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Nuclear power plants – Electrical power system – General requirements

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

NUCLEAR POWER PLANTS – ELECTRICAL POWER SYSTEM – GENERAL REQUIREMENTS

FOREWORD

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International Standard IEC 63046 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

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

FDIS	Report on voting
45A/XX/FDIS	45A/XX/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- withdrawn,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.

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INTRODUCTION

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

The purpose of this standard is to provide the high level specification and requirement to implement a suitable Electrical Power System in a Nuclear Power Plant (NPP).

The electric power system in NPPs supports reactor systems important to safety. It also allows electric energy production providing the transmission grid with active and reactive power and electro-mechanical inertia.

The designers, operators of NPPs (utilities), equipment suppliers, systems evaluators and licensors, may use this document.

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

The entry point of the IEC SC 45A standard series should be summary report introducing the two first level standards for I&C (IEC 61513) and the Electrical Power System (IEC 63046).

This document is the first level IEC SC 45A document tackling the issue of general requirements for Electrical Power System and sub-systems.

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

It is important to note that this Standard 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 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 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, 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 was launched to cover this objective. As IEC 63046 is published, from now on this Note 2 of the introduction of IEC/SC 45A standards will not be included in the newly published standards.

NUCLEAR POWER PLANTS – ELECTRICAL POWER SYSTEM – GENERAL REQUIREMENTS

1 Scope

1.1 General

This document:

- provides requirements and recommendations for the overall Electrical Power System. In particular, it covers interruptible and uninterruptible Electrical Power Systems including the systems supplying the I&C systems;
- is consistent and coherent with IEC 61513. Like IEC 61513, this document also highlights the need for complete and precise requirements, derived from the plant safety goals. Those requirements are prerequisites for generating the comprehensive requirements for the overall Electrical Power System architecture, and for the electrical power supply sub-systems;
- has to be considered in conjunction with and at the same level as IEC 61513. These two standards provide a complete framework establishing general requirements for instrumentation, control, and Electrical Power System for Nuclear Power Plants.

This document establishes:

- the high level specification and requirement to implement a suitable Electrical Power System in a NPP that supports reactor systems important to safety. It also enables electrical energy production providing the transmission grid with active and reactive power and electro-mechanical inertia;
- the relationships between:
 - the plant safety requirements and the architecture of the overall Electrical Power System and its sub-systems (see Figure 1) including:
 - a) the contribution to the plant Defence in Depth;
 - b) the independency and redundancy provisions;
 - the electrical requirements and the architecture of the Electrical Power System and its sub-systems;
 - the functional requirements and the architecture of the Electrical Power System and its sub-systems;
 - the requirements associated with the maintenance strategy and the architecture of the Electrical Power System and its sub-systems;
- the design of Electrical power sub-systems (e.g. interruptible and uninterruptible);
- the requirements for supporting systems of Electrical Power System (HVAC, I&C, etc.);
- the Electrical Power System life-cycle framework.

This document does not cover the specification of:

- I&C systems;
- the transmission lines connecting to substations outside the NPP;
- electrical equipment requirements already defined in the industrial IEC standards;
- electrical power for security systems (e.g., fences, surveillance systems, entrance control);

- lighting and socket facility.

This document does not consider power production requirements.

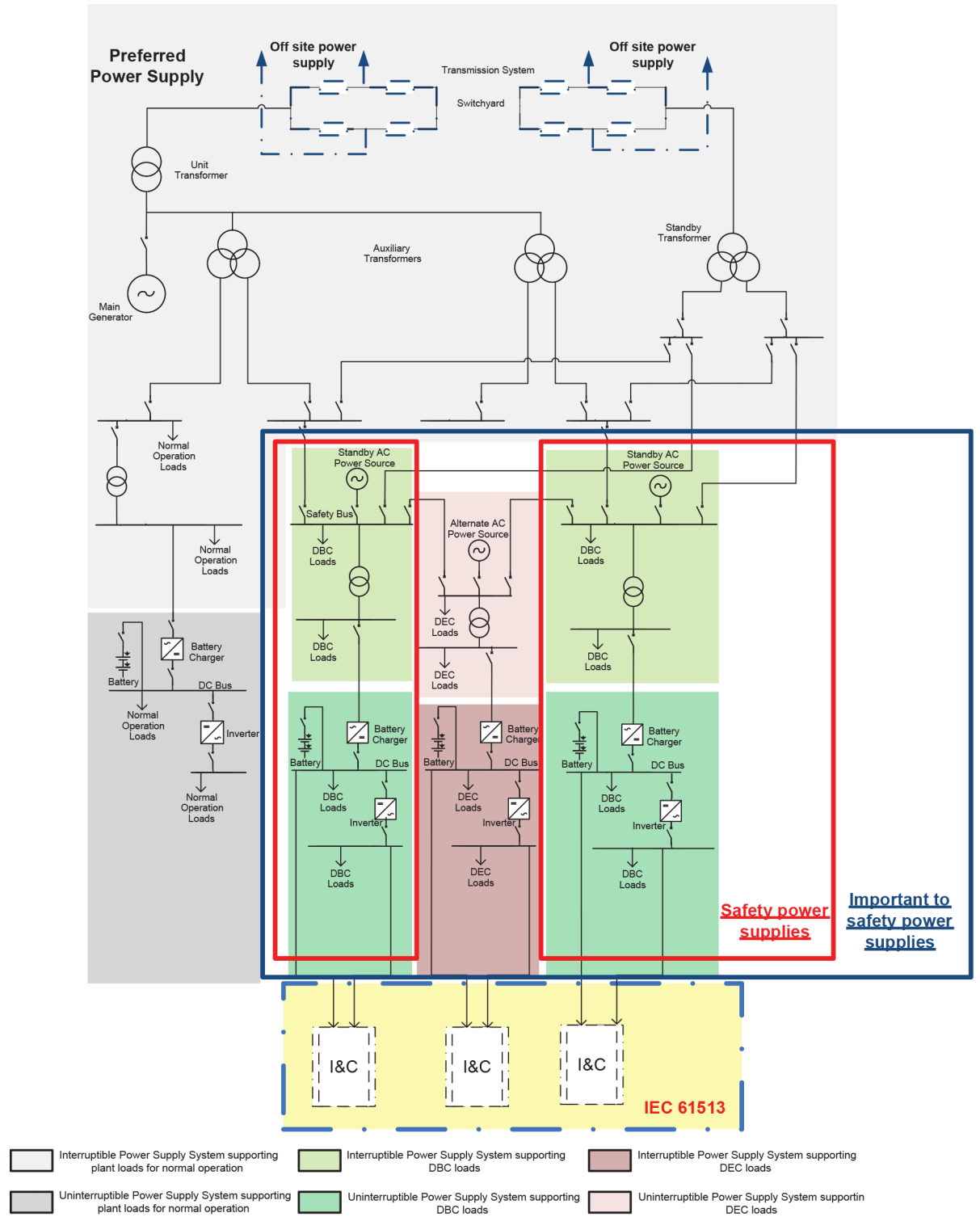


Figure 1 – Scope of work of this document

NOTE Figure 1 is based on IAEA SSG34:2016, Figure 3, with adaptation regarding the scope.

This figure provides only an example. Various possible arrangements of buses, loads, generators and interconnections would meet the requirements of SSR-2/1. Furthermore, many elements of the plant system, such as buses that are not important to safety and direct current power systems, are not shown. This figure is intended only to represent the relationship between the elements of the plant power systems that are within the safety classification and the preferred power supply. The elements of the preferred power supply that are not within the bounds of the important to safety power supply are outside the scope of the plant safety classification. The system elements included in the important to safety power supplies will differ according to plant design and the classification methods applied in different States. The classification methods are held by IEC 61226. Some plant designs may not require safety standby power sources. All nuclear power plants are expected to have safety direct current power supplies.

1.2 Application: new and pre-existing plants

This document is applicable to the Electrical Power System of new nuclear power plants and upgrading or back fitting of existing plants.

For existing plants, only a subset of requirements may be applicable and this subset should be identified at the beginning of any project.

1.3 Framework

This document consists of six normative clauses (an overview is provided in Figure 2):

- Clause 6 addresses the identification of requirements;
- Clause 7 addresses the design of the electrical architecture;
- Clause 8 addresses the sub-system requirements;
- Clause 9 addresses the verification;
- Clause 10 addresses the overall integration and commissioning;
- Clause 11 addresses the overall operation and maintenance.

1.4 Interaction with level 2 standards

This document shall permit an electrical designer to establish the list of requirements applicable for the design.

It also provides the different provisions applicable for the different requirements.

These provisions will be applied to the different type of power networks (sub-system):

- interruptible AC power network;
- uninterruptible power network.

Moreover, other transverse level 2 standards will define requirements applicable to electrical architecture definition.

The nuclear standards linked with the safety provisions (such as safety classification, separation, qualification or surveillance testing, etc.) are considered as input data for this document.

6 Architecture of Electrical Power System: Identification of requirements		
6.2 Safety requirements	6.3 Electrical requirements	
6.2.1 Defence in Depth	6.3.1 Requirements coordinated with the electric grid operator	
6.2.2 Application of Single Failure Criterion	6.3.2 Electrical disturbances	
6.2.3 Management of the Common Cause Failure		
6.2.4 Loss Of Off-site Power conditions	6.4 Functional, performance requirements	
6.2.5 Station Black Out conditions	6.5 Maintenance requirements	
6.2.6 Loss of Electrical power conditions		
6.2.7 Application of internal and external Hazards		
6.2.8 Nuclear security requirements		
6.2.9 Classification requirements		
6.2.10 Probabilistic requirements		
7 Overall Architecture of Electrical Power System and structured approach: Design of the electrical architecture		
7.2 Safety design provision	7.3 Electrical design provision	7.6 Multi-unit shared electrical power systems
7.2.1 Defence in Depth in the Electrical Power System	7.3.2 Coordination with the grid	
7.2.2 SF in the Electrical Power System	7.3.3 Design to achieve electrical requirements	7.7 Electrical system layout
7.2.3 CCF in the Electrical Power System	7.4 Functional and performance design provisions	7.8 Supporting and associated systems for the EPS
7.2.4 Provisions for coping with LOOP	7.4.2 Electrical Power System studies	7.9 Overall quality assurance programs
7.2.5 Provisions for coping with SBO	7.4.3 Design of the Interruptible Power Supply System	
7.2.6 Provisions to avoid or reduce Loss of Electrical Power	7.4.4 Design of the Uninterruptible Power Supply System	7.10 Requirements for output documentation
7.2.7 Classification consideration		
7.2.7.2 Qualification	7.5 Maintenance	
7.2.7.3 Surveillance Testing	7.5.1 Consideration of the maintenance in the electrical design	
7.2.8 Provisions to achieve the reliability target for the Electrical Power System		
8 Sub-System requirements		
8.1 Electrical Power System basis requirements	8.4 AC Interruptible Electrical Power Supply System	8.6 Coordination and interaction with the grid
8.2 Equipment design specification	8.5 AC/DC Uninterruptible Power Supply System	8.7 Earthing
8.3 Equipment requirements		
9 Verification of the architecture of the Electrical Power System		
9.2 Computerised tools and models verification	9.3 Test requirements	
10 Overall integration and commissioning		
10.2 Requirements	10.3 Output documentation	
11 Overall operation and maintenance		
11.2 Requirements	11.3 Output documentation	
12 System quality assurance plan		
12.2 System verification plan	12.3 System configuration management plan	12.4 Fault resolution procedures

Figure 2 – Architecture of Electrical Power System

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 60671, *Nuclear power plants – Instrumentation and control systems important to safety – Surveillance testing*

IEC 60709:2018, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation*

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

IEC 60964:2018, *Nuclear power plants – Control rooms – Design*

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

IEC 61225, *Nuclear power plants – Instrumentation, control and electrical power systems – Requirements for static uninterruptible DC and AC power supply systems*

IEC 61226:2020, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Categorization of functions and classification of systems*

IEC 61513:2011, *Nuclear power plants – Instrumentation and control important to safety – General requirements for systems*

IEC 62671, *Nuclear power plants – Instrumentation and control important to safety – Selection and use of industrial digital devices of limited functionality*

IEC 62808, *Nuclear power plants – Instrumentation and control systems important to safety – Design and qualification of isolation devices*

IEC 62855:2016, *Nuclear power plants – Electrical power systems – Electrical power systems analysis*

IEC 62859, *Nuclear power plants – Instrumentation and control systems – Requirements for coordinating safety and cybersecurity*

IEC 63272, *Nuclear facilities – Electrical power systems – AC interruptible power supply systems*

ISO 9001:2015, *Quality management systems – Requirements*

IAEA Safety Guide GS-G-3.1:2006, *Application of the management System for facilities and activities*

IAEA GS-R, Part 2:2016, *Leadership and Management for Safety*

IAEA Safety Guide SSG-34:2016, *Design of electrical power systems in Nuclear Power Plants*