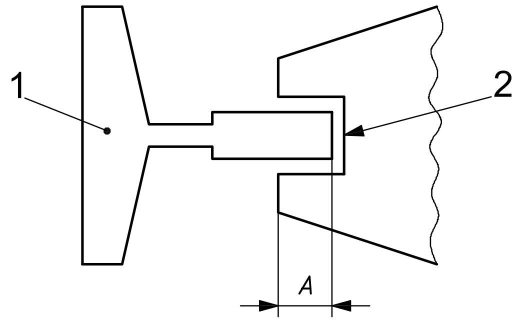
Type	Equipment coefficient of usage, I	
	Equipment in machine room	Equipment in hoistway
Passenger and bed elevator	1,0	1,0
Freight elevator	1,0	0,75

B.2.5 Horizontal seismic coefficient, K_H

Do not apply the lower limit value, 0,4, of the horizontal seismic coefficient for design of elevator equipment.

B.3 Equipment design requirements

B.3.1 Engagement dimensions between shoe (off-stopper) and rail



5 mm [$D_m \leqslant (A - 1{,}0)$ cm]

Key

1 guide rail

2 guide shoe or off-stopper

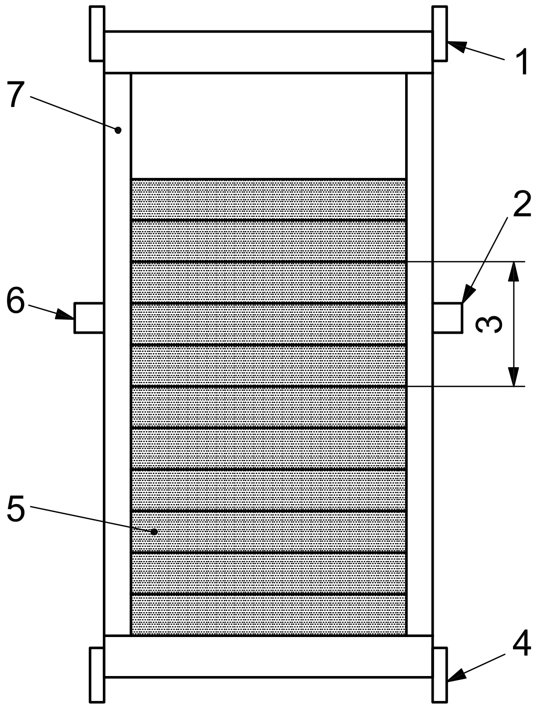
Figure B.1 — Guide rail engagement

B.3.2 Structure of sheave

Table B.4 — Structure of sheave

Class	Structure of sheave
B	Install rope guard or deepen the ditch (groove) of sheave
A	Install rope guard
S	

B.3.3 Installed position of intermediate stopper

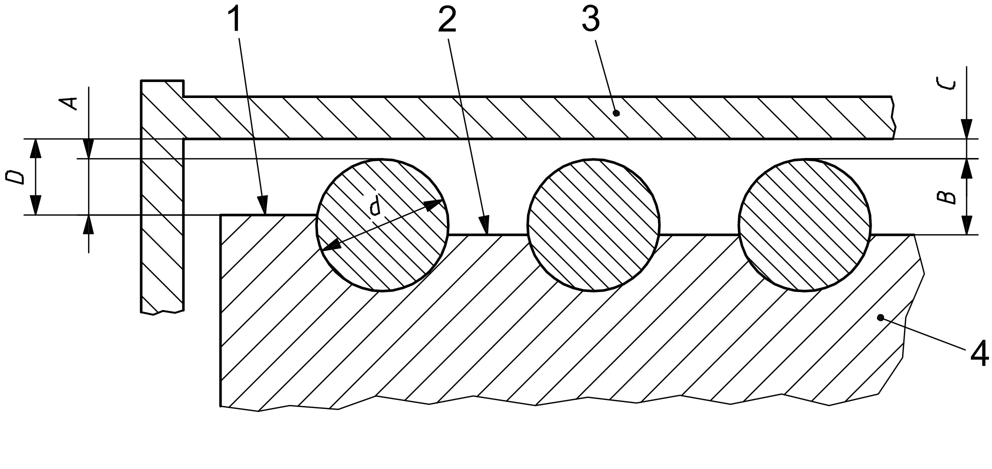


Key

1 upper guide
2 intermediate position of upper and lower guide
3 installed intermediate stopper in this range
4 lower guide
5 centre height position of counterweight blocks
6 intermediate stopper
7 counterweight frame

Figure B.2 — Counterweight

B.3.4 Rope guard installation standard



Key

1 edge
2 outside
3 rope guard
4 sheave

$A \leqslant 2/3d$; $B \leqslant 2/3d$; $C \leqslant 3$ mm; $D \leqslant 3/4d$

Figure B.3 — Rope guard dimensions

B.4 Classification of hoistway height

Table B.5 — Classification of hoistway height

Year	Hoistway height above ground				
Prior to 1998	< 15 m	< 30 m; > 15 m	< 60 m; > 30 m	< 120 m; > 60 m	> 120 m
Starting in 1998	< 10 m	< 60 m; > 10 m		> 60 m	

B.5 Protection measures

Table B.6 — Protection measures

Height	Effective 1998	Up to 1998
~ 10 m	Not necessary	~ 15 m
10 m ~ 60 m	(1) (2) (3) Travelling cable	~ 15 m
	(4) Governor rope: rope guide and protector, or protection wire, shall be mounted.	30 m ~ 60 m
	(5) steel rope: tape guide and protector, or protection wire, shall be mounted.	
60 m ~	(1) (2) (3) (4) (5) are the same as above.	120 m ~
	Travelling cable: protector, or protection wire, shall be mounted.	

B.6 Structure for preventing drop-out of counterweight blocks

Table B.7 — Prevention of drop-out of counterweight blocks

Vibration direction	Through bolt		Clamping	Frame stopper	With middle stopper
	Lower frame through counterweight	Through upper and lower frame, or no frame			
Horizontal seismic force	X	O	X	O	O
Vertical seismic force	O	O	O	X	X
Notation: O = Effective; X = Ineffective.					

B.7 Setting value of earthquake sensor

Table B.8 — Setting value of earthquake sensor

Height of buildings	Special low setting value gal [a]	Low setting value gal [a]	High setting value gal [a]
$<$ 60 m	80 or P Wave Detection	150	200
$<$ 120 m, $>$ 60 m	30, 40, 60 or P Wave Detection	60, 80 or 100	100, 120 or 150
$>$ 120 m	25, 30 or P Wave Detection	40, 60 or 80	80, 100 or 120

[a] gal or Gallileo; 1 gal = 10^{-2} m s^{-2} acceleration.

B.8 Anti-earthquake standard for hydraulic piping for hydraulic elevators

B.8.1 Installed with enough strength to resist against earthquake and not to get damaged.

B.8.2 Considered layer deformation angle.

Table B.9 — Layer deformation angle

Building structure	Layer deformation angle
Steel structure	1/100
Steel-reinforced concrete	1/200
Reinforced concrete	

B.9 Anti-earthquake design and construction for escalators

B.9.1 Drop-out prevention of escalators from supporting material, such as, beam, etc.

B.9.2 Standard seismic intensity for design.

Table B.10 — Standard seismic intensity for design

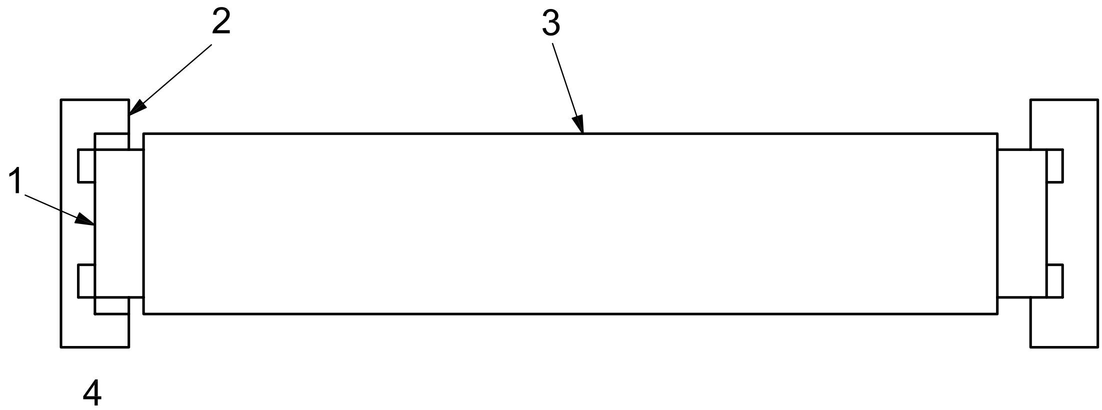
Installed floor	Standard seismic intensity for design
Floors over 2F	0,6
IF and basement	0,4

B.9.3 Layer deformation angle = less than 1/100

B.9.4 Standard of engagement

B.9.5 Calculation of strength

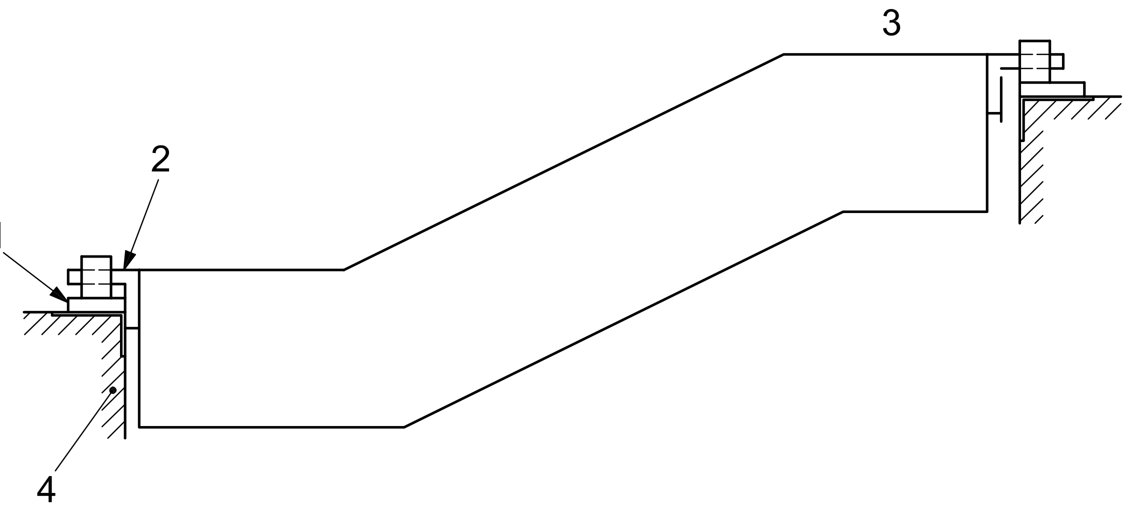
B.9.6 Example of fixing methods or pedestal and truss supporting angle



Key

1 truss support angle
2 pedestal
3 truss
4 L steel angle

Figure B.4 — Plan view of escalator truss



Key

1 pedestal
2 truss support angle
3 non-support side
4 building material support such as beam

Figure B.5 — Elevation of escalator truss

Annex C
(normative)

NZS 4332 [9]: passenger and goods lifts

NOTE 1 This annex contains actual text from the NZS 4332:1997 (copyright © Standard New Zealand).

NOTE 2 The organization and numbering of sections, clauses, rules and tables of NZS 4332:1997 is modified in this annex to suit the numbering sequence in this Technical Report. The specific rule numbering which appears in the NZS Standard is shown in parentheses after the titles.

PART 1 GENERAL REQUIREMENTS

C.1 Scope

C.1.1 The scope of this Technical Report is the design, construction, operation and testing of passenger carrying lifts, including goods lifts with car controls.

It is not intended for lifts in single unit dwellings.

This Standard applies to new building work being either the installation of a new lift or new work associated with an existing installation.

New work includes the complete or substantial replacement of a major part of the lift such as occurs with:

a) an increase in the carrying load requiring a new hoisting machine and new ropes;

b) an extension of travel by addition of a new floor or floors;

c) a conversion of hydraulic or belt driven lift to electric drive.

It does not include routine maintenance, or repair or replacement of any component or assembly with a comparable component or assembly.

NOTE 1 A conversion or assembly replacement that results in a speed increase will count as new work if the resulting installation can no longer comply with the speed-related requirements of this Standard, such as, top and bottom clearances, etc. A refit of a lift car which significantly increases the car weight may also count as new work. An increase in car weight requires the balancing to be checked and a review of the lift drive capacity, guide rail capability, etc.

NOTE 2 The structural design of the building necessary to support the installation of the lift shall comply with clause B1 of the NZBC, and is not covered by the Standard.

C.2 General

C.2.1 Earthquake loadings

NZS 4203 [10] shall be used for determining loadings due to seismic accelerations on lift machinery, lift guides, lift car and landing doors and standby equipment. Alternatively, these shall be calculated by using the seismic coefficient details from the lift particular sheets (see 5.2 and 31.2). The appropriate risk factor shall be determined from Table C.1 and seismic zone from Appendix B.

NOTE These references pertain to the NZS 4203:1994 Code.

Table C.1 — Risk factors (See NZS 4203:1994 Code, Table 2-1)

Building category	Description	Risk factor R
1	Structures containing highly hazardous contents	2,0
2a	Buildings that are intended to remain functional in the emergency period for major earthquakes	1,6
2b	Buildings whose failure could cause high loss of life in the surrounding area	1,6
3a	Buildings that should be functioning in the restoration period for major earthquakes	1,3
3b	Buildings whose contents have a high value to the community	1,3
4	Buildings with normal occupancy or usage	1,0

C.2.2 Drawings and particulars of the lift installation

C.2.2.1 General

The design and construction of each lift or group of lifts shall be recorded on drawings, calculation sheets, data sheets and certificates. See NZS 4302:1994, Appendix D for details on how this information can be presented.

NOTE 1 These documents are required to ensure a safe design and to assist in the correct construction of the lift. The documents may be required by the territorial authority as plans and specifications and supporting information for building consent, and during subsequent inspections of the lift installation.

NOTE 2 The lift designer needs to convey all necessary information (such as, the requirements for machine room and pit sizes, mass of components and clearances) to enable the building design to properly cater for the lift installation.

C.2.2.2 Certificates

The following aspects of the design and/or construction of the lift installation shall be verified for compliance with this Standard by a certificate from an appropriate accredited or certified testing laboratory, or qualified signatory. Certificates originating from overseas are acceptable providing their equivalence is recognised by a mutual recognition scheme or arrangement, or by acceptance of professional qualifications.

a) the hoist ropes (see 16.1);

b) oil buffers (see 10.5);

c) strength of liftwell enclosures (see 12.2);

d) strength of car and landing doors (see 13.3.1);

e) welder qualification certificates (to be available for inspection);

f) for caisson used to protect hydraulic cylinder (see 34.3.7).

NOTE These references pertain to the NZS 4203:1994 Code.

C.2.2.3 Lift particulars

Lift particulars shall be recorded as detailed in 5.2 for electric lifts and 31.2 for hydraulic lifts.

[See these sections in the NZS 4203:1994 Code].

PART 2 ELECTRIC LIFTS: PASSENGER AND GOODS

C.3 General (NZS 4203 [10] Sect. 5)

C.3.1 Scope (NZS 4203 [10] Sect. 5.1)

This part of the Standard applies to electric lifts for carrying passengers and goods. Every electric lift designed for the carrying of passengers and goods shall, in addition to meeting the relevant requirements of Part 1, comply with the requirements of this part of this Standard. As goods lifts must be attendant-controlled and are often used by passengers, it is not intended to treat them as a separate entity.

C.3.2 Electric lift particulars to be documented (NZS 4203 [10] Sect. 5.2)

(All dimensions in millimetres unless otherwise specified)

Owner's name
Address
Location of lift

Lift maker
Lift submitter
Reference No. of submitter
Date of submission
Observation lift: Yes/No
Type of lift (Passenger/Passenger and Goods/Attended Goods)
Serial number(s) of lift(s) which comply with NZS 4121 [37]
Machine maker
Clearance under lifting beam

Internal car floor particulars:
(Measured 1 000 mm above the car floor; ignore handrails, etc.):
Internal car floor width
Internal car floor depth

Masses:
Car (kg)
Rated load (kg)
No. of persons
Counterweight (kg)

Car details:
Platform weight (kg)
Platform direct on buffer members/isolators
Floor details
Sides and top details
Plank or platform support members
Bow members
Weight of additional machinery on bow members (kg)
Buffer members
Sling members
Free length of sling member

Miscellaneous:
Total lift travel (m)
No. of floors of travel/openings served
Maximum speed (m/s)
Governor tripping speed (m/s)

Machine type - drum/traction/geared traction
If drum: overtravel to fixed stop
Terminal speed checking and stopping device: fitted/not fitted
If fitted: speed at contact with buffer (m/s)

Guide shoe data:
Vertical distance between guide shoe centres
- car
- counterweight

Eccentricity of car guide shoes with respect to c.o.g. of car
Toe-to-toe distance between guide rails
- car; (D.B.G.)
- counterweight

Distance from toe of guide rail to centre of guide roller

Clearances for car and counterweight:
Top clearances with car at top landing
Above guide shoes
Mechanical clearance
Man clearance
Clearance above counterweight

Bottom clearances:
Mechanical clearance
Man clearance
Below counterweight, on fully compressed buffer
Car-buffer clearance
Counterweight - buffer clearance (including rope stretch)

Car buffers:
Type - solid/spring/hydraulic
No. of buffers
Stroke of the counterweight buffers

Seismic categories:
$C_{\mathrm{P\ max}}$: Zone A = 0,6; Zone B = 0,5; Zone C = 0,4
Seismic design coefficient $C_\mathrm{d} = R \times C_{\mathrm{P\ max}}$
See Annex D for seismic zones and Table C.1 for risk factor (R)

Car guide rails data:
Type of rail
Distance between fixings
Tie bracket section: modulus Z_{yy} (cm^3)
Height

Safety gear type:
None/A/B/C/D

Counterweight guide rails data:
Type of rail
Distance between fixings
Tie bracket section:
modulus Z_{yy} (cm^3)
height
Safety gear fitted? Yes/No
Type: None/A/B/C/D

Liftwell enclosure (description):

Landing entrances:
Clear opening height
Clear opening width
Door locks type/maker

Terminal stopping device:
Cam operated from car
Selector in machine room driven by car
Electro-mechanical inductors

Final terminal stopping devices (description):

Hoist ropes:
Roping 1:1, 2:1, 3:1
Rope diameter
Ropes total length (m)
Rope effective No.
Breaking strength/rope (tonnes)
Maker
Rope construction
Eye bolt dia.

Machine position:
Traction sheave dia.
Diverter sheave dia.
Weight (kg)
Gear ratio
Traction sheave shaft dia.
Diverter sheave shaft dia.
Motor (kw)
Motor r.p.m.
Governor type
Governor rope dia.

Drawings list:

NOTE The following is a continuation from p. 33 of the NZS 4332 Standard to p. 94.

ii) In the liftwell shall operate at a temperature of 75 °C, or 11 °C below the operating temperature of any sprinkler head fitted, whichever is the lower;

iii) Shall be installed within 300 mm radius of each sprinkler head and heat detector forming part of the building fire alarm system. Where sprinkler heads or heat detectors are not fitted, excessive temperature switches shall be located in accordance with the requirements of NZS 4512 [38] for positioning heat detectors.

c) Sprinkler heads, heat detector sensors and excessive temperature switches shall be protected from accidental damage by approved guards.

d) Operation of an excessive temperature switch shall take all lifts, except those operating on inspection service, non-stop to the main floor and then render them inoperative with the doors open.

e) While returning to the main floor the following sign shall be illuminated in each lift car, “LIFT RETURNING TO MAIN FLOOR”.

f) The lifts shall remain inoperative until such time as the power driving circuit is reset by competent lift service personnel who are satisfied that the lift installation is safe.

g) The excessive temperature switches shall be fixed temperature, heat actuated fire detectors complying with NZS 2139, constructed and installed for operation at extra low voltage. The definition of “extra low voltage” as given in the Electricity Regulations 1993 means “any voltage normally not exceeding 32 volts a.c. or 115 volts d.c.”

C.3.3 Operation of lifts under earthquake conditions (NZS 4203 [10] Sect. 25.8)

C.3.3.1 Major component displacement detector (NZS 4203 [10] Sect. 25.8.1)

All lifts with a travel exceeding 15 m, shall be fitted with a counterweight derailment switch. This device (see Figure 25.1) shall be actuated when the displacement of the counterweight in any one direction of the horizontal plane exceeds 20 mm.

C.3.3.2 Operation (NZS 4203 [10] Sect. 25.8.2)

Upon operation of this device every lift shall:

a) If in motion, immediately decelerate and stop at the next possible floor and remain stopped with the doors open;

b) If stopped at a floor, remain in that position with the doors open.

For lifts in a common shaft, all lifts shall follow this procedure if the device is operated by any one or more lifts in the shaft.

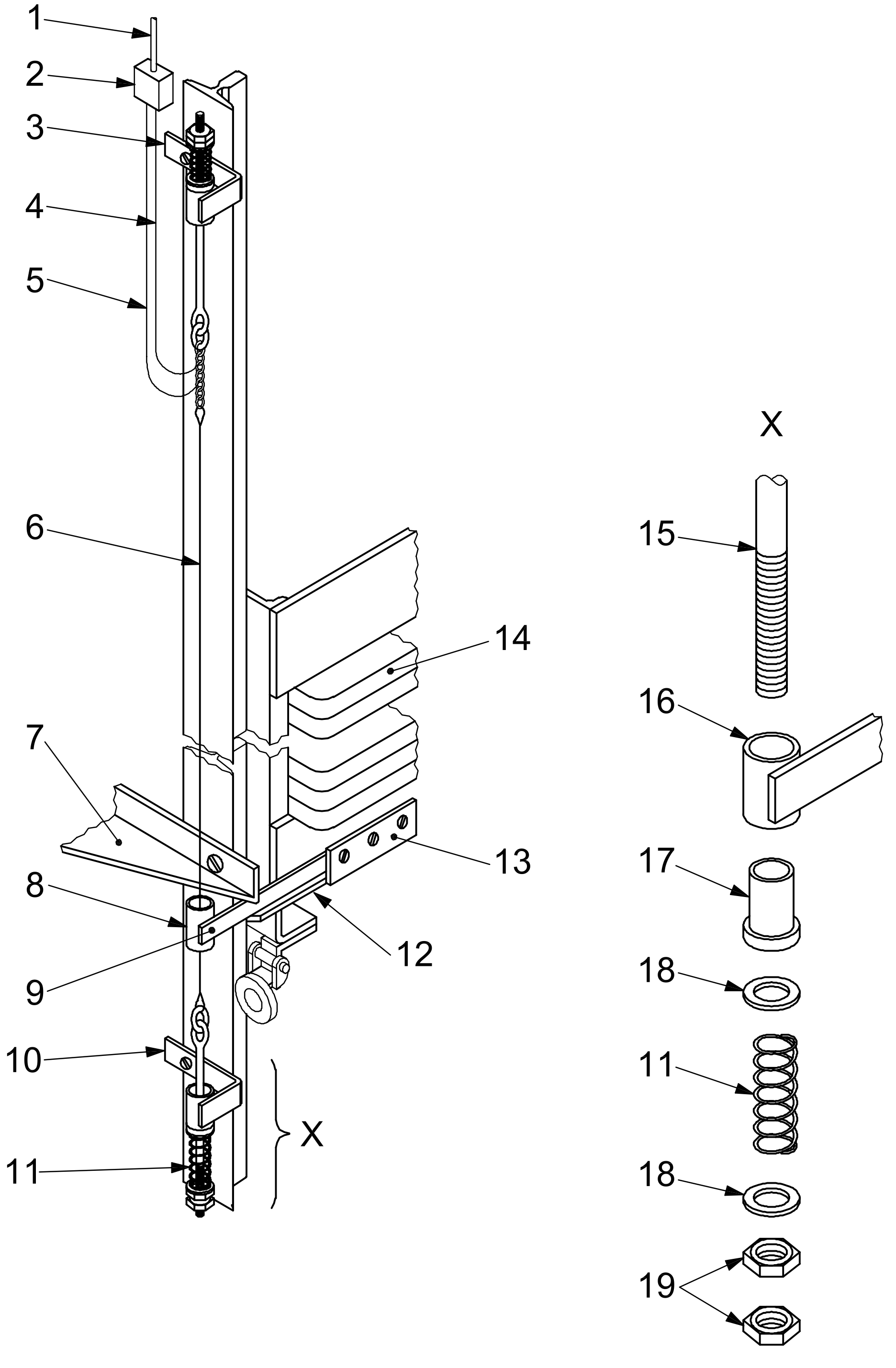
All lifts that have been stopped in this manner shall not be put back into operation until a thorough inspection of the lifts and liftwells has been carried out and certified to be satisfactory by competent lift service personnel.

C.4 Electrical protective devices (NZS 4203 [10] Sect. 26)

C.4.1 Protective devices — General (NZS 4203 [10] Sect. 26.1)

C.4.1.1 Stop switch on top of car (NZS 4203 [10] Sect. 26.1.1)

A stop switch, complying with 24.1, shall be provided on the top of every electric and every electrically-controlled lift car.



Key

1	conduit to controller	8	metal ring	15	eyebolt
2	junction box	9	strap	16	pipe guide
3	bracket at top of railrun	10	bracket at bottom of railrun	17	insulating bushing
4	test wire	11	spring	18	washer
5	detector wire	12	counterweight restraining plate	19	nuts
6	sensing wire	13	bracket		
7	guide rail bracket	14	counterweight		

Figure C.1 — (NZS Code 4332:1997, Fig. 25.1)

PART 3 ELECTROHYDRAULIC LIFTS

C.5 General (NZS 4203 [10] Sect. 31)

C.5.1 Scope (NZS 4203 [10] Sect. 31.1)

This part of the Standard applies to electro-hydraulic lifts as defined in 3.1. The liquid pressure is generated by a pump driven by an individual electric motor. These clauses are complementary to Parts 1 and 2. Should there be conflict, the requirements of this part take precedence over corresponding requirements of Part 2.

C.5.2 Drawings and particulars (NZS 4203 [10] Sect. 31.2)

Drawings and particulars of the lift installation to be documented.

(All dimensions in millimetres unless otherwise specified)

Owner's name
Address
Location of lift

Lift maker
Lift submitter
Reference number of submitter
Date of submission
Observation lift: Yes/No
Type of Lift: Passenger/Pass & Goods/Attended Goods
Serial number(s) of lift(s) which comply with NZS 4121 [37]

Internal car floor particulars:

(Measured 1 000 mm above the car floor; ignore handrails, etc.):
Internal car floor width
Internal car floor depth
Area (cm^2)

Masses:

Car (kg)
Rated load (kg)
No. of persons
Flying counterweight (kg)

Car details:

Platform weight (kg)
Platform direct on buffer members/isolators
Floor details
Sides and top details
Plank or platform support members
Bow members
Weight of additional machinery on bow members (kg)
Buffer members
Sling members
Free length of sling member

Miscellaneous:

Total lift travel (m)
No. of floors of travel/openings served
Rated speed of car (m/s)
Maximum full load down speed (m/s)
Self-closing doors fitted? Yes/No
Top overtravel limiter; none/switch/cushioned ram

For suspended lift:

Governor tripping speed (m/s)
Overtravel limit switch: fitted/not fitted

Guide shoe data:

Vertical distance between car guide shoes' centres
Eccentricity of car guide shoes with respect to c.o.g. of car
Toe-to-toe distance between guide rails (D.B.G.)
Distance from toe of guide rail to centre of guide roller

Clearances and overtravel: clearances at top landing above following equipment:

Above guide shoes
Above equipment 300 mm within perimeter of roof
Above region 450 mm either side of bows
Above car roof
Above all other equipment
Top overtravel of car

Bottom clearances:

Mechanical clearance
Man clearance
Car-buffer clearance
Clearance to landing sill
Clearance to liftwell
Compressed ram clearance

Car buffers:

Type: solid/spring/hydraulic
No. of buffers
Stroke of the buffers

Seismic categories:

$C_{\mathrm{P\,max}}$: Zone A = 0,6; Zone B = 0,5; Zone C = 0,4
Seismic design coefficient $C_{\mathrm{d}} = R \times C_{\mathrm{P\,max}}$
See Annex D for seismic zones and Table C.1 for Risk factors (R)

Car guide rails data:

Type of rail
Distance between fixings
Tie bracket section description (if fitted):
Modulus Z_{yy} (cm^3)
Height

Safety gear type:

None/A/B/C/D

Flying counterweight guide rails data:

Type of rail
Distance between fixings
Buffer type
Buffer stroke
Buffer clearance
Top clearance
Bottom clearance

Tie bracket section description (if fitted):

Modulus Z_{yy} (cm^3)
Height

Liftwell enclosure (description):

Landing entrances:

Clear opening height
Clear opening width
Door locks type/maker

Terminal stopping device:

Cam operated from car
Selector in machine room driven by car
Electro-mechanical inductors

Normal limit switches; maker - description:

Anti-creep levelling device; fitted/not fitted:

Hydraulic system:

Working pressure (kPa)
Relief valve pressure (kPa)
Ram hollow and subject to external pressure: Yes/No

Cylinder:

Outside diameter
Inside diameter
Corrosion allowance (if provided)
Cylinder material
Cylinder yield strength

Type of end:

Flat concave/convex to pressure
Thickness

For dished end:

Radius to which end is dished

Ram:

	Stage 1	Stage 2	Stage 3
Outside diameter			
Inside diameter			
Free length			
Mass (kg)			
Ram follower guide fitted/not fitted			
Ram material			
Ram yield strength (N/mm^2)			

Annex D
(normative)

Seismic zones

Figure D.1 shows the seismic zones when used in conjunction with 5.2 and 31.2 of NZS 4332:1997.

Figure D.1 — Seismic zones (NZS Code 4332:1997, Figure B.1)

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