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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear facilities – Electrical equipment important to safety – Qualification

Installations nucléaires – Équipements électriques importants pour la sûreté – Qualification

IEC/IEEE 60780-323:2016-02(en-fr)

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NUCLEAR FACILITIES – ELECTRICAL EQUIPMENT IMPORTANT TO SAFETY – QUALIFICATION

FOREWORD

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International Standard IEC/IEEE 60780-323 has been prepared by subcommittee 45A: Instrumentation, control and electrical systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation, in cooperation with the Nuclear Power Engineering Committee of the Power & Energy Society of the IEEE, under the IEC/IEEE Dual Logo Agreement between IEC and IEEE.

This publication is published as an IEC/IEEE Dual Logo standard.

NOTE A list of IEEE participants can be found at the following URL:
http://standards.ieee.org/downloads/60780/60780-323-2016/60780-323-2016_wg-participants.pdf

This new edition cancels and replaces the first edition of IEC 60780, published in 1998. It constitutes a technical revision. It also supersedes IEEE Std 323-2003.

The main technical changes with regard to IEC 60780:1998 are as follows:

- to harmonize in a unique standard qualification practices formerly given by IEC 60780:1998 and IEEE Std 323-2003 on initial qualification,
- to take into account the need to reassess and extend the qualified life of electrical equipment regarding projects to extend the operating life of nuclear facilities.

This revision incorporates current practices and lessons learned from the implementation of previous versions of this standard by the nuclear industry.

Several issues are clarified or changed in this revision:

- This standard defines the methods for equipment qualification when it is desired to qualify equipment for the applications in the environments to which it may be exposed. This standard is generally utilized for qualification of all electrical equipment important to safety in accordance with IAEA terminology. The documentation and test requirements are, however, more rigorous for equipment located in a harsh environment.
- The test margins have been updated to better identify the parameters that achieve test margin on design basis event profiles.
- An important concept in equipment qualification is the recognition that significant degradation could be caused by ageing mechanisms occurring from the environments during the service life, and therefore equipment important to safety should be brought to the end of qualified life (operating ageing) prior to imposing design basis event simulations. Previous versions recognised that the period of time for which acceptable performance was demonstrated is the qualified life. The qualified life does not include the time during or after the accident conditions for which qualification is demonstrated (mission time). The concept of qualified life continues in this revision. This revision also recognises that the condition of the equipment for which acceptable performance was demonstrated is the qualified condition. Thus, new license renewal and life extension options are available by ensuring that qualified equipment continues to remain in a qualified condition.

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

FDIS	Report on voting
45A/1058/FDIS	45A/1075/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 website 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.

INTRODUCTION

a) Technical background, main issues and organisation of the Standard

This standard is applicable to electrical equipment important to safety and its interfaces that are necessary to perform a safety function, or whose failure could adversely affect the safety functions of other equipment.

Electrical equipment in nuclear facilities shall meet its safety functional requirements throughout its installed life. This is accomplished by a thorough programme of quality assurance, design control, quality control, qualification, production, transportation, storage, installation, maintenance, periodic testing, and surveillance. This IEC/IEEE standard specifically focuses on qualification.

Other aspects, relating to quality assurance, reliability, selection and use of electronic devices, design and modification of digital systems including V&V activities are not part of this standard.

Industry research in the area of equipment qualification and decades of its application have greatly benefited this standard. Future activities of the working group to update this standard will consider the following:

– Experience and knowledge gained by using condition monitoring techniques,

– Knowledge gained on ageing mechanisms and kinetics,

– Significance of refinements in ageing mechanisms, equipment sealing, interfaces, extrapolation, similarity, test sequence and parameters (such as ramp rates, time duration, timing of spray initiation and its duration), and qualification documentation.

It is intended that the Standard be used by operators of NPPs (utilities), systems evaluators, equipment manufacturers, test facilities, qualification laboratories and by licensors.

b) Situation of the current standard in the structure of the IEC SC 45A standard series

IEC 61513 is a first level IEC SC 45A document and gives guidance applicable to I&C at system level.

These documents are supplemented by guidance on functional classification (IEC 61226), hardware design (IEC 60987), software (IEC 60880 and IEC 62138), selection and use of HDL programmed integrated circuit (IEC 62566) and requirements in order to reduce the possibility and limit the impact of common cause failure of category A functions (IEC 62340).

IEC/IEEE 60780-323 is a second level IEC SC 45A document which focuses on environmental qualification of electrical equipment important to safety.

For more details on the structure of the IEC SC 45A standard series, see item d) of this introduction.

c) Recommendations and limitations regarding the application of this standard

This dual logo standard applies to all electrical equipment important to safety in accordance with IAEA terminology including Class 1E equipment in accordance with the IEEE classification scheme and Classes 1, 2 and 3 in accordance with IEC 61226 classification scheme.

For equipment that needs to be qualified for design extension conditions, including severe accident conditions, this international standard shall be applied after a new DBE profile covering these conditions has been fully defined. Conservatism taken into account to define this severe accident profile should nevertheless be adapted.

To ensure that the Standard will continue to be relevant in future years, the emphasis has been placed on issues of principle, rather than specific technologies.

d) Description of the structure of the IEC SC 45A standard series and relationships with other IEC documents and other bodies documents (IAEA, ISO)

The top-level document of the IEC SC 45A standard series is IEC 61513. It provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 61513 structures the IEC SC 45A standard series.

IEC 61513 refers directly to other IEC SC 45A standards for general topics related to categorisation of functions and classification of systems, qualification, separation of systems, defence against common cause failure, software aspects of computer-based systems, hardware aspects of computer-based systems, and control room design. The standards referenced directly at this second level should be considered together with IEC 61513 as a consistent document set.

At a third level, IEC SC 45A standards not directly referenced by IEC 61513 are standards related to specific equipment, technical methods, or specific activities. Usually these documents, which make reference to second-level documents for general topics, can be used on their own.

A fourth level extending the IEC SC 45A standard series, corresponds to the Technical Reports which are not normative.

IEC 61513 has adopted a presentation format similar to the basic safety publication IEC 61508 with an overall safety life-cycle framework and a system life-cycle framework. Regarding nuclear safety, it provides the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector, regarding nuclear safety. In this framework IEC 60880 and IEC 62138 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 refers to ISO as well as to IAEA GS-R-3 and IAEA GS-G-3.1 and IAEA GS-G-3.5 for topics related to quality assurance (QA).

The IEC SC 45A standards series consistently implements and details the principles and basic safety aspects provided in the IAEA code on the safety of NPPs and in the IAEA safety series, in particular the Requirements SSR-2/1, establishing safety requirements related to the design of Nuclear Power Plants, and the Safety Guide SSG-39 dealing with instrumentation and control systems important to safety in Nuclear Power Plants. The terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

NUCLEAR FACILITIES – ELECTRICAL EQUIPMENT IMPORTANT TO SAFETY – QUALIFICATION

1 Scope and object

This International Standard describes the basic requirements for qualifying electrical equipment important to safety and interfaces (electrical and mechanical) that are to be used in nuclear facilities. The principles, methods, and procedures described are intended to be used for qualifying equipment, maintaining and extending qualification, and updating qualification, as required, if the equipment is modified. The qualification requirements in this standard, when met, demonstrate and document the ability of equipment to perform safety function(s) under applicable service conditions, including design basis events and certain design extension conditions, and reduce the risk of environmentally induced common-cause equipment failure.

This standard does not provide environmental stress levels or performance requirements.

Other aspects, relating to quality assurance, selection and use of electronic devices, design and modification of digital systems are not part of this standard.

Other IEC or IEEE standards that present qualification programmes for specific equipment, specific environments, or specific parts of the qualification programme may be used to supplement this standard, as applicable. The bibliography lists other standards related to equipment qualification.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60980, *Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations*

IEEE Std 344™-2013, *IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
age conditioning
process of subjecting equipment or a component to elevated stress conditions (environmental and operational) in order to render its physical and electrical properties similar to those it would have at a predetermined natural age when operating under expected operational conditions, corresponding at least to the qualified life

3.2
ageing
general process in which characteristics of a system or component gradually change with time or use

[SOURCE: IAEA Safety Glossary, 2007]

3.3
Class 1E
safety classification of the electrical equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment

[SOURCE: IEEE Standards Dictionary Online][1]

3.4
common cause failure
failure of two or more structures, systems or components due to a single specific event or cause

[SOURCE: IAEA Safety Glossary, 2007]

3.5
components
discrete elements of a system. Examples of components are wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks and valves

[SOURCE: IAEA Safety Glossary, 2007]

3.6
condition-based qualification
qualification based on measurement of one or more condition indicators of equipment, its components, or materials for which an acceptance criterion can be correlated to the equipment's ability to function as specified during an applicable design basis event

[SOURCE: IEEE Standards Dictionary Online]

3.7
condition indicator
characteristic of equipment or its components that can be observed, measured and trended to infer or directly indicate the current and future ability of equipment to function within acceptance criteria in all specified service conditions (including DBE conditions)

3.8
design basis events
postulated events used in the design to establish the acceptable performance requirements for the structures, systems, and components

[SOURCE: IEEE Standards Dictionary Online]

3.9
design extension conditions
accident conditions that are not considered for design basis events, but that are considered in the design process of the facility in accordance with best estimate methodology, and for which releases of radioactive material are kept within acceptable limits. Design extension conditions include severe accident conditions.

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1 IEEE Standards Dictionary Online is available at:
http://ieeexplore.ieee.org/xpls/dictionary.jsp

[SOURCE: IAEA Safety Standards Series SSR2/1:2012]

3.10
end condition
value(s) of equipment condition indicator(s) at the conclusion of age conditioning

3.11
equipment
assembly of components designed and manufactured to perform specific functions

Note 1 to entry: Sensors, cables, electrically operated valves, I&C cabinet or racks are examples of equipment.

[SOURCE: IEEE Standards Dictionary Online]

3.12
equipment important to safety
equipment that is part of a safety group and/or whose malfunction or failure could lead to undue radiation exposure of the site personnel or members of the public. Equipment including:

- those structures, systems and components that prevent anticipated operational occurrences from leading to accident conditions;
- those features that are provided to mitigate the consequences of malfunction or failure of structures, systems and components.

A) For usage consistent with IEC 61226, equipment important to safety are as follows:

  – all I&C equipment performing Category A to Category C functions (in accordance with the IEC 61226 categorisation scheme),

  – all electrical equipment needed to ensure emergency energy supply to this equipment in case of a loss of normal power supply,

  – all electrical equipment needed to ensure ultimate energy supply in case of total loss of on-site power (if selected as design extension condition to be mitigated).

B) For usage consistent with other IEEE documents and a Class 1E categorization; for equipment important to safety, qualification is essential to the following:

  – electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or

  – electric equipment that are otherwise essential in preventing significant release of radioactive material to the environment.

Note 1 to entry: Users of this standard are advised that Class 1E is a functional term. Equipment and systems are to be classified Class 1E only if they fulfill the functions listed in the definition. Identification of systems or equipment as Class 1E based on anything other than their function is an improper use of the term and should be avoided.

3.13
equipment qualification
generation and maintenance of evidence to ensure that equipment will operate on demand to meet system performance requirements during normal and abnormal service conditions and postulated design basis events

[SOURCE: IAEA Safety Glossary, 2007]

3.14
equipment similarity
demonstration of physical, operational and dynamic equivalency between equipment being qualified and equipment previously qualified

3.15
harsh environment
environment that significantly changes as a result of a design basis event, e.g., loss-of-coolant accident (LOCA), high-energy line break (HELB), and main steam line break (MSLB)

[SOURCE: IEEE Standards Dictionary Online]

3.16
interfaces
shared boundary between structures, systems and components that includes physical attachments, mounting, auxiliary components, and connectors (electrical and mechanical) to the equipment

3.17
margin
difference between service conditions and the conditions used for equipment qualification

[SOURCE: IEEE Standards Dictionary Online]

3.18
mild environment
environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences

3.19
qualified condition
condition of equipment, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service conditions. This could include certain post accident cooling and monitoring systems that are expected to remain operational.

3.20
qualified life
period for which an equipment has been demonstrated, through testing, analysis and/or experience, to be capable of functioning within acceptance criteria during specific operating conditions while retaining the ability to perform its safety functions in accident condition or earthquake

Note 1 to entry: This note applies to the French language only.

[SOURCE: IAEA Safety Glossary, 2007]

3.21
service conditions
actual physical states or influences during the service life of equipment, including normal operating conditions, abnormal operating conditions, design basis event conditions and conditions following a design basis event and design extension conditions

Note 1 to entry: In 2007-edition of IAEA safety glossary, accident conditions include both design basis accident and beyond design basis accident. This second notion has been replaced within IAEA by the notion of design extension conditions (AIEA, SSR-2/1). It explains the need of changing the definition.

[SOURCE: IAEA Safety Glossary, 2007, modified]

3.22
service life
period from initial operation to final withdrawal from service of a structure, system or component

[SOURCE: IAEA Safety Glossary, 2007]

3.23
severe accident
accident conditions more severe than a design basis event and involving significant core degradation

[SOURCE: IAEA Safety Glossary, 2007]

3.24
significant ageing mechanism
ageing mechanism that, under normal and abnormal service conditions, causes degradation of equipment that progressively and appreciably renders the equipment vulnerable to failure to perform its safety function(s) during the design basis event conditions

[SOURCE: IEEE Standards Dictionary Online]

4 Symbols and abbreviations

DBE	Design Basis Event
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
HELB	High Energy Line Break
I&C	Instrumentation and Control
LOCA	Loss of Coolant Accident
MSLB	Main Steam Line Break
NPP	Nuclear Power Plant
RFI	Radio Frequency Interference

5 Principles of equipment qualification

5.1 Qualification objective

The primary objective of qualification is to demonstrate with reasonable assurance that equipment important to safety can perform its safety function(s) without experiencing common-cause failures before, during, and after applicable DBE.

Equipment important to safety, including its interfaces, shall meet or exceed the equipment specification requirements. This continued capability is ensured through a programme that includes, but is not limited to, design control, quality control, qualification, installation, maintenance, periodic testing, and surveillance. The focus of this standard is on qualification, although it affects the other parts of the programme.

For all items of equipment required to operate under design extension conditions, demonstrable evidence shall be provided that it is able to perform its function(s) under the applicable service conditions including design extension conditions.

Equipment located in normal and mild environments shall be specified, designed, and selected to perform their functions in their intended service conditions including anticipated operational occurrences. Requirements, including EMC, environmental/operational ageing and seismic requirements shall be specified in the design/purchase specifications.

A maintenance/surveillance programme based on a vendor's recommendations, which may be supplemented with operating experience, should ensure that equipment meets the specified performance requirements. A qualified life is not required for equipment located in a mild environment and which has no significant ageing mechanisms and is operated within the limits established by applicable specifications and standards. Qualification for equipment located in mild environments shall be demonstrated by providing evidence that equipment meets or exceeds the specified requirements, including those of recognized industry associations. When seismic testing is used to qualify equipment located in a mild environment, pre-ageing prior to the seismic tests is required only where significant ageing mechanisms exist (see 7.3.3).

5.2 Qualified life and qualified condition

Degradation with time followed by exposure to the applicable environmental extremes of temperature, pressure, humidity, radiation, vibration, chemical spray and submergence resulting from a DBE condition can precipitate failures of equipment important to safety. For this reason, it is necessary to establish a qualified life for equipment with significant ageing mechanisms. The qualified life determination shall consider degradation of equipment capability prior to, during and in post-accident conditions as applicable. Inherent in establishing a qualified life is that a qualified condition is also established. This qualified condition is the state of degradation for which successful performance during a subsequent DBE was demonstrated.

A qualified life is established in initial qualification by putting test sample(s) in the state of degradation expected at the end of the qualified life, followed by simulated DBE(s) in which the ability of the equipment to perform its function important to safety is demonstrated.

Adjustment and extension of qualified life of existing equipment may be achieved through the use of different techniques. These techniques are further described in 6.2.

5.3 Qualification elements

The preferred approach is qualification by type-testing. Other methods as described in 7.4.3 and 7.4.4 are also applicable.

Essential elements needed to demonstrate equipment qualification shall include the following:

- equipment specification including the required safety function(s),
- acceptance criteria,
- description of the service conditions, including DBEs and their duration,
- qualification programme plan,
- implementation of the plan,
- documentation demonstrating successful qualification.

5.4 Qualification documentation

The result of a qualification programme shall be documented to demonstrate the ability of equipment to perform its safety function(s) during its qualified life and applicable design basis events. All activities that are required to maintain qualification during the qualified life shall be included in the documentation. The documentation shall allow verification by competent personnel, other than the qualifier, that the equipment is qualified.