



**IEEE**

**IEC/IEEE 60980-344**

Edition 1.0 2020-10

# **INTERNATIONAL STANDARD**

**Nuclear facilities – Equipment important to safety – Seismic qualification**

IEC/IEEE 60980-344 Ed.1.0 - Preview only Copy via ILNAS e-Shop

IEC/IEEE 60980-344:2020-10(en)





**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2020 IEC, Geneva, Switzerland**  
**Copyright © 2020 IEEE**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing being secured. Requests for permission to reproduce should be addressed to either IEC at the address below or IEC's member National Committee in the country of the requester or from IEEE.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

Institute of Electrical and Electronics Engineers, Inc.  
3 Park Avenue  
New York, NY 10016-5997  
United States of America  
[stds.ipr@ieee.org](mailto:stds.ipr@ieee.org)  
[www.ieee.org](http://www.ieee.org)

#### **About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

#### **About the IEEE**

IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through its highly cited publications, conferences, technology standards, and professional and educational activities.

#### **About IEC/IEEE publications**

The technical content of IEC/IEEE publications is kept under constant review by the IEC and IEEE. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### **IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)**

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### **IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### **IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### **Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### **IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)**

67 000 electrotechnical terminology entries in English and French extracted from the Terms and definitions clause of IEC publications issued between 2002 and 2015. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.



**IEEE**

**IEC/IEEE 60980-344**

Edition 1.0 2020-10

# INTERNATIONAL STANDARD

---

**Nuclear facilities – Equipment important to safety – Seismic qualification**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 27.120.10; 27.120.20

ISBN 978-2-8322-8482-7

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	11
2 Normative references .....	11
3 Terms and definitions .....	11
4 Abbreviated terms .....	19
5 General discussion of earthquake environment and equipment response.....	20
5.1 General.....	20
5.2 Earthquake environment .....	20
5.3 Equipment on foundations.....	20
5.4 Equipment on structures .....	20
5.5 Interfaces and adverse interactions.....	21
5.6 Simulating vibration induced by an earthquake .....	21
5.6.1 General .....	21
5.6.2 Response spectrum .....	21
5.6.3 Time history.....	22
5.6.4 PSD function .....	22
5.7 Damping .....	22
5.7.1 General .....	22
5.7.2 Measurement of damping .....	23
5.8 Application of damping.....	23
5.8.1 General .....	23
5.8.2 Application of damping in testing .....	23
5.8.3 Application of damping in analysis .....	24
6 Seismic qualification requirements.....	24
6.1 General.....	24
6.2 Specification of equipment to be qualified .....	25
6.3 Specification of ageing condition.....	25
6.4 Specification of seismic requirements .....	25
6.5 Specification of acceptance criteria.....	25
7 Seismic qualification approach .....	26
7.1 Safety function.....	26
7.2 Seismic qualification methods .....	26
8 Ageing.....	27
8.1 General.....	27
8.2 Thermal ageing.....	28
8.3 Radiation ageing.....	28
8.4 Material degradation and corrosion .....	28
8.5 Mechanical or electrical cycle ageing .....	28
8.6 Vibration ageing.....	28
8.6.1 General .....	28
8.6.2 Ageing from non-seismic vibration conditions .....	29
8.6.3 Hydrodynamic loads .....	29
8.6.4 Seismic ageing (OBE/S1) .....	29
9 Testing .....	29
9.1 General.....	29

9.1.1	Test programme .....	29
9.1.2	Mounting .....	31
9.1.3	Monitoring .....	31
9.1.4	Loading .....	31
9.1.5	Refurbishment .....	32
9.1.6	Exploratory tests.....	32
9.1.7	Seismic ageing (OBE/S1) .....	34
9.2	Proof and generic testing .....	34
9.3	Fragility testing .....	35
9.4	Component testing.....	35
9.5	Assembly testing.....	35
9.5.1	General .....	35
9.6	Test methods .....	36
9.6.1	General .....	36
9.6.2	Single-frequency test.....	37
9.6.3	Multiple-frequency tests.....	40
9.6.4	Other tests.....	45
9.6.5	Test duration and low-cycle fatigue potential .....	45
9.6.6	Multi-axis tests .....	45
9.6.7	Line-mounted equipment .....	47
9.6.8	Additional tests.....	48
9.7	Test documentation .....	48
10	Qualification by similarity.....	48
10.1	General.....	48
10.2	Excitation.....	48
10.3	Physical systems .....	48
10.4	Safety function.....	49
11	Analysis.....	49
11.1	General.....	49
11.2	Seismic analysis methods .....	50
11.2.1	General .....	50
11.2.2	Static analysis .....	51
11.2.3	Static coefficient analysis .....	51
11.2.4	Dynamic analysis.....	51
11.3	Nonlinear equipment response.....	52
11.4	Other dynamic loads .....	52
11.5	Seismic analysis results .....	52
11.6	Documentation of analysis .....	53
12	Combined analysis and testing .....	53
12.1	General.....	53
12.2	Modal testing .....	53
12.2.1	General .....	53
12.2.2	Normal-mode method .....	53
12.2.3	Transfer-function method.....	54
12.2.4	Analytical methods utilizing test data .....	54
12.2.5	Qualification .....	54
12.3	Extrapolation for similar equipment .....	54
12.3.1	General .....	54
12.3.2	Test method .....	54

12.3.3	Analysis.....	55
12.4	Shock testing.....	55
12.5	Extrapolation for multi-cabinet assemblies.....	55
12.6	Other test/analysis.....	55
13	Documentation.....	56
13.1	General.....	56
13.2	Seismic qualification report.....	56
13.2.1	General.....	56
13.2.2	Analysis.....	56
13.2.3	Testing.....	56
13.2.4	Combined analysis and testing or similarity.....	57
Annex A	(normative) Experience-based seismic qualification.....	58
A.1	General.....	58
A.2	Earthquake experience data.....	58
A.2.1	General.....	58
A.2.2	Characterization of the earthquake experience motions.....	58
A.2.3	Earthquake experience spectrum (EES).....	59
A.2.4	Characterization of reference equipment class.....	59
A.2.5	Qualification of candidate equipment.....	61
A.3	Test experience data.....	62
A.3.1	General.....	62
A.3.2	Characterization of test experience input motions.....	62
A.3.3	Test experience spectra (TES).....	62
A.3.4	Characterization of reference equipment class.....	63
A.3.5	Qualification of candidate equipment.....	64
A.4	Special considerations.....	64
A.4.1	Inherently rugged equipment.....	64
A.4.2	Limitations.....	65
A.5	Experience-based documentation.....	65
A.5.1	General.....	65
A.5.2	Reference data.....	66
A.5.3	Candidate equipment qualification.....	66
Annex B	(informative) Measurement of zero period acceleration.....	67
Annex C	(informative) Frequency content and stationarity.....	68
Annex D	(informative) Fragility testing.....	69
D.1	General.....	69
D.2	Excitation motion.....	69
D.3	Application of results.....	70
D.4	Other considerations.....	70
Annex E	(informative) Test duration and number of cycles.....	72
Annex F	(informative) Statistically independent motions.....	76
Annex G	(informative) Seismic qualification illustrative flowcharts.....	77
G.1	General.....	77
G.2	Establishment of seismic conditions and acceptance criteria.....	77
G.3	Qualification by testing.....	77
G.4	Qualification by analysis.....	77
G.5	Qualification by combination of analysis and testing.....	77
Bibliography	.....	82

Figure 1 – Sine beat ..... 39

Figure 2 – Decaying sine ..... 39

Figure 3 – Random spectrum with superimposed sine beats ..... 43

Figure 4 – Resonant amplification versus cycles per beat ..... 44

Figure E.1 – Fractional cycles to obtain one equipment maximum peak cycle ..... 73

Figure E.2 – Equivalent peak-stress cycles induced by stationary random motion ..... 74

Figure E.3 – Equivalent peak-stress cycles induced by stationary random motion to 20 Hz... 74

Figure G.1 – Seismic qualification flowchart..... 78

Figure G.2 – Seismic qualification test flowchart ..... 79

Figure G.3 – Seismic qualification analysis flowchart ..... 80

Figure G.4 – Seismic qualification analysis and test flowchart..... 81

  

Table A.1 – EES reduction factor based on number of independent items ..... 60

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**NUCLEAR FACILITIES –  
EQUIPMENT IMPORTANT TO SAFETY –  
SEISMIC QUALIFICATION**
**FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation.

IEEE Standards documents are developed within IEEE Societies and Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. IEEE develops its standards through a consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of IEEE and serve without compensation. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards. Use of IEEE Standards documents is wholly voluntary. *IEEE documents are made available for use subject to important notices and legal disclaimers (see <http://standards.ieee.org/ipr/disclaimers.html> for more information).*

IEC collaborates closely with IEEE in accordance with conditions determined by agreement between the two organizations.

- 2) The formal decisions of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees. The formal decisions of IEEE on technical matters, once consensus within IEEE Societies and Standards Coordinating Committees has been reached, is determined by a balanced ballot of materially interested parties who indicate interest in reviewing the proposed standard. Final approval of the IEEE standards document is given by the IEEE Standards Association (IEEE-SA) Standards Board.
- 3) IEC/IEEE Publications have the form of recommendations for international use and are accepted by IEC National Committees/IEEE Societies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC/IEEE Publications is accurate, IEC or IEEE cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications (including IEC/IEEE Publications) transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC/IEEE Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC and IEEE do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC and IEEE are not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or IEEE or their directors, employees, servants or agents including individual experts and members of technical committees and IEC National Committees, or volunteers of IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board, for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC/IEEE Publication or any other IEC or IEEE Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that implementation of this IEC/IEEE Publication may require use of material covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. IEC or IEEE shall not be held responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patent Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

International Standard IEC/IEEE 60980-344 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation, in cooperation with Nuclear Power Engineering Committee of the IEEE, under the IEC/IEEE Dual Logo Agreement.

It is published as an IEC/IEEE dual logo standard.

This new edition cancels and replaces the first edition of IEC 60980, published in 1989, and constitutes a technical revision. It also supersedes IEEE Std 344™-2013.

The text of this standard is based on the following IEC documents:

FDIS	Report on voting
45A/1323/FDIS	45A/1334/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

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

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.