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TECHNICAL REPORT

Nuclear power plants – Instrumentation and control systems, control rooms and electrical power systems – Specific features of small modular reactors and needs regarding standards

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FOREWORD

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IEC TR 63335 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation. It is a Technical Report.

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

Enquiry draft	Report on voting
45A/1357/DTR	45A/1371/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.

The language used for the development of this Technical Report 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/standardsdev/publications.

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- withdrawn,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 the Technical Report

Prior the April 2019 Paris meeting, the need to develop a TR to define which orientations could be followed by IEC SC 45A to cover SMRs (Small Modular Reactors) was identified and the decision to develop the TR was taken during the meeting.

A team of more than 30 IEC/SC 45A experts to the different SC 45A Working Groups was set up to cover the multi-disciplinary aspects of the subject.

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

The technical report IEC TR 63335 is a fourth level IEC SC 45A document.

This document draws roadmaps for the different SC 45A Working Groups to define orientations to cover SMRs. It is worthwhile noting that some of these orientations are also relevant for all NPPs.

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 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 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.

NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS, CONTROL ROOMS AND ELECTRICAL POWER SYSTEMS – SPECIFIC FEATURES OF SMALL MODULAR REACTORS AND NEEDS REGARDING STANDARDS

1 Scope

This document identifies a number of issues of particular importance to light water Small Modular Reactors (SMRs), which are not currently adequately addressed by existing IEC SC 45A standards, and that could be considered when revising existing publications or that could be the object of new work item proposals. Whether each of these issues will indeed be addressed, and if so in which publication, will be the decision of each SC 45A working group.

Though there are a number of advanced Generation IV SMR projects underway, their specific needs are not covered by this document.

This document is organized as follows:

- Clause 5 presents the main features of SMRs that are not typically found in large reactors or that are of particular importance for SMRs, and that could require specific or additional requirements and recommendations over those already provided in IEC SC 45A standards.
- Clause 6 suggests, for each working group, a number of issues that could be considered in the revision of existing publications or as subjects for new work items.
- Clause 7 suggests topics of importance to SMRs but that do not fit in the current scope of existing working groups.

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

ISO/IEC 15026-2:2011, *Systems and software engineering – Systems and software assurance – Part 2: Assurance case*

ISO/IEC/IEEE 15288, *Systems and software engineering – System life cycle processes*

IAEA SSR-2/1, *Safety of Nuclear Power Plants: Design*

WENRA Report, *Safety of New NPP Designs*

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
Small Modular Reactor
SMR
small: reactor the electrical output of which is less than 300 MW.

Modular: design and construction approach based in a large part on the assembly of fully operational modules built and pre-tested in dedicated factories

4 Abbreviated terms

AC	Alternating Current
CORDEL	Cooperation in Reactor Design Evaluation and Licensing
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EQ	Equipment Qualification
HMI	Human Machine Interface
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
I&C	Instrumentation and Control
LEP	Loss of Electrical Power
LOOP	Loss Of Offsite Power
MCR	Main Control Room
MDEP	Multinational Design Evaluation Programme
NEA	Nuclear Energy Agency
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
OECD	Organisation for Economic Co-operation and Development
RF	Radio Frequency
RFI	Radio Frequency Interference
SBO	Station Black Out
SMR	Small Modular reactors
TSO	Transmission System Operator
VDU	Visual Display Unit
V&V	Verification and Validation
WENRA	Western European Nuclear Regulators Association
WG	Working Group
WNA	World Nuclear Association

5 SMR specific features

5.1 General

The 2018 edition of IAEA report: *Advances in Small Modular Reactor Technology Developments* identifies more than 50 ongoing SMR design projects worldwide. The target of this document is those design projects that aim at power or industrial production, though many of the features listed and many of the suggestions proposed are applicable, or could be applied, to those with different aims (e.g., research). Also, as there is a wide variety of SMR designs, this document aims to be generic by focussing on commonly found SMR features.

Two key objectives of production SMRs are:

- To be at least as safe and secure as large nuclear reactors.
- To be economically competitive with respect to large nuclear reactors, and also to other, non-nuclear sources of energy.

Concerning economic competitiveness, SMRs cannot rely on the scale effect like large nuclear reactors, and need to take advantage of different features such as:

- Modular design (whereby a significant part of a plant construction consists in the transportation and assembly on site of fully operational modules built and pre-tested in dedicated factories) in order to lower construction costs and shorten construction durations.
- Series effect (whereby multiple units are based on a standardised design, possibly with minor adjustments to take account of site-specific constraints, and of country-specific requirements in case of worldwide deployment) to lower component costs and build-up construction experience.
- Simplified design, whereby advantage is taken of smaller size and lower power levels for simpler, more integrated and more passive designs. Simplified designs also tend to have positive effects on the safety and security of NPPs.

5.2 Passive design features and systems

Many SMR designs include so-called passive design features and passive systems where the performance of particular functions (in particular, safety functions) requires little or no external power and human control. For example, a passive residual heat removal system does not require the activity of powered pumps, but relies solely on natural convection, possibly after the opening of a few valves. Such features are not specific to SMRs, but their small size and low power levels facilitate their introduction.

As such features place less demand on non-passive support systems, they significantly contribute to design simplification and to cost reduction and hopefully reliability. However, the extensive use of such design features/systems is relatively new in nuclear power plants: there is limited experience in operation, and thus few lessons learned regarding design, construction, maintenance in operating condition, surveillance and periodic testing. Regulatory experience and international consensus on licensing approaches are also limited.

Also, the categorisation of functions important to safety could benefit from the incorporation of passive safety features.