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Nuclear power plants - Instrumentation, control and electrical power systems - Requirements for static uninterruptible DC and AC power supply systems

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Nuclear power plants - instrumentation, control and electrical power systems - requirements for static uninterruptible dc and ac power supply systems

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.
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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.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61225:2019. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61225 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2019. This edition constitutes a technical revision.

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

a) expansion and clarification of the requirements for static uninterruptible DC and AC power supply systems to ease the application in SMRs and passive designs.

This International Standard is to be used in conjunction with IEC 61513:2011, IEC 60709:2018, IEC 60880:2006, IEC 62138:2018, IEC 62855:2016 and IEC 63046:2020.

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

Draft	Report on voting
45A/1591/FDIS	45A/1610/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

a) Technical background, main issues and organization of the standard

The 1993 issue of IEC 61225 was developed for specifying the requirements relevant to the design of electrical supplies for I&C systems in nuclear power plants. Considering the experience gathered worldwide on this subject, in 2003 working group A2 recommended a revision to this document ~~so that~~ to allow a new revision, IEC 61225 Ed. 2 (2005), ~~could~~ to be consistently integrated into the SC 45A standard series. In 2015, working group A11 recommended a revision to this document following the publication of the revision of IAEA SSG-34 and that the scope of the standard should cover static uninterruptible power supplies for all types of connected equipment. In 2022, working group A11 recommended a revision to this document to ease the application to SMRs and passive designs.

International operating experience with electrical supply systems in nuclear power plants has highlighted a number of supply voltage variations and malfunctions, such as:

- voltage perturbations due to disturbances on the internal AC distribution system (with origin off-site or on-site).
- voltage overshoot on loss of grid.
- open phase conditions (one or two phases).
- asymmetrical faults.

These types of perturbations can degrade the performance of static uninterruptible power supplies and ultimately result in failure of connected equipment.

One of the objectives of the uninterruptible power supplies is to protect connected equipment from voltage variations on the on-site AC interruptible distribution system (the immunity concept). The power supplies ~~shall~~ also guarantee an output voltage with specified magnitude and waveform (in case of AC) to connected loads. The power supplies ~~shall~~ have the capacity to supply the relevant loads during a specified time regardless of any voltage variations on the on-site AC interruptible distribution system.

Examples of voltage and frequency variations in the incoming feeder to the supplies can be found in informative Annex A. Examples of specifications for static uninterruptible power supplies can be found in informative Annex B. Requirements for SMRs and passive designs are given in Annex C.

This document is applicable to the design of static uninterruptible electrical power supplies in new nuclear power plants (including SMRs and passive designs) when design work is initiated after the publication of this document and in general for nuclear facilities. It also serves as a reference for upgrading and modernizing existing nuclear power plants and facilities.

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

IEC 61225 is a second level document specifically addressing the particular topic of requirements for electrical supplies.

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

c) Recommendations and limitations regarding the application of this document

It is important to note that this document establishes no additional functional requirements for safety systems.

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.

~~This standard is to be applied in conjunction with IEC 61513, IEC 60709, IEC 60880, IEC 62138, IEC 62855 and IEC 63046 (to be published).~~

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 the categorization of functions and the 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 45 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, and process energy hazards) international or national standards ~~would be~~ are 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.~~

1 Scope

This document specifies the performance and the functional characteristics of the low voltage static uninterruptible power supply (SUPS) systems in a nuclear power plant (NPP) and, when applicable, in nuclear facilities in general. An uninterruptible power supply (UPS) is an electrical equipment which draws electrical energy from a source, stores it, and maintains the supply in a specified form by means inside the equipment to output terminals. A SUPS has no rotating parts to perform its functions.

The specific design requirements for the components of the power supply system are covered by IEC standards and other standards listed in the normative references ~~and~~. Otherwise, specific component-level design requirements are ~~otherwise~~ outside the scope of this document.

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, *IEC standard voltages*

IEC 60146-1-1, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC 60146-2, *Semiconductor converters – Part 2: Self-commutated semiconductor converters including direct d.c. converters*

IEC 60364-4-41, *Low voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60709, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation*

~~IEC/IEEE 60780-323, *Nuclear power plants – Electrical equipment important to safety – Qualification*~~

~~IEC 60880, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions*~~

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

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

~~IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*~~

IEC 61513, *Nuclear power plants – Instrumentation and control important to safety – General requirements for systems*

IEC 62003, *Nuclear power plants – Instrumentation, control ~~important to safety~~ and electrical power systems – Requirements for electromagnetic compatibility testing*

IEC 62040 (all parts), *Uninterruptible power systems (UPS)*

~~IEC 62138, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category B or C functions*~~

~~IEC 62566, *Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits for systems performing category A functions*~~

~~IEC 62566-2, *Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits – Part 2: HDL-programmed integrated circuits for systems performing category B or C functions* (to be published)~~

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

IEC/IEEE 60980-344, *Nuclear facilities – Equipment important to safety – Seismic qualification*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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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.
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INTRODUCTION

a) Technical background, main issues and organization of the standard

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International operating experience with electrical supply systems in nuclear power plants has highlighted a number of supply voltage variations and malfunctions, such as:

- voltage perturbations due to disturbances on the internal AC distribution system (with origin off-site or on-site).
- voltage overshoot on loss of grid.
- open phase conditions (one or two phases).
- asymmetrical faults.

These types of perturbations can degrade the performance of static uninterruptible power supplies and ultimately result in failure of connected equipment.

One of the objectives of the uninterruptible power supplies is to protect connected equipment from voltage variations on the on-site AC interruptible distribution system (the immunity concept). The power supplies also guarantee an output voltage with specified magnitude and waveform (in case of AC) to connected loads. The power supplies have the capacity to supply the relevant loads during a specified time regardless of any voltage variations on the on-site AC interruptible distribution system.

Examples of voltage and frequency variations in the incoming feeder to the supplies can be found in informative Annex A. Examples of specifications for static uninterruptible power supplies can be found in informative Annex B. Requirements for SMRs and passive designs are given in Annex C.

This document is applicable to the design of static uninterruptible electrical power supplies in new nuclear power plants (including SMRs and passive designs) when design work is initiated after the publication of this document and in general for nuclear facilities. It also serves as a reference for upgrading and modernizing existing nuclear power plants and facilities.

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

IEC 61225 is a second level document specifically addressing the particular topic of requirements for electrical supplies.

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

c) Recommendations and limitations regarding the application of this document

It is important to note that this document establishes no additional functional requirements for safety systems.

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 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 the categorization of functions and the 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 45 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 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, and process energy hazards) international or national standards are applied.

1 Scope

This document specifies the performance and the functional characteristics of the low voltage static uninterruptible power supply (SUPS) systems in a nuclear power plant (NPP) and, when applicable, in nuclear facilities in general. An uninterruptible power supply (UPS) is an electrical equipment which draws electrical energy from a source, stores it, and maintains the supply in a specified form by means inside the equipment to output terminals. A SUPS has no rotating parts to perform its functions.

The specific design requirements for the components of the power supply system are covered by IEC standards and other standards listed in the normative references. Otherwise, specific component-level design requirements are outside the scope of this document.

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, *IEC standard voltages*

IEC 60146-1-1, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC 60146-2, *Semiconductor converters – Part 2: Self-commutated semiconductor converters including direct d.c. converters*

IEC 60364-4-41, *Low voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60709, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation*

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61513, *Nuclear power plants – Instrumentation and control important to safety – General requirements for systems*

IEC 62003, *Nuclear power plants – Instrumentation, control and electrical power systems – Requirements for electromagnetic compatibility testing*

IEC 62040 (all parts), *Uninterruptible power systems (UPS)*

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

IEC/IEEE 60980-344, *Nuclear facilities – Equipment important to safety – Seismic qualification*