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

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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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.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 [3].

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 Addenda1), 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.