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Nuclear facilities – Human factors engineering – Application to the design of human-machine interfaces

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Nuclear facilities – Human factors engineering – Application to the design of human-machine interfaces

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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NUCLEAR FACILITIES – HUMAN FACTORS ENGINEERING – APPLICATION TO THE DESIGN OF HUMAN-MACHINE INTERFACES

FOREWORD

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IEC 63351 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
45A/XX/FDIS	45A/XX/RVD

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 International Standard 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- withdrawn, or
- revised.

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INTRODUCTION

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

The technical background that led to the decision to develop this International Standard is given in technical report IEC TR 63214.

In brief, IEC TR 63214 recognized that:

- IEC 60964 entitled "Control Room Design" (then at edition 2.0) included a detailed set of requirements to be applied when designing a control room and a process to implement Human Factors Engineering;
- The above two topics were mixed and the Human Factors part was incomplete and did not reflect state-of-the-art knowledge and wording;
- IEC 60964 was also written considering only Human Factors within the scope of the I&C systems in control room designs. The result was that the document did not take a holistic approach towards the design of the plant-wide control rooms and human-machine interfaces (HMI), including e.g. the local control stations located throughout the plant;
- In addition, the IAEA was in the process of developing a Human Factors Guide (now published as SSG-51) that should also be reflected in the IEC standards.

In view of the above, IEC TR 63214 proposed the development of a dedicated Human Factors Engineering standard while reducing the scope of IEC 60964 to a pure Control Room Design standard. This reduction in scope is for a future edition of IEC 60964.

This document focuses on the application of a human factors engineering (HFE) programme to the design of the human-machine interfaces throughout the lifetime of a nuclear facility, including consideration of plant modifications.

This document is applicable to nuclear facilities such as: nuclear power plants (NPPs), research reactors, uranium enrichment and nuclear fuel fabrication facilities, spent fuel storage and reprocessing facilities.

It is intended that this document be used by operators of NPPs (utilities), and of other facilities associated with the production of nuclear energy, systems designers, system evaluators and by licensors.

It is further noted that, whilst existing standards such as those in the ISO 9241 series address many aspects of the ergonomics of human-system interactions, those standards are judged to be too detailed, extensive and in constant evolution to adequately guide the HFE programme requirements within the scope of IEC SC 45A. However, reference is made to ISO 11064 for certain aspects of the ergonomic design of control centres.

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

The IEC human factors engineering (HFE) standard is on the same level as IEC 60964 and is the second encompassing document within WG 8. The intention of WG 8 is to update the standard environment step by step with the goal of linking all HFE related standards to this HFE standard and linking all control room (CR) and HMI design-related standards to IEC 60964.

Figure 1 shows the new structure after the update of all WG 8 standards.

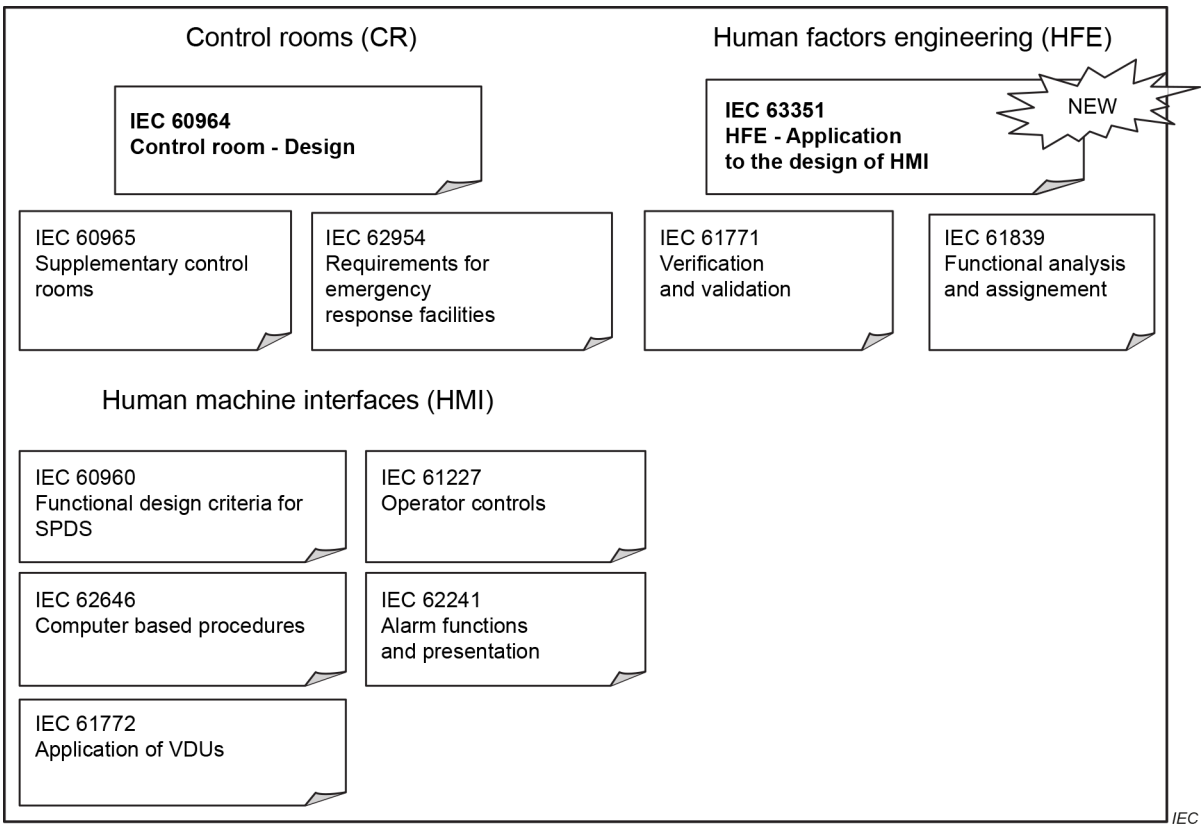

Figure 1 – New WG 8 document structure

The documents shown on the left of the figure below the "IEC 60964" box constitute the existing set of control room (CR) and HMI design-related standards and those on the right of the figure below the "IEC 63351" box constitute the HFE related standards.

Due account has to be taken of the relationship between the standards in WG 8 when updating IEC 60964 and the new HFE standard. New standards covering detailed information about HFE may follow and be linked to this standard. Other standards currently pointing to IEC 60964 will in future revisions need to point to both WG 8 high level documents. After the final update this can be adapted based on the relevant content.

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 Standard

This standard specifies the basic principles and requirements of an HFE programme for all stages of the lifecycle of a nuclear facility.

It builds on the guidance provided by state-of-the-art HFE guides, such as IAEA SSG-51. It covers the minimum requirements for the complete technical scope recognized by such guides but points to other standards for specific detailed requirements.

To ensure that the standard will continue to be relevant in future years, the emphasis has been placed on issues of principle, rather than on specific technologies or techniques.

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 consistent set of documents organised in a hierarchy of four levels. The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046, covering respectively general requirements for instrumentation and control (I&C) systems and general requirements for electrical power systems of NPPs. IEC 61513 and IEC 63046 adopt an overall system life-cycle framework and constitute, along with the relevant second-level standards, the nuclear implementation of the basic safety series IEC 61508.

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.

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 refer to second-level documents for general requirements and can be used on their own.

A fourth level extending the IEC SC 45A standard series, corresponds to the Technical Reports which are not normative.

The IEC SC 45A standards series consistently implements and details the safety and security principles and basic aspects provided in the relevant IAEA safety standards and in the relevant documents of the IAEA nuclear security series (NSS). In particular this includes the IAEA requirements SSR-2/1 , establishing safety requirements related to the design of nuclear power plants (NPPs), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs, 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 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 IEC TR 63400 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 – HUMAN FACTORS ENGINEERING – APPLICATION TO THE DESIGN OF HUMAN-MACHINE INTERFACES

1 Scope

This document specifies the basic principles and requirements for the application of a human factors engineering (HFE) programme to the design of the human-machine interfaces (HMI) throughout the lifetime of a nuclear facility. The focus of this document is on control rooms and control functions as discussed in the text.

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 60964:2018, *Nuclear power plants – Control rooms – Design*

IEC 60965, *Nuclear power plants – Control rooms – Supplementary control room for reactor shutdown without access to the main control room*

IEC 61227, *Nuclear power plants – Control rooms – Operator controls*

IEC 61771, *Nuclear power plants – Main control room – Verification and validation of design*

IEC 61772, *Nuclear power plants – Main control room – Application of visual display units (VDUs)*

IEC 61839, *Nuclear power plants – Design of control rooms – Functional analysis and assignment*

IEC 62241, *Nuclear power plants – Main control room – Alarm functions and presentation*

IEC 62954:2019, *Nuclear power plants – Control rooms – Requirements for emergency response facilities*

IEC TR 63214:2019, *Nuclear power plants – Control rooms – Human factors engineering*

IEC 63260:2020, *Guide for incorporating human reliability analysis into probabilistic risk assessments for nuclear power generating stations and other nuclear facilities*

IEC/IEEE 63260-1082, *Guide for incorporating human reliability analysis into probabilistic risk assessments for nuclear power generating stations and other nuclear facilities*

ISO 11064-1, *Ergonomic design of control centres – Part 1: Principles for the design of control centres*

ISO 11064-2, *Ergonomic design of control centres – Part 2: Principles for the arrangement of control suites*

ISO 11064-3:1999, *Ergonomic design of control centres – Part 3: Control room layout*

ISO 11064-4, *Ergonomic design of control centres – Part 4: Layout and dimensions of workstations*

ISO 11064-5, *Ergonomic design of control centres – Part 5: Displays and controls*

ISO 11064-6, *Ergonomic design of control centres – Part 6: Environmental requirements for control centres*

ISO 11064-7, *Ergonomic design of control centres – Part 7: Principles for the evaluation of control centres*