IEC 60772

Edition 2.0 2018-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Instrumentation systems important to safety – Electrical penetration assemblies in containment structures

Centrales nucléaires de puissance – Systèmes d'instrumentation importants pour la sûreté – Ensembles de traversée électrique dans les structures de confinement

IEC 60772:2018-05(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - 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 It also gives information on projects, replaced and withdrawn publications.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
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms, containing 21 000 terms and definitions 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
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - 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.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 21 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC 60772

Edition 2.0 2018-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Instrumentation systems important to safety – Electrical penetration assemblies in containment structures

Centrales nucléaires de puissance – Systèmes d'instrumentation importants pour la sûreté – Ensembles de traversée électrique dans les structures de confinement

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 27.120.20

ISBN 978-2-8322-5691-6

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

NUCLEAR POWER PLANTS – INSTRUMENTATION SYSTEMS IMPORTANT TO SAFETY – ELECTRICAL PENETRATION ASSEMBLIES IN CONTAINMENT STRUCTURES

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. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements 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.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC 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 transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is 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 its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees 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 Publication or any other IEC 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 some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60772 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 1983. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Adaptation of terminology and definitions to current available IAEA and IEC glossaries.

b) Inclusion of new requirements with respect to DBEs and DECs.

c) Inclusion of new requirements with respect to design, construction and material used for electrical penetration assembly.

d) Inclusion of discussion of ageing models to be used for accelerated ageing due to temperature and radiation.

e) Inclusion of requirements in accordance with current standards on switchgears and cables.

f) Inclusion of definitions of characteristics for instrumentation electrical penetration assemblies.

g) More demand of electrical measurement during DBE and DEC.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
45A/1190/FDIS	45A/1203/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

INTRODUCTION

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

This International Standard focuses on electrical penetration assemblies (EPAs) in containment structures. EPAs used in safety systems in nuclear facilities need to comply with various Standards in order to meet their safety functional requirements throughout their qualified life. This goal is accomplished by thorough designing, qualifying, manufacturing, testing, installation and commissioning.

Therefore, this IEC standard specifically focuses on the above-mentioned aspects. Other aspects, relating to quality assurance, reliability and selection including validation and verification activities are not part of this standard.

This second edition cancels and replaces the first edition published in 1983. The current version of this standard is intended to accomplish the following:

- Respecting new technologies (e.g. fibre optic application for signal transfer in NPPs).
- Additional potential events/accidents scenarios are to be taken into consideration. For instance, DEC scenarios are now considered in the design requirements and qualification of electrical penetration assemblies.
- Adaptation to revised or new second level standards such as IEC 60980 or IEC/IEEE 60780-323.
- Respecting the utilisation of digital electronic equipment in I&C systems instead of relay-based devices requires that more detailed consideration shall be given to resistance against electromagnetic disturbances,
- Inclusion of the comprehensive considerations of design and materials. Herein approaches as stated in IEC 60216 series and IEC 60544 series are taken into account.
- Methods for the performance of on-going qualification/reassessing the qualified life as requested in the newest revision of IEC/IEEE 60780-323 are taken into account.

This revision incorporates current practices and lessons learned from the implementation of previous versions of this standard by the nuclear industry. As part of the pressure boundary of the containment the electrical penetration assembly is always equipment important to safety, which has to ensure the containment integrity. Also, the electrical function of the EPA has to be ensured under DBE and DEC condition when it is part of an actuator or measurement chain.

This Standard does not address the design, associated calculations and test conditions of the mechanical aspects of penetration assemblies; these are published in other Standards such as ASME and European Boiler and Vessel codes. Therefore, this Standard provides references to other Standards as necessary.

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

IEC 60772 is a third level IEC SC 45A document which addresses the design, qualification, manufacturing, manufacturing testing, installation and commissioning of electrical penetration assemblies.

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 the Standard

IEC/IEEE 60780-323 and IEC 60980 are second level standards that give guidance for specific aspects of functional qualification of electrical equipment important to safety; in particular to environmental and seismic qualification. IEC 60772 is to be read in conjunction with those two documents.

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. Therefore, it is the task of the manufacturer, architect engineer or operator to adapt this standard to the respective needs.

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 documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046. IEC 61513 provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 63046 provides general requirements for electrical power systems of NPPs; it covers power supply systems including the supply systems of the I&C systems. IEC 61513 and IEC 63046 are to be considered in conjunction and at the same level. IEC 61513 and IEC 63046 structure the IEC SC 45A standard series and shape a complete framework establishing general requirements for instrumentation, control and electrical systems for nuclear power plants.

IEC 61513 and IEC 63046 refer directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation, defence against common cause failure, control room design, electromagnetic compatibility, cybersecurity, software and hardware aspects for programmable digital systems, coordination of safety and security requirements and management of ageing. The standards referenced directly at this second level should be considered together with IEC 61513 and IEC 63046 as a consistent document set.

At a third level, IEC SC 45A standards not directly referenced by IEC 61513 or by IEC 63046 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.

The IEC SC 45A standards series consistently implements and details the safety and security principles and basic aspects provided in the relevant IAEA safety standards and in the relevant documents of the IAEA nuclear security series (NSS). In particular this includes the IAEA requirements SSR-2/1, establishing safety requirements related to the design of nuclear power plants (NPPs), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs and the implementing guide NSS17 for computer security at nuclear facilities. The safety and security terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

IEC 61513 and IEC 63046 have adopted a presentation format similar to the basic safety publication IEC 61508 with an overall life-cycle framework and a system life-cycle framework. Regarding nuclear safety, IEC 61513 and IEC 63046 provide the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. In this framework IEC 60880, IEC 62138 and IEC 62566 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 and IEC 63046 refer 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). At level 2, regarding nuclear security, IEC 62645 is the entry document for the IEC SC 45A security standards. It builds upon the valid high level principles and main concepts of the generic security standards, in particular ISO/IEC 27001 and ISO/IEC 27002; it adapts them and completes them to fit the nuclear context and coordinates with the IEC 62443 series. At level 2, IEC 60964 is the entry document for the IEC SC 45A control room standards and IEC 62342 is the entry document for the IEC SC 45A ageing management standards.

NOTE 1 It is assumed that for the design of I&C systems in NPPs that implement conventional safety functions (e.g. to address worker safety, asset protection, chemical hazards, process energy hazards) international or national standards would be applied.

NOTE 2 IEC SC 45A domain was extended in 2013 to cover electrical systems. In 2014 and 2015 discussions were held in IEC SC 45A to decide how and where general requirements for the design of electrical systems were to be considered. IEC SC 45A experts recommended that an independent standard be developed at the same level as IEC 61513 to establish general requirements for electrical systems. Project IEC 63046 is now launched to cover this objective. When IEC 63046 is published, this NOTE 2 of the introduction of IEC SC 45A standards will be suppressed.

NUCLEAR POWER PLANTS – INSTRUMENTATION SYSTEMS IMPORTANT TO SAFETY – ELECTRICAL PENETRATION ASSEMBLIES IN CONTAINMENT STRUCTURES

1 Scope

This document applies to electrical penetration assemblies (EPAs) in containment structures of nuclear power plants. It covers the engineering safety requirements to be met in the design, calculation, qualification, fabrication, assembly, testing, and installation of EPAs.

EPAs provide gas-tight and pressure-resistant penetrations through the containment for one or more electrical circuits. EPA requirements are divided into mechanical (e.g. containment integrity), and electrical or optical aspects regarding safety. The mechanical requirements are valid for all EPAs. The electrical or optical requirements are derived from the functional requirements of the connected systems, applied for monitoring and mitigating postulated events such as design basis events (DBE; e.g. loss of coolant accidents) and/or design extension conditions (DEC; e.g. severe accidents).

EPAs are distinguished by the type of electrical or optical circuit in which they are used. The derived types of EPAs are identified as follows:

- medium voltage power,
- low voltage power,
- control,
- instrumentation, and
- fibre optic.

For the purpose of this document, EPAs include:

- electrical conductors up to the connection interface inside and outside the containment (penetration conductors);
- the electrical insulation systems of penetration conductors including the electrical insulation of the connection interface;
- components for the resistance to environmental conditions, such as pressure resistance, gas tightness, temperature resistance, radiations resistance, seismic resistance enclosure of this EPA, and for connection with the containment wall;
- if required, permanently connected equipment for leak tightness monitoring;
- standard electrical connection interfaces such as cable lugs, terminals, and connectors;
- terminals and/or junction boxes (if necessary).

The components, which are not part of an EPA, include:

- components of the containment wall for the attachment of the EPA, such as sealing surfaces for bolting, or pipe connections, or nozzles requiring welding;
- cables and wires connected to the EPA conductors or connectors;
- terminal elements such as cable lugs, terminals, connectors or soldering sleeves attached to the cables and lines connected;
- leak test or evacuation devices connected temporarily to penetrations;
- the requirements for external circuits, connected to the EPA or the containment structure.

This document does not cover requirements for EPAs regarding operation and maintenance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038:2009, *IEC standard voltages*

IEC 60059:1999, *IEC standard current ratings*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-3-3, *Environmental testing – Part 3-3: Guidance – Seismic test methods for equipments*

IEC 60137:2017*, Insulated bushings for alternating voltages above 1 000 V*

IEC 60216 (all parts), *Electrical insulating materials – Thermal endurance properties*

IEC 60332 (all parts), *Tests on electric and optical fibre cables under fire conditions*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60544 (all parts), *Electrical insulating materials – Determination of the effects of ionizing radiation*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: principles, requirements and tests*

IEC 60754-2:2011, *Test on gases evolved during combustion of materials from cables – Part 2: determination of acidity (by pH measurement) and conductivity*

IEC/IEEE 60780-323:2016, *Nuclear facilities – Electrical equipment important to safety – Qualification*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

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

IEC 61034-2:2005, *Measurement of smoke density of cables burning under defined conditions – Part 2: test procedure and requirements*

IEC 61156-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: General specification*

IEC 61196-1-113:2009, *Coaxial communication cables – Part 1-113: Electrical test methods – Test for attenuation constant*

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-200:2011, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62855, *Nuclear power plants – Electrical power systems – Electrical power systems analysis*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 9712:2012, *Non-destructive testing – Qualification and certification of NDT personnel*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
acceptance criteria
specified bounds on the value of a functional indicator or condition indicator used to assess the ability of a structure, system or component to perform its design function

[SOURCE: IAEA Safety Glossary 2016 edition]

3.2
accident conditions
deviations from normal operation that are less frequent and more severe than anticipated operational occurrences

EXAMPLE Examples of such deviations include a major fuel failure or a loss of coolant accident.

Note 1 to entry: Accident conditions comprise design basis accidents and design extension conditions.

[SOURCE: IAEA Safety Glossary 2016 edition]

3.3
ageing
general process in which characteristics of a structure, system or component gradually change with time or use

[SOURCE: IAEA Safety Glossary edition 2016]

3.4
analysis
process and result of a study aimed at understanding the subject of the analysis, while assessment may also include determinations or judgements of acceptability

Note 1 to entry: The term "analysis" is often used interchangeably with assessment. The term "assessment" may also include determinations or judgements of acceptability. Analysis is also often associated with the use of a specific technique. Hence, one or more forms of analysis may be used in assessment.

[SOURCE: IAEA Safety Glossary edition 2016]

3.5
anticipated operational occurrence
deviation of an operational process from normal operation that is expected to occur at least once during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions

EXAMPLES Examples of anticipated operational occurrences are loss of normal electrical power and faults such as a turbine trip, malfunction of individual items of a normally running plant, failure to function of individual items of control equipment, and loss of power to the main coolant pump.

Note 1 to entry: Some States and organisations use the term abnormal operation (for contrast with normal operation) for this concept.

[SOURCE: IAEA Safety Glossary edition 2016]

3.6
assessment
process and result, of analysing systematically and evaluating the hazards associated with facilities and activities, and associated protection and safety measures

Note 1 to entry: Assessment is often aimed at quantifying performance measures for comparison with criteria.

Note 2 to entry: Assessment should be distinguished from analysis. Assessment is aimed at providing information that forms the basis of a decision on whether or not something is satisfactory. Various kinds of analysis may be used as tools in doing this. Hence an assessment may include a number of analyses.

[SOURCE: IAEA Safety Glossary edition 2016]

3.7
conductor module
assembly of electrical conductors and/or optical fibres and sealing material in one module

3.8
containment
methods or physical structures designed to prevent or control the release and the dispersion of radioactive substances

[SOURCE: IAEA Safety Glossary edition 2016]

3.9
design basis
range of conditions and events taken explicitly into account in the design of structures, systems and components and equipment of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits

Note 1 to entry: Used as a noun, with the definition above. Also often used as an adjective, applied to specific categories of conditions or events to mean ‘included in the design basis’; as, for example, in design basis accident, design basis external events and design basis earthquake.

[SOURCE: IAEA Safety Glossary 2016 edition]

3.10
design basis accident
postulated accident leading to accident conditions for which a facility is designed in accordance with established design criteria and conservative methodology, and for which releases of radioactive material are kept within acceptable limits

[SOURCE: IAEA Safety Glossary 2016]