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Nuclear facilities – Instrumentation and control, and electrical power systems – Artificial Intelligence applications

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NUCLEAR FACILITIES – INSTRUMENTATION AND CONTROL, AND ELECTRICAL POWER SYSTEMS – ARTIFICIAL INTELLIGENCE APPLICATIONS

FOREWORD

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IEC TR 63468 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:

Draft	Report on voting
45A/1458/DTR	45A/1472/RVDTR

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

The language used for the development of this 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/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

a) Technical background, main issues and organization of the technical report

Artificial intelligence(AI) is transforming many fields including nuclear industry drastically. It has been explored and deployed for many years in the nuclear industry and recent advances in AI have enabled many more potentials. Wide adoption of AI calls for standardization efforts to minimize the risks and optimize the efficiency in developing and deploying AI applications. Due to its nature as an enabling technology, the topic of AI applications will cross-cut with almost all working groups within SC 45A, which entails discussions on the setting up of a new working group to dedicate to this new technical field.

This technical report overviews AI technologies from a nuclear perspective, and summaries potential AI application scenarios in nuclear facilities. Based on these inputs, a three-tiered structure for nuclear AI standards within the framework of SC 45A is proposed, and development priorities are discussed. This document then moves on from technical discussions to the organizational challenges in SC 45A. It analyses the cross-cutting nature of AI applications in nuclear facilities and makes the recommendation the setting-up a new working group, whose title and scope are also proposed. Possibility of SC 45A liaison with other technical subcommittees is explored and recommendation is given accordingly.

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

The technical report IEC TR 63468 is a fourth level IEC SC 45A document. This document overviews the fundamentals of artificial intelligence (AI) and its potential applications in nuclear facilities to foster better understanding and adoption of AI technologies within such facilities. It also proposes a structure for future SC 45A standard series on nuclear AI applications.

For more details on the structure of the SC 45A standard series, see item d) of this introduction.

c) Recommendations and limitations regarding the application of this technical report

This document is the first of its kind within SC 45A, intended to pave the road for extensive and systematic efforts in the standard development activities with regard to AI applications. It helps stakeholders to understand the main benefits and challenges of AI from a nuclear perspective. More documents are expected to follow in this direction in the coming years.

It is important to note that a technical report is entirely informative in nature, 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 IEC SC 45A standard series comprises a hierarchy of four levels. The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046.

IEC 61513 provides general requirements for instrumentation and control (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 power systems for nuclear power plants.

IEC 61513 and IEC 63046 refer directly to other IEC SC 45A standards for general requirements for specific topics, such as categorization of functions and classification of systems, qualification, separation, defence against common cause failure, control room design, electromagnetic compatibility, human factors engineering, 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 requirements for specific equipment, technical methods, or activities. Usually these documents, which make reference to second-level documents for general requirements, 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, the IAEA safety guide SSG-51 dealing with human factors engineering in the design of NPPs and the implementing guide NSS42-G for computer security at nuclear facilities. The safety and security terminology and definitions used by the 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 9001 as well as to IAEA GSR 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, IEC 63351 is the entry document for the human factors engineering standards and IEC 62342 is the entry document for the ageing management standards.

NOTE 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 TR 64000 provides a more comprehensive description of the overall structure of the IEC SC 45A standards series and of its relationship with other standards bodies and standards.

NUCLEAR FACILITIES – INSTRUMENTATION AND CONTROL, AND ELECTRICAL POWER SYSTEMS – ARTIFICIAL INTELLIGENCE APPLICATIONS

1 Scope

This document overviews the fundamentals of artificial intelligence (AI) as it could potentially be applied within nuclear facilities and identifies proven or potential applications, with the objective to foster better understanding and adoption of AI technologies within such facilities. With the objective of supporting future standard development work of IEC SC 45A in this technical area, this document takes the initiative to propose a structure for SC 45A standard series on nuclear AI applications, and recommends setting up a new dedicated working group to be responsible for and coordinate standard development efforts in this particular area, taking into account its cross-cutting nature.

As some technical aspects of AI are still evolving, and the regulatory framework from nuclear regulators is not yet established, this document focuses on AI applications in nuclear facilities that are non-safety related. However, this approach does not necessarily exclude the applicability of AI technologies in safety applications in nuclear facilities where the technology itself and the related regulatory framework support such potentials.

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*

IEC 63046, *Nuclear power plants – Electrical power system – General requirements*

IEC TR 63400, *Nuclear facilities – Instrumentation, control and electrical power systems important to safety – Structure of the IEC SC45A standards series*

ISO/IEC 22989:2022, *Information technology – Artificial intelligence – Artificial intelligence concepts and terminology*

ISO/IEC 23053, *Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)*

ISO/IEC TR 29119-11, *Software and systems engineering – Software testing – Part 11: Guidelines on the testing of AI-based systems*