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Nuclear power plants – Instrumentation and control important to safety – Platform qualification for systems important to safety

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TECHNICAL REPORT

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Nuclear power plants – Instrumentation and control important to safety – Platform qualification for systems important to safety

IEC TR 63084:2017-06(en)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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Nuclear power plants – Instrumentation and control important to safety – Platform qualification for systems important to safety

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – PLATFORM QUALIFICATION FOR SYSTEMS IMPORTANT TO SAFETY

FOREWORD

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IEC TR 63084, which is a technical report, has been prepared by subcommittee 45A: Instrumentation, control and electrical systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
45A/1106/DTR	45A/1141/RVDTR

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

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INTRODUCTION

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

It is recommended that platforms are used for the development and implementation of I&C systems. These platforms are understood here as a set of hardware and software components that may work co-operatively in one or more defined architectures (configurations).

Some I&C platforms were not conceived originally for the implementation of nuclear specific, safety applications. These I&C platforms have been proven and certified for industrial applications but the qualification for the nuclear safety application has to be demonstrated.

There are standards within SC 45A and in particular WG A3 which cover the development and qualification of computer-based systems and the corresponding application functions. However, it is not clear how the standards from SC 45A can be used on the qualification of I&C platforms.

Other relevant standards of SC 45A are in WG A7 (safety categories) and in WG A9 (qualification of electrical equipment).

Annexes are included to illustrate the approaches applied in different countries and their experiences.

This Technical Report is written to support decision makers related to the issues, goals and results of the platform qualification and the system qualification.

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

IEC 63084 as a technical report is a fourth level IEC SC 45A document.

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 the Technical Report

It is important to note that a technical report is entirely informative in nature. It gathers data collected from different origins and it establishes no requirements.

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 NPP; 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, equipment 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

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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 (NPP), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPP, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPP, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPP 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 (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, 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 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 will be published this Note 2 of the introduction of IEC SC 45A standards will be suppressed.

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – PLATFORM QUALIFICATION FOR SYSTEMS IMPORTANT TO SAFETY

1 Scope

1.1 General

This Technical report provides an assessment framework and activities for efficient and transparent qualification of I&C platforms for use in nuclear applications important to safety, according to nuclear standards and state of the art. The assessment aims at a pre-qualification of I&C platforms outside the framework of a specific plant design. Qualification is assumed to be pre-requisite for allowing the particular I&C platform to be used for implementation of the safety classified I&C system. It is to enable parties implementing particular plant specific I&C systems to concentrate on application functions, while for basic system functions to rely on platform qualification.

The I&C platform qualification is based on evaluation of the hardware and software functions provided by the platform ensuring safe and cost-effective life-cycle support of I&C systems. That would include tools for software engineering and software development (software module libraries), code generation, validation, maintenance, etc.

Basic means of equipment qualification, as prescribed by the IEC/IEEE 60780-323, are through analysis, type testing and documented operational experience. Other documents applicable for qualification for nuclear use include IEC 61513, IEC 60880, IEC 62138, IEC 62566, IEC 62671 and IEC 61226.

The features of the I&C platform to be qualified will be identified in requirements on the I&C platform. The requirements can vary, but in essence are based on suppliers' claims on the product scope and functionality. Those claims are normally given in platform documentation such as system descriptions and supplier's requirements for design, implementation, verification & validation. They are all based on the appropriate IEC SC 45A standards and national regulations.

1.2 Framework

This document is organized as follows:

- Clause 5 addresses the role of the platform qualification, including the conceptual design and the documentation constituting the basis for the process of platform qualification.
- Clause 6 is the main clause of this document addressing the process and methods of platform qualification. Crucial aspects of documentation and maintenance of the qualification are included.
- Clause 7 addresses platform elements necessary for safe and efficient implementation and life cycle support of plant-specific I&C systems.
- Aspects of the I&C platform qualification are further developed and exemplified in annexes. Annex A lists licensing issues of the Finnish licensing approach. Annex B discusses the qualification of Areva's TELEPERM XS platform, actualized with notes on qualification from the Finnish Olkiluoto 3 NPP. Annex C discusses the qualification of Westinghouse's FPGA-based platform of modules type ALS (Advanced Logic System). Annex D discusses the qualification of CTEC's digital platform FirmSys for use in systems important to safety in NPP. Annex E discusses the qualification of SOOSAN ENS's POSAFE-Q platform. Annex F discusses the qualification of Rolls-Royce's digital safety I&C platform Spinline in the framework of the type approval for the ELSA project. The five examples given in Annexes B to F are all of platforms developed for nuclear application.

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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/IEEE 60780-323:2016, *Nuclear facilities – Electrical equipment important to safety – Qualification*

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

IEC 61226:2009, *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 62138:2004, *Nuclear power plants – Instrumentation and control important for safety – Software aspects for computer-based systems performing category B or C functions*

IEC 62566:2012, *Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits for systems performing category A functions*

IEC 62645:2014, *Nuclear power plants – Instrumentation and control systems – Requirements for security programmes for computer-based systems*

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

IAEA SSG-39:2016, *Specific Safety Guide: Design of Instrumentation and Control Systems for Nuclear Power Plants*

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
application software library
collection of software modules implementing typical application functions

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

[SOURCE: IEC 61513:2011, 3.3, modified – The parentheses "(here platform)" have been added to Note 1 to entry.]

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3.2
assessment
systematic process that is carried out throughout the design process to ensure that all the relevant safety requirements are met by the proposed (or actual) design

Note 1 to entry: See independent assessment in 3.10 below.

3.3
audit
planned and documented activity performed by qualified personnel to determine by investigation, examination, or evaluation of objective evidence, the adequacy and compliance with established procedures, or applicable documents, and the effectiveness of implementation

Note 1 to entry: The term refers here to internal or external control of organisations on quality management, project management, and all other issues concerning safety requirements on nuclear processes.

Note 2 to entry: It is further assumed that the audited organisation provides "auditable data", i.e. technical information which is documented and organized in a readily understandable and traceable manner that permits independent review of the inferences or conclusions based on the information (see IEC/IEEE 60780-323).

3.4
automated code generation
function of automated tools allowing transformation of the application-oriented language into a form suitable for compilation or execution

[SOURCE: IEC 60880:2006, 3.5]

3.5
commissioning
process by means of which systems and components of facilities and activities, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria

Note 1 to entry: Commissioning may include both non-nuclear/non-radioactive and nuclear/radioactive testing.

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.6
equipment platform
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 I&C platform 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 I&C platform may be a product of a defined manufacturer or a set of products interconnected and adapted by a supplier.

[SOURCE: IEC 61513:2011, 3.17, modified – The term "equipment family" has been replaced by "equipement platform" and by "I&C platform" in the definition. Note 1 and 3 have been removed and Note 2 has been adapted to I&C platform.]

3.7
Hardware Description Language
HDL
language used to formally describe the functions and/or the structure of an electronic component for documentation, simulation or synthesis

Note 1 to entry: The most widely used HDLs are VHDL (IEEE 1076) and Verilog (IEEE 1364).

[SOURCE: IEC 62566:2012, 3.6]

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3.8
HDL-Programmed Device
HPD
integrated circuit configured (for NPP I&C systems), with Hardware Description Languages and related software tools

Note 1 to entry: HPDs are typically represented by ASICs, FPGAs, PLDs or similar micro-electronic technologies.

[SOURCE: IEC 62566:2012, 3.7, modified – Notes 1 and 2 have been removed and Note 3 has been modified.]

3.9
I&C System
system, based on electrical and/or electronic and/or programmable electronic technology, performing I&C functions as well as service and monitoring functions related to the operation of the system itself

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 (see Note 2). The different functions within a system may use dedicated or shared resources.

Note 1 to entry: See also "system".

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

Note 4 to entry: In the scope of this technical report, the term I&C system is linked to the particular process, in contrast to the generic term of I&C platform.

[SOURCE: IEC 61513:2011, 3.29, modified – The words "and I&C function" have been removed from Note 1 and Note 4 has been added.]

3.10
independent assessment
assessments such as audits or surveillances carried out to determine the extent to which the requirements for the management system are fulfilled, to evaluate the effectiveness of the management system and to identify opportunities for improvement. They can be conducted by or on behalf of the organization itself for internal purposes, by interested parties such as customers and regulators (or by other persons on their behalf), or by external independent organizations

Note 1 to entry: This definition applies in management systems and related fields.

Note 2 to entry: Persons conducting independent assessments do not participate directly in the work being assessed.

Note 3 to entry: Independent assessment activities include internal and external audit, surveillance, peer evaluation and technical review, which are focused on safety aspects and areas where problems have been found.

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.11
item important to safety
item that is part of a safety group and/or whose malfunction or failure could lead to radiation exposure of the site personnel or members of the public

[SOURCE: IAEA Safety Glossary, 2007 edition]

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3.12
license
legal document issued by the regulatory body granting authorization to perform specified activities related to a facility or activity

Note 1 to entry: Any authorization granted by the regulatory body to the applicant to have the responsibility for the siting, design, construction, commissioning, operation or decommissioning of a nuclear installation. In IAEA usage, a licence is a particular type of authorization, normally representing the primary authorization for the operation of a whole facility or activity. The conditions attached to the licence may require that further, more specific, authorization or approval be obtained by the licensee before carrying out particular activities.

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.13
operating experience
accumulation of verifiable operational data for conditions equivalent to those for which particular equipment is to be qualified

3.14
qualification
process of determining whether a system or component is suitable for operational use. The qualification is performed in the context of a specific class of the I&C system and a specific set of qualification requirements

Note 1 to entry: Qualification of I&C systems is always a plant- and application-specific activity while platform qualification relies to a large degree on qualification activities performed outside the framework of a specific plant design (these are called “generic qualification” or “pre-qualification”).

[SOURCE: IEC 61513:2011, 3.38, modified – Notes 1 and 2 have been removed and Note 3 has been revised.]

3.15
redundancy
provision of alternative (identical or diverse) structures, systems or components, so that any one can perform the required function regardless of the state of operation or failure of any other

[SOURCE: IEC 60880:2006, 3.29]

3.16
regulatory body
authority or system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating nuclear, radiation, radioactive waste and transport safety

Note 1 to entry: For each Contracting Party any body or bodies given the legal authority by that Contracting Party to grant licences and to regulate the siting, design, construction, commissioning, operation or decommissioning of nuclear installations.

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.17
system
set of components which interact according to a design, where an element of a system can be another system, called a subsystem

Note 1 to entry: See also "I&C system".

Note 2 to entry: I&C systems are distinguished from mechanical systems and electrical systems of the NPP.

Note 3 to entry: This IEC SC 45A definition is totally compatible with the sub-definition of "system" given in the frame of the 2007 edition of the IAEA Safety Glossary definition of "Structures, Systems and Components (SSC)".

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Note 4 to entry: The term "system" is a very general term that is used for different objects. Examples are Reactor Trip Systems, Engineered Safety Actuation Systems, etc. But also Core Cooling systems, ventilation systems, etc. are systems. The IEC SC 45A standards provide requirements and recommendations for such systems.

Note 5 to entry: Systems can be built from equipment platforms.

[SOURCE: IEC 61513:2011, 3.56, modified – Notes 4 and 5 have been added.]

3.18
type test
demonstration of the capability of a type of equipment to meet specified requirements by subjecting a representative item, or number of items, of the type to a set of physical, chemical, environmental or operational conditions

3.19
validation
process of determining whether a product or service is adequate to perform its intended function satisfactorily. Validation is broader in scope, and may involve a greater element of judgement, than verification

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.20
vendor
design, contracting or manufacturing organization supplying a service, component or facility

Note 1 to entry: The organization able and capable to provide required services and accepting contracted responsibilities bound to those services.

Note 2 to entry: An alternative term which may be used in this report is "contractor", referring to the supplier quoting, contracting, manufacturing and installing the I&C equipment for systems important for safety. It means as well that contractor is a certified vendor.

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.21
vendor qualification
process of determining whether a vendor is suitable for delivery, technical support and maintenance of the equipment and services contracted formally by the nuclear plant operating organization

Note 1 to entry: Formal contracting means in this context as being able and competent to fulfil all by contract defined responsibilities.

3.22
verification
confirmation by examination and by provision of objective evidence that the results of an activity meet the objectives and requirements defined for this activity

[SOURCE: IEC 62138:2004, 3.35, modified – The reference to ISO 12207 at the end of the definition has been removed.]

4 Abbreviated terms

ALS	Advanced Logic System® Platform
ASIC	Application Specific Integrated Circuit
BTP	Branch Technical Position
CFR	Code of Federal Regulations
CPLD	Complex Programmable Logic Device

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CPU	Central Processing Unit
CTEC	Company Profile-China Techenergy Co., Ltd.
DI&C	Digital Instrumentation and Control
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPR	European Power Reactor
EQ	Equipment Qualification
FPGA	Field Programmable Gate Array
GDC	General Design Criteria
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (Association for plant and reactor safety)
HDL	Hardware Description Language
HPD	HDL Programmed Device
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISG	Interim Staff Guidance
ISO	International Organization for Standardization
ISSN	International Standard Serial Number
ISTec	TÜV Rheinland ISTec GmbH – Institut für Sicherheitstechnologie
IV&V	Independent Verification and Validation
KTA	Nuclear Safety Standards Commission (Kerntechnischer Ausschuss)
LOP	List of Open Points
NIST SP	National Institute of Standards and Technology, Special Publication
NPIC&HMIT	Nuclear Plant Instrumentation, Control & Human-Machine Interface Technologies
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
OBE	Operating Basis Earthquake
PLC	Programmable Logic Controller
PLD	Programmable Logic Device
POSAFE-Q	Qualified Poscon Safety PLC
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
RFI	Radiofrequency Interference
RG	Regulatory Guide
SC	Sub-Committee
SSC	Structures, Systems and Components
SFS-EN	European standard implemented in Finland
SRP	Publication under Systematic Review
SSE	Safe Shutdown Earthquake
TXS	TELEPERM XS
V&V	Verification and Validation

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