

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation

Centrales nucléaires de puissance – Systèmes d'instrumentation, de contrôle-commande et d'alimentation électrique importants pour la sûreté – Séparation



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2018 IEC, Geneva, Switzerland

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 from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
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.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation

Centrales nucléaires de puissance – Systèmes d'instrumentation, de contrôle-commande et d'alimentation électrique importants pour la sûreté – Séparation

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 27.120.20

ISBN 978-2-8322-5582-7

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	10
1.1 General.....	10
1.2 Application: new and pre-existing plants	10
2 Normative references	11
3 Terms and definitions	12
4 Abbreviated terms	15
5 Principles and requirements for separation	16
5.1 Principles.....	16
5.1.1 General	16
5.1.2 Separation reasoning and boundaries.....	16
5.1.3 Plant safety principles and requirements	17
5.2 Safety class separation requirements.....	17
5.3 Associated circuits	18
5.3.1 General	18
5.3.2 Criteria	19
5.4 Separation issues at existing plants	20
5.4.1 General	20
5.4.2 Criteria	20
6 Separation design basis	20
6.1 Design inputs.....	20
6.2 Environmental conditions and hazards	21
6.2.1 General	21
6.2.2 Environmental conditions.....	21
6.2.3 External hazards.....	21
6.2.4 Internal hazards.....	21
6.2.5 Fire protection	22
6.3 EMI/EMC	22
6.4 Electrical fault.....	22
6.5 Requirements from non-nuclear technical standards	22
6.6 Requirements from special operating conditions	22
7 Electrical isolation	23
7.1 Principles.....	23
7.1.1 General	23
7.1.2 Overvoltage barrier.....	23
7.1.3 Short circuit / Overcurrent protection	23
7.1.4 Electrical nonreactive (retroaction free)	24
7.1.5 Galvanic isolation (electrical insulation)	24
7.2 Isolation devices	24
7.2.1 General	24
7.2.2 Isolation characteristics	25
7.2.3 Actuation priority	25
8 Physical separation	26
8.1 Principles.....	26

8.1.1	General	26
8.1.2	Separation by distance	26
8.1.3	Structural separation	26
8.2	Separation of cables and cable support structures	26
8.2.1	General	26
8.2.2	Divisional separation of redundant cables and cable support structures	27
8.2.3	Separation of system cables and cable supporting structures of different safety classes	27
8.2.4	Separation of signal cables from power cables	28
8.2.5	Reduced separation distances	28
8.2.6	Associated circuits	28
8.2.7	Separation of cables from tubes or pipes	28
8.2.8	General routing considerations	28
8.2.9	Identification	28
8.3	Separation of components inside the I&C and electrical system important to safety	28
8.3.1	Divisional separation of redundant components inside the I&C and electrical system important to safety	28
8.3.2	Separation of components of different safety classes	29
8.3.3	Installation of equipment of different voltage levels	29
8.3.4	Reduced separation distances	29
8.3.5	Associated circuits	30
8.3.6	Separation of components from sources of hazards	30
8.4	Control room cabinets, desks, panels and related cables	30
9	Verification	31
Annex A (normative)	Relation to IAEA guidelines and IEC 61226	32
A.1	Object of this Annex	32
A.2	Applicability of this document	32
A.3	IAEA Guidelines, applicable for this document	32
A.4	IEC standards, applicable for the safety categorization and classification	32
A.5	Defence in Depth levels, simplified definitions	33
Annex B (informative)	Examples of separation realizations	34
B.1	Object of this Annex	34
B.2	Example of physical separation	34
B.2.1	General	34
B.2.2	Examples of physical separation by distance	34
B.2.3	Examples of physical separation by structure	36
B.3	Example of electrical isolation	37
B.3.1	General	37
B.3.2	Examples of overvoltage barriers	37
B.3.3	Examples of short circuit / overcurrent protection	38
B.3.4	Examples of galvanic isolation	39
B.4	Example of EMC protection	40
B.5	Associated circuits	41
Annex C (informative)	Examples of design errors and I&C and electrical failure events	43
C.1	Object of this Annex	43
C.2	Design errors	43
C.3	I&C and electrical system failure events	43
C.3.1	General	43

C.3.2	Single random failure.....	43
C.3.3	Multiple failures from a single common cause	43
Annex D (informative)	Functional independence and independence of communication.....	44
D.1	Object of this Annex.....	44
D.2	Functional independence	44
D.2.1	General	44
D.2.2	Independence from control system	44
D.3	Independence of communication	45
Bibliography.....		46
Figure 1 – Physical separation by structure or distance		17
Figure 2 – Separation by electrical isolation.....		17
Figure 3 – Electrical Isolation measures and selection of components		23
Figure B.1 – Separation of cable supporting structures by distance		35
Figure B.2 – Separation of cable trays by distance.....		35
Figure B.3 – Separation by structures		36
Figure B.4 – Overvoltage barriers in I&C systems		37
Figure B.5 – Overvoltage protection in electrical systems		38
Figure B.6 – Short circuit protection in case of a cross-connection.....		39
Figure B.7 – Galvanic isolation in I&C systems		39
Figure B.8 – Galvanic isolation in electrical systems		40
Figure B.9 – EMC protection of I&C cables		41
Figure B.10 – Examples of associated circuits		42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NUCLEAR POWER PLANTS –
INSTRUMENTATION, CONTROL AND ELECTRICAL
POWER SYSTEMS IMPORTANT TO SAFETY – SEPARATION****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 60709 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This third edition cancels and replaces the second edition published in 2004. This edition constitutes a technical revision.

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

- a) include requirements referring to the separation principle in electrical systems important to safety;
- b) define separation criteria for I&C and electrical systems in a generic way;
- c) restructure the standard following the criteria;
- d) consider interferences between I&C and electrical equipment from different safety classes;

- e) align with the new revisions of IAEA documents and broaden the scope to include other aspects of separation;
- f) cover new technologies that either present unique separation issues or provide new means of achieving separation;
- g) enhance requirements and guidance for areas of cable congestion, e.g. control room, cable spreading galleries, etc;
- h) introduce the concept of “associated circuits” (from US practice) to deal with equipment not important to safety and cables that are not separated from safety equipment and cables;
- i) address the implications of low energy circuits, such as the possible use of analysis to reduce the minimum separation distance;
- j) review existing requirements, update terminology and definitions;
- k) provide guidance for the application of the standard to existing plants.

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

FDIS	Report on voting
45A/1185/FDIS	45A/1195/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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

a) Background, main issues and organization of the standard

I&C and electrical systems important to safety in nuclear power plants need to tolerate the effects of plant / equipment faults as well as internal and external hazards. Various techniques are available to increase the level of tolerability of I&C and electrical systems to such effects, including the provision of independent systems, subsystems and equipment. For claims to be made of independence between such systems and equipment, adequate separation should be provided and maintained. This standard provides generic technical requirements and recommendations for the implementation of separation in the design of I&C and electrical systems.

The object of this standard is as follows:

- in Clause 5 to present the principles for separation of I&C and/or electrical systems. Subclause 5.4 focuses on modernization of existing nuclear power plants;
- in Clause 6, to define the separation design basis, including inputs, and to identify a certain number of possible causes of internal and external hazards;
- in Clause 7, to establish the electrical isolation measures for I&C and electrical systems important to safety and also requirements referring isolation devices;
- in Clause 8, to give requirements to be fulfilled for cabling and component separation within an I&C and electrical system important to safety.

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

IEC 60709 is a document of the second level, directly referenced by IEC 61513 and IEC 63046 in regard to physical separation and electrical isolation being required between subsystems of different safety trains of I&C and electrical systems important to safety, and between I&C and electrical systems important to safety and those that are not important to safety and between different defence in depth levels.

IEC 61226, that is consistent with IAEA SSG-30, establishes the principles of categorization of I&C and electrical functions and the classification of structures, systems and components (SSC) according to their level of importance to safety. IEC 61226 refers to IEC 60709 as the normative standard regarding requirements for separation.

For more details on the relation of this standard to IAEA guidelines and IEC 61226, see Annex A to this standard.

c) Recommendations and limitations regarding the application of the Standard

IEC 60709 applies to I&C and electrical systems and equipment important to safety. It establishes requirements for physical and electrical separation as one means to provide independence between the functions performed in those systems and equipment. Other aspects of independence that may be required to address concerns of common cause failure are not included in this standard. Furthermore, separation criteria due to security requirements are also not considered.

The requirements given in this standard for the separation of safety classes can be applied to separation for other design constraints, such as the defence in depth concept. These rules shall be defined at the beginning of a project by a separation concept.

The separation of safety class 1 from other classes, as used in this standard, is only an example of the application of the requirements of the standard.

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 SC45A 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 part 2 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 rooms standards and IEC 62342 is the entry document for the 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 will be published this NOTE 2 of the introduction of IEC SC 45A standards will be suppressed.

NUCLEAR POWER PLANTS – INSTRUMENTATION, CONTROL AND ELECTRICAL POWER SYSTEMS IMPORTANT TO SAFETY – SEPARATION

1 Scope

1.1 General

This document is applicable to nuclear power plant instrumentation and control (I&C) and electrical systems and equipment, whose functions are required to be independent due to their contribution to:

- a redundant or diverse safety group;
- different defence in depth levels;
- different safety classes and also with non-classified (NC) systems.

It is also applicable to temporary installations which are part of those I&C and electrical systems important to safety (for example, auxiliary equipment for commissioning tests and experiments or mobile power supply systems). Clause 7 is intended particularly for electrical isolation, Clause 8 is intended particularly for the cabling and the arrangement of equipment of I&C and electrical systems important to safety.

This document applies to I&C and electrical systems of new nuclear power plants and to I&C and electrical upgrading or back-fitting of existing plants. For existing plants see 1.2 and 5.4.

Where independence is required by general safety standards such as IAEA safety guides, IEC 61513 (for I&C), IEC 63046 (for electrical systems) and other project constraints, one aspect of achieving this independence is physical separation and electrical isolation between the systems and their equipment that perform safety functions. This document defines the assessments needed and the technical requirements to be met for I&C and electrical systems, equipment or cables for which separation is required. Those means are to achieve adequate physical separation and electrical isolation between redundant sections of a system and between a higher and lower class systems. This separation is needed to prevent or minimise the impact on safety that could result from faults and failures which could be propagated or affect several sections of a system or several systems.

The requirements for functions, and their associated systems and equipment, to be independent are normally defined in detail in the project documentation; the method of determining and defining these requirements is not the subject of this document.

Following IAEA SSR-2/1 Requirement 21, separation means by physical separation, electrical isolation, functional independence and independence of communication are considered. In this document physical separation and electrical isolation are treated. Functional independence and independence of communication are not considered in this document. More details referring to functional independence, independence from control systems and independence of communication are given in Annex D.

1.2 Application: new and pre-existing plants

This document applies to the I&C and electrical of new nuclear power plants as well as to upgrading or back-fitting of existing plants.

For existing plants, only a subset of requirements is applicable and this subset is normally specified and argued at the beginning of any project.