IEC TR 63335

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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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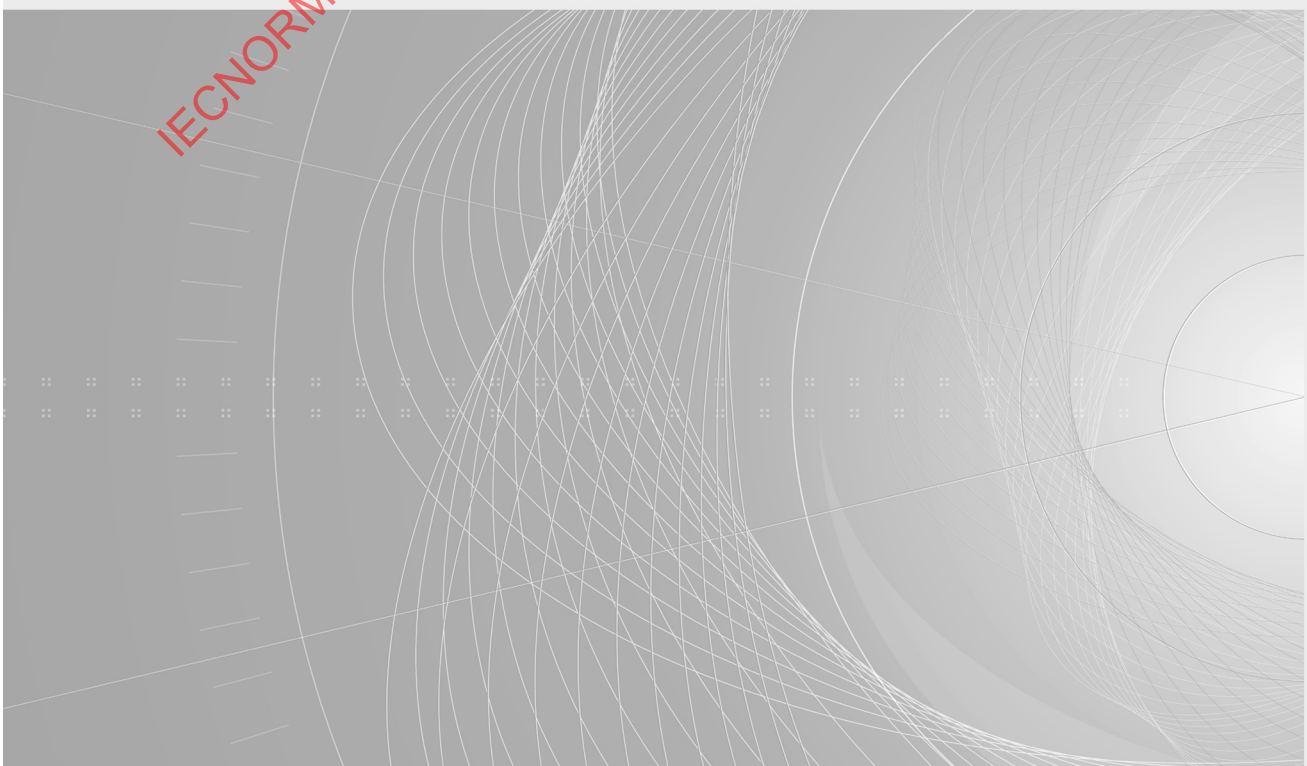

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS, CONTROL ROOMS AND ELECTRICAL POWER SYSTEMS – SPECIFIC FEATURES OF SMALL MODULAR REACTORS AND NEEDS REGARDING STANDARDS

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- withdrawn,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.

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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.

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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.

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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.

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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

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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.

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5.3 Mutualised operation

As a production SMR generates much less power (with sometimes a factor of up to 10 or 20) and thus much less revenue than a large nuclear reactor, economic competitiveness needs not only to be addressed in design and construction, but also in operation. This sometimes leads to the notion of mutualised operation, whereby multiple SMR units at the same site are operated by a single team (including control room personnel, field operators and maintenance staff), approximatively the size of the team for a large reactor, and from a single main control room. This practice is commonly seen in non-nuclear plants (whether for power generation or not), but in a nuclear context where safety is of primary importance, this raises a number of issues such as:

- How to determine an adequate staffing for the different teams involved.
- The operation of multiple units from the same main control room, where the handling of outage, incidental or accidental conditions in one or more units should not disturb the operation of units in normal conditions.
- The role and number of supplementary control rooms. For large reactors, the supplementary control room is essentially a backup to be used when the main control room is not available. In the case of mutualised operation, to avoid disturbing the operation of units in normal conditions, one might consider using one or more supplementary control rooms for units in conditions requiring the intervention of large numbers of persons, with the need of communication and coordination between the different rooms.
- How to ensure that each operator action, whether from the control room or in the field, is performed on the right unit.

5.4 Optimised maintenance

Maintenance represents an important part of the operation and personnel costs, and SMR projects often look for ways to optimise it, e.g., by using on-line monitoring to promote condition-based maintenance, or off-site e-monitoring to assist local operators in prognostics and diagnostics. Longer operation cycles (as is the case for some SMRs) and reduced inventory of active components (valves, pumps, etc.) may also need to be considered when addressing on-line and off-site monitoring.

5.5 Mutualised plant systems

Though there could be the occasional case of plants with a single SMR unit, many SMR design projects have plans for multi-unit plants, where units are in a large part independent, but where some plant systems are shared by all or some units of the plant. This naturally has impacts on I&C architectures, control rooms, control room systems, and electrical power systems.

5.6 Integrated designs

Several SMR projects are based on integrated primary circuit designs, where some or all steam generators, pressurizer and control rods are integrated within the reactor vessel. This may have many implications, in particular regarding:

- Hazards analysis and identification of postulated initiating events.
- Instrumentation and access to instrumentation.

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5.7 Modular construction

The letter “M” of SMR stands for Modular: the objective is that a significant percentage of a plant construction is made by assembling modules that are themselves built and verified in factory, and then transported to the construction site in sealed containers (of standard size whenever possible). There is then a need to ensure the integrity of these containers and their contents (absence of damage and absence of malicious tampering) during transportation, and then to verify that integrity on site. What constitutes adequate on-site verification and commissioning tests is a key issue.

Conversely, it could be argued that construction of more complete and larger modules in well-controlled factory conditions could justify less on-site confirmatory testing as these modules will not have been disassembled before transporting to site.

5.8 Staged construction

As individual SMR units generate relatively low levels of power, a given plant may be composed of multiple units. If some of them are constructed while others are already in operation, one needs to ensure that construction or renovation works do not disturb operation to the point of causing safety or security issues. This is particularly true for mutualised equipment and rooms, such as the main control room.

5.9 Consideration of emerging technologies

To keep construction and operational costs to acceptable levels, SMR projects often take consideration of I&C industrial standards and technologies that have emerged in recent years or of older technologies that have not been extensively used up to now in the nuclear industry. Examples include OPC-UA (OPC Unified Architecture), TSN (Time Sensitive Network) remote Input / Outputs and field buses (which have accumulated significant volumes of experience in operation in other industries), extensive use of multiplexed communications for NC or Class 3 I&C systems. They may also have benefits for dependability, interoperability, maintainability on the long term, safety or cyber-security.

5.10 Designing for an international market

Modifying an existing nuclear reactor design is often a lengthy, costly and uncertain process. When seeking a series effect in an international market as is the case for many SMR projects, design modifications to meet unexpected country-specific requirements are to be minimised as far as reasonably possible for the economic case for SMRs to be viable.

Though there have been, and still are, several ongoing international regulatory harmonisation programmes (such as the work performed by the MDEP programme of OECD NEA, or by the CORDEL working group of WNA), full harmonisation of country specific requirements has yet to be achieved, and may be still far away in the future:

- There still are significant differences between many IEC and IEEE standards. This is not due to lack of will from these organisations, but to well established and different industrial and regulatory practices and to the fact that each standards corpus is highly integrated and difficult to modify piecewise.
- Some IEC standards are interpreted in very different ways in different countries: designs referring to these standards that have been accepted in one country may be (or even, have been) rejected in another.
- Some key subjects (e.g., levels of defence-in-depth in overall I&C architectures, identification of postulated initiating events, or necessary trade-offs between conflicting objectives such as the independence of levels of defence-in-depth and human factors) are not addressed at a sufficiently practical level in IEC standards and thus fail to provide an adequate and robust framework for internationally accepted solutions.

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Fortunately, even though standards unambiguity and regulatory harmonisation are highly desirable, they are not an absolute necessity. Also, country's positions regarding the interpretation of international standards can evolve over time and the contents of standards can be revised. Designers mainly need to have an early and clear understanding of the differences in requirements, in possible interpretations, in acceptable solutions and in licensing practices. When harmonisation and clarification cannot be achieved in international standards, such information could be provided by technical reports. If there are not too many variations, designers can strive to develop a design that would require only minor country-specific or site-specific adjustments. Such a design would not necessarily be optimal for any targeted country, but would be so for an international market. In this endeavour, designers may rely on the smaller size, lower level of power and greater simplicity of SMRs.

5.11 Licensing in an international market

Licensing a new design, in particular an innovative one, in one country may require significant amounts of effort and time. When aiming at an international market, it is important to be able to streamline the licensing process and to reuse, as far as possible, licensing effort from one country to another. To this end, best practices and guidance in the application of justification frameworks (ISO/IEC15026-2:2011) for both licensees and licensors could be very beneficial.

5.12 New designs (versus evolutionary designs)

As opposed to evolutionary designs, where limited changes are made with respect to designs that have both licensing and operational experience, many SMR projects incorporate innovative design features, including but not limited to those listed in the previous subclauses. While developing an evolutionary design may be done using roughly the same engineering and licensing approaches as previous designs (sometimes from many decades in the past), developing a new, innovative design could greatly benefit from more recent and supposedly more efficient systems engineering approaches such as model-based approaches, with extensive use of simulation and analysis (including formal verification). These advanced approaches could enhance reactor efficiency, safety and the economics of construction, and also provide improved evidence for licensing and enhanced models for operation.

5.13 Remote monitoring and support centres

Though there already are remote support centres for large reactors, they are intended mainly to provide assistance in case of emergency situations. With the series effect, where the same SMR design is used for many units at different sites, some projects also consider remote centres for monitoring and providing assistance in more normal and every day situations, e.g., regarding condition-based maintenance.

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6 Recommendations to existing working groups

6.1 WGA2: Sensors and measurement techniques

6.1.1 Current portfolio

Reference	Title	Publication date	Stability date	Revision going on?
IEC 60515 Ed. 2.0	Radiation detectors – Characteristics and test methods	2007	2021	
IEC 60568 Ed. 2.0	In-core instrumentation for neutron fluence rate (flux) measurements in power reactors	2006	2022	
IEC 60737 Ed. 2.0	Temperature sensors (in-core and primary coolant circuit) – Characteristics and test methods	2010	2023	
IEC 60744 Ed. 2.0	Safety logic assemblies used in systems performing category A functions: Characteristics and test methods	2018	2022	
IEC 60772 Ed. 2.0	Electrical penetration assemblies in containment structures for nuclear power generating stations	2018	2024	
IEC 60988 Ed. 2.0	Acoustic monitoring systems for detection of loose parts: characteristics, design criteria and operational procedures	2009	2023	
IEC 61224 Ed. 1.0	Response time in resistance temperature detectors (RTDs) – In situ measurements	1993	2020	Revision underway Merging with IEC 62397
IEC 61468 Ed. 1.0 + amendment 1.0	In-core instrumentation – Characteristics and test methods of self-powered neutron detectors	2000	2020	Revision underway
IEC 61501 Ed. 1.0	Wide range neutron fluence rate meter – Mean square voltage method	1998	2020	
IEC 61502 Ed. 1.0	Vibration monitoring of internal structures	1999	2024	
IEC 62397 Ed. 1.0	Resistance temperature detectors	2007	2020	Revision underway Merging with 61224
IEC 62651 Ed. 1.0	Thermocouples: characteristics and test methods	2013	2024	
IEC 62887 Ed. 1.0	Pressure transmitters: Characteristics and test methods	2018	2021	
IEC 63186 Ed. 1.0	Criteria for seismic trip system			In development

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6.1.2 Topics of interest

WGA2 could consider the opportunity of addressing the following issues in the revision of existing publications, or in new publications:

- Whether the requirements and recommendations of current publications are also needed by, and applicable to, smaller cores and lower powers (and thus lower levels of radiation and flux).
- Impacts of integrated primary circuit designs: no external circuit: how to measure water levels and flow rate.
- Impacts of factory manufacturing and transport at site (many parts of the reactor are installed in factory and may be shocked during transportation).
- Impacts of limited space for implementation of sensors : needs for new sensors and detectors.

- Small volume of the reactor containment and consequences on environmental accident and post-accident conditions.
- Metallic reactor containment instead of concrete reactor building : Specific penetrations are needed .
- Reactor electrical penetration assemblies for integrated devices inside reactor vessel like control rod drive mechanism and reactor coolant pump.
- Intensive use of mineral insulated cables may require specific considerations for splices, terminations, moisture intrusion corrosion and environmental qualification.
- Use of interconnections between containment and reactor electrical penetration assemblies housed in flexible metal bellows with sealed back-shell connections for submergence in water flooded annulus.
- Long life sensors used in confined vessels subject to extreme environments.
- Sensing technologies such as fibre optic sensors, ultrasonic flow meters, and wireless sensors have been fully developed for industrial applications and may play a role in nuclear power applications.

6.1.3 WGA2 roadmap

WGA2 standards focus on instrumentation so the impact of SMR architecture needs to have details on specific instrumentation used. Thus, WGA2 proposes on a first stage to launch a technical report that gathers the SMR needs in order to decide which standards are missing or which other one shall be revised.

Topic	Action
Technical reports on specific SMR instrumentation needs: – Instrumentation in the reactor containment (requirements for accident conditions , maintainability) – Instrumentation dedicated on SMR transport from the manufacture to the operational plant (accelerometers to detect shocks during transport and installation) – Instrumentation dedicated to the passive features of the SMR (flow rate and water level inside the reactor vessel) – New instrumentation technologies (smaller size) or use of existing industrial technologies (for example: wireless sensors) – Cabling: • Reduction (example multiplexing) or mineral insulated cables • Lifetime (example mineral insulated cables) – Integration of existing industrial standards	Technical reports
Penetration assemblies SMR requirements	IEC 60772-Amendment

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6.2 WGA3: I&C systems: architecture and system specific aspects

6.2.1 Current portfolio

Reference	Title	Publication date	Stability Date	Revision going on ?
IEC 60880 Ed. 2.0	Software aspects for computer-based systems performing category A functions	2006	2021	
IEC 60987 Ed. 2.0 + Amendment 1	Hardware design requirements for computer-based systems	2007	2020	Revision underway
IEC 61500 Ed. 2.0	Data communication in systems performing category A functions	2018	2021	
IEC 61513 Ed. 2.0	General requirements for systems	2011	2021	
IEC 62138 Ed. 2.0	Software aspects for computer-based systems performing category B or C functions	2018	2022	
IEC 62340 Ed. 1.0	Requirements for coping with common cause failure (CCF)	2007	2022	Revision should start
IEC 62566 Ed. 1.0	Development of HDL-programmed integrated circuits for systems performing category A functions	2012	2022	Revision should start
IEC 62566-2 Ed. 1.0	Development of HDL-programmed integrated circuits for systems performing category B and C functions	2020	2023	
IEC TR 63084 Ed. 1.0	Platform qualification for systems important to safety	2017	2020	
IEC TR 63192 Ed. 1.0	Hazard analysis: A review of current approaches	2019	2022	

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6.2.2 Topics of interest

WGA3 could consider the opportunity of addressing the following issues in the revision of existing publications, or in new publications:

- Defence-in-depth in I&C architectures, as this topic is very sketchily addressed in IEC 61513, but is addressed in more detail in IAEA SSR-2/1 and in the WENRA report on safety of new NPP designs.
- Assessment of emerging industrial standards such as OPC UA (IEC 62541) and TSN (IEC/IEEE 60802 project).
- I&C architectures in a multi-unit and mutualised operation framework.
- Extensive use of multiplexed digital communication, field buses and remote I/O.
- Extensive exploitation of the information provided by "smart devices".
- Similarities and differences with respect to equivalent IEEE publications.

6.2.3 WGA3 roadmap

Topic	Action
Levels of Defence-in-Depth	IEC 61513 (amendment) or NWIP (International Standard), to be decided at the next meeting of WGA3 and SC 45A
Multiplexed data communication for Safety Class 2	IEC 61500 (amendment or revision)
Multiplexed data communication for Safety Class 3	NWIP (International Standard)
Assessment of OPC UA (IEC 62541) and TSN (IEC/IEEE 60802 project)	Technical Report
I&C for mutualised plant systems	IEC 62340 (Revision)
Modular construction: V&V in factory and on site after transportation	IEC 60987 (Amendment)
Similarities and differences with respect to IEEE publications	No action, refer to Gary Johnson's work on the subject published by CORDEL (International Nuclear I&C and Electrical System Standards Tables with URLs)

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6.3 WGA5: Special process measurement and radiation monitoring

6.3.1 Current portfolio

Reference	Title	Publication date	Stability Date	Revision going on?
IEC 60768 Ed. 2.0	Equipment for continuous in-line or on-line monitoring of radioactivity in process streams for normal and incident conditions	2009	2022	
IEC 60910 Ed. 1.0	Containment monitoring instrumentation for early detection of developing deviations from normal operation in light water reactors	1988	2020	Revision underway
IEC 60911 Ed. 1.0	Measurements for monitoring adequate cooling within the core of pressurized light water reactors	1987	2022	
IEC 60951-1 Ed. 2.0	Radiation monitoring for accident and post-accident conditions – Part 1: General requirements	2009	2020	Revision underway
IEC 60951-2 Ed. 2.0	Radiation monitoring for accident and post-accident conditions – Part 2: Equipment for continuous off-line monitoring of radioactivity in gaseous effluents and ventilation air	2009	2022	
IEC 60951-3 Ed. 2.0	Radiation monitoring for accident and post-accident conditions – Part 3: Equipment for continuous high range area gamma monitoring	2009	2020	Revision underway
IEC 60951-4 Ed. 2.0	Radiation monitoring for accident and post-accident conditions – Part 4: Equipment for continuous in-line or on-line monitoring of radioactivity in process streams	2009	2022	
IEC 61031 Ed. 2.0	Design, location and application criteria for installed area gamma radiation dose rate monitoring equipment for use in nuclear power plants during normal operation and anticipated operational occurrences	2020	2023	
IEC 61250 Ed. 1.0	Detection of leakage in coolant systems	1994	2023	
IEC 61343 Ed. 1.0	Boiling light water reactors (BWR) – Measurements in the reactor vessel for monitoring adequate cooling within the core	1996	2021	
IEC 61504 Ed. 1.0	Plant-wide radiation monitoring	2017	2022	
IEC 62117 Ed. 1.0	Pressurized light water reactors (PWR) – Monitoring adequate cooling within the core during cold shutdown	1999	2022	
IEC 62705 Ed. 1.0	Radiation monitoring systems (RMS): Characteristics and lifecycle	2014	2020	Revision underway
IEC TR 62235 Ed. 1.0	Systems of interim storage and final repository of nuclear fuel and waste	2005	2021	
IEC/IEEE 63113 Ed.1.0	Spent fuel pool instrumentation			First edition being drafted

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6.3.2 Topics of interest

WGA5 could consider the opportunity of revising existing publications, or of new publications, considering:

- Whether existing requirements and recommendation for process measurement are necessary, applicable and sufficient for small size reactors.

- Whether existing requirements and recommendation for process measurement are necessary, applicable and sufficient for integrated reactors.
- Whether existing requirements and recommendation for process measurement are necessary, applicable and sufficient for passive design features and passive systems.

6.4 WGA7: Functional and safety fundamentals of I&C and electrical power systems

6.4.1 Current portfolio

Reference	Title	Publication date	Stability Date	Revision going on?
IEC 60671 Ed. 2.0	Surveillance testing	2007	2021	
IEC 60709 Ed. 3.0	Separation	2018	2021	
IEC 61226 Ed. 3.0	Classification of instrumentation and control functions	2009	2020	Revision underway
IEC 62671 Ed. 1.0	Selection and use of industrial digital devices of limited functionality	2013	2021	
IEC 62671 Cor. to Ed. 1.0	Corrigendum to IEC 62671 Ed. 1.0	2016	2021	
IEC 62808 Ed. 1.0 + Amendment 1	Design and qualification of isolation devices	2015	2021	
IEC 63147 Ed.1.0	Criteria for accident monitoring instrumentation for nuclear power generating stations	2017	2020	
IEC TR 61838 Ed. 1.0	Use of probabilistic safety assessment for the classification of functions	2009	2021	
IEC TR 62987 Ed. 1.0	Use of Failure Mode and Effect Analysis (FMEA) and related methods to support justification of systems	2015	2022	
IEC TR 63123 Ed. 1.0	Guidance for the application of IEC 63147:2017	2017	2020	
IEC/IEEE 63160 Ed. 1.0	Common cause failure, system analysis and diversity			In development

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6.4.2 Topics of interest

WGA7 could consider the opportunity of addressing the following issues in the revision of existing publications, or in new publications:

- Definition of "passive systems" and requirements for monitoring their action and correct function.
- Conditions for safe operation of passive systems.
- Hazards and risk analysis with passive systems and integrated primary circuits.
- Hazards and risk analysis in a multi-unit framework.
- Impacts of smart devices and cyber security requirements in electrical power systems.
- Rigorous functional validation of I&C requirements (to avoid requirements specification errors, in particular in innovative plant designs such as SMRs).
- Similarities and differences with respect to IEEE publications.
- Modularisation and size constraints affecting separation/isolation.

6.4.3 WGA7 roadmap

Topic	Action
Separation in modular and space constrained plants	IEC 60709 (Amendment or revision) and IEC 62808 (Revision)
Passive systems delivering safety functions	IEC 61226 (Revision), with IEEE joint working also required IEC 60671 (Revision) to account for surveillance of passive functions and extended operation cycles
Prevalence of smart devices and methods of qualification or mitigation	NWIP (International Standard) with IEEE working group 6.6
Passive system monitoring requirements	Technical Report to identify any gaps in existing standards
Multi-unit operation hazard and risks	Technical Report
PSA of passive systems	TR 61838 (Revision)
Methods of validation and qualification	NWIP already forecast for 2021

6.5 WGA8: Control rooms

6.5.1 Current portfolio

Reference	Title	Publication date	Stability Date	Revision going on ?
IEC 60960 Ed. 1.0	Functional design criteria for a safety parameter display system for nuclear power stations	1988	2020	Revision should start
IEC 60964 Ed. 3.0	Control rooms – Design	2018	2020	
IEC 60965 Ed. 3.0	Supplementary control room for reactor shutdown without access to the main control room	2016	2020	
IEC 61227 Ed. 2.0	Operator controls	2008	2020	
IEC 61771 Ed. 1.0	Main control-room – Verification and validation of design	1995	2020	
IEC 61772 Ed. 2.0	Application of visual display units (VDUs)	2009	2023	
IEC 61839 Ed. 1.0	Functional analysis and assignment	2000	2020	
IEC 62241 Ed. 1.0	Main control room – Alarm functions and presentation	2004	2020	Revision should start
IEC 62646 Ed. 2.0	Computer based procedures	2016	2023	
IEC 62954 Ed. 1.0	Control rooms – Requirements for emergency response facilities	2019	2021	
IEC 63214 Ed. 1.0	Control Rooms – Human Factors Engineering	2019	2022	
IEC 63260 Ed. 1.0	Human Reliability in Probablistic Risk Assessment (adoption of IEEE 1082 Guide for incorporating human reliability analysis into probabilistic risk assessments for nuclear power generating stations and other nuclear facilities)	2020	2022	

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6.5.2 Topics of interest

In many cases, to make SMRs economically viable, staffing needs to be optimised, often by mutualised operation, where a single team (in control rooms and possibly in the field) operates multiple units. WGA8 could consider the opportunity of addressing the following issues in the revision of existing publications, or in new publications:

- Impacts of mutualised operation on main control rooms design.

- Impacts of mutualised operation on supplementary control rooms and their design.
- Impacts of mutualised operation on emergency response facilities.
- Impacts of passive systems on operator displays and controls.
- Impacts of staged construction in multi-unit plants.
- Control of mutualised equipment in a multi-unit plant.
- Concept of operation, functional analysis and assignment in a mutualised operation framework.
- HMIs in the field, including for mobile field operators.
- Off-site HMIs (emergency, remote equipment monitoring, etc.).
- Integrity of pre-fabricated modules during transportation to site.
- V&V on site vs. V&V in factory.

6.5.3 WGA8 roadmap

Topic	Action
Impacts of mutualised operation on main control rooms design	Technical Report leading to IEC 60964 revision
Impacts of mutualised operation on supplementary control rooms and their design	Technical Report leading to IEC 60965 revision
Impacts of mutualised operation on emergency response facilities	Technical Report leading to IEC 62954 amendment
Impacts of passive systems on operator displays and controls	IEC 61227 amendment; IEC 61772 amendment; IEC 62441 amendment; IEC 62646 amendment.
Impacts of staged construction in multi-unit plants	Technical Report leading to IEC 60964 revision
Control of mutualised equipment in a multi-unit plant	IEC 61227 amendment; IEC 62646 amendment.
Concept of operation, functional analysis and assignment in a mutualised operation framework	Technical Report leading to IEC 61839 revision NWIP (International Standard – HFE)
HMIs in the field, including for mobile field operators	IEC 61227 amendment; IEC 61772 amendment.
Off-site HMIs (emergency, remote equipment monitoring, …).	Technical Report leading to IEC 60964 revision and IEC 62954 amendment
Integrity of pre-fabricated modules during transportation to site	IEC 60964 amendment
V&V on site vs. V&V in factory.	IEC 61771 amendment

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6.6 WGA9: System performance and robustness toward external stress

6.6.1 Current portfolio

Reference	Title	Publication date	Stability Date	Revision going on ?
IEC/IEEE 60780-323 Ed.1.0	Electrical equipment – Qualification	2016	2023	
IEC 60980 Ed. 1.0	Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations	1989	2020	Revision underway
IEC 61497 Ed. 1.0	Electrical interlocks for functions important to safety – Recommendations for design and implementation	1998	2021	
IEC 61888 Ed. 1.0	Determination and maintenance of trip setpoints	2002	2021	
IEC 62003 Ed. 2.0	Requirements for electromagnetic compatibility testing	2020	2023	
IEC 62385 Ed. 1.0	Methods for assessing the performance of safety system instrument channels	2007	2021	
IEC 62645 Ed. 1.0	Requirements for security programmes for computer-based systems	2019	2024	
IEC 62859 Ed.1.0 + Amendment 1	Requirements for coordinating safety and cybersecurity	2016	2022	
IEC TR 62918 Ed. 1.0	Use and selection of wireless devices to be integrated in systems important to safety	2014	2022	
IEC 62988 Ed.1.0	Selection and use of wireless devices	2018	2022	
IEC 63096 Ed. 1.0	Security controls	2020	2023	
IEC 63147 Ed. 1.0 + IEC TR 62123 Ed.1.0	IEEE 497	2017	2020	
IEC TR 63192 Ed. 1.0	Hazard analysis	2019	2022	

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6.6.2 Topics of interest

WGA9 could consider the opportunity of addressing the following issues in the revision of existing publications, or in new publications:

- Mutualised operation of multiple units.
- Integrity of modules manufactured and tested in factory, and then transported to site, taking account of malicious and non-malicious aggressions.
- Impacts of multi-unit plants and large fleets of identical units on security programmes.
- Impacts of mutualised operation on security programmes.
- Assessment of emergent industrial standards (such as OPC UA) in terms of cybersecurity.
- Impacts of multi-unit plants operated from a single control room from an EMC perspective.
- Determination of the profile for equipment qualification (environmental, seismic, EMC).
- Methods for the characterization of the electromagnetic environment to determine the risks for EMC.
- Guidance for RF spectrum monitoring to ensure interoperability of wireless devices.
- Grounding, shielding, and installation practices for new installations necessary to maintain EMC.

- Methods for in-situ verification of immunity to EMI/RFI, particularly during equipment commissioning.
- Enhancement of the requirements for wireless sensors and infrastructure.
- Similarities and differences with respect to IEEE publications.

6.6.3 WGA9 roadmap

Topic	Action
Enhanced EMC background testing to validate different operability and reliability in SMRs than large LWRs	IEC 62003 Ed. 2 revision
Determination of the reviewed EQ profile for SMR designs including techniques for qualifying newer digital devices	IEC/IEEE 60780-323 revision or Technical Report
Impacts of multi-units plants and large fleets of identical SMRs to optimize cybersecurity while maintaining safety and assessment of emerging industrial standards such as OPC UA	IEC 62645 revision or new Technical Report
Establishing risk-based approach to cybersecurity for optimizing graded approach in SMR operation	Technical Report in progress – update to address specific SMRs
Updating ongoing TR scope of cybersecurity modelling to address specific SMR and multi-modular needs.	Technical Report in progress – update to address specific SMR needs
Update to the wireless standard to address specific needs of SMR for optimized deployment	IEC TR 62918 revision
Identifying updates to the online monitoring and use of diagnostics/prognostics to reduce or eliminate required human manual surveillances and reducing required plant staff.	IEC 62385 revision

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