CSA Group

N289.4-12

Testing procedures for seismic qualification of nuclear power plant structures, systems, and components

Legal Notice for Standards

Canadian Standards Association (operating as "CSA Group") develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group's and/or others' intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:
- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to
- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.

CSA Group

Standards Update Service

N289.4-12
August 2012

Title: *Testing procedures for seismic qualification of nuclear power plant structures, systems, and components*
Pagination: 61 pages (x preliminary and 51 text), each dated **August 2012**

To register for e-mail notification about any updates to this publication

- go to **shop.csa.ca**
- click on **CSA Update Service**

The **List ID** that you will need to register for updates to this publication is **2421981**.

If you require assistance, please e-mail **techsupport@csagroup.org** or call 416-747-2233.

Visit CSA Group's policy on privacy at **csagroup.org/legal** to find out how we protect your personal information.

N289.4-12

Testing procedures for seismic qualification of nuclear power plant structures, systems, and components

CSA Group

Published in August 2012 by CSA Group
A not-for-profit private sector organization
5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6
1-800-463-6727 • 416-747-4044

CSA Group prints its publications on Rolland Enviro100, which contains 100% recycled post-consumer fibre, is EcoLogo and Processed Chlorine Free certified, and was manufactured using biogas energy.

*To purchase standards and related publications, visit our Online Store at **shop.csa.ca** or call toll-free 1-800-463-6727 or 416-747-4044.*

ISBN 978-1-55491-733-4

Contents

Annexes

Tables

Figures

Technical Committee on Seismic Design

T.S. Aziz	TSAziz Consulting Inc., Mississauga, Ontario	*Chair*
A. Blahoianu	Canadian Nuclear Safety Commission, Ottawa, Ontario	*Vice-Chair*
J. Adams	Natural Resources Canada, Ottawa, Ontario	
C.M. Alexander	ARES Corporation, Cobourg, Ontario	
N.M. Aly	Ontario Power Generation Inc., Pickering, Ontario	*Associate*
A. Babin	Hydro-Québec Centrale nucléaire de Gentilly-2 Bécancour, Québec	
J.P. Brock	RCM Technologies Canada Corp., Pickering, Ontario	
B. Chan	Technical Standards & Safety Authority, Toronto, Ontario	
K. Chaudhry	Canadian Nuclear Safety Commission, Ottawa, Ontario	*Associate*
O. Coman	International Atomic Energy Agency, Vienna, Austria	*Associate*
T.D. Cromie	Hatch, Mississauga, Ontario	
A. Dar	Bruce Power Inc., Toronto, Ontario	
A. Ghobarah	McMaster University, Hamilton, Ontario	
M.S. Nashid	Toronto, Ontario	*Associate*
L.T. Nguyen	Babcock & Wilcox Canada Ltd., Cambridge, Ontario	
T. Nishaj	Ontario Power Generation Inc., Pickering, Ontario	
G. Pernica	National Research Council Canada, Ottawa, Ontario	*Associate*

W. Ridley	GE-Hitachi Nuclear Energy Canada Inc., Peterborough, Ontario	
G. Roberts	NB Power Nuclear Corp., Point Lepreau, New Brunswick	
P. St-Amand	Hydro-Québec Centrale nucléaire de Gentilly-2, Bécancour, Québec	*Associate*
C. Sypher	Sypher & Associates Field Engineering Ltd., Toronto, Ontario	
A. Usmani	AMEC NSS, Toronto, Ontario	
D. Yang	Candu Energy Inc., Mississauga, Ontario	
M. Khan	CSA Group, Mississauga, Ontario	*Project Manager*
L. Logan	CSA Group, Mississauga, Ontario	*Project Manager*

Subcommittee on Testing Procedures for Seismic Qualification of Nuclear Power Plant Structures, Systems, and Components

A. Usmani	AMEC NSS, Toronto, Ontario	*Chair*
C.M. Alexander	ARES Corporation, Cobourg, Ontario	
T.S. Aziz	TSAziz Consulting Inc., Mississauga, Ontario	
K. Chaudhry	Canadian Nuclear Safety Commission, Ottawa, Ontario	
R. Cook	Canadian Power Utility Services Limited, Georgetown, Ontario	
L. Li	Ontario Power Generation Inc., Pickering, Ontario	
W. Liu	Candu Energy Inc., Mississauga, Ontario	
C. Sypher	Sypher & Associates Field Engineering Ltd., Toronto, Ontario	
M. Khan	CSA Group, Mississauga, Ontario	*Project Manager*

In addition to the members of the Subcommittee, Binh-Le Ly made valuable contributions to the development of this Standard.

Preface

This is the second edition of CSA N289.4, *Testing procedures for seismic qualification of nuclear power plant structures, systems, and components*. It supersedes the previous edition, published in 1986 under the title *Testing Procedures for Seismic Qualification of CANDU Nuclear Power Plants*. The title of this Standard has been changed to reflect an extension of its scope: it now addresses not only CANDU® reactors, but also includes any nuclear power plant's systems, structures, and components.

Note: *CANDU (CANada Deuterium Uranium) is a registered trademark of Atomic Energy of Canada Limited (AECL).*

Standards in the CSA N289 Series of Standards were initiated in response to the recognition on the part of the utilities and industries concerned with nuclear facilities in Canada of a need for consistent standards for seismic design and qualification of nuclear structures, systems, and components (SSCs) of nuclear power plants. Although this compilation includes regulatory requirements (see below) in addition to those of a technical nature, users of these Standards should recognize that they have the force of law only when adopted by the Canadian Nuclear Safety Commission (CNSC) or, in countries other than Canada, the appropriate regulatory body.

The purpose of this Standard is to provide a basis for the development of specifications for seismic qualification by testing, and to aid purchasers, suppliers, and testing laboratories in selecting the appropriate test method(s) for performing acceptable seismic qualification tests that meet a quality and standard commensurate with the safety principles necessary to comply with the Canadian nuclear safety philosophy.

The CSA N289 Series consists of five separate Standards

(a) N289.1, *General requirements for seismic design and qualification of CANDU nuclear power plants* — provides guidelines for identifying structures and systems requiring seismic qualification based on nuclear safety considerations;
(b) N289.2, *Ground motion determination for seismic qualification of nuclear power plants* — determines the appropriate seismic ground motion parameters for a particular site;
(c) N289.3, *Design procedures for seismic qualification of nuclear power plants* — provides design requirements and methods:
    (i) for determining the engineering representation of ground motion, ground response spectra, and floor response spectra for use in the design and seismic qualification of SSCs;
    (ii) for performing seismic qualification of specified SSCs by analytical methods; and
    (iii) to perform evaluations of beyond design basis seismic events;
(d) N289.4, *Testing procedures for seismic qualification of nuclear power plant structures, systems, and components* — provides design requirements and methods for seismic qualification of specific components and systems by testing methods; and
(e) N289.5, *Seismic instrumentation requirements for nuclear reactors and nuclear facilities* — establishes the requirements for seismic instrumentation.

Users of this Standard are reminded that the design, manufacture, construction, commissioning, operation, and decommissioning of nuclear facilities in Canada are subject to the provisions of the *Nuclear Safety and Control Act* and its Regulations. Thus, requirements additional to those specified in this Standard may be imposed by the CNSC.

This Standard was prepared by the Subcommittee on Testing Procedures for Seismic Qualification of Nuclear Power Plant Structures, Systems, and Components, under the jurisdiction of the Technical Committee on Seismic Design and the Strategic Steering Committee on Nuclear Standards, and has been formally approved by the Technical Committee.

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This Standard was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*

(4) *To submit a request for interpretation of this Standard, please send the following information to* ***inquiries@csagroup.org*** *and include "Request for interpretation" in the subject line:*
(a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;
(b) provide an explanation of circumstances surrounding the actual field condition; and
(c) where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.
Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are available on the* Current Standards Activities *page at* ***standardsactivities.csa.ca****.*

(5) *This Standard is subject to periodic review, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to* ***inquiries@csagroup.org*** *and include "Proposal for change" in the subject line:*
(a) Standard designation (number);
(b) relevant clause, table, and/or figure number;
(c) wording of the proposed change; and
(d) rationale for the change.

N289.4-12
Testing procedures for seismic qualification of nuclear power plant structures, systems, and components

1 Scope

1.1 Structures, systems, and components requiring seismic qualification

This Standard defines the processes and requirements for performing seismic qualification by testing and presents the test methods that may be used for the seismic qualification of the nuclear power plant structures, systems, and components (SSCs). Seismic qualification by testing is typically used for SSCs that will be performing both an active function and that are required to change state during or following a seismic event in order to perform a safety function, while maintaining structural and/or pressure-boundary integrity.

Notes:

(1) *Clause 5.3 of CSA N289.1 specifies acceptable seismic qualification methodologies, including qualification by analysis, testing, or a combination thereof and qualification by similarity, depending on the nature and complexity of the SSC.*

(2) *Some mechanical and electrical components are inherently seismically rugged and do not need to be tested to demonstrate seismic capability as discussed in Clause 5.8.5.*

1.2 Specification development

This Standard is intended to provide a basis for developing specifications for seismic qualification of SSCs by testing, or by a combination of analysis and testing, and to aid component purchasers, suppliers, and testing laboratories in selecting the appropriate test method(s) for performing a seismic qualification test. The specification provides the basis for the development of the test plan by the testing laboratory.

1.3 Acceptable methods

This Standard presents several acceptable methods with the intent of permitting the user to make a judicious selection from among the various options. In making such a selection, the user of this Standard should choose those test methods which best recognize the characteristics of a particular SSC and the seismic environment under which it is required to perform its function.

Note: *It should be recognized that seismic qualification forms only a portion of the overall equipment qualification program. It is important that the qualification program for a component include consideration of all operational loadings (e.g., seismic, environmental, aging, thermal and mechanical stresses, deformation, etc.) for which the component must demonstrably meet its SSC functionality objectives.*

1.4 Terminology

In CSA standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.