IEC 62138

Edition 2.0 2018-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Centrales nucléaires de puissance – Systèmes d'instrumentation et de contrôle-commande importants pour la sûreté – Aspects logiciels des systèmes informatisés réalisant des fonctions de catégorie B ou C

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – SOFTWARE ASPECTS FOR COMPUTER-BASED SYSTEMS PERFORMING CATEGORY B OR C FUNCTIONS

FOREWORD

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International Standard IEC 62138 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 2004. This edition constitutes a technical revision.

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

a) align the standard with standards published or revised since the first edition, in particular IEC 61513, IEC 60880, IEC 62645 and IEC 62671;
b) merge Clause 5 and Clause 6 of the first edition into a single clause in order to avoid the repetition of the vast majority of the text which proves to be extremely difficult to maintain in consistency;

c) revise clause on the selection of pre-developed software based on experiences from the application of the first edition of the standard on industrial projects. More precise criteria are proposed for the evidence of correctness of pre-developed software;

d) introduce requirements on traceability in consistency with IEC 61513;

e) introduce an Annex A that gives a typical list of software documentation;

f) introduce an Annex B that establishes relationship between IEC 61513 and this document;

g) introduce an Annex C that establishes relationship between IEC 61508 and this document.

The text of this standard is based on the following documents:

FDIS	Report on voting
45A/1201/FDIS	45A/1209/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.

In this document, the following print types are used:

- *Requirements and recommendations applicable specifically to class 2 or to class 3 systems appear in italics in Clause 6.*

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 this document

This International Standard provides requirements on the software aspects for computer-based instrumentation and control (I&C) systems performing category B or C functions as defined by IEC 61226. It complements IEC 60880 which provides requirements for the software of computer-based I&C systems performing category A functions.

It is consistent with, and complementary to, IEC 61513:2011. Activities that are mainly system level activities (for example, integration, validation and installation) are not addressed exhaustively by this document: requirements that are not specific to software are deferred to IEC 61513:2011.

This document takes into account the current practices for the development of software for I&C systems, in particular:

– the use of pre-developed software, equipment and equipment families that were not necessarily designed to nuclear industry sector standards;

– the use of application-oriented languages.

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

IEC 61513 is a first level IEC SC 45A document and gives guidance applicable to I&C at system level.

IEC 62138 is a second level IEC SC 45A document that supplements IEC 61513 concerning software development of computer-based I&C systems performing category B or C functions.

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

This document is not intended to be used as a general-purpose software engineering guide. It applies to the software of I&C systems performing category B or C functions for 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 and this subset has to be identified at the beginning of any project.

The purpose of the guidance provided by this document is to reduce, as far as possible, the potential for latent software faults to cause system failures, either due to single software failures or multiple software failures (i.e. Common Cause Failures due to software).

This document does not explicitly address how to protect software against those threats arising from malicious attacks, i.e. cybersecurity, for computer-based systems. IEC 62645 provides requirements for security programmes for computer-based systems.

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 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 nuclear power plants (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. 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, regarding control rooms, IEC 60964 is the entry document for the IEC SC 45A control rooms 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 requirement 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 will be suppressed.

NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – SOFTWARE ASPECTS FOR COMPUTER-BASED SYSTEMS PERFORMING CATEGORY B OR C FUNCTIONS

1 Scope

This document specifies requirements for the software of computer-based instrumentation and control (I&C) systems performing functions of safety category B or C as defined by IEC 61226. It complements IEC 60880 which provides requirements for the software of computer-based I&C systems performing functions of safety category A.

It is consistent with, and complementary to, IEC 61513. Activities that are mainly system level activities (for example, integration, validation and installation) are not addressed exhaustively by this document: requirements that are not specific to software are deferred to IEC 61513.

The link between functions categories and system classes is given in IEC 61513. Since a given safety-classified I&C system may perform functions of different safety categories and even non safety-classified functions, the requirements of this document are attached to the safety class of the I&C system (class 2 or class 3).

This document is not intended to be used as a general-purpose software engineering guide. It applies to the software of I&C systems of safety classes 2 or 3 for 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 and this subset has to be identified at the beginning of any project.

The purpose of the guidance provided by this document is to reduce, as far as possible, the potential for latent software faults to cause system failures, either due to single software failures or multiple software failures (i.e. Common Cause Failures due to software).

This document does not explicitly address how to protect software against those threats arising from malicious attacks, i.e. cybersecurity, for computer-based systems. IEC 62645 provides requirements for security programmes for computer-based systems.

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 60880:2006, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions*

IEC 61226, *Nuclear power plants – Instrumentation and control important to safety – Classification of instrumentation and control functions*

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

IEC 62671:2013, *Nuclear power plants – Instrumentation and control important to safety – Selection and use of industrial digital devices of limited functionality*

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
animation
process by which the behaviour defined by a specification is displayed with actual values derived from the stated behaviour expressions and from some input values

[SOURCE: IEC 60880:2006, 3.1]

3.2
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

[SOURCE: IEC 61513:2011, 3.1]

3.3
application software
part of the software of an I&C system that implements the application functions

Note 1 to entry: Application software contrasts with system software.

Note 2 to entry: Application software is plant specific, so it is not to be considered pre-developed software.

[SOURCE: IEC 61513:2011, 3.2 modified (modified notes to entry)]

3.4
application-oriented language
computer language specifically designed to address a certain type of application and to be used by persons who are specialists of this type of application

Note 1 to entry: Equipment families usually feature application-oriented languages so as to provide easy to use capability for adjusting the equipment to specific requirements.

Note 2 to entry: Application-oriented languages may be used to specify the functional requirements of an I&C system, and/or to specify or design application software. They may be based on texts, on graphics, or on both.

Note 3 to entry: Examples: function block diagram languages, languages defined by IEC 61131-3.

Note 4 to entry: See also general-purpose language.

[SOURCE: IEC 60880:2006, 3.3 modified (addition of note 4 to entry)]

3.5
common cause failure
CCF
failure of two or more structures, systems or components due to a single specific event or cause

Note 1 to entry: Common causes may be internal or external to an I&C system.

[SOURCE: IAEA Safety Glossary, 2016 edition]

3.6
complexity
degree to which a system or component has a design, implementation or behaviour that is difficult to understand and verify

[SOURCE: IEC 61513:2011, 3.9]

3.7
computer program
set of ordered instructions and data that specify operations in a form suitable for execution by a computer

Note 1 to entry: This includes traditional programs written in general-purpose languages. This also includes programs written in application-oriented languages.

[SOURCE: IEC 60880:2006, 3.10, modified (addition of note 1 to entry)]

3.8
computer-based item
item that relies on software instructions running on microprocessors or microcontrollers

Note 1 to entry: In this term and its definition, the term item can be replaced by the terms: system or equipment or device.

Note 2 to entry: A computer-based item is a kind of programmable digital item.

Note 3 to entry: This term is equivalent to software-based item.

3.9
configuration management
process of identifying and documenting the characteristics of a facility's structures, systems and components (including computer systems and software), and of ensuring that changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the facility documentation

[SOURCE: IAEA Safety Glossary, 2016 edition]

3.10
cybersecurity
set of activities and measures whose objective is to prevent, detect, and react to digital attacks that have the intent to cause:

- disclosures that could be used to perform malicious acts which could lead to an accident, an unsafe situation or plant performance degradation (confidentiality),
- malicious modifications of functions that may compromise the delivery or integrity of the required service by I&C CB&HPD systems (including loss of control) which could lead to an accident, an unsafe situation or plant performance degradation (integrity),
- malicious withholding or prevention of access to or communication of information, data or resources (including loss of view) that could compromise the delivery of the required service by I&C systems which could lead to an accident, an unsafe situation or plant performance degradation (availability).

Note 1 to entry: This definition is tailored with respect to the IEC 62645 scope, focusing on the prevention of, detection of and reaction to malicious acts by digital means on I&C CB&HPD systems. It is recognized that the term "cybersecurity" has a broader meaning in other standards and guidance, often including non-malevolent threats, human errors and protection against natural disasters, which are all out of the scope of IEC 62645.

[SOURCE: IEC 62645:2014, 3.6 modified (removal of note 2 to entry)]

3.11
dedicated functionality
property of devices that have been designed to accomplish only one clearly defined function or only a very narrow range of functions, such as, for example, capture and signal the value of a process parameter, or invert an alternating current power source to direct current. This function (or narrow range of functions) is inherent in the device, and not the product of programmability by the user

Note 1 to entry: Ancillary functions (e.g., self-supervision, self-calibration, data communication) may also be implemented within the device, but they do not change the fundamental narrow scope of applicability of the device.

Note 2 to entry: "Dedicated" in the sense in which it is used in IEC 62671 refers to design for one specific function that cannot be changed in the field.

[SOURCE: IEC 62671:2013, 3.7]

3.12
design specification
document or set of documents that describe the organisation and functioning of an item, and that are used as a basis for the implementation and the integration of the item

3.13
documentation for safety
document or set of documents that specifies how a product can be safely used for applications important to safety

Note 1 to entry: This definition is used in the context of pre-developed software (see 6.3).

3.14
dynamic analysis
process of evaluating a system or component based on its behaviour during execution. In contrast to static analysis

[SOURCE: IEC 60880:2006, 3.15]

3.15
electrical/electronic/programmable electronic item
E/E/PE item
item based on electrical (E) and/or electronic (E) and/or programmable electronic (PE) technology

Note 1 to entry: In this term and its definitions, the word "item" can be replaced by the words: system or equipment or device.

[SOURCE: IEC 61508-4:2010, 3.2.13, modified ("item" added and note to entry modified)]

3.16
equipment family
set of hardware and software components that may work co-operatively in one or more defined architectures (configurations). The development of plant specific configurations and of the related application software may be supported by software tools. An equipment family usually provides a number of standard functionalities (e.g. application functions library) that may be combined to generate specific application software

Note 1 to entry: An equipment family may be a product of a defined manufacturer or a set of products interconnected and adapted by a supplier.

Note 2 to entry: The term "equipment platform" is sometime used as a synonym of "equipment family".

[SOURCE: IEC 61513:2011, 3.17 modified (removal of note 1 to entry)]

3.17
error
discrepancy between a computed, observed or measured value or condition, and the true, specified or theoretical value or condition

Note 1 to entry: See also human error, fault, failure.

[SOURCE: IEC 61513:2011, 3.18, modified (addition of note 1 to entry)]

3.18
executable code
software that is included in the target system

Note 1 to entry: Executable code usually includes instructions to be executed by the hardware of the target system, and associated data.

3.19
failure
loss of the ability of a structure, system or component to function within acceptance criteria

Note 1 to entry: Equipment is considered to fail when it becomes incapable of functioning, whether or not it is needed at that time. A failure in, for example, a backup system may not be manifest until the system is called upon to function, either during testing or on failure of the system it is backing up.

Note 2 to entry: A failure is the result of a hardware fault, software fault, system fault, or operator or maintenance error, and the associated signal trajectory which results in the failure.

Note 3 to entry: See also human error, fault, error.

[SOURCE: IAEA Safety Glossary, edition 2016]

3.20
fault
defect in a hardware, software or system component

Note 1 to entry: Faults may be originated from random failures, that result e.g. from hardware degradation due to ageing, and may be systematic faults, e.g. software faults, which result from design errors.

Note 2 to entry: A fault (notably a design fault) may remain undetected in a system until specific conditions are such that the result produced does not conform to the intended function, i.e. a failure occurs.

Note 3 to entry: See also human error, error, failure.

[SOURCE: IEC 61513:2011, 3.21, modified (note 3 to entry modified)]

3.21
firmware
software which is closely coupled to the hardware characteristics on which it is installed. The presence of firmware is generally “transparent” to the user of the hardware component and, as such, may be considered to be effectively an integral part of the hardware design (a good example of such software being processor microcode). Generally, firmware may only be modified by a user by replacing the hardware components (for example, processor chip, card, EPROM) which contain this software with components which contain modified software (firmware). Where this is the case, configuration control of the hardware components of the equipment effectively provides configuration control of the firmware. Firmware, as considered by IEC 60987, is effectively software that is built into the hardware

[SOURCE: IEC 60987:2007, 3.4]

3.22
functional validation
verification of the correctness of the application functions specifications against the top level plant functional and performance requirements. It is complementary to the system validation that verifies the compliance of the system with the functions specification

[SOURCE: IEC 61513:2011, 3.23]

3.23
general-purpose language
computer language designed to address all types of usage

Note 1 to entry: The system software of equipment families is usually implemented using general-purpose languages.

Note 2 to entry: Examples: Ada, C, Pascal.

Note 3 to entry: See also application-oriented language.

[SOURCE: IEC 60880:2006, 3.20 modified (note 3 to entry added)]

3.24
human error (or mistake)
human action that produces an unintended result

Note 1 to entry: See also fault, error, failure.

[SOURCE: IEC 61513:2011, 3.26 modified (note 1 to entry added)]

3.25
I&C architecture

organisational structure of the I&C systems of a plant which are important to safety

[SOURCE: IEC 61513:2011, 3.27]

3.26
I&C system
system, based on E/E/PE items, performing plant I&C functions as well as service and monitoring functions related to the operation of the system itself

Note 1 to entry: The term is used as a general term which encompasses all elements of the system such as internal power supplies, sensors and other input devices, data highways and other communication paths, interfaces to actuators and other output devices. The different functions within a system may use dedicated or shared resources.

Note 2 to entry: The elements included in a specific I&C system are defined in the specification of the boundaries of the system.

Note 3 to entry: See also the definition of E/E/PE item and the associated notes.

Note 4 to entry: According to their typical functionality, IAEA distinguishes between automation / control systems, HMI systems, interlock systems and protection systems.

3.27
integration
progressive aggregation and verification of components into a complete system

3.28
library
collection of related software elements that are grouped together, but which are individually selected for inclusion in the final software product