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Nuclear power plants - Instrumentation and control important to safety - General requirements for systems

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Nuclear power plants - Instrumentation and control important to safety - General requirements for systems

FOREWORD

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IEC 61513 has been prepared by subcommittee 45A: Instrumentation and control of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

This third edition cancels and replaces the second edition, published in 2011. This edition constitutes a technical revision.

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

a) to align this document with the recent IAEA documents SSR-2/1 and SSG-39, to review the existing requirements and to update the terminology and definitions;
b) to take account of, as far as possible, requirements associated with standards published or thoroughly revised since the second edition, IEC 62566, IEC 61226, IEC 62138, IEC 60987, IEC 63046 and IEC 63351;
c) to incorporate the technical requirements related to I&C systems and equipment from IEC 61226:2020, Annex A.

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

Draft	Report on voting
45A/1645/FDIS	45A/1651/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– withdrawn, or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 this document

This International Standard sets out requirements applicable to instrumentation and control systems and equipment (I&C systems) that are used to perform functions important to safety in nuclear power plants (NPPs).

This document highlights the relations between

1) the safety objectives of the NPP and the requirements for the overall architecture of the I&C systems important to safety;
2) the overall architecture of the I&C systems and the requirements of the individual systems important to safety.

It is intended that this document be used by designers, operators of NPPs (utilities), systems evaluators and by licensors.

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

IEC 61513 is the first level IEC SC 45A document tackling the issue of general requirements for systems. It is the entry point of the IEC SC 45A standard series regarding I&C 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 document

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

To ensure that this document 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 IEC SC 45A standard series comprises a consistent set of documents organized in a hierarchy of four levels. The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046, covering respectively general requirements for instrumentation and control (I&C) systems and general requirements for electrical power systems of NPPs. IEC 61513 and IEC 63046 adopt an overall system life-cycle framework and constitute, along with the relevant second-level standards, the nuclear implementation of the basic safety series IEC 61508.

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 cybersecurity requirements and management of ageing. The standards referenced directly at this second level are to 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 implement and details the safety and cybersecurity 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, the IAEA safety guide SSG-51 dealing with human factors engineering in the design of NPPs, and the implementing guide IAEA NSS No. 42-G for computer security at nuclear facilities. The safety and cyber security terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

IEC 61513 and IEC 63046 refer to ISO 9001 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 cybersecurity standards. It builds upon the valid high-level principles and main concepts of the generic cybersecurity 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, IEC 63351 is the entry document for the human factors engineering standards, and IEC 62342 is the entry document for the ageing management standards.

NOTE IEC TR 63400 provides a more comprehensive description of the overall structure of the IEC SC 45A standards series and of its relationship with other standards bodies and standards.

1 Scope

1.1 General

I&C systems important to safety may be implemented using hardwired equipment, programmable digital equipment such as processor-based or HDL-programmed devices, or by using a combination of several types of technologies. This document provides requirements and recommendations for the overall I&C which may contain one or several of these technologies.

This document highlights also the need for complete and precise requirements, derived from the plant safety goals, as a pre-requisite for generating the comprehensive requirements for the overall I&C, and hence for the individual I&C systems important to safety.

This document introduces the concept of a safety lifecycle for the overall I&C including the I&C architecture, and a safety lifecycle for the individual systems. By this, it highlights the relations between the safety objectives of the NPP and the requirements for the architecture of the I&C systems important to safety, and the relations between the I&C architecture and the requirements of the individual systems important to safety.

Standards such as ISO/IEC/IEEE 15288 provide an overarching concept of system lifecycle provisions covering product-related processes as well as business development. The scope of IEC 61513 refers to safety aspects and their demonstration, and significantly deepens the considerations of ISO/IEC/IEEE 15288 in this field.

The lifecycles illustrated in and followed by this document are not the only ones possible; other lifecycles can be followed, provided that the requirements stated in this document are satisfied.

NOTE This document addresses the safety lifecycle of the overall I&C and of the individual systems. Although systems not important to safety are not in the scope of this document, they are considered in the overall I&C safety lifecycle, as they can constitute constraints for the design and qualification of systems important to safety (e.g. installation in common rooms, interfaces, sizing of support systems, coordination of installation and commissioning works).

Furthermore, this document does not describe the handling of interfaces between organizations (owner, architect engineering organization, engineering organizations, commissioning organizations). In practice, responsibilities for plans, activities and documents will be allocated according to the contractual arrangements.

1.2 Application: new and existing plants

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

For existing plants, only a subset of requirements is applicable depending on the scope of the project, and this subset is identified at the beginning of any project.

1.3 Framework

This document comprises four normative clauses (an overview is provided in Figure 1):

– Clause 5 addresses the overall I&C safety lifecycle:
  - defining requirements for the I&C functions, and associated systems and equipment derived from the safety analysis of the NPP, the defence-in-depth and diversity concept of the NPP, the categorization of I&C functions, and the plant layout and operational context;
  - structuring the I&C architecture, dividing it into a number of systems and assigning the I&C functions to systems. Design criteria are identified, including those to give defence-in-depth and to minimize the potential for common cause failure (CCF);
  - planning the I&C architecture.

– Clause 6 addresses the requirements for the individual I&C systems important to safety, particularly the requirements for systems built from programmable digital equipment. A differentiation of requirements according to the safety category of the I&C functions (A, B or C) or according to the safety class of the systems (1, 2 or 3) is made when relevant;
– Clause 7 and Clause 8 address the overall integration, commissioning, operation and maintenance of the I&C systems.

Figure 1 outlines the structure of this document to support navigation and readability. It is not intended to prescribe how this document is practically applied.

Additionally, this document provides informative annexes:

– Annex A highlights the relations between IAEA and basic safety concepts that are used throughout this document;
– Annex B provides guidance to support comparison of this document with parts 1, 2 and 4 of IEC 61508. Annex B surveys the main requirements of IEC 61508 to verify that the issues relevant to safety are adequately addressed, considers the use of common terms and explains the reason for adopting different or complementary techniques or terms;
– Annex C provides a proposal for the documentation structure for overall I&C planning and I&C system design;
– Annex D indicates the main changes to be considered during the next update cycles of several SC 45A standards to align them to this revision of IEC 61513.

5 Overall I&C safety lifecycle: Requirements specification for the overall I&C

5.2 Deriving the I&C requirements from the plant safety design base	Output documentation
5.2.2 Functional, performance and independence requirements 5.2.3 Categorization 5.2.4 Plant constraints	5.2.5 Requirements specifications for the individual I&C functions

5 Overall safety lifecycle: Derivation of requirements for the overall I&C and design of the I&C architecture

5.3 Design of the I&C architecture	5.4 Overall I&C (O) planning	5.5 Output documentation
5.3.2 Definition of the systems 5.3.3 Human machine interfaces and HFE 5.3.4 Data communication 5.3.5 Engineering tools 5.3.6 Defence against CCF 5.3.7 Assignment of the functions to systems 5.3.8 Required analysis	5.4.2 O QA programs 5.4.3 O cybersecurity planning 5.4.4 O configuration management plan 5.4.5 O requirements management plan 5.4.6 O integration and commissioning plan 5.4.7 O operation plan 5.4.8 O maintenance plan 5.4.9 Planning of training	5.5.2 Architectural design 5.5.3 Functional assignment 5.5.4 Overarching design concepts

6 System safety lifecycle: Realisation and planning of the individual I&C systems

6.1 System (S) lifecycle phases	6.9 System (S) planning	6.10 Output documentation
6.2 S requirements specification 6.3 S specification 6.4 S detailed design & implementation 6.5 S integration 6.6 S validation testing 6.7 S installation and commissioning 6.8 S modification	6.9.2 S quality plan 6.9.3 S verification plan 6.9.4 S configuration management plan 6.9.5 Fault resolution procedures 6.9.6 S integration plan 6.9.7 S validation plan 6.9.8 S installation and commissioning plan 6.9.9 S operation plan 6.9.10 S maintenance plan	6.10.2 S requirements specification 6.10.3 S specification 6.10.4 S detailed design 6.10.5 S integration 6.10.6 S validation test 6.10.7 S modification
	6.11 System qualification	
6.11.2 Generic / application-specific qualification	6.11.3 S qualification plan 6.11.6 Maintaining qualification	6.11.7 S qualification documentation

7 Overall integration and commissioning

7.2 Requirements on the objectives	7.3 Output documentation

8 Overall operation and maintenance

8.2 Requirements on the objectives	8.3 Output documentation

Key QA: Quality Assurance; O: Overall I&C; S: System

Figure 1 – Overall framework 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 60671, *Nuclear power plants - Instrumentation and control systems important to safety - Surveillance testing*

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/IEEE 60880:–[1], *Nuclear power plants - Instrumentation and control systems important to safety - Software aspects for computer-based systems performing category A functions*

IEC 60964, *Nuclear power plants - Control rooms - Design*

IEC 60965, *Nuclear power plants - Control rooms - Supplementary control room for reactor shutdown without access to the main control room*

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

IEC 60987, *Nuclear power plants - Instrumentation and control important to safety - Hardware requirements*

IEC 61500, *Nuclear power plants - Instrumentation and control important to safety - Data communication in systems performing category A functions*

IEC 62138:2018, *Nuclear power plants - Instrumentation and control systems important for safety - Software aspects for computer-based systems performing category B or C functions*

IEC 62340, *Nuclear power plants - Instrumentation and control systems important to safety - Requirements for coping with common cause failure (CCF)*

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 systems important to safety - Development of HDL-programmed integrated circuits - Part 2: HDL-programmed integrated circuits for systems performing category B or C functions*

IEC 62645, *Nuclear power plants - Instrumentation, control and electrical power systems - Cybersecurity requirements*

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

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[1] Under preparation. Stage at the time of publication: IEC/IEEE CDV 60880:2025.

IEC 62988, *Nuclear power plants - Instrumentation and control systems important to safety - Selection and use of wireless devices*

3 Terms and definitions

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

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

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

In order to be consistent with IEC directives, the articles at the beginning of the IAEA definitions are removed.

3.1
application function
function of an I&C system that performs a task related to the process being controlled rather than to the functioning of the system itself

Note 1 to entry: An application function is normally a subfunction of an I&C function. The term is independent from the used technology. For example, in a software-based systems, the application functions will typically have parts implemented in the hardware, in the application software and in the operational system software.

Note 2 to entry: See also “I&C function”, “I&C system”, “application software”, “service function”. “Application software” contrasts with “system software” whereas “application function” contrasts with “service function”.

3.2
application software
software part of an I&C system which is distinct from the operational system software

Note 1 to entry: The distinction between system software (generic, re-usable) and application software (typically plant-specific) is generally made to minimize re-development of code and to optimize the allocation of the qualification activities. It is an especially useful distinction when using an I&C platform.

Note 2 to entry: See also “system software”, “application function”, “service function”.

3.3
application software library
collection of software modules with functionality suitable to create application software

Note 1 to entry: When using pre-existing equipment, such a library is considered to be part of the system software and qualified as such.

Note 2 to entry: See also Figure 2.

3.4
category of an I&C function
one of three possible safety assignments (A, B, C) of I&C functions resulting from considerations of the safety relevance of the function to be performed. An uncategorized assignment may be made if the function has no importance to safety

Note 1 to entry: See also “class of an I&C system”, “I&C function”.

Note 2 to entry: IEC 61226 defines three categories of I&C functions. It sets out requirements for each category on the I&C function and the I&C chain involved in its delivery.