ASME TR A17.1-8.4–2020
(Revision of ASME TR A17.1-8.4–2013)

Guide for Elevator Seismic Design

AN ASME TECHNICAL REPORT



The American Society of Mechanical Engineers

ASME TR A17.1-8.4–2020
(Revision of ASME TR A17.1-8.4–2013)

Guide for Elevator Seismic Design

AN ASME TECHNICAL REPORT

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: June 15, 2020

This Technical Report will be revised when the Society approves the issuance of a new edition.

The Committee Pages can be found at http://cstools.asme.org/. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code, standard, or technical report. This option can be found on the appropriate Committee Page after selecting “Errata” in the “Publication Information” section.

ASME is the registered trademark of The American Society of Mechanical Engineers.

ASME does not “approve,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representative(s) or person(s) affiliated with industry is not to be interpreted as government or industry endorsement of this technical report.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

No part of this document may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

Copyright © 2020 by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
All rights reserved
Printed in U.S.A.

CONTENTS

Foreword v

Committee Roster vi

Summary of Changes vii

Part 1 **Modification of ASME A17.1-2010/CSA B44-10, Section 8.4, Elevator Safety Requirements for Seismic Risk Zone 2 or Greater** 1

1-1 Scope 1

1-2 Introduction 1

1-3 Elevator Design Impact With IBC/NBCC 2

1-4 Using IBC/ASCE 7 for Elevator Seismic Design (Quick Reference) 5

1-5 Summary 5

1-6 Explanation of Terms 6

Part 2 **Derivations** 15

2-1 Figures 8.4.8.2-1 Through 8.4.8.2-7 15

2-2 Requirement 8.4.8.9 16

2-3 Requirement 8.4.12 16

2-4 Requirement 8.4.12.2.1(a) (Zone > 3) 19

2-5 Requirement 8.4.12.2.1 (IBC/NBCC Jurisdictions) 23

2-6 Requirement 8.4.14.1.1(b) 27

2-7 Requirement 8.4.14.1.2, Load Combinations 28

Part 3 **Sample Calculations** 29

3-1 Sample Calculation(s) 1: Determining Proper Seismic Requirements and Forces 29

3-2 Sample Calculation(s) 2: Controller Anchorage (SI Units) 33

3-3 Sample Calculation(s) 3: Guide Rail Bracket Spacing (SI Units) 34

3-4 Sample Calculation(s) 4: Guide Rail Bracket Strength and Design (SI Units) 44

3-5 Sample Calculation(s) 2: Controller Anchorage (Imperial Units) 46

3-6 Sample Calculation(s) 3: Guide Rail Bracket Spacing (Imperial Units) 48

3-7 Sample Calculation(s) 4: Guide Rail Bracket Strength and Design (Imperial Units) 57

Mandatory Appendix

I Sample Calculation Figures 61

Figures

1-2-1 Seismic Zone Map 2

1-3.1.2-1 Building Base Designation and Associated Variables 4

2-2-1 Sample Counterweight Force Diagram 17

2-4.1-1 Rail Force Free Body Diagrams for ASME A17.1/CSA B44 20

2-5.1-1 Rail Force Free Body Diagrams for IBC/NBCC 24

3-1.5.1-1 SBC 1994, Figure 1607.1.5B, Contour Map of Effective Peak Velocity-Related Acceleration Coefficient, A_v 32

3-3.1.4-1 ASME A17.1/CSA B44, Figure 8.4.8.2-4, 22.5 kg/m (15 lb/ft) Guide-Rail Bracket Spacing (Marked for Sample Calculation 3a) 38
3-3.1.5-1 ASME A17.1/CSA B44, Figure 2.23.4.1-1 (Marked for Sample Calculations 3a and 3b) . . 39
3-3.2.4-1 ASME A17.1/CSA B44, Figure 8.4.8.2-4, 22.5 kg/m (15 lb/ft) Guide-Rail Bracket Spacing (Marked for Sample Calculation 3b) 43
3-6.1.4-1 ASME A17.1/CSA B44, Figure 8.4.8.2-4, 22.5 kg/m (15 lb/ft) Guide-Rail Bracket Spacing (Marked for Sample Calculation 3a) 51
3-6.1.5-1 ASME A17.1/CSA B44, Figure 2.23.4.1-1 [Marked for Sample Calculations 3a and 3b (Imperial Units)] 53
3-6.2.4-1 ASME A17.1/CSA B44, Figure 8.4.8.2-4, 22.5 kg/m (15 lb/ft) Guide-Rail Bracket Spacing (Marked for Sample Calculation 3b) 56
I-1 Case 1, Load Eq. 8.4.14.1.2(b): Seismic Loading (F_v in the UP Direction) 62
I-2 Case 2, Load Eq. 8.4.14.1.2(b): Seismic Loading (F_v in the DOWN Direction) 62
I-3 Case 3, Load Eq. 8.4.14.1.2(a): Seismic Loading (F_v in the UP Direction) 62
I-4 Case 4, Load Eq. 8.4.14.1.2(a): Seismic Loading (F_v in the DOWN Direction) 62
I-5 Pictorial View of F_p Forces 63
I-6 Elevator Guide Rail Force Orientations 63
I-7 ASME A17.1/CSA B44, Figure 8.4.8.9, Guide Rail Axes 63
I-8 Seismic Rail Loading Force for Counterweight 64
I-9 Rail Bracket Free Body and Bending Moment Diagram 65

Tables

1-3.1.3-1 Geographic Impact Comparison: IBC/NBCC Versus ASME A17.1/CSA B44 Seismic Zone 3 (Guide Rail) 7
1-3.1.3-2 Impact of IBC/NBCC Forces on Elevator Components in U.S. and Canada (Comparison of IBC/NBCC Forces to ASME A17.1/CSA B44 Seismic Zone 3) 13
1-4-1 IBC/ASCE 7 Seismic Parameters Correlation to ASME A17.1/CSA B44 Zones 14
I-1 ASME A17.1/CSA B44, Table 8.4.12.2.2, Maximum Allowable Deflection 61

FOREWORD

Seismic requirements have been part of ASME A17.1/CSA B44 since 1981 with their introduction in Nonmandatory Appendix F. ASME A17.1/CSA B44 seismic requirements are based on input provided from building code seismic maps and charts. Since the mid-1980s, building codes and their seismic maps and charts have undergone major modifications. These modifications created difficulty for the user to properly apply ASME A17.1/CSA B44 requirements in jurisdictions using the latest building codes. This difficulty necessitated the need to realign the ASME A17.1/CSA B44 earthquake requirements with the latest building codes. The 2013 edition of ASME A17.1/CSA B44 introduced a completely revised earthquake safety section, realigned with the latest building codes available at the time, IBC 2009 and NBCC 2010.

The first edition of ASME TR A17.1-8.4, Guide for Elevator Seismic Design, was released in conjunction with the publication of ASME A17.1-2013/CSA B44-13. The Technical Report was prepared by the ASME A17.1/CSA B44 Earthquake Safety Committee. This Technical Report is intended as an aid to the user to better understand the history behind the development of the latest building and elevator safety codes, the rationale behind the latest Section 8.4 revisions, and the proper application of the Section 8.4 requirements in conjunction with a jurisdiction's adopted building code. This second edition includes minor revisions and editorial corrections.

Publication of this Technical Report has been approved by ASME in accordance with the Procedures for Development of ASME Technical Reports. This Technical Report is not an American National Standard, and the material contained herein is not normative in nature. Comments on the content of this Technical Report should be sent to the Secretary, A17 Standards Committee, The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME A17 COMMITTEE
ELEVATORS AND ESCALATORS

(The following is the roster of the Committee at the time of approval of this Technical Report.)

STANDARDS COMMITTEE OFFICERS

J. W. Coaker, *Chair*
R. E. Baxter, *Vice Chair*
H. E. Peelle III, *Vice Chair*
G. Burdeshaw, *Secretary*

STANDARDS COMMITTEE PERSONNEL

E. V. Baker, IUEC
R. E. Baxter, Baxter Residential Elevators, LLC
L. Bialy, Louis Bialy and Associates, LLC
K. Brinkman, National Elevator Industry, Inc.
J. R. Brooks, Wagner Consulting Group, Inc.
R. C. Burch, VANTAGE/GAL Manufacturing Co., LLC
G. Burdeshaw, The American Society of Mechanical Engineers
J. W. Coaker, Coaker & Co., PC
J. Filippone, Vertical Transportation Consultant
R. A. Gregory, Vertex Corp.
P. Hampton, ThyssenKrupp Elevator
J. T. Herrity, Engineering Technician VTE
D. A. Kalgren, KONE, Inc.
J. W. Koshak, Elevator Safety Solutions, LLC
R. Kremer, Technical Standards and Safety Authority
D. McColl, Otis Canada, Inc.
D. McLellan, Technical Standards and Safety Authority
A. L. Peck, Consultant
H. E. Peelle III, The Peelle Co., Ltd.
J. Rearick, Rearick & Co., Inc.
A. Rehman, Schindler Elevator Corp.
V. P. Robibero, Schindler Elevator Corp.
R. S. Seymour, Robert L. Seymour & Associates, Inc.
R. D. Shepherd, NAESA International
W. M. Snyder, VTE Solution, LLC
M. H. Tevyaw, MHT Codes & Consulting
D. L. Turner, Davis L. Turner & Associates, LLC
J. Xue, *Delegate,* Shanghai Institute of Special Equipment Inspection and Technical Research
J. W. Blain, *Alternate,* Schindler Elevator Corp.
D. S. Boucher, *Alternate,* KONE, Inc.
J. Carlson, *Alternate,* Schindler Elevator Corp.
J. Day, *Alternate,* NAESAI
M. V. Farinola, *Alternate,* MV Farinola, Inc.
J. D. Henderson, *Alternate,* ThyssenKrupp Elevator
M. D. Morand, *Alternate,* QEITF
S. P. Reynolds, *Alternate,* The Peelle Co., Ltd.
P. S. Rosenberg, *Alternate,* Performance Elevator Consulting, LLC
H. Simpkins, *Alternate,* ThyssenKrupp Elevator

A17 EARTHQUAKE SAFETY COMMITTEE

W. C. Schadrack III, *Chair,* William C. Schadrack Consulting, LLC
B. Blackaby, *Vice Chair,* B. Blackaby and Associates, LLC
N. Gomez, *Secretary,* The American Society of Mechanical Engineers
J. D. Henderson, ThyssenKrupp Elevator
R. Lorenzo, Otis Elevator Co.
J. L. Meyer, National Elevator Inspection Services
W. C. Ribeiro, Schindler Elevator Corp.
A. J. Shelton, KONE, Inc.
M. J. Smith, Schindler Elevator Corp.
R. Taylor, Draka Elevator Products
D. A. Kalgren, *Alternate,* KONE, Inc.
R. K. Leckman, *Alternate,* Otis Elevator Co.
M. A. Mueller, *Alternate,* ThyssenKrupp Elevator
J. A. Varona, *Alternate,* Schindler Elevator Corp.
C. A. Cullum, *Contributing Member,* KONE, Inc.
G. W. Gibson, *Contributing Member,* George W. Gibson & Associates, Inc.
A. J. Schiff, *Contributing Member,* Consultant

ASME TR A17.1-8.4–2020
SUMMARY OF CHANGES

ASME TR A17.1-8.4–2020 includes minor editorial corrections throughout. In addition, it includes the following changes identified by a margin note, **(20)**.

Page	*Location*	*Change*
5	1-4	Last paragraph revised
29	3-1.1.1	Subparagraph (b) revised
29	3-1.2.1	Subparagraph (b) revised
30	3-1.3.1	Subparagraph (b) revised
31	3-1.4.1	Subparagraph (b) revised
31	3-1.5.1	Subparagraph (b) revised
32	3-1.6.1	Subparagraph (b) revised
33	3-1.7.1	Subparagraph (b) revised
33	3-2.1.2	ASCE 7 reference updated
33	3-2.1.3	ASCE 7 reference updated
42	3-3.2.6	Equation in subpara. (b)(2) revised
49	3-6.1.2	ASCE 7 reference updated
50	3-6.1.5	In-text table and equations revised
51	Figure 3-6.1.4-1	Axes revised
53	Figure 3-6.1.5-1	Title and axes revised
55	3-6.2.4	Note in subpara. (b)(1) revised
55	3-6.2.5	In-text table and equations revised
56	Figure 3-6.2.4-1	Added
57	3-6.2.6	Subparagraph (b)(2) revised

Part 1
Modification of ASME A17.1-2010/CSA B44-10, Section 8.4, Elevator Safety Requirements for Seismic Risk Zone 2 or Greater

1-1 SCOPE

This Technical Report provides rationale for elevator seismic force determination in ASME A17.1/CSA B44, Section 8.4. It details ASME A17.1/CSA B44 harmonization efforts with all building codes and summarizes the harmonization impact on elevator design via force comparisons based on component, component mounting location, and building geographical location, and provides an International Building Code (IBC) quick reference for seismic requirements and equivalent zone force levels.

1-2 INTRODUCTION

For many years, U.S. and Canadian model building codes such as the Uniform Building Code (UBC), Standard (Southern) Building Code (SBC), and National Building Code of Canada (NBCC) differentiated the force levels expected during seismic activity by zones. For example, a building in a zone 1 location was expected to see lower seismic forces than a building in a zone 2 location. A United States Geological Survey (USGS) map of the U.S. (see Figure 1-2-1), published in the various building codes, indicated the appropriate zone for any part of the country.

Seismic requirements were first specified in ANSI/ASME A17.1-1981, Appendix F. They were based on ANSI A58.1, the American National Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. Seismic force levels that the elevator must withstand would vary based on whether the subject building was in a zone 2 or zone 3 location. Zone 1 locations did not have elevator seismic requirements. Therefore, to determine elevator seismic forces for any part of the country, one would review the appropriate adopted building code for that particular location, determine the zone for that location from the seismic zone map used by that building code, and then reference the appropriate elevator forces for that zone in ANSI/ASME A17.1.

In the mid-1980s, the National Earthquake Hazard Reduction Program (NEHRP) published its Recommended Provisions for the Development of Seismic Regulations for New Buildings with new seismic maps from the USGS. Instead of using zones, these new contour maps designated seismic ground motion in terms of a velocity-related coefficient, A_v. The ground motion parameter, in addition to other building variables, was input into an equation to determine seismic force levels for building structural (buildings) and nonstructural components (elevators, escalators, etc.). Throughout the late 1980s and 1990s, the model building codes [Building Officials and Code Administrators International, Inc. (BOCA), UBC, SBC] began adopting these new maps and variations of the NEHRP seismic force equation into their codes. In Canada, the 1985 edition of NBCC discarded Canada's traditional seismic zones for seven seismic zones based on the velocity-related seismic zone parameter, Z_v.

With different building codes using different seismic force equations and no longer using traditional seismic zone maps, the need to properly align the ASME A17.1/CSA B44 seismic requirements with the new building codes became imperative. Requirement 8.4.13, introduced in the harmonized ASME A17.1/CSA B44 2000 edition, correlated ground motion parameters (such as A_v and Z_v) to the traditional seismic zones. Using this correlation, the ASME A17.1/CSA B44 requirements could continue to be used as written. For reference, the correlating values were as follows:

(U.S.: See ASME A17.1/CSA B44, 8.4.13.1)

Zone(s)	Affected Peak Velocity Acceleration, A_v
0 and 1	$A_v < 0.10$
2	$0.10 \le A_v < 0.20$
3 and 4	$0.20 \le A_v$

(Canada: See ASME A17.1/CSA B44, 8.4.13.2)

Zone(s)	Velocity-Related Seismic Zone, Z_v
2	$2 \le Z_v < 4$
≥ 3	$Z_v \ge 4$

NOTE: All future references in this Technical Report refer to ASME A17.1/CSA B44 unless otherwise stated.

In 1994, the three U.S. model building codes [International Conference of Building Officials (ICBO), BOCA, and Southern Building Code Conference International (SBCCI)] established the International Code Council